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Bibliography of
Interactions of Nucleons with Nucleons
in the Energy Range 100 keV to 1 GeV

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Bibliography of
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Compiled by

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BIBLIOGRAPHY OF INTERACTIONS OF NUCLEONS WITH NUCLEONS
IN THE ENERGY RANGE 100 keV TO 1 GeV

A search of Nuclear Science Abstracts from Volume 20 (1966) through Volume 22, Number 12 (June 30, 1968) was made for information on the following types of interactions: neutrons with neutrons, neutrons with protons, and protons with protons. In general the energy range was limited to 100 keV to 1 GeV, and theoretical as well as experimental papers have been included. The abstracts have been arranged in numerical order within each volume of Nuclear Science Abstracts with the abstracts from the most recent volume placed first.

Volume 22 (1968)

1451 ANALYSIS OF NUCLEON-NUCLEON SCATTERING WITH LARGE MOMENTUM TRANSFERS. Nagasaki, Masayuki; Hirasawa, Toshiaki; Taketani, Mituo (Rikkyo Univ., Tokyo). *Progr. Theor. Phys. (Kyoto)*, 38: 514-16(Aug. 1967).

The Serber model, which is based on an approximation for the amplitude of waves scattered from a soft medium at forward directions, is discussed. The scattering amplitude for the Klein-Gordon equation is considered. (J.F.P.)

1452 DYNAMICAL STATISTICAL MODEL OF HIGH ENERGY ELASTIC SCATTERING. Namiki, Mikio; Ohba, Ichiro (Waseda Univ., Tokyo). *Progr. Theor. Phys. (Kyoto)*, 38: 431-48(Aug. 1967).

High energy elastic scattering is discussed through a proposal of the "dynamical statistical model," in which large angle elastic scattering at high energies is considered to be caused by some sort of irreversible process taking place in the inner system of colliding nucleons. The "dynamical statistical model" enables one to obtain both the rapid decrease of the differential cross section for increasing energy and the small fluctuation of the scattering amplitude, for the large angle elastic scattering at high energies. After a few manipulations, it is shown that the model can derive the differential cross section proportional to $\exp(-\alpha p_\perp)$ similar to Orear's empirical formula for large $p_\perp$, α and $p_\perp$ being, respectively, the Orear constant and the transverse momentum. The present model also gives the relation between the exponential $p_\perp$ -dependence for large $p_\perp$ and the Gaussian $p_\perp$ -dependence for small $p_\perp$ within a unified theoretical framework, from which follows $\alpha^{-1} \geq 0.158 M$, M being the nucleon mass. This is in good agreement with experiment. Furthermore it is remarked that the present model has the possibility of deriving, even for large $p_\perp$, the Gaussian $p_\perp$ -dependence like Krisch's empirical formula in some extreme cases, which may not be obtained by the simple statistical model given by Hagedorn and others and by the unitarity-analyticity argument. The irreversibility of the large-angle scattering—to be realized even by the time-reversal invariant Hamiltonian—does not permit one to impose the time-reversal invariance requirement and the simple unitarity-analyticity argument on the large angle scattering amplitude except on the forward amplitude. Its consequence may be used for a crucial test of the model. The "dynamical statistical model" was built on the basis of critical discussion against the simple statistical model. For this reason a detailed discussion of the latter is given. (auth)

1453 TWO-PION EXCHANGE CONTRIBUTION TO THE NUCLEON-NUCLEON POTENTIAL. Kapadia, P. D. (University Coll., London). *Nucl. Phys.*, B3: 291-311(1967).

The low energy scattering of two nucleons is studied within the framework of dispersion theory, using the Mandelstam representation.

Certain ρ -functions occur in the treatment of this problem and these ρ -functions are expressed in terms of the helicity amplitudes for the process $2\pi \rightarrow N\bar{N}$ for any value of the angular momentum J . These ρ -functions are evaluated using the BCL model and using the "realistic" helicity amplitudes for the S- and P-waves for the process $2\pi \rightarrow N\bar{N}$. Next, going over to the potential approximation, the two-pion contribution to the nucleon-nucleon potential was evaluated. In the nucleon-nucleon potential, as calculated by Cottingham and Vinh Mau, the BCL S- and P-wave model-dependent contributions are replaced by the corresponding S- and P-wave contributions calculated using the realistic helicity amplitude data for the process $2\pi \rightarrow N\bar{N}$. The nucleon-nucleon potentials so obtained in the various cases, such as the central potential, the spin-orbit potential, etc., are described graphically by curves for both the triplet and singlet states. The various ρ -functions obtained are also illustrated graphically and a critical discussion of the work is included. In conclusion, it is observed that the nucleon-nucleon potential calculated agrees with that calculated by Cottingham and Vinh Mau and with the Yale curves for the potential, except in special cases where the ω meson is expected to contribute strongly. (auth)

1454 PROTON-PROTON BREMSSTRAHLUNG. Pearce, W. A.; Gale, W. A.; Duck, I. M. (Univ. of Rice, Houston, Tex.). *Nucl. Phys.*, B3: 241-76(1967).

Proton-proton bremsstrahlung cross sections are calculated using the Tabakin separable potentials to generate off-shell nucleon-nucleon t-matrix elements in low partial waves and off-shell one-pion-exchange amplitudes for the higher partial waves. The results are in good agreement with the experimental values reported by Warner, Halbert, Gottschalk and Thorndike at proton bombarding energies of 48, 62, 158 and 204 MeV, but are at the lower limit of the experimental results of Warner at 30 MeV and of Slaus at 46 MeV. The calculated cross sections in the Harvard geometry decrease monotonically to zero at zero proton energy. The effect of rescattering corrections and of nonlocal corrections to the bremsstrahlung amplitude were estimated and these terms were found to be negligible for proton-proton bremsstrahlung. The results are insensitive to the choice of Tabakin's "soft-core" or "hard-shell" S_0 potential, and are insensitive to small changes in the P-wave potentials. (auth)

1456 INFLUENCE OF THE $\pi\pi$ - $N\bar{N}$ INTERACTION UPON THE NUCLEON-NUCLEON SCATTERING. Lend'el, V. I.; Ernst, B. M. (Uzhgorod State Univ., USSR). *Yadern. Fiz.*, 6: 614-24(Sept. 1967). (In Russian).

The amplitude of the nucleon-nucleon scattering is expressed via the parameters of the πN and $\pi\pi$ -interactions. The constants of the ρ , σ and ω meson-nucleon couplings are obtained on basis of the differential approach. The partial amplitudes of the NN -interaction are described reasonably with these constants. (auth)

1457 PROTON-PROTON SCATTERING AT HIGH ENERGY AND LARGE ANGLES AND THE THEORY OF THE COMPLEX ANGULAR MOMENTA. Ansel'm, A. A.; Dyatlov, I. T. (Ioffe Inst. of Physics and Tech., Leningrad). *Yadern. Fiz.*, 6: 603-9 (Sept. 1967). (In Russian).

Proton-proton scattering at high energy and large momentum transfer are discussed in view of the complex angular momenta. It is shown that the available experimental data are in good accordance with the predictions based on the calculations of the contribution from the Mandelstam branch points in the angular momentum plane. A picture is proposed to explain the change of the character of the momentum transfer dependence of the cross section at large angles. (auth)

1733 THE REACTION $d + {}^3\text{He} \rightarrow {}^3\text{H} + (pp)$. Henley, E. M. (Univ. of Washington, Seattle); Richards, F. C.; Yu, D. U. L. Contract AT(45-1)-1388. *Nucl. Phys.*, A103: 361-84(1967). (RLO-1388-515).

The reaction $d + {}^3\text{He} \rightarrow {}^3\text{H} + 2p$ is studied in the region of phase space where the (pp) final-state interaction is important, that is for the most energetic ${}^3\text{H}$ nuclei. Two reaction processes are considered in detail, a pick-up mechanism and a charge-exchange reaction. The cross section is computed by three methods; a modified Born approximation, comparison with the elastic scattering $d + {}^3\text{He}$, and a distorted wave approximation. The dependence of the calculated differential cross section on the form of the interaction is studied, and results are compared with experiment. (auth)

3256 PHASE-SHIFT ANALYSIS OF HIGH-PRECISION (p,p) POLARIZATION DATA AT 19.7 MeV. MacGregor, Malcolm H. (Univ. of California, Livermore); Wright, Robert M.; Arndt, Richard A. *Phys. Rev. Lett.*, 19: 1209-12(Nov. 13, 1967). (UCRL-70673).

A recent high-precision (p,p) polarization measurement at 19.7 MeV was phase-shift analyzed. It is not consistent with other (p,p) measurements at nearby energies. (auth)

3310 CROSSOVER AND POLARIZATION PHENOMENA IN HIGH-ENERGY SCATTERING. CUTS, CONSPIRACIES, AND SECONDARY REGGE POLES. Barger, V.; Durand III, L. (Univ. of Wisconsin, Madison). *Phys. Rev. Lett.*, 19: 1295-8(Nov. 27, 1967).

The usual interpretation, in Regge-pole models, of the change in signs of the cross section differences $d\sigma(\bar{A}B)/dt - d\sigma(AB)/dt$ at $t \sim -0.15$ (GeV/c)² observed in elastic πN , KN , and NN scattering is inconsistent with recent data on the reaction $\gamma p \rightarrow \pi^0 p$. It is pointed out that this contradiction is direct evidence for the existence of contributions to the high-energy scattering amplitudes in addition to those of the leading Regge poles. Alternative explanations of the crossover phenomena which avoid the foregoing difficulty are proposed, and their implications are discussed. (auth)

3371 HIGH ENERGY STRONG INTERACTIONS OF ELEMENTARY PARTICLES. Bertocchi, L. (CERN, Geneva); Ferrari, E. pp 71-217 of *High Energy Physics*. Vol. II. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

A review is given of the experimental and theoretical ideas relevant to the dynamical approach to the physics of strong interactions. Only those initial states that are experimentally accessible are considered; i.e., pp , np , $\bar{p}p$, π^+p , K^+p , and the reactions initiated by them. Section II gives a review of the experimental situation on elastic scattering, inelastic scattering, charge exchange scattering, quasi-elastic interactions, and inelastic processes with many-particle production. A summary of the general properties of the scattering amplitude follows in Section III. The basic models used for the description of experimental facts on elastic and inelastic interactions are presented in Sections IV and V. Section VI deals specifically with the asymptotic region. (~400 references). (L.B.S.)

3419 ELASTIC AND INELASTIC CHARGE EXCHANGE PROCESSES IN THE QUARK MODEL. Bialas, A. (Univ., Krakow. Inst. of Nuclear Physics, Krakow); Gula, A.; Muryn, B. *Acta Phys. Pol.*, 32: 443-59(1967).

Two-body charge-exchange processes, with or without resonance production are discussed in the framework of the generalized quark model. Relations between the cross sections and spin density elements are derived and compared with the experimental data. The comparison shows a rather good agreement for the density matrix elements. On the other hand, relations between the cross sections predicted by the model seem to disagree, in general, with the data. (auth)

3424 STUDY OF TWO-PION EXCHANGE CONTRIBUTIONS TO QUASI-ELASTIC SCATTERING AT HIGH ENERGIES. Smrz, P.; von Baeyer, H. C. (McGill Univ., Montreal). *Nuovo Cim.*, (10), 51A: 879-98(Oct. 21, 1967).

The two-pion exchange contributions to the absorptive amplitude are estimated for the processes $\gamma p \rightarrow \rho p$, $\pi p \rightarrow A_1 p$, $\pi p \rightarrow A_1 p$, $pp \rightarrow N^* p$ for $N^*(1400)$ and $N^*(1520)$ and $\pi p \rightarrow \omega N^*(1238)$. The off-shell πN scattering amplitude in the Feynman diagram is replaced by its experimental on-shell value. It is found that, with appropriate form factors, it is possible to fit the shape of the differential cross section in all cases, but the absolute magnitude predicted by the model is too small for the processes $\gamma p \rightarrow \rho p$, $\pi p \rightarrow A_1 p$ and $\pi p \rightarrow N_{33}^* \omega$. Possible reasons for this failure are discussed and the model is compared to similar ones suggested by other authors. (auth)

3448 ANALYTIC HELICITY AMPLITUDES AND REGGE-POLE FORMULAE FOR DIFFERENTIAL CROSS SECTIONS. Wang, Ling-lie Chau. Berkeley, Calif., Univ. of California, 1966. 58p.

Thesis.

A simple and straightforward method to identify and remove the kinematic singularities of helicity amplitudes is constructed from the Trueman-Wick crossing relations. A set of amplitudes free of all kinematic singularities and zeros is obtained for two-particle - two-particle reactions of any spin and masses except for boson-fermion interactions. It is shown that for boson-fermion interactions with general mass assignments there is always a

kinematic S^+ singularity left in the amplitude. Therefore it is natural to consider the amplitudes of boson-fermion interactions as functions of S_+ instead of S . The amplitudes obtained by the above method are suitable for Reggeization and their residue functions are free of kinematic singularities. Regge pole formulas for differential cross sections of some quasi two-body πN and NN interactions, which can have one or two meson trajectories exchanged, are given. The reactions treated are: $\pi N \rightarrow \pi \Delta$ (1236), $\pi N \rightarrow \omega N$, $\pi N \rightarrow \omega \Delta$ (1236), $\pi N \rightarrow A_2 N$, $\pi N \rightarrow \eta N$, $\pi N \rightarrow \eta \Delta$, $\pi N \rightarrow \rho N$, $\pi N \rightarrow \rho \Delta$ (1236), $NN \rightarrow N \Delta$ (1236), $NN \rightarrow NN^*$ (1500, $\frac{1}{2}^-$), $NN \rightarrow NN^*$ (1480, $\frac{1}{2}^-$). (Disser. Abstr.)

3455 CONTRIBUTION OF MANDELSTAM BRANCH CUTS TO PROTON-PROTON SCATTERING AND TO PRODUCTION AMPLITUDES AT HIGH ENERGY. Dunne, S. A. (Ioffe Inst. of Physics and Tech., Leningrad). Phys. Rev. Lett., 19: 1299-1302 (Nov. 27, 1967).

The contribution of Mandelstam branch cuts to the processes $p + p \rightarrow p + p$, $p + K^- \rightarrow p + K^+$, $\gamma + p \rightarrow p + \pi$, and $p + \pi \rightarrow p + A_2$ is investigated by considering the structure of diagrams in which two or more Reggeons (asymptotic Regge-pole amplitudes) are exchanged. Three or more Reggeons are required for the forward nucleon-nucleon scattering amplitude $\sigma_X^{(1)}\sigma_X^{(2)} + \sigma_Y^{(1)}\sigma_Y^{(2)}$, and for the forward production amplitudes. These amplitudes are expected to behave asymptotically as $s/(\ln s)^5$. (auth)

3456 COMPARISONS BETWEEN ON-SHELL AND OFF-SHELL METHODS FOR THE TWO-BODY T-MATRIX. Wong, D. Y. (Univ. of California, San Diego, La Jolla). pp 49-55 of Elementary Particle Physics. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

The nonrelativistic Low equation is extended to include the relativistic phase space factor. A general velocity dependent potential is also allowed. A method for solving the Low-equations is derived and applied to the NN , NN , and $\pi\pi$ scattering problems. The results are compared with solutions of the on-shell N/D equations. It is found that the off-shell method does not alter significantly the results of semi-phenomenological on-shell calculations except in the case when there are strongly bound states. (L.B.S.)

3457 PLOT OF ALL HIGH-ENERGY p - p ELASTIC SCATTERING DATA USING PARTICLE IDENTITY. Kriesch, A. D. (Univ. of Mich., Ann Arbor). Phys. Rev. Lett., 19: 1149-51 (Nov. 6, 1967).

Previous attempts to find a single variable against which all cross sections for proton-proton elastic scattering could be plotted in an energy-independent way are briefly summarized. It is proposed that the flattening observed near 90° in a recent plot of $d\sigma/dt$ against $\beta^2 P_\perp^2$ (β is the center-of-mass velocity and $P_\perp$ is the transverse momentum) is caused by the fact that the system contains two identical particles. The cross section is studied when identity effects are subtracted out. A single smooth curve was obtained over a cross-section range of 10^{12} . (L.B.S.)

3458 NUCLEON-NUCLEON SCATTERING. Breit, G.; Haracz, R. D. (Yale Univ., New Haven). Contract AT(30-1)-1807. pp 21-191 of High Energy Physics. Vol. I. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

Some progress in the field of nucleon-nucleon scattering is reviewed in section I. Section II deals with the meaning of phase shift, the concept being introduced directly in a relativistic manner. In section III the scattering matrix is discussed in terms of explicit formulas involving phase shifts and coupling parameters. The transition from the magnetic quantum number representation to one involving spin functions transforming under rotations like Cartesian coordinates is explicitly presented for the scattering as well as the density matrices. In section IV the calculation of quantities measured in experiments is discussed with results usually stated in two equivalent forms. Some references to work on polarized proton sources are also included. Section V is concerned with relativistic kinematics and with some relativistic electromagnetic effects. Section VI deals with the one pion exchange interaction assuming pseudoscalar coupling. The lack of a firm foundation for the localization of OPE effects is discussed. In addition, some usually omitted Coulomb effects are mentioned which may have an influence on the values of the pion-nucleon coupling constant derived from data analysis. In section VII the procedures used in searching for phase shifts giving the best fits to experimental data are discussed. Section VIII begins with a discussion of the conclusion reached by Noyes to the effect that the effective range of the 1S_0 state is about 10% smaller for n - p than for p - p scattering. Section VIII-B deals with the laboratory energy region from about 10 to 350 MeV. A brief account is given of phase shift analyses above the meson threshold production and of the way in which it joins on to the intermediate region in section VIII-C. A very brief account is also given of typically high energy phenomena in the region of several BeV and of some of the existing theoretical explanations. Section IX is concerned with the empirical evidence that has accumulated from partial wave data analyses concerning charge independence at large distances. A brief account is also given of empirical tests of the mathematical form of the OPEP. In section X a few remarks are made regarding the present status of the theory and test of space-time symmetries of nucleon-nucleon interactions. (417 references with supplementary references added in proof). (L.B.S.)

3467 VELOCITY DEPENDENT BOSON EXCHANGE POTENTIALS AND NUCLEON-NUCLEON SCATTERING IN THE BORN APPROXIMATION. Sharma, Ravi Dutta. Gainesville, Fla., Univ. of Florida, 1966. 295p.

Thesis.

An attempt was made to understand the nucleon-nucleon (NN) interaction in terms of the one-boson-exchange-potential (OBEP) model and to account for NN elastic scattering phase-shifts in the Born approximation for nonrelativistic energies (25-310 MeV) in the laboratory frame. Theoretically, the OBEP are derived by Green, the resulting expressions being given in the Diracian form. The two-particle Dirac equation is reduced to a Schrodinger-Pauli form using a method similar to Breit's method of reduction to large components. A general form of interaction is then obtained in the Pauli-form which is applied to scalar, pseudoscalar and three different forms of vector meson exchange potentials. The Schrodinger-type equation with velocity dependence can be treated by the method of effective mass generally used in exact treatments. Another possible method in the Born-approximation is the direct-method which can treat the velocity dependence directly in phase-shift integrals without going to an effective potential. The experimentally known mesons π , ω , ρ and η are used together with two postulated scalar mesons in Green's purely relativistic model (cancellation of static scalar vector terms) as well as in broken-relativistic models and use is made of modified Yukawa form with

a higher mass subtractive meson coming from Green's work on generalized Lagrangian. This removes the singularities from the integrands and parameterizes the OBEP in the inner regions where it is uncertain. The scalar meson masses are very important for the results presented in this study on phase shifts. Only phases higher than S-waves are considered. The Born phases are found to be quite reliable for D-waves and higher and can be corrected empirically for P-waves. The Born-approximation generally gives larger P-wave results. Comparisons are made for certain sets of parameters between exact and Born phases and the differences are large only for the P-waves. Coupled states are treated according to Stapp's formalism and are also found to conform to these conclusions. Three different vector meson interactions are treated and Born phases resulting from them indicate that their relativistic terms agree for P-waves and higher. Various theoretical questions should be resolved before treating the S-waves, for which these interactions are likely to differ. The effective mass method is shown to break down if ρ meson parameters play an important role. The Born approximation, direct method, can help in that case and also the effects of various mesons and various terms in the interactions can be seen more explicitly in the Born approximation. A more correct treatment of the problem would require an exact relativistically correct treatment. Two pion exchange interactions as well as other processes like pair production, etc., should be considered for correct treatment of the S-waves. (Dissert. Abstr.)

4470 (HASL-186) RELATIVISTIC N-P SCATTERING CALCULATIONS FOR RECOIL PROTON SPECTROMETERS. Hajnal, Ferenc (New York Operations Office (AEC), N. Y. Health and Safety Lab.). Oct. 1967. 35p. Dep: CFSTI.

Two-particle relativistic elastic scattering formulas were adapted for recoil proton spectrometry. The basic equations of the special theory of relativity are reviewed. Elastic scattering is briefly described in the cms and laboratory coordinate systems. Derivations are given for the momentum, velocity, and total and kinetic energies for the scattering and recoil particles in the cms and laboratory coordinate systems before and after scattering. The differential cross sections are then calculated after deriving the scattering and recoil angles in the cms and laboratory systems. The transformation of the physical quantities from the cms to the laboratory coordinate system is described. Empirical fitting of the differential elastic scattering cross sections in the cms system was carried out in the energy range from 27 to 630 MeV. (auth)

5501 POLARIZED PROTON TARGETS AND LOW-ENERGY NUCLEON-NUCLEON EXPERIMENTS. Lehar, F.; Winternitz, P. (Joint Inst. for Nuclear Research, Dubna, USSR). Fortschr. Phys., 15: 495-536(1967).

The possible use of a polarized proton target in the investigation of low-energy nucleon-nucleon interactions is reviewed. The reconstruction of the scattering matrix and verification of P-, T-, and isotropic invariances are briefly discussed. Possible sources and detectors of polarized particles are considered. The problems of phase-shift analysis and nucleon-nucleon potentials are treated. Tables of experimental values are given for the polarization of nucleons scattered on nucleons. Experimental quantities determined from the phase-shift analysis are given in graphs for the energies 11.5 and 23.1 MeV. (auth)

5503 NUCLEON-NUCLEON POLARIZATION BETWEEN 300 AND 700 MeV. Cheng, David (Univ. of California, Berkeley); MacDonald, Burns; Helland, Jerome A.; Ogden, Philip M. Phys. Rev., 163: 1470-8(Nov. 25, 1967). (UCRL-11926(Rev.)).

The polarization parameter $P(\theta^*)$ was measured at beam energies of 310, 400, 500, 600, and 700 MeV over the range in the c.m. scattering angles $30 \text{ deg} \leq \theta^* \leq 150 \text{ deg}$ to an accuracy of typically ± 0.03 for pn scattering, and ± 0.02 for pp scattering. A polarized proton beam was scattered from an unpolarized target—deuterium for quasifree pn and pp measurements, hydrogen for free pp measurements—and both of the outgoing nucleons from the (quasi-) elastic scatter were detected by an array of 27 scintillation counters in multichannel coincidences. It was found that $P(\theta^*)$ for pp scattering can be approximated by $A \sin^2 \theta^* \cos \theta^*$, where A varies from -0.25 at 310 MeV to -0.4 at 700 MeV in this range. A comparison of $P(\theta^*)$ for free and quasifree pp scattering reveals good agreement between the two. (auth)

5505 MEASUREMENT OF THE R PARAMETER AND THE PHASE SHIFT ANALYSIS OF THE pp SCATTERING AT 600 MeV. Golovin, B. M.; Zulkarneev, R. Ya.; Kiselev, V. S.; Medved', S. V.; Nikanorov, V. I.; Pisarev, A. F.; Semashko, G. L. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 6: 804-8(Oct. 1967). (In Russian).

The R parameter of the triple scattering of protons with energy 605 MeV on protons is measured by means of the spark chambers controlled by the scintillation counters. The phase shift analysis of the experimental data on the pp-scattering near 600 MeV is carried out. (auth)

5598 (JINR-P1-3525) NOVYE REZULTATY FAZOVOGO ANALIZA NUKLON-NUKLONNOGO RASSEYANIYA PRI ENERGI 630 MeV. (New Results of the Phase-Shift Analysis of the Nucleon-Nucleon Scattering at 630 MeV). Glonti, L. M.; Kazarinov, Yu. M.; Rozanova, A. M.; Silin, I. N. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 32p. (In Russian). Dep.

The phase-shift analysis of data on the nucleon-nucleon scattering at the energies near to 630 MeV was performed. It is shown that under the assumption of the validity of one-meson approximation, beginning from the orbital moments $l = 6$, the number of solutions with $\chi^2 \leq 1.5 \bar{\chi}^2$ is equal to 5. Using a stronger criterion than the χ^2 -one, one can show that the maximum probability of a first type error rejecting certain solutions is $5 \cdot 10^{-4}$, $5 \cdot 10^{-4}$, and 4%, respectively. A new set appears which differs essentially from the previously known set. An additional set appears when taking into account the meson production from the nonresonance state 3F_4 . (auth)

5603 REGGE-POLE ANALYSIS OF pn $\rightarrow$ np AND $\bar{p}p \rightarrow \bar{n}n$ SCATTERING. Arbab, Farzam; Dash, Jan W. (Univ. of California, Berkeley). Phys. Rev., 163: 1603-10(Nov. 25, 1967).

The differential cross sections for the reactions $pn \rightarrow np$ and $\bar{p}p \rightarrow \bar{n}n$ were investigated. It is found that besides the p and $R(A_2)$ trajectories, the π and B trajectories must be included. A variety of schemes suggested by four-dimensional symmetry were investigated. The existence of various daughter trajectories does not suffice to explain the data, though the data can be fitted with a parity doublet, of which the pion may or may not be a member. In the former case some structure must be introduced into the pion residue function. (auth)

5606 ABSORPTIVE PERIPHERAL MODEL FOR THREE-BODY FINAL STATES: $NN \rightarrow NN\rho$. Saperstein, Alvin M. (Wayne State Univ., Detroit); Shrauner, E. Phys. Rev., 163: 1559-68 (Nov. 25, 1967).

An absorptive peripheral model for production processes involving three-body final states is developed. Motivated by the success of the absorptive peripheral model for the two-body reactions ($\pi N \rightarrow \rho N$), the same Born approximation is incorporated as a subprocess into a double peripheral Born approximation for production of mesonic resonances in nucleon-nucleon collisions ($NN \rightarrow NN\rho$). Absorptive effects of interactions in the three-body final states are taken into account by the method of the high-energy distorted-wave Born approximation applied successively to two-body subsystems (ρ, N) that are then recoupled: $(N(\rho, N))$. An approximation scheme for very-low-momentum-transfer events is developed from which curves predicting the characteristic shapes and magnitudes of the differential cross sections are calculated. The general formalism developed is sufficient for more detailed calculations at almost any degree of complexity in case the basic foundations of the model are found to be justified. (auth)

5607 PLANNING OF REGRESSION AND DISCRIMINATING EXPERIMENTS ON THE NN SCATTERING. Pazman, A.; Fedorov, V. V. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 6: 853-7 (Oct. 1967). (In Russian).

Formulas are deduced that allow one to substitute the continuous regression planning by the successive one (with a finite time). A new method for planning the discriminating experiments is presented and compared with other methods. (auth)

5608 TESTS FOR REGGE CUTS IN $N-N$ SCATTERING. Phillips, R. J. N. (Atomic Energy Research Establishment, Harwell, Eng.). Phys. Lett., 25B: 517-18 (Oct. 30, 1967).

Spin-dependent effects from cuts are considered. Those in forward scattering, suggested recently, are already known to be small. Other effects in nonforward scattering would be interesting to measure. (auth)

5626 HIGH ENERGY TOTAL CROSS SECTIONS AND 36-PIET 2^+ -MESONS. Kitakado, Shinsaku (Nagoya Univ., Japan). Progr. Theor. Phys. (Kyoto), 38: 653-61 (Sept. 1967).

High-energy total cross sections of nucleons and pseudoscalar mesons are analyzed under the assumption that 2^+ -mesons (Reggeons), which are exchanged between hadrons, are described by the 36-dimensional reducible representation of $SU(3)$. The universal coupling properties and the extended nonet coupling ansatz are used to determine the coupling of the relevant interaction. (auth)

5911 THEORY OF PROTON-PROTON BREMSSTRAHLUNG CONSISTENT WITH EXPERIMENT. Brown, V. R. (Univ. of California, Livermore). Phys. Lett., 25B: 506-9 (Oct. 30, 1967).

Proton-proton bremsstrahlung is calculated with the Bryan-Scott and the Hamada-Johnston potentials. Quantitative agreement with existing experiments, including photon angular distributions, is obtained. The results disagree in part with those of previous calculations. (auth)

7458 THEORY OF UNIVERSAL PRIMARY INTERACTIONS. Sudarshan, E. C. G. (Syracuse Univ., N. Y.). Nature (London), 216: 979-81 (Dec. 9, 1967). (NYO-3399-127).

This theory originates from observations that the theory of particle interactions becomes much simpler and more capable of correlating apparently unrelated phenomena if it is postulated that electromagnetism and weak interactions are not primary properties of the nucleons but are acquired by virtue of their interaction with vector and axial vector fields. (auth)

7494 REGGE-POLE MODELS FOR PION EXCHANGE REACTIONS. Durand III, Loyal (Univ. of Wisconsin, Madison). Phys. Rev. Lett., 19: 1345-8 (Dec. 4, 1967).

The problem of obtaining a satisfactory Regge-pole model for the pion-exchange reactions $np \rightarrow pn$, $\pi N \rightarrow \rho N^*$, $\gamma p \rightarrow \pi^* n$, and $\bar{p} p \rightarrow \bar{N}^* N^*$, is discussed with particular emphasis on the dynamics as seen in the s channel. It is pointed out that (i) satisfactory models can be obtained using a modified conspiracy model; (ii) pion exchange should provide the dominant contribution to the forward cross sections for incident momenta up to 30 to 50 GeV/c; and (iii) the energy dependence of the differential cross sections should change from that characteristic of pion exchange for $t \sim 0$ to that characteristic of the exchange of vector or tensor mesons at large momentum transfers $t \lesssim -0.5$ (GeV/c).² (auth)

7505 (UCRL-17903) SPIN DEPENDENT EFFECTS IN πN AND NN INTERACTIONS. Steiner, Herbert (California Univ., Berkeley, Lawrence Radiation Lab.). Oct. 1967. Contract W-7405-eng-48. 50p. Dep. CFSTI.

Some of the experimental and theoretical considerations that are pertinent to the study of spin-dependent effects in πN and NN interactions are discussed. The basic formalism is outlined, and the experimental situation in πN scattering at energies where resonance production is important is discussed. Also the experimental situation at high energies is considered with emphasis on the crucial tests of high energy theories afforded by the study of various spin-dependent quantities in πN and NN scattering. (J.F.P.)

7512 SUM RULES FOR MULTIPION PRODUCTION PROCESSES. Satz, H. (Univ. of California, Los Angeles). Phys. Rev. Lett., 19: 1453-5 (Dec. 18, 1967).

An additive quark model (together with an isospin distribution of charge configurations) is used to establish sum rules connecting pion-nucleon with nucleon-nucleon induced multipion production cross sections. The resulting relations are shown to be well satisfied by present experimental data. (auth)

7524 (ISS-67/25) EFFECTS OF THE s -STATE PION-NUCLEON INTERACTION ON THE PARTIAL-WAVE NUCLEON-NUCLEON ABSORPTIONS. Francaviglia, S. (Istituto Superiore di Sanita, Rome (Italy). Laboratori di Fisica). Sept. 8, 1967. 14p. Dep.

The absorption in proton-proton scattering around 1 GeV of laboratory kinetic energy of incident proton are computed. A previous calculation is extended by taking into account, besides the production of the resonance $I = \frac{1}{2}$, $J = \frac{3}{2}(P_{32})$, the production

v.22 (1968)

of pions in S_{11} and S_{31} state in respect to one nucleon as are inelastic process. These waves are the most important in the hypothesis of P_{33} dominance in scattering. The 3P_0 and 3P_1 absorptions are found to violate the unitarity limits, while the other waves are almost unaffected. (auth)

7525 (JINR-P2-3561) K VOPROSU O ROZYGYSHE ELEMENTARNOGO AKTA VZAIMODEISTVIYA PRI RASCHETAKH VNUTRIYADERNOGO KASKADA. (To the Sampling Problem of an Elementary Act of Interaction at the Intranuclear Cascade Calculation). Toneev, V. D. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1967. 7p. (In Russian). Dep.

A method for sampling the characteristics of inelastic πN - and NN -interactions, when calculating fast particle interaction with the nucleus in terms of cascade theory, is treated. The method suggested exactly takes into account both the conservation of energy principle and the law of momentum conservation. (auth)

7527 SEPARABLE POTENTIAL FOR THE NUCLEON-NUCLEON INTERACTION. Hammann, Th.; Oberlechner, G.; Trapp, G. (Centre de Recherches Nucleaires, Strasbourg). J. Phys. (Paris), 28: 755-62 (Oct. 1967). (In French).

A nonlocal separable potential is presented, which reproduces S , P and D wave phase shifts for nucleon-nucleon scattering up to 350 MeV. This potential contains very strong and short-ranged terms. As a preliminary theoretical test, the binding energy of nuclear matter is calculated using the reaction matrix G of the Brueckner-Goldstone theory. Saturation is found at a density corresponding to a Fermi momentum $k_F = 1.85 \text{ fm}^{-1}$, with an average binding energy per particle of -18 MeV . (auth)

7637 (COO-1573-33) NUCLEAR PHYSICS LABORATORY PROGRESS REPORT FOR THE PERIOD NOVEMBER 1, 1966 TO OCTOBER 31, 1967. (Case-Western Reserve Univ., Cleveland, Ohio. Dept. of Physics). Contract AT(11-1)-1573. 54p. Dep. CFSTI.

The results of experimental investigations of neutron elastic and inelastic scattering by ^{12}C , ^{58}Co , ^{63}Cu , ^{56}Fe , ^{58}Ni , and ^{60}Ni ; neutron polarization from the reaction $^{13}\text{C}(d,n)^{14}\text{N}$; and fluctuations in neutron total cross sections are presented. Developments in a number of areas of nuclear theory, elementary-particle theory, and scattering theory are summarized. (D.C.W.)

9578 ON THE TESTS OF THE BASIC ASSUMPTIONS OF COMPLEX ANGULAR MOMENTUM METHOD. Kaidalov, A. B. (Inst. for Theoretical and Experimental Physics, Moscow). Phys. Lett., 26B: 20-3 (Dec. 11, 1967).

The relations between the helicity amplitudes of the two-body processes with identical particles in the t -channel, valid for both poles and cuts in j -plane, are derived. Possible experiments to test these relations are discussed. (auth)

9620 ANGULAR DISTRIBUTION OF p - p SCATTERING AT HIGH ENERGY. Armoudian, G. A. (Columbia Univ., New York). Contract AT(30-1)-1932. Nuovo Cim. (10), 52A: 1328-32 (Dec. 21, 1967). (NYO-1932(2)-125).

A previous analysis of p - p interactions indicated the possibility of approximating the full p - p elastic amplitude in terms of several Born terms which have the effective potential $U(x)$ obtained by shifting the singularity from $x^2 = 0$ of the propagator in the usual theory. Calculations are carried out of the angular distributions and the cross sections and are compared with the data. (L.B.S.)

9623 COMPOUND STRUCTURE MODEL FOR THE P_{11} RESONANCE AND THE SHIFT OF ITS MASS IN THE $pp \rightarrow pn^*$ REACTION. Kobayashi, Tsunehiro (Waseda Univ., Tokyo). Progr. Theor. Phys. (Kyoto), 38: 990-2 (Oct. 1967).

A previous experiment on the $p + p \rightarrow p + N^*$ interaction showed that the peak of the P_{11} resonance production in the missing mass distribution shifts from 1400 to 1500 MeV as momentum transfer increases. The simplest case that the P_{11} is constructed from two resonances is treated. (L.B.S.)

9624 NUCLEON-NUCLEON POTENTIAL OF ONE-BOSON-EXCHANGE TYPE. Kishi, Yosuke (Kyoto Univ.); Sawada, Shoji; Watari, Wataro. Progr. Theor. Phys. (Kyoto), 38: 892-906 (Oct. 1967).

A phenomenological energy independent nucleon-nucleon potential is proposed, which has a form corresponding to the one-boson-exchange model. For the exchanged bosons, scalar bosons of mass 540 MeV and vector bosons of mass 750 MeV are considered in addition to the pion. The potential parameters which satisfactorily reproduce the experimental data on the proton-proton and the neutron-proton systems below 350 MeV are determined. From the potential parameters thus determined, coupling constants of bosons with nucleon are estimated and it is found that they have the values similar to those obtained in other analyses. (auth)

9627 PROTON-PROTON BREMSSTRAHLUNG. Marker, David George. University Park, Pa., Pennsylvania State Univ., 1966. 171p. Thesis.

In order to investigate the off-energy-shell behavior of phenomenological two-nucleon potentials, off-energy-shell K -matrix elements and proton-proton bremsstrahlung cross sections have been calculated from four fundamentally different models. These included: (1) hard core plus strong attraction of Hamada-Johnston and Brueckner-Gammel and Thaler (BGT); (2) soft core plus weak attraction of Bressel, Kerman, and Lomon (BKL); (3) weak, momentum dependent potential of Green (G) (in the S -wave only); and (4) non-local, separable potential of Tabakin (TAB). K -matrix elements of these potentials have been calculated for energies of the incident proton of 50, 100, 150 MeV, and for values of x , the ratio of final to initial center of mass momenta, of .2-2.0. At 50 MeV, the behavior of all four as a function of x is nearly the same while at 150 MeV there are greater differences, especially in the 3P_0 state. (BKL and HJ are nearly the same; both differ appreciably from TAB) in this state. The results of pp cross-section calculations at 46 and 158 MeV are presented and compared with the experiments of Warner, Richardson, and Gottshalk. At 46 MeV, all models give approximately $7 \text{ } \mu\text{b/ster.}^2$ for $d\sigma/d\Omega$, $d\Omega$, while at 158 MeV, HJ and BKL predict $11 \text{ } \mu\text{b/ster.}^2$ and TAB, $\mu\text{b/ster.}^2$. Agreement of theory with experiment at 158 MeV is excellent for

HJ and BKL but at 46 MeV, the predictions are too large by a factor greater than two. Both the Coulomb interaction and double scattering correction have been omitted from these calculations and when included, better agreement may be obtained at the lower energies. (Dissert. Abstr.)

9655 PARITY-VIOLATING NUCLEAR FORCES. Okun, L. B. (Academy of Sciences, Moscow). Comments Nucl. Particle Phys., 1: 181-6(Nov.-Dec. 1967).

The significance of investigating the P-violating nuclear forces as a test of the theory of the universal weak interaction is pointed out. Experimental results of nuclear reactions with cadmium, tantalum, and lutetium are summarized. It is suggested that investigation of the $n + p \rightarrow d + \gamma$ reaction would allow the establishment of the isotopic-spin dependence of the parity-violating nuclear force. (L.B.S.)

9700 (NYO-2262TA-165) IMPACT PARAMETER DESCRIPTION OF HIGH-ENERGY SCATTERING. Islam, M. M. (Brown Univ., Providence, R. I. Dept. of Physics. Connecticut Univ., Storrs, Dept. of Physics). Sept. 1967. Contract AT(30-1)-2262. 92p. Dep. CFSTI.

The description of high-energy scattering of particles is emphasized. The formalism is considered including the eikonal approximation from the Klein-Gordon equation, the impact parameter representation of the elastic scattering amplitude, unitarity condition and the overlap function, the properties of the function $a_1(s, \beta)$, and the optical potential in the impact parameter description. The applications given are Coulomb scattering and bound states in the Coulomb potential, high-energy $p + p$ scattering and hadronic structure of the proton, and high-energy behavior of diffraction peaks. (J.F.P.)

9967 NUCLEON-NUCLEON SCATTERING FROM ONE-BOSON-EXCHANGE POTENTIALS. II. INCLUSION OF ALL MOMENTUM-DEPENDENT TERMS THROUGH ORDER p^2 . Bryan, R. A. (Univ. of California, Livermore); Scott, Bruce I. Phys. Rev., 164: 1215-22(Dec. 20, 1967).

The nucleon-nucleon interaction in relative angular momentum states $l \geq 1$ is described over the energy range 25 to 350 MeV by a potential used in conjunction with the Schrödinger equation. The potential is a superposition of pole terms obtained from single exchanges of ω , ρ , π , η , σ_0 , and σ_1 mesons and, rather than taking the usual static limit, all terms of order k^2/M^2 are retained. Because of these momentum-dependent terms, no cutoff is necessary in $l \geq 1$ states. The meson coupling constants and the masses of the scalar mesons (σ_0 and σ_1) are the parameters which are adjusted to fit the experimentally determined phase parameters. A comparison with the data is given, showing a quantitative fit ($\chi^2/\text{datum} = 1.6$) when the model is augmented with reasonable values of the s-wave parameters. (auth)

9971 MORSE FUNCTION AND VELOCITY-DEPENDENT NUCLEON-NUCLEON POTENTIALS. Darewych, G.; Green, A. E. S. (Univ. of Florida, Gainesville). Phys. Rev., 164: 1324-31(Dec. 20, 1967).

A static soft-core potential (the Morse potential) and three representative velocity-dependent N-N potentials are investigated. First, the problem of adjusting potentials to maintain the 1s state bound near zero energy is studied, and two integral criteria are tested. For the Morse potential a convenient analytical expression for the s-wave phase shifts is derived. By fitting experimental phase shifts in the energy range $E_{lab} \leq 400$ MeV for elastic nucleon-nucleon scattering, the potential parameters for the 1s_0 and 3s_1 states are evaluated. A phenomenological and two-meson-theoretic one-boson-exchange potentials in s states which are representative of a number of N-N potentials in current use are then examined and compared. Ways of characterizing these potentials which are helpful in assessing their scattering consequences are pointed out. It is shown that different mechanisms embodied in such potentials can account equally well for the negative s-wave phase shifts observed at higher energies. (auth)

11584 MEASUREMENTS OF THE POLARIZATION PARAMETERS P AND C_{nn} IN pp ELASTIC SCATTERING BETWEEN 500 AND 1200 MeV. Cozzika, G. (Centre d'Etudes Nucleaires de Saclay, France); Ducros, Y.; de Lesquen, A.; Movchet, J.; Raoul, J. C.; van Rossum, L.; Derregel, J.; Fontaine, J. M. Phys. Rev., 164: 1672-9(Dec. 25, 1967).

The polarization parameter P and the spin correlation parameter C_{nn} in proton-proton elastic scattering were measured in an experiment with a polarized-proton target in the beam extracted from the synchrotron "Saturne." The angular distribution of P was measured at 7 energies between 0.5 and 1.2 GeV. The value of P shows a maximum of +0.6 at about 700 MeV for a scattering angle of 45° in the center-of-mass system. At 1.2 GeV the value of P is consistent with 0 for scattering angles $\geq 70^\circ$ (momentum transfers $-t \geq 0.8$ (GeV/c) 2). The spin correlation coefficient C_{nn} was measured at three energies, 0.735, 0.978, and 1.19 GeV, by scattering a polarized-proton beam on the polarized target. The value of C_{nn} at 90° c.m. decreases from 0.7 to 0.4 as the energy increases from 0.735 to 1.19 GeV. (auth)

11671 LARGE-ANGLE pp SCATTERING AS AN EXPERIMENTAL TEST OF THE MINIMAL INTERACTION HYPOTHESIS. Chiu, C. B.; Harte, J.; Tan, Chung-I (Univ. of California, Berkeley). Contract W-7405-eng-48. Nuovo Cim. (10), 53A: 174-86(Jan. 1, 1968). (UCRL-17553).

Recently a lower bound of the general form $\sim \exp[C s^\gamma \ln s]$ has been suggested for the pp scattering amplitude at fixed angle, where $\gamma \geq 1/2$. A discussion is given of the characteristic features in the pp differential cross section should the minimal interaction hypothesis be valid. This form is compared with the experimental data for the cases $\gamma = 1/2$ and $\gamma = 1$, and it is found that the present data beyond the recently observed "break" in the 90° data are compatible with both cases although $\gamma = 1/2$ gives a slightly better fit to the data. Should the lower-bound behavior indeed saturate the amplitude in the large momentum transfer region, then the break can be attributed to the transition between the region where the lower bound contribution dominates and the smaller $|t|$ region where specific t-channel exchange mechanisms are dominating. (auth)

11683 KINEMATICAL CONSTRAINTS ON REGGE-PÓLE RESIDUES. Diu, B.; Le Bellac, M. (Faculté des Sciences, Orsay, France). *Nuovo Cim.* (10), 53A: 158-73 (Jan. 1, 1968).

The problem of kinematical singularities and zeros of Regge-pole residues for processes with external spins is re-examined. The analyticity of the classical Mandelstam invariants introduce additional constraints into the Reggeization procedure proposed by Wang. The way these constraints work is described using simple examples, and the role of daughter trajectories discussed. These considerations are then applied to vector meson production and charged pion photoproduction. In particular, the sharp forward peak observed in this last process, as in neutron-proton charge exchange, is seen to raise a serious problem within the conventional Regge-pole model. (auth)

11687 (JINR-P2-3597) K PERIFERICHESKOI MODELI PROTESSA $N + N \rightarrow N + N + \pi$. (On the Peripheral Model of the $N + N \rightarrow N + N + \pi$ Process). Suslenko, V. K. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 39p. (In Russian). Dep.

A theoretical analysis of the $NN \rightarrow NN\pi$ process was made. A convenient reference system is suggested. The limits of the invariant changes for the process of one-meson production are determined. The differential cross sections are calculated by means of the peripheral model and the critical analysis of the calculation methods, existing previously, is made. The comparison with experimental data is also made and the applicability of the peripheral model concepts at the energy region 500 to 700 MeV is shown. (auth)

11688 NUCLEON-NUCLEON AND NUCLEON-ANTINUCLEON CHARGE-EXCHANGE SCATTERING AND CONSPIRACY OF SINGULARITIES IN THE COMPLEX ANGULAR MOMENTUM PLANE. Huang, Kerson; Muzinich, I. J. (Massachusetts Inst. of Tech., Cambridge). *Contract AT(30-1)-2098. Phys. Rev.*, 164: 1726-35 (Dec. 25, 1967). (MIT-2098-349).

The experimental data on the reactions $pn \rightarrow np$ and $p\bar{p} \rightarrow n\bar{n}$ near the forward direction are analyzed for evidence of "conspiracy." From a comparison between the forward differential cross section of $pn \rightarrow np$ and the total cross sections for pp and pn , it is concluded that conspiracy exists, and the nature of the conspiracy is then investigated. Using experimental data, all Regge-pole conspiracy schemes involving the pion and at most one other conspiring family can be ruled out, under the assumption of constant residue functions. An extremely simple semi-phenomenological formula that agrees with experiments is then proposed. The formula is consistent with a model which includes π exchange and conspiracies of branch cuts in the angular momentum plane. It is suggested that the relevant branch cuts are those arising from ρ -P and A_2 -P exchange, where P is the vacuum trajectory. (auth)

11689 NONRELATIVISTIC SUM RULES AND THE BINDING ENERGY OF THE DEUTERON. Chadan, K.; Montes Lozano, A. (Laboratoire de Physique Théorique et Hautes Energies, Orsay, France). *Phys. Rev.*, 164: 1762-6 (Dec. 25, 1967).

Nonrelativistic sum rules obtained in potential scattering with potentials of finite radius are used to calculate in a very simple way the deuteron binding energy from the neutron-proton triplet-S phase shift. In order to use these sum rules, one must know the imaginary zeros in the k plane ($k = \sqrt{E}$) of the regular solution

$\phi(k, r)$ of the radial Schrödinger equation. These are studied in detail for an arbitrary potential (whether having a finite radius or not), and their properties are established. It is found that these zeros are closely related to the bound states. In particular, their number is the same as the number of bound states. If we denote the zeros by $\gamma_j(r)$, $j = 1 \dots n$, it is shown that each $\gamma_j(r)$ is an increasing function of r and has a finite limit for $r \rightarrow \infty$, which corresponds to a bound state of energy $E_j = -\gamma_j^2(\infty)$. These facts, together with the sum rules, enable us to calculate the bound-state energies in a very simple and direct manner from the phase shift and the interaction radius, which is an arbitrary parameter in the sum rules and may be chosen as large as necessary in order to be sure that one is really outside the range of the interaction. The method is applied to the deuteron, assuming that the n -p interaction in the 3S_1 state has a radius of the order of the triplet scattering-length ($a_t = 5.4$ F), i.e., more than 3 times the triplet effective range ($r_0 = 1.73$ F). The result is 2.30 MeV, in good agreement with the experimental value 2.224 MeV. This particular example shows that although, in general, the phase shift and the binding energies are (except for the Levinson theorem) independent of each other, it may be possible, for interactions of short range, to calculate the latter from the former in a simple way by making the physically reasonable assumption that the interaction vanishes identically beyond some radius, which may be taken as large as necessary. Some possible applications of the sum rules are briefly indicated at the end. (auth)

11690 SYNCHROTRON-RADIATION MODEL FOR MESON PRODUCTION IN HIGH-ENERGY PHOTON-PROTON COLLISIONS. Arnold, Richard C. (Argonne National Lab., Ill.); Heckman, Philip E. *Phys. Rev.*, 164: 1822-8 (Dec. 25, 1967).

A semiclassical model for emission of bosons in high-energy hadron collisions is proposed, based on an analogy with electromagnetic radiation from a radially accelerated moving charge. A simple assumption concerning the shape of the effective classical trajectories leads to absolute predictions with no free parameters for reactions such as $pp \rightarrow pp\pi^0$ and $pp \rightarrow pn\pi^+$. These predictions are in good agreement with available experimental data in the region of validity of the model, which is confined to relatively large momentum transfers. (auth)

11691. SIMULTANEOUS np AND pp PHASE SHIFT ANALYSIS AT 18.2 AND 9.9 MeV AND THE QUESTION OF ADDITIVITY OF COULOMB AND NUCLEAR PHASE SHIFT. Janout, Z.; Kazarinov, Yu. M.; Lehar, F.; Ulehla, I. (Joint Inst. for Nuclear Research, Dubna, USSR). *Czech. J. Phys.*, 18: 18-23 (1968).

The simultaneous phase-shift analysis of np and pp data is performed at 18.2 and 9.7 MeV. Three and four sets of phase-shifts are obtained, respectively. The previously obtained nuclear potentials for non-mixing states of the two-nucleon system are used to calculate the maximum error in the simultaneous phase-shift analysis, due to the assumption on the additivity of the Coulomb and nuclear phase-shifts. Optimal experiments are planned for a further specification of the experimental quantities. (auth)

11692 POLARIZATION CORRELATION IN THE SCATTERING OF POLARIZED NUCLEONS. Janout, Z.; Lehar, F.; Winternitz, P. (Joint Inst. for Nuclear Research, Dubna, USSR). *Czech. J. Phys.*, 18: 8-17 (1968).

Experiments concerning the spin correlation tensor C_{polik} in the scattering of polarized nucleons on polarized nucleons are dis-

cussed. Relativistic formulas are derived for the experimental quantities. The scattering matrix is directly reconstructed with the help of experimentally measured quantities. The components of C_{pik} are predicted for n-p scattering at 630 MeV and are given on graphs. (auth)

11694 ONE-MESON-EXCHANGE POTENTIALS AND PROPERTIES OF NUCLEON-NUCLEON SCATTERING AND OF NUCLEAR MATTER. Ingber, Lester. San Diego, Calif., Univ. of California, 1967. 91p.

Thesis.

The problem this thesis undertakes is to define an interaction between nucleons to be used to consistently calculate: Nucleon-nucleon elastic scattering processes reproducing experimental scattering data (phase shift analyses). The binding energy and equilibrium density of a "large" system of nucleons (nuclear matter). The nature of these two problems requires that this interaction: Be applicable throughout a laboratory incident energy range of about 0-400 MeV [below inelastic thresholds], be defined with minimum phenomenology — i.e., to use as much theoretic guidance as possible to define a unique interaction. This last requirement actually prompted this work as phase-shift analyses of nucleon-nucleon scattering seem to be relatively insensitive to various functional forms of potentials, compared to the more sensitive nuclear matter calculations using the same potentials. Since the last major hurdle to understanding of nuclear matter appeared to be the inability to define such a potential, this work was undertaken after an enlightening seminar given by David Wong on the use of a one-meson exchange model to rather successfully calculate nucleon-nucleon scattering processes using dispersion-relation theory. David Wong also suggested a method for deriving a potential to be used in Schroedinger's theory, which is necessary to solve the nuclear matter problem. The total Lagrangian describing nucleons and their interaction via one-meson exchanges was nonrelativistically reduced, corresponding to a Schroedinger equation with a velocity-dependent (not energy-dependent) potential of the form described by Scotti-Wong (modified to interpret cutoffs and momentum dependence). To preserve the correct eigenvalue properties of the integral-equation formulation of the two-body Schroedinger's equation, it was found necessary to keep the potential of operator form (i.e., containing differential operators), and not merely a function of the radial parameter. However, integration by parts allows one to operate on the Green's function instead of on the wave-function. As the Green's function is expressed in simple analytic (differentiable) functions, the resulting integral-equation is really no harder to solve than one involving a simple potential function. Keeping the potential in this operator form also allows one to correctly project the potential from a set of five invariant helicity amplitudes onto the more common, though phenomenological, set of five invariant Wigner forms which are eigen-operators of the partial-wave reduced wave-functions, in turn expressed as eigenfunctions of the total angular momentum. Then this potential, so "uniquely" defined, and giving analytic functions throughout coordinate space, is similarly defined to perform a modified nuclear matter calculation similar to that done by Brueckner and Masterson. When compared with other current potentials, this potential, with only 8 parameters (themselves reasonable physical quantities), proves itself to be the best overall description of the nucleon-nucleon interaction, after doing detailed calculations of nucleon-nucleon scattering, the deuteron state, and nuclear matter. (Disser. Abstr.)

11898 MEASUREMENTS OF THE CORRELATION PARAMETER C_{NN} IN PROTON-PROTON SCATTERING. Jarvis, O. N. (Atomic Energy Research Establishment, Harwell, Eng.); Brogden, T. W. P.; Rose, B.; Scanlon, J. P.; Orchard-Webb, J.; Wigan, M. R. Nucl. Phys., A108: 63-80(1968).

The spin-correlation parameter C_{NN} in proton-proton scattering was determined for the scattering angle 90° cms at the three energies 143.2, 98.0, and 73.5 MeV. The value of C_{NN} (61.8°) was also determined at 143.2 MeV. The results are expressed (where appropriate) as ratios to the C_{NN} (90°) value at 143.2 MeV. The experimental technique involved a polarized proton beam and a polarized proton target. The radiation damage of the proton target constituted a serious problem in this work. (auth)

11902 DETERMINATION OF THE NEUTRON-NEUTRON SCATTERING LENGTH. Shield, Edward. Berkeley, Calif., University of California, 1967. 71p.

Thesis.

Measurements on the reaction $T(d, {}^3\text{He})2n$ at 32.7-MeV incident deuteron energy were used to determine the n-n scattering length. Watson's theory of final-state interactions provides a theory with which the experimental data giving the number of ${}^3\text{He}$ at 6 and 8° vs energy can be compared. Comparison is made with numbers of ${}^3\text{He}$ near the maximum energy in which case the neutrons go off with little relative energy, under the influence of a final-state s-wave interaction. The best fit of the data to theory gives $a_{nn} = -16.1 \pm 0.1^\circ\text{F}$. The applicability of this method is proved by measurements on the reaction ${}^3\text{He}(d, t)2p$ which give a value for a_{pp} equal to the accepted value within the experimental errors. Comparisons of results with other measurements of a_{nn} are given. (Disser. Abstr.)

11903 FINAL-STATE INTERACTIONS IN THE ${}^2\text{H}(p, pn)p$ REACTION. Jackson, William Roy Jr. Houston, Tex., Rice Univ., 1967. 155p.

Thesis.

The ${}^2\text{H}(p, pn)p$ reaction was studied at a bombarding energy of 9.0 MeV and several coincidence detection angles using the Rice University Tandem Van de Graaff accelerator and computer-analyzer system. The energies of the detected coincident particles were determined using a solid-state surface-barrier detector for the proton and time-of-flight measurement on the neutron. The data are discussed with regard to the observed final-state interactions and the generalized density of states. Evidence is seen for a neutron-proton final-state interaction corresponding to an interaction energy from slightly more than zero to about 75 keV; however, no evidence is found for a proton-proton final-state interaction. (Disser. Abstr.)

11994 ONE-BOSON-EXCHANGE MODEL. Ogawa, Shuzo (Hiroshima Univ.); Sawada, Shoji; Ueda, Tamotsu; Watari, Wataro; Yonezawa, Minoru. Progr. Theor. Phys. (Kyoto), Suppl. No. 39, 140-89(1967).

The one-boson-exchange model is reviewed. Topics discussed are: the Sakata model and the one-hadron-exchange model; nuclear force in the one-boson-exchange model; assumptions of the one-hadron-exchange-contribution model; calculation of the one-boson exchange contribution; comparison of the one-boson-exchange-contribution model with experimental data; non-static effects involved in the one-boson-exchange contribution; the one-boson-exchange potential; experimental evidence for the

mesons required by the one-boson-exchange model, including scalar mesons, pseudoscalar mesons, vector mesons, and other types of mesons; the one-boson-exchange-contribution model of high energy nucleon-nucleon collisions; and problems of the one-boson-exchange model. (S.F.L.)

11995 DISPERSION THEORETIC APPROACH. Furuichi, Susumu (Rikkyo Univ., Tokyo). *Progr. Theor. Phys. (Kyoto)*, Suppl. No. 39, 190-285(1967).

The dispersion theoretic approach to nuclear forces is reviewed. Topics discussed are: the dispersion relation for N-N scattering in the early period; how to apply the dispersion relation to N-N scattering; foundations of the partial-wave dispersion relation and the Mandelstam representation; application of the partial-wave dispersion relation to the evaluation of the two-pion-exchange contribution; spectral representations for N-N scattering in the neutral spinless model; structure of the G_{NN} and N-N dispersion relations; structure of the partial-wave dispersion relation and the "proper" 2π contribution; energy dependence of the two-pion-exchange contributions in the neutral spinless model; properties of the right-hand cut and solution of the partial-wave dispersion relation; kinematics of the N-N system; realistic N-N scattering; two-pion exchange contribution without pion-pion correlation; comparison of two-pion-exchange with one-boson-exchange and with empirical phase shifts; pion-pion correlation effects in the two-pion-exchange contribution; effect of higher π -N resonances; analytic continuation of $\text{Im}A(s,t)$ and $\text{Im}B(s,t)$; and application of partial-wave dispersion relation as a dynamical equation and to the S-wave amplitudes. (S.F.L.)

11996 PRESENT STATUS OF EXPERIMENTAL STUDY OF NUCLEON-NUCLEON SCATTERING. Nisimura, Keigo (Kyoto Univ.). *Progr. Theor. Phys. (Kyoto)*, Suppl. No. 39, 287-346 (1967).

A survey is presented of the present status of experimental information on nucleon-nucleon scattering. Investigations being carried out on proton-proton scattering at 50 MeV are reviewed. (S.F.L.)

13646 (UCRL-17408(Rev.)) NUCLEON-NUCLEON SCATTERING EXPERIMENTS AT INTERMEDIATE ENERGIES IN BERKELEY. Cheng, David (California Univ., Berkeley, Lawrence Radiation Lab.). Mar. 1967. Contract W-7405-eng-48. 24p. (CONF-670302-8). Dep. CFSTI.

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla.

Various N + N experiments are described. The energies studied range from about 310 to 740 MeV. The polarization parameter is the primary object of study, and results on polarization and angular distributions are shown for the various experiments. (J.F.P.)

13649 DIFFERENTIAL CROSS SECTIONS IN PROTON-PROTON SCATTERING AT 52.34 MeV. Sanada, J. (Tokyo Univ.); Kuriyama, K.; Takeuchi, Y. (and others). *Progr. Theor. Phys. (Kyoto)*, 38: 1202-3(Nov. 1967).

Differential cross sections for proton-proton scattering at 52.34 MeV are tabulated. The measurements were performed using a large scattering chamber of sliding cylinder type filled with hydrogen gas, and NaI(Tl) scintillation detectors for detection of the scattered protons. (L.B.S.)

13650 REANALYSIS OF THE PROTON-PROTON SCATTERING DATA AT 50 MeV. Hoshizaki, Norio (Kyoto Univ.). *Progr. Theor. Phys. (Kyoto)*, 38: 1203-4(Nov. 1967).

Proton-proton phase shifts at 50 MeV are tabulated based on new scattering data of Sanada et al. (*Progr. Theor. Phys.*, 38: No. 5, 1202(1967)). The anomaly that appeared in earlier analyses was found to disappear. (L.B.S.)

13651 THE $U(\theta)$ ASYMMETRY IN ELASTIC 635 MeV pp-SCATTERING. Zul'karneev, R. Ya.; Kiselev, V. S.; Nadezhdin, V. S.; Satarov, V. I. (Joint Inst. for Nuclear Research, Dubna, USSR). *Yadern. Fiz.*, 6: 995-7(Nov. 1967). (In Russian).

The results of the $U(\theta)$ asymmetry measurements of elastic pp-scattering are described as being completely due to the totally polarized beam. The measurements were performed at 635 MeV in the angle range from 28 to 90° (cms). Earlier pp-scattering phase shifts were improved by using both these results and those of other experiments. In searching for solutions beginning from random values three solutions with $l_{\max} = 5$ and two solutions with $l_{\max} = 4$ were obtained. Thus, in the energy range analyzed no evidence for the existence of a single phase-shift solution was obtained. (auth)

13741 DIFFRACTION MODEL FOR STRONG INTERACTIONS AND THE SHRINKAGE OF THE DIFFRACTION PEAK. Krisch, A. D. (Univ. of Michigan, Ann Arbor). pp 1-17 of *Lectures in Theoretical Physics*, Vol. IX B. Brittin, Wesley E. Barut, Asim O. (eds.). New York, Gordon and Breach, Science Publishers, Inc., 1967.

The diffraction model for strong interactions at high energies is considered. A model is assumed having a spherically symmetric interaction probability density which is squashed down in the direction of the motion by the Lorentz contraction. This model leads to the prediction that the differential elastic scattering cross section should depend only on $B^2 P^2$. When the $p + p$ and $\pi + p$ elastic data are plotted against this variable, the energy dependence is removed. Thus this model seems to offer a kinematic explanation for the well-known shrinkage of the diffraction peak. (J.F.P.)

13744 (IPNO/TH-108) FORWARD NN AND NN CHARGE EXCHANGE SCATTERING AT HIGH ENERGY. Gauron, P.; Lacombe, M. (Paris Univ., Orsay (France). Institut de Physique Nucleaire). Nov. 1967. 10p. Dep.

The existence of the speculative ρ' , having the same quantum numbers as the ρ , is assumed, and $N + N$ and $N + \bar{N}$ scattering only are considered. The possibility of additional terms in the forward differential cross sections permits the ρ' parameters to be varied. Then solutions consistent either with evasion or conspiracy can be found, the latter fitting the data slightly better. But these two eventualities cannot be distinguished due to experimental uncertainties. The possibility of a ρ P cut is considered. Although crude approximations were used, it seems impossible to fit the forward differential cross sections without the help of a conspiracy, either of the cut with itself or between poles. Good results were obtained with a pole A_1 such that $\alpha_1(0) = -0.2$. But a self-conspirating cut cannot be excluded. (J.F.P.)

13755 EXPERIMENTAL STUDY OF NUCLEAR AMPLITUDES IN FORWARD ELASTIC PROCESSES AT HIGH ENERGIES. Nikitin, V. A.; Sviridov, V. A.; Strunov, L. N. pp 609-26 of *Voprosy Fiziki Elementarnykh Chastits*. Alikhanyan, A. I. (ed.). Erevan, Izdatel'stvo Akademii Nauk Armyanskoi SSR, 1966. (In Russian).

On the basis of the optical model, the imaginary part $\text{Im } A$ of forward scattering increases infinitely with increasing energies, while there is no reason for a corresponding increase in the real amplitude $\text{Re } A$ of scattering. With energies tending to approach infinity, the ratio $\alpha = \text{Re } A / \text{Im } A$ approaches zero. At present α can be determined and the basic principles of the theory checked by relating $\text{Re } A(0)$ through the principles of causality, unitarity, and Lorentz invariance to the observed cross sections of scattering. Experimental data obtained by Nikitin and others on elastic $\pi\pi$ -, $\pi^+\pi^-$, and $\pi^+\pi^-$ -scattering accompanied by the charge exchange $\pi^+\pi^- \rightarrow \pi^0\pi^0$ indicated that at energies ≤ 1 BeV the calculated magnitude of meson-proton scattering agreed with experimental results. At energies of 3 to 18 BeV, the agreement both for meson-proton elastic scattering and scattering accompanied by charge exchange was not so good. The necessity of increasing in $\pi^+\pi^-$ experiments the precision of determinations of full cross sections and of elastic scattering determinations in the Coulomb interference region became apparent. It is possible that at high energies disturbances of microcausality at dimensions $< 10^{-14}$ cm affect the results. (JPRS)

13768 INFLUENCE OF ISOBAR PRODUCTION ON CHARGE RATIO AND TRANSVERSE MOMENTUM OF SECONDARY PARTICLES IN HIGH ENERGY COLLISIONS. Rengarajan, T. N. (Tata Inst. of Fundamental Research, Bombay). *Proc. Indian Acad. Sci., Sect. A*, 56: 153-73 (Sept. 1967).

An isobar model in which collision between two particles leads to the creation of only two bodies which by subsequent decay give rise to the observed secondaries was considered. On the basis of such a model, the charge ratios of pions, kaons and Σ -hyperons in p - p and π - p collisions were computed and compared with the available experimental data. Some features of transverse momentum of pions and protons in 24 GeV/c p - p collisions were also studied. (J.F.P.)

13772 (UCRL-17980) MULTI-REGGE APPROACH TO HIGH-ENERGY PRODUCTION PROCESSES. Ball, Naren F.; Chew, Geoffrey F.; Pignotti, Alberto (California Univ., Berkeley, Lawrence Radiation Lab.). Dec. 1967. Contract W-7405-eng-48. 17p. (CONF-680103-4). Dep. CFSTI.

From Conference on High-Energy Collisions of Hadrons, Geneva, Switzerland.

The production of several uncorrelated particles especially in the high-energy region is considered. Recent work is summarized, and a detailed model for production processes is proposed. As an example a preliminary calculation for the proton-proton case is shown. This example illustrates certain basic features of the model. (J.F.P.)

13774 KINEMATICAL CONSIDERATIONS ON THREE-PION-EXCHANGE CONTRIBUTIONS IN NUCLEON-NUCLEON SCATTERING. Furuichi, Susumu (Rikkyo Univ., Tokyo); Yonezawa, Minoru. *Progr. Theor. Phys. (Kyoto)*, 38: 1200-2 (Nov. 1967).

A preliminary discussion is given on the three-pion-exchange effects in nucleon-nucleon scattering in the intermediate region,

and on how these effects could compete with the two-pion effects. The possible classification of three-pion states is discussed, considering only the possible states of the $3\pi = NN$ process. The question of whether the ω meson could effectively represent the three-pion exchange effects is considered. (L.B.S.)

13776 SUPPRESSION OF REGGE CUTS AT $t = 0$ DUE TO UNIVERSALITY OF FACTORIZED RESIDUES. Horwitz, L. P. (State Univ. of New York, Stony Brook); Ne'eman, Y. *Phys. Lett.*, 26B: 88-90 (Dec. 25, 1967).

The contribution of the two- p cut to the partial wave amplitude for N - N scattering is examined. It is shown that a significant contribution from cuts at $t = 0$ would be inconsistent with the universality prescription followed by factorized residues of the Regge poles. It is conjectured that these cut residues simply vanish in the forward direction. (L.B.S.)

13777 THE ONE PION EXCHANGE CONTRIBUTION TO THE WEAK PARITY VIOLATING NUCLEON-NUCLEON POTENTIAL. McKellar, B. H. J. (Inst. for Advanced Study, Princeton, N. J.). *Phys. Lett.*, 26B: 107-8 (Dec. 25, 1967).

The one pion exchange contribution to the weak parity violating nucleon-nucleon potential is calculated by relating the weak $NN\pi$ vertex to the nonleptonic hyperon decays by the Suzuki-Sugarawa method. It is also shown that the G parity odd part of the weak Hamiltonian cannot contribute to the potential. (auth)

13779 STRUCTURE OF HIGH-ENERGY, LARGE-MOMENTUM-TRANSFER COLLISION PROCESSES. Abarbanel, H. D. I.; Drell, S. D.; Gilman, F. J. (Stanford Univ., Calif.). *Phys. Rev. Lett.*, 20: 280-3 (Feb. 5, 1968). (SLAC-PUB-371).

It was previously argued that a qualitative connection should exist between high-energy, large-momentum-transfer proton-proton scattering and the structure of the proton as revealed in elastic electron-proton scattering at large momentum transfers. A suggestion is made for the origin of this connection based on the idea that, in hadron processes, under a "diffractive tail" a contact interaction of a current-current nature should emerge with the same currents whose transition form factors are measured in weak and electromagnetic processes. Some implications of the suggestion for future experiments are also presented. (L.B.S.)

13865 CRITERION OF WEAK PERTURBING SYSTEMS BASED ON ELASTIC SCATTERING MEASUREMENTS. Ivanov, V. V.; Fedorovich, G. V. (Inst. of Optico-Physical Measurements, Moscow). *Zh. Eksp. Teor. Fiz.*, 53: 2012-24 (Dec. 1967). (In Russian).

A criterion is proposed which can be used for identifying systems which weakly perturb incident waves during scattering. It is based on a comparison of the elastic scattering differential cross sections measured for different impinging particle energies. The criterion is investigated for the case of scattering of neutrons on nuclei and for some cases of scattering of fundamental particles. It is demonstrated that nuclei exist which weakly perturb the neutron wave. The Orear formula for nucleon-nucleon scattering and some properties of the angular distribution of elastically scattered high energy particles are interpreted as being a consequence of weakness of perturbation of the incident wave. (auth)

13869 HIGH-ENERGY PHASE SHIFTS PRODUCED BY REPULSIVE SINGULAR POTENTIALS. Paliov, A.; Rosendorf, S. (Technion-Israel Inst. of Tech., Haifa). *J. Math. Phys.* (N. Y.), 8: 1829-37 (Sept. 1967).

An expansion in inverse powers of the energy (usually fractional powers) of the WKB phase shifts δ_l produced by repulsive potentials, singular at the origin, was derived. In most cases this expansion is valid for angular momenta $l < l_{\max}$, where $l_{\max}$ increases with energy. For large l a power series expansion in the "coupling constant" g is developed. The two regions of validity complement each other and sometimes even overlap. The potentials considered have an r^{-p} , $p \geq 1$, singularity and a k^m , $m < 2$, energy dependence. Define $q = p + m - 2$; then for $q > 0$, the case of strong interaction, one obtains $\delta_l \sim - (gk^q)^{1/p}$, when $k \rightarrow \infty$. The constant of proportionality is independent of l . However, the next term in the expansion depends on l . For $q = 0$, the case of intermediate interaction, δ_l becomes independent of energy when $k \rightarrow \infty$, but it depends in a complicated way on both g and l . Finally, for $q < 0$, the case of weak interaction, $\delta_l \sim -gk (1 + 1/2)^{1/p}$, $p > 1$. (auth)

15752 HIGH ENERGY INELASTIC SCATTERING BY REARRANGEMENT OF SAKATONS. Imachi, Masahiro; Matsuo, Tokeo; Ninomiya, Kansuke; Sawada, Shoji (Nagoya Univ., Japan). *Progr. Theor. Phys.* (Kyoto), 38: 1198-1200 (Nov. 1967).

High-energy two- and quasi-two-body scattering is examined on the basis of the sakaton triplet. Examples are given of allowed and forbidden processes caused by rearrangement of sakatons. Differential cross sections are illustrated schematically for several processes. (L.B.S.)

15779 REGGE-POLE MODEL FOR πp , pp , AND $\bar{p}p$ SCATTERING. Rarita, William (Univ. of California, Berkeley); Riddell, Robert J. Jr.; Chiu, Charles B.; Phillips, Roger J. N. *Contract W-7405-eng-48. Phys. Rev.*, 165: 1615-39 (Jan. 25, 1968). (UCRL-17523).

A model for high-energy πp , pp , and $\bar{p}p$ elastic scattering at small momentum transfer is presented, based on the assumed dominance of a few Regge poles in the crossed channel. For πp scattering these are the P , P' , and ρ poles; for pp and $\bar{p}p$, ignoring isospin dependence, they are P , P' , and ω . This model fits a wide variety of data, including the differential cross sections that shrink for pp but not for πp or $\bar{p}p$, recent results from Brookhaven on total cross sections and ratios of the real to imaginary parts of the forward scattering amplitude, and also recent πp and pp polarization results, but it gives zero polarization for πp charge-exchange scattering. (Although the latter disagrees with experiment, additions to the model to correct this insufficiency would affect the other results but little.) The factorization property of Regge poles is tested by these fits to data for the P and P' couplings. (auth)

15785 (BNL-12058) FORWARD DISPERSION RELATIONS: THEIR VALIDITY AND PREDICTIONS. Lindenbaum, S. J. (Brookhaven National Lab., Upton, N. Y.). Dec. 29, 1967. 64p. (CONF-671203-4). Dep. CFSTL

From Conference on πN Scattering, Irvine, Calif.

The discussion of forward dispersion relations includes meson (π)-nucleon elastic scattering, meson (π)-nucleon forward dispersion relations, asymptotic bounds on total cross sections, early applications of forward dispersion relations, experimental measurements of π -N forward scattering amplitude, and a comparison

of experimental results with the predictions of the π + N forward dispersion relations. Also considered are the fundamental length, charge independence, $p + p$ and $\bar{p} + p$ forward scattering amplitudes and dispersion relations, and asymptotic theory. (J.F.P.)

15792 GENERAL FEATURES OF HIGH-ENERGY PROTON-PROTON AND PION-PION ELASTIC SCATTERING. McClure, J. A. (Tufts Univ., Medford, Mass). *Nuovo Cim.* (10), 53A: 921-32 (Feb. 21, 1968).

Certain similarities in transverse momentum dependence between high-energy hadron elastic scattering and multi-pion production are pointed out. It is suggested these may be a consequence of unitarity, and a calculation with a simple model is done to explore this possibility. Among other things, these considerations suggest that the slope of the large-angle p - p elastic cross section is not constant, as has been thought, but that it decreases with energy. (auth)

15794 AN EXPANSION OF THE SCATTERING AMPLITUDE AT VANISHING FOUR-MOMENTUM TRANSFER USING THE REPRESENTATIONS OF THE LORENTZ GROUP. Toller, M. (CERN, Geneva). *Nuovo Cim.* (10), 53A: 671-716 (Feb. 1, 1968).

The scattering amplitude at vanishing four-momentum transfer is expanded by means of the matrix elements of the irreducible representations of the Lorentz group including space reflection and the PCT transformation. These representations are labelled by a complex parameter λ and other "quantum numbers." The high-energy asymptotic behavior of the amplitude is assumed to be determined by the contributions of some poles in the complex λ -plane (Lorentz poles). The contribution of a Lorentz pole is decomposed into a family of Regge-pole contributions with given parities and signatures. The connection with other formalisms which give rise to families of Regge trajectories is briefly discussed. Particles with arbitrary spin and parity are considered. The selection rules for the quantum numbers of the Lorentz poles are treated in detail. The role of the internal symmetries and of the symmetry with respect to the permutation of identical particles is discussed. The general formalism is applied to the meson-nucleon and nucleon-nucleon scattering. (auth)

15810 A POSSIBLE EXISTENCE OF A SPIN-2 REGGE RECURRENCE OF THE 1S_0 p - p POLE (THE UNBOUND DIPROTON). Arndt, Richard A. (Univ. of California, Livermore). *Contract W-7405-eng-48. Phys. Rev.*, 165: 1834-8 (Jan. 25, 1968). (UCRL-70462).

A model is developed wherein the 1D_2 p - p partial-wave amplitude is coupled through N/D equations to a second, inelastic channel containing a proton and a second particle in a relative S wave. The mass of the second particle is "smeared out" according to an appropriate Breit-Wigner form around the (3,3) resonance at 1260-1120 MeV. The phenomenological potential is adjusted to fit the elastic 1D_2 phase shift to 400 MeV and the existing imprecise data at 660 MeV. The model, when adjusted to fit experiment, predicts a pole on the second Riemann sheet at 400-1300 MeV. This pole may be interpreted as a bound state in the inelastic channel and has quantum numbers ($I = 1$, $B = 2$, $J = 2$) consistent with the spin-2 Regge recurrence of the pole in the 1S_0 amplitude, the "unbound" diproton. An alternative coupled-channel model is developed which fits the elastic data but which does not predict the pole. The high-energy predictions for elastic scattering which are derived from the second model are found to differ drastically from those of the first model and from the predictions of various theories for high-energy inelastic processes. (auth)

15816 REGGE THEORY OF HIGH-ENERGY SCATTERING WITH RELATIVELY LARGE MOMENTUM TRANSFER. Sawada, Tetsuo (Tokyo Univ.). Phys. Rev., 165: 1848-56 (Jan. 25, 1968).

Functional equations for the Regge parameters $\alpha(t)$ and $\beta(t)$ are derived from the unitarity condition, which is valid for relatively large momentum transfer. By solving these equations the high-energy cross section with relatively large momentum transfer are computed up to two arbitrary periodic functions. The result agrees with Orear's fit except for the appearance of dips. This result is compared with high-energy experiments on p-p scattering with large momentum transfer, and some prediction is made concerning the position of the dips. (auth)

15817 PHENOMENOLOGICAL PHASE-PARAMETER FITS TO N-N DATA UP TO 350 MeV. Seamon, R. E.; Friedman, K. A.; Breit, G.; Haracz, R. D.; Holt, J. M.; Prakash, A. (Yale Univ., New Haven). Contract AT(30-1)-1807. Phys. Rev., 165: 1579-86 (Jan. 25, 1968). (YALE-1807-42; YALE-1807-48).

Results of phenomenological phase-parameter fits intended primarily for energies between somewhat below 10 and 350 MeV are presented in the form of tables suitable for interpolation. Comparisons of the pion-nucleon coupling constant as derived from p-p and n-p scattering data are made. Indications of a difference in the value of this constant are obtained. Though relatively small, this difference is outside the apparent statistical uncertainty of the determination. Some possible reasons for the difference are briefly discussed. A total of 1988 experimental data has been used. Corrections for the effect of nucleon magnetic moments, for Coulomb effects, and for short-range charge dependence are included. (auth)

15831 ON THE TRANSFORMATION FROM O_3 TO $O_{2,1}$ BASES IN $SL_{2,C}$. Akycampong, D. A.; Boyce, J. F.; Rashid, M. A. (International Atomic Energy Agency, Trieste, Italy). Nuovo Cim. (10), 53A: 737-44 (Feb. 1, 1968).

The overlap function from O_3 to $O_{2,1}$ basis vectors for unitary representations of $SL_{2,C}$ group obtained originally by Sciarrino and Toller is recast as a finite series of products of Γ -functions. This has the advantage of simplifying explicit calculations of the overlap function for cases of practical interest. The use of the formula for the case of forward NN scattering is illustrated. (auth)

17858 NUCLEON- AND ANTINUCLEON-NUCLEON ELASTIC AND CHARGE EXCHANGE PROCESSES. Sumi, Yoshio; Yoshida, Toshihiro (Osaka Univ. Kyoto Univ.). Progr. Theor. Phys. (Kyoto), Suppl. No. 41-42, 53-89 (1967).

Experimental data on nucleon-nucleon and nucleon-antinucleon elastic interactions in the high energy region are summarized and presented. The data include total and total elastic cross sections; singular distribution of elastic and charge-exchange cross section; and recoil proton polarization, together with the ratio of the real to imaginary forward amplitude in the pp elastic scattering. In the appendix several kinematical quantities are tabulated. Values of the incident laboratory momentum, observed quantities, and the method used are presented for the 67 references, which cover a main part of the experimental information published from 1960 to 1966. (L.B.S.)

17859 NN INELASTIC PROCESSES. Fujimura, Kimio (Waseda Univ., Tokyo). Progr. Theor. Phys. (Kyoto), Suppl. No. 41-42, 282-315 (1967).

Experimental data obtained from accelerators are summarized for pp inelastic scattering, and their characteristic features are shown. The data are separately compiled for the two final channels; the quasi-elastic scattering (isobar production) and the multiple production. Some cosmic ray data are also included. Twenty-five references are tabulated together with incident momentum, observed quantities and experimental methods. (L.B.S.)

17941 SOME REMARKS CONCERNING HIGH-ENERGY SCATTERING. Chou, T. T.; Yang, C. N. (State Univ. of New York, Stony Brook). pp 348-59 of High Energy Physics and Nuclear Structure. Alexander, Gideon (ed.). New York, John Wiley and Sons, Inc., 1967.

From 2nd International Conference on High Energy Physics and Nuclear Structure, Rehovoth, Israel. See CONF-670207.

The usefulness of describing high-energy meson(π)-nucleon and nucleon-nucleon scattering in terms of the interaction of extended structures is emphasized. Then some speculative considerations, based on this idea, are reported concerning the form factors of nucleons and meson (π) and meson (π)-meson (π) scattering at high energies. (J.F.P.)

17977 NUCLEAR FORCES. II. Feshbach, Herman; Kerman, Arthur K. Comments Nucl. Particle Phys., 2: 22-7 (Jan.-Feb. 1968).

The boson-exchange theory of nuclear forces is reviewed, and the form of the nucleon-nucleon potential is indicated. (C.E.S.)

20125 (NP-17315) THE PRODUCTION OF COSMIC GAMMA RAYS IN INTERSTELLAR AND INTERGALACTIC COSMIC-RAY COLLISIONS. III. THE FORM OF THE COSMIC GAMMA-RAY SOURCE SPECTRUM FROM p-p INTERACTIONS FOR GAMMA-RAY ENERGIES LESS THAN 1 GeV. Stecker, F. W. (Smithsonian Astrophysical Observatory, Cambridge, Mass.). Dec. 19, 1967. 39p. (SAO-260). Dep. CFSTI.

The cosmic gamma spectrum below 1 GeV arising from p-p interactions is calculated. Its properties are determined by the properties of secondary neutral pion production occurring at accelerator energies. First a detailed discussion of the general properties of the gamma spectra arising from neutral pion decay is given. A determination is made of the various features of such spectra that must, in general, hold true. This discussion includes the results of analytic calculations of normalized gamma spectra from ideal neutral pion energy distributions. An "isobar-plus-fireball" model is then chosen for numerical calculations in which the two dominant modes of neutral pion production at accelerator energies are production of the $N_1^*(1237)$ isobar and one fireball. Each of these modes of production then yields a component to the total gamma spectrum. The components are summed and the results are given in terms of integral and differential gamma spectra. A comparison is made with recent balloon data of gamma rays resulting from atmospheric high-energy interactions, and good agreement is found. (auth)

v.22 (1968)

20130 SPIN CORRELATION PARAMETERS IN p - p SCATTERING AT LOW ENERGY. Catillon, P.; Chapellier, M.; Garreta, D. (Centre d'Etudes Nucleaires de Saclay, Gif-sur-Yvette, France). pp 614-16 of International Nuclear Physics Conference, Gatlinburg, Tennessee. Becker, Richard L. (ed.). New York, Academic Press, 1967.
See CONF-660906.

Spin correlation parameters A_{xx} and A_{yy} in proton-proton scattering were measured at 11.4, 19.15, 23.45, and 26.5 MeV with a polarized target and a polarized beam. The accuracy is better than 2%. (auth)

20131 NUCLEON-NUCLEON BREMSSTRAHLUNG. Verba, J. W.; Slaus, Ivo; Richardson, J. Reginald; August, Leon S.; Van Oers, W. T. H.; Carlson, R. F. (Univ. of California, Los Angeles). pp 619-23 of International Nuclear Physics Conference, Gatlinburg, Tennessee. Becker, Richard L. (ed.). New York, Academic Press, 1967.
See CONF-660906.

The proton-proton bremsstrahlung cross section was measured at $E_{inc} = 33.5$ and 46 MeV. The experimental data disagree with the present theoretical predictions in both magnitude of the cross section and in its dependence on the incident energy. A direct measurement of the neutron-proton bremsstrahlung cross section has been undertaken. At present only an upper limit of $300 \mu b/(sr)^2$ can be quoted. (auth)

20134 TWO pn EXPERIMENTS AT 200 MeV: ASYMMETRIES FROM CARBON AND DEUTERIUM, AND A MEASUREMENT OF THE TRIPLE SCATTERING PARAMETER D_t . Spalding, David. Rochester, N. Y., Univ. of Rochester, 1967. 117p.
Thesis.

A double and a triple scattering experiment was performed. The double scattering experiment was performed on targets of deuterium and carbon, using 215 MeV, 85% polarized protons as incident particles. The asymmetry of recoil neutrons was measured at laboratory angles between 10 and 35°, using a neutron counter consisting of a polyethylene converter and multi-element scintillation telescope. The deuterium measurements are related to the free n - p polarization parameter by an impulse approximation calculation. The deuterium results are in good agreement with the predictions of Yale phase shift solutions 3M, 4M, and the new Livermore solution, and are incompatible with Yale solutions 0, 1, 2, 2M. The asymmetries from carbon agree with free n - p scattering except at laboratory angles of 10 and 35°, where they are greater in absolute value. The asymmetry from carbon showed the greatest dependence on neutron energy at these angles. The triple scattering experiment was a measurement of the parameter D_t . The 215-MeV, 85% polarized proton beam was used with a deuterium target. The results were related to the free D_t parameter using an impulse approximation. They are in agreement with the predictions of Yale phase shift solutions 3M and 4M, but are incompatible with the Livermore solution and Yale solution 0, 1, 2, 2M, and 3. The two experiments together are then compatible only with Yale solutions 3M and 4M. The D_t values obtained from deuterium respectively at laboratory angles of 15, 20, and 25-25° are $+0.087 \pm 0.068$, -0.018 ± 0.071 , and $+0.058 \pm 0.103$. (Dissertation. Abstr.)

20245 RECONSTRUCTION OF THE FORWARD SCATTERING MATRIX AMPLITUDES. Lapidus, L. I. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 7: 178-82(1968). (In Russian).

Comparison with the dispersion relations, sum rules, etc. requires the reconstruction of the amplitudes of meson-nucleon, NN and γN forward scattering. Formulas necessary for this procedure at $\theta = 0^\circ$ are obtained. (auth)

20271 (JINR-E1-3707) UNAMBIGUOUS PHASE SHIFT ANALYSIS OF NUCLEON-NUCLEON SCATTERING AT 400 MeV AND THE ENERGY DEPENDENCE OF PHASE SHIFTS ABOVE THE PION PRODUCTION THRESHOLD. Yanout, Z.; Kazarinov, Yu. M.; Legar, F.; Rozanova, A. M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1968. 34p. Dep.

The phase shift analysis of nucleon-nucleon scattering data at energies near 400 MeV was performed. The search for the solutions of the phase shifts was carried out for the maximal orbital momentum $l_{max} = 4$. Only the 1D_2 wave is assumed to have an imaginary part. Seven solutions were obtained in the region $\chi^2 \leq 1.5 \chi^2_{min}$. A detailed investigation has shown, that six of them can be rejected with the probability of Type I error smaller than 0.59%. Tables of phase shifts and the angular dependences of the experimental quantities are given. The energy dependences of phase shifts in the region 10 to 630 MeV are shown in the graphs. (auth)

20272 (JINR-P1-3702) AMPLITUDY UPRUGOGO NN -RASSEYANIYA V SOSTOYANIYAKH S IZOTOPICHESKIM SPINOM $T = 0$ I $T = 1$. (Elastic N - N Scattering Amplitudes in the States With the $T = 0$ and $T = 1$ Isotopic Spins). Golovin, B. M.; Rozanova, A. M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1968. 29p. (In Russian). Dep.

The amplitudes of the elastic nucleon-nucleon scattering in the states with $T = 0$ and $T = 1$ isotopic spins were calculated for a number of energies in the region 23 to 630 MeV. The calculations were made according to the data of the previously published phase shift analysis. (auth)

20273 POLARIZATION PARAMETERS AND RESONANCE DECAY DISTRIBUTIONS IN HIGH-ENERGY TWO-BODY PROCESSES. I. BARYON-BARYON COLLISIONS. Golab, Z.; Kotanski, A. (Jagellonian Univ., Krakow). Acta Phys. Pol., 33: 37-50(Jan. 1968).

The cross sections, polarization parameters and resonance decay distributions for the simplest types of two-body reactions are expressed in terms of independent transversity amplitudes. Crossing relations are explicitly written down for each type of process. Implications of discrete symmetries are taken into account. The case of a polarized target is also considered. Finally, the discussion of the number of independent parameters, which can be found by performing various measurements, is presented for each reaction. (auth)

20277 FORWARD NN AND $\bar{N}\bar{N}$ CHARGE-EXCHANGE SCATTERING AT HIGH ENERGY. Gauron, P.; Lacombe, M. (Institut de Physique Nucleaire, Orsay, France). *Nuovo Cim.* (10), 54A: 203-8 (Mar. 1, 1968).

For the discussion of the NN and $\bar{N}\bar{N}$ charge exchange scattering at high energy it is supposed, in a first step, that the meson (ρ'), previously introduced, exists. Solutions are found consistent either with evasion or conspiracy. But if the ρ' parameters are made consistent with those deduced from πN and KN scattering, the necessity of a conspiracy is found. On the other hand, instead of the ρ' the possibility of a ρ P cut is considered. Although rather crude approximations are used, it seems impossible to fit the forward differential cross sections without the help of conspiracy, either of the cut with itself or between poles. Good results were obtained in the second case with a pole A_1 such that $\alpha_{A_1}(0) = -0.2$. But a self-conspirating cut can not be excluded. (J.F.P.)

20279 APPLICATION OF THE FADDEEV EQUATIONS TO THE DETERMINATION OF THE NEUTRON-NEUTRON LOW-ENERGY PARAMETERS. Fontannaz, M. (Laboratoire de Physique Theorique et Hautes Energies, Orsay, France). *Nuovo Cim.* (10), 53B: 53-62 (Jan. 11, 1968).

The Faddeev equations are used in the framework of separable approximation in order to determine the parameters of the neutron-neutron system at low energy from the doublet neutron-deuteron scattering length a_2 . The sensitivity of the 3-body results to the parameters of the 2-body T-matrices is exhibited and it is shown that a good value (0.7 fm) of the doublet n-d scattering length a_2 may be obtained if we use an n-n interaction characterized by $a_{nn} = -16.25$ fm and $r_{0nn} = 3.79$ fm. Simultaneously a good value of the binding energy ($E = 8.77$ MeV) is obtained. (auth)

20279 DIFFRACTION MODEL FOR HIGH-ENERGY pp SCATTERING. Durand III, Loyal; Lipes, Richard (Univ. of Wisconsin, Madison). *Phys. Rev. Lett.*, 20: 637-40 (Mar. 18, 1968).

The asymptotic limit of the pp scattering cross section is considered using a diffraction-scattering model. The calculated differential cross section displays diffraction zeros, which at present energies should be filled in by the real part of the pp scattering; the pp polarization should also show considerable structure. It is shown that the high-energy, large-momentum-transfer hadron-hadron scattering amplitude is proportional in this model to a product of hadron form factors. (auth)

20353 CONSPIRACY AND EVASION: PROPERTY OF REGGE POLES. Leader, Elliot (Cambridge Univ., Eng.). *Phys. Rev.*, 166: 1599-1621 (Feb. 25, 1968).

It is shown that if standard methods are used to apply the Regge-pole theory to relativistic problems in which the external particles have nonzero spin, then there exist constraint equations which enforce relationships between the residue and trajectory functions of the participating poles in the region $t \sim 0$. The constraint equations follow directly from general quantum-mechanical principles and it is therefore essential to satisfy them. Moreover, the number of constraint equations increases roughly as the fourth power of the spin of the external particles. The structure of the constraint equations also differs radically according to whether the t-channel process has equal-mass particles in both the initial and the final state or unequal-mass particles in both the initial and the final

state. A separate treatment of the various situations is given. Several examples are worked out in detail: $\pi N \rightarrow \pi N$, $\pi N^* \rightarrow \pi N^*$, $\pi p \rightarrow \pi p$, $NN \rightarrow NN$, and $pp \rightarrow pp$. The discussion of the general case in which the external particles have arbitrary spins requires a slight extension of previously given methods for the Reggeization of processes with spin. A very simple, and completely general scheme for the Reggeization, and for the classification of the Regge poles involved, is given. Finally, a discussion is given of the fundamental underlying group-theoretical origin of the constraint equations, and it is suggested that the necessity to satisfy them artificially represents a weakness in our present methods of applying Regge-pole theory to relativistic processes. (auth)

20438 MEASUREMENT OF PROTON-PROTON POLARIZATION AT 20 MeV. Catillon, P.; Sura, J.; Tarrats, A. (Centre d'Etudes Nucleaires, Saclay, France). *Phys. Rev. Lett.*, 20: 602-3 (Mar. 18, 1968).

The (p,p) polarization asymmetry was measured at 20.2-MeV laboratory energy with an accuracy as good as ± 0.001 . The results are consistent with the phase-shift analyses at this energy. (auth)

20751 NUCLEON-NUCLEON SCATTERING. Bryan, R. A. (Univ. of California, Livermore). pp 603-13 of International Nuclear Physics Conference, Gatlinburg, Tennessee. Becker, Richard L. (ed.). New York, Academic Press, 1967. See CONF-660906.

The presentation is limited to the so-called "pole models" for nucleon-nucleon scattering. The essential feature of these models is the ability to account for the gross structure of the N-N amplitude using just the Born, or one-meson-exchange, terms of the π , η , ρ , and ω mesons, provided the Born term of a $T = 0$, $J = 0^+$ meson, or equivalent effect, is included. An equivalent effect might be a $T = 0$ S-wave dipion, with which the scalar meson communicates. There is as yet no conclusive experimental evidence for a scalar meson or dipion in the desired mass range, 400 to 600 MeV, but there is some evidence for a scalar meson near 700 MeV. Some prescription is required to generate the scattering amplitude, since it is complex whereas the Born terms are real. Three methods have been proposed: the Schroedinger equation model, the partial-wave dispersion relation model, and the "geometric unitarization" model. By and large, coupling constants determined by these models are consistent with determinations from other experiments or from higher symmetry schemes. Certain applications of the pole models are discussed, such as to infinite nuclear matter, N-N bremsstrahlung, and N-N scattering, and bound states. (auth)

20752 OBEP INTERACTION AND NUCLEAR MATTER. Preston, M. A.; Kiang, D.; Yip, P. (McMaster Univ., Hamilton, Ont.). pp 654-6 of International Nuclear Physics Conference, Gatlinburg, Tennessee. Becker, Richard L. (ed.). New York, Academic Press, 1967. See CONF-660906.

The velocity-dependent nucleon-nucleon potential obtained from the exchange of several mesons was found to give reasonable agreement with both the two-nucleon data and the properties of nuclear matter. (auth)

20754 NUCLEON-NUCLEON POTENTIAL WITH A SOFT CORE IN THE ENERGY REGION 0.17 TO 310 MeV. Ulehla, I.; Bystricky, J.; Lehar, F. (Joint Inst. for Nuclear Research, Dubna, USSR). pp 687-91 of International Nuclear Physics Conference, Gatlinburg, Tennessee. Becker, Richard L. (ed.), New York, Academic Press, 1967.

See CONF-660906.

Nucleon-nucleon potentials with a soft core, giving a good description of the energy dependence of the nonmixing phase shift in elastic pp and np scattering, are found. However, at low energies the simultaneous description of pp and np scattering in the 1S_0 state with the help of a single potential is in disagreement with the experimental data. (auth)

20755 NUCLEON-NUCLEON INTERACTION CONSISTENT WITH EXPERIMENT AND THE BOSON-EXCHANGE THEORY OF NUCLEAR FORCES. Lomon, Earle; Feshbach, Herman (Massachusetts Inst. of Tech., Cambridge). pp 692-3 of International Nuclear Physics Conference, Gatlinburg, Tennessee. Becker, Richard L. (ed.), New York, Academic Press, 1967.

See CONF-660906.

Nucleon-nucleon data were fitted by a boundary condition model interaction in which the external potentials are given by field-theoretic forms arising from the one- and two-pion exchange, ρ , ω , and η exchange. Good fits were obtained for nucleon laboratory energies below 350 MeV, which are comparable with the best phenomenological fits. The optimum values of the boson-nucleon coupling constants and masses correspond to their known physical values as determined by other experiments. (auth)

22299 INELASTIC INTERACTION CROSS SECTIONS OF NUCLEONS AND π AND K MESONS ON VARIOUS NUCLEI AT HIGH ENERGIES. Volkova, I. V. Izv. Akad. Nauk SSSR, Ser. Fiz., 31: 1472-3 (Sept. 1967). (In Russian).

Inelastic interaction cross sections for nucleons and π and K mesons on various nuclei were calculated from the optical model to a quasi-stationary approximation for various values of the elementary cross section σ_0 —the cross section of interaction of these particles with nucleons. On the basis of the calculations the paths (in $\text{g} \cdot \text{cm}^{-2}$) for nuclear interaction of the particles in water, air, and emulsions were calculated as a function of the elementary cross section σ_0 . The total (inelastic + elastic) cross sections for pp, np, π^+p , π^-p , K^+p , and K^-p type interactions, respectively, were found to be 38, 37 to 38, 21.5, 23.5, 19 to 21, and 18 to 19 mbarn, respectively, and the inelastic cross sections, 31, 30 to 31, 18.5 to 19, 2.0, 16 and 14 to 16 mbarn, respectively. (JPRS)

22303 n-p DIFFERENTIAL CROSS SECTION AND POLARIZATION AT 199 MeV. Thomas, A. R.; Spalding, D.; Thorndike, E. H. (Univ. of Rochester, N. Y.). Contract AT(30-1)-875. Phys. Rev., 167: 1240-9 (Mar. 25, 1968). (UR-875-223).

The relative differential cross sections and polarization parameters for free n-p scattering and for the reaction $n + d \rightarrow p + 2n$ in which only the proton is detected (bound n-p scattering), were measured at an incident energy of 199 MeV, at two-nucleon c.m. angles between 77° and 158° . The neutron beam used, created by charge-exchange scattering of a polarized proton beam on a deuterium target, had an energy spread of ± 12 MeV, a polarization of 73%, and an intensity of 1000 n/sec. The differential cross section σ and the polarization P, for free n-p scattering, the ratio R_M of the bound to the free cross section, and the difference $P - P_0$ between the free and bound polarization parameters are listed.

The cross-section measurements agree with those of Kazarinov and Simónov and with the phase-shift solution (Y-IV)_{pp} of Breit et al. but disagree with the older measurements of Guernsey, Mott, and Nelson. The polarization measurements are in satisfactory agreement with the (less accurate) results of Tinlot and Warner, but in only fair agreement with the phase-shift solution (Y-IV)_{pp}. The ratio R_M , typically 0.65 ± 0.04 , is significantly smaller than that given by an impulse-approximation calculation, typically 0.76. The difference between polarization parameters for free and bound scattering is consistent with an impulse-approximation calculation but also consistent with zero. (auth)

22306 NEUTRON-PROTON BREMSSTRAHLUNG AT 208 MeV. Brady, F. P.; Young, J. C.; Badrinathan, C. (Univ. of California, Davis). Phys. Rev. Lett., 20: 750-2 (Apr. 1, 1968).

Neutron-proton bremsstrahlung measurements were carried out using a 208-MeV neutron beam produced by deuterons striking an internal Be target in the LRL 184-in. cyclotron. The measured n-p differential cross sections are shown along with corresponding pp-p cross sections. (L.B.S.)

22308 APPLICATION OF THE SATZ SUM RULES TO THE HIGH MULTIPLICITY PROCESSES. Hofmök, T. (Univ. of Warsaw); Szeptycka, M. Phys. Lett., 26B: 546-8 (Mar. 18, 1968).

The relation which follows from the Satz additive quark model between cross sections for the reactions $\pi p \rightarrow N(k+1)\pi$ and $pp \rightarrow NNk\pi$ is found to be in agreement with experimental data for $k = 4$ and $k = 5$. (auth)

22367 SOME ELECTROMAGNETIC POLARIZATION EXPRESSIONS. Csonka, P. (CERN, Geneva). Nuovo Cim., 54A: 809-12 (Apr. 1, 1968).

Some of the expressions for the cross section of electromagnetic scattering of polarized particles with anomalous magnetic moments are given. The calculation is performed in the first Born approximation. The expressions given are valid for the electromagnetic scattering of any two spin- $1/2$ fermions. Special cases are considered, proton-proton and proton-electron scattering. (L.B.S.)

22381 (JINR-P2-3691) GEOMETRICHESKAYA PROVERKA IZOTOPICHESKOI INVARIANTNOSTI ELEMENTARNYKH CHAS-TITS. (Geometrical Check of the Isotopic Invariance). Grishin, V. G.; Podgoretskii, M. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1968. 6p. (In Russian). Dep.

Some possible experiments are considered for checking the isotopic invariance of strong interactions of elementary particles. (auth)

22412 EFFECT OF n - p TENSOR INTERACTIONS IN $^3\text{H}_A$ ON Λ - p SCATTERING PARAMETERS. Schriis, R.; Buxton, L. D. (Univ. of Kentucky, Lexington). *Nuovo Cim.*, 54B: 267-80 (Apr. 11 1968).

Recent analyses of Λ - p scattering data are used to deduce ranges and depths for the Λ -nucleon triplet interaction. Variational calculations incorporating this information are then performed for the hypertriton with Hamiltonians which contain tensor components in the neutron-proton potentials. From the results of these variational calculations, properties of the singlet Λ -nucleon interaction are deduced. It is found that the inclusion of a tensor component in the neutron-proton interaction leads to differences of the order of 15% in the scattering lengths and 10% in the effective ranges when compared to equivalent calculations which do not include such tensor components. (auth)

22414 THREE-BODY ASSOCIATED PRODUCTION IN PROTON-PROTON COLLISIONS AND THE ONE-BOSON-EXCHANGE MODEL. Ferrari, E. (Univ. of Chicago. Univ., Rome); Serio, S. Contract AT(11-1)-264. *Phys. Rev.*, 167: 1298-1308 (Mar. 25, 1968). (COO-264-402).

The reactions $pp \rightarrow YKN$ are studied under the hypothesis of a dominant contribution from the exchange of a pseudoscalar meson (π or K) between the initial protons. The difficulty of a rigorous theoretical treatment of a true three-body final state is circumvented by assuming that the various damping effects at large momentum transfers (form factors, absorption) can be described in terms of a simple multiplicative cutoff function. Also, the assumptions and approximations which usually come into play in the theoretical analysis of these reactions are discussed critically. It is found that the agreement between theory and experiment is fairly good, within the limits of the model. (auth)

22416 NOTE ON THE EFFECTIVE RANGE APPROXIMATION FOR THE HULTHÉN AND MORSE POTENTIALS. Eriksson, B. (Royal Inst. of Tech., Stockholm). *Ark. Fys.*, 34: 49-57 (1967).

The Hultén and Morse potentials were analyzed in terms of the effective range method. Diagrams illustrate the relations between the various parameters characteristic of the effective range theory. The usual central two-nucleon potentials, those previously examined as well as the above two, are adjusted to reproduce the low-energy two-nucleon scattering data now accepted. (auth) (Sweden)

22417 MESON BREMSSTRAHLUNG MODEL TAKING PHASE SPACE INTO ACCOUNT. Mack, G. (Univ., Munich). *Phys. Lett.*, 26B: 515-19 (Mar. 18, 1968).

Kastrup's meson bremsstrahlung model is reconsidered. Energy-momentum conservation is taken into account following in part a proposal by Anderson and Collins. Good agreement with the experimentally observed inelastic final proton spectrum in proton proton collisions is obtained. Elastic pp cross sections can also be accounted for. (auth)

22418 POTENTIAL MODEL CALCULATION FOR COPLANAR AND NONCOPLANAR PROTON-PROTON BREMSSTRAHLUNG. Drechsel, D. (Catholic Univ. of America, Washington, D. C.); Maximon, L. C. *Phys. Lett.*, 26B: 477-9 (Mar. 18, 1968).

The cross section for coplanar and noncoplanar proton-proton bremsstrahlung is calculated with Hamada-Johnston and Reid potentials. The results agree with experiments and show a rapid decrease as the kinematic limit for noncoplanarity is approached. (auth)

24510 PROTON PROTON BREMSSTRAHLUNG AT 10.5 MeV. Crawley, G. M.; Powell, D. L.; Rao, B. V. Narasimha (Australian National Univ., Canberra). *Phys. Lett.*, 26B: 576-8 (Apr. 1, 1968).

The proton proton bremsstrahlung cross section was measured at an incident proton energy of 10.5 MeV. The upper limit of 1.3 $\mu\text{b}/\text{sr}^2$ helps to distinguish between the various calculations at this energy. (auth)

24519 PROTON PROTON BREMSSTRAHLUNG AT 20 MeV. Bahnsen, A.; Burman, R. L. (Univ. of Rochester, N. Y.). *Phys. Lett.*, 26B: 585-7 (Apr. 1, 1968).

The proton proton bremsstrahlung was investigated at 20 MeV beam energy. The outgoing protons were detected at equal angles of 35° to the beam, and the cross section $d^2\sigma/d\Omega d\Omega$ was found to be $1.3 \pm 0.4 \mu\text{b}/\text{sr}^2$. This value is in agreement with theoretical calculations, and with other experimental data at low energies. (auth)

24532 (JINR-E1-3708) ELASTIC SCATTERING OF 660 MeV PROTONS ON LMN CRYSTALS. Chekh, Ya.; Yanout, Z.; Legar, F.; Malek, Z. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1968. 21p. Dep.

Elastic and quasielastic 660 MeV proton scattering on various targets was investigated. Crystal LMN ($\text{La}_2\text{Mg}_3(\text{NO}_3)_{12} \times 24 \text{H}_2\text{O}$), the equivalent dummy target consisting of $\text{Ba}(\text{NO}_3)_2$ (36.3%) and MgO (63.63%) and polythene were used as targets. The results can be used for the planning of the nucleon-nucleon scattering experiments on a proton polarized target. (auth)

24538 DATA COMPILATION ON BARYON-BARYON INTERACTIONS. 1. PROTON-PROTON COLLISIONS BETWEEN 1 AND 32 GeV/c. Alexander, G.; Bernary, O.; Maor, U. (Weizmann Inst. of Science, Rehovoth, Israel). *Nucl. Phys.*, B5: 1-28 (1968).

A data compilation on pp interactions is reported as the beginning of a systematic review of the strong-interaction properties of elementary particles. The list of references are followed by curves showing the total and elastic pp cross sections as a function of the incident momentum. Following are differential cross sections and polarization curves for various proton incident momenta. (L.B.S.)

24540 DIFFERENTIAL CROSS SECTIONS IN PROTON-PROTON SCATTERING AT 52.34 MeV. Sanada, J. (Tokyo Univ. of Education); Kuriyama, K.; Takeuchi, Y.; (and others). Nucl. Phys., B4: 379-91(1968).

A measurement of differential cross sections in proton-proton scattering at 52.34 MeV, of a higher precision than that of the measurement of 1961 was made at 29 angles from 14° to 90° c.m. angle. A large scattering chamber of sliding-cylinder type, hydrogen gas target and NaI(Tl) detectors were used. The total error of the differential cross sections was $\pm 0.5\%$ over most of the angular range. The agreement of the present results with recent results at 49.41 MeV is very good in the angular range greater than 20° c.m. angle in spite of the difference in method. (auth)

24541 MEASUREMENTS OF THE DIFFERENTIAL CROSS SECTION AND POLARIZATION IN PROTON-PROTON SCATTERING AT ABOUT 143 MeV. Cox, G. F. (Univ. of Birmingham, Eng.); Eaton, G. H.; Van Zyl, C. P.; Jarvis, O. N.; Rose, B. Nucl. Phys., B4: 353-73(1968).

The differential cross section and polarization in proton-proton scattering were measured over the angular range 16.6° to 113° c.m. at mean scattering energies of 144.1 and 140.7 MeV, respectively. The cross sections were determined to within a relative precision of $\pm 0.5\%$ and the absolute value of the 90° c.m. cross section was determined to $\pm 0.7\%$. The asymmetry measurements were made to a precision of ± 0.002 and the beam polarization is known from previous work to an accuracy of $\pm 0.85\%$ of its value. (auth)

24596 PROTON-PROTON BREMSSTRAHLUNG AT 20 MeV, 35° : THEORY. Signell, P. (Michigan State Univ., East Lansing); Marker, D. Phys. Lett., 26B: 559-61(Apr. 1, 1968).

Proton-proton bremsstrahlung predictions from the Hamada-Johnston and Tabakin potentials are found to be in close agreement with each other, with the on-energy-shell approximation, and with the experimental value at 20 MeV, 30° . The Coulomb interaction is included in the on-shell approximation. The Low approximation is also examined. (auth)

24628 EXCITATION OF NEGATIVE PARITY NUCLEON ISOBARS IN THE QUARK MODEL. Clegg, A. B. (Univ. of Lancaster, Eng.). Nucl. Phys., B5: 59-69(1968).

Recent measurements of excitation of higher nucleon isobars in both pp and np collisions, together with speculations that have been made that their excitation is due to a diffraction dissociation process are discussed. It is shown how this mechanism can be related to recent models ascribing such high energy direct reactions to sums of quark-quark interactions, together with suggested assignments for higher isobars in the quark model: if these assumptions are valid, including the L-excitation assignments to the isobars, the quark-quark diffraction scattering must then include a contribution involving spin-flip. This contribution has some consequences which can be used to check these models and the $L = 1$ assignments to the negative parity isobars. It is also noted how such a spin-flip contribution could be involved in other processes, including one, production of the A_2 meson, in which its effects may already have been observed. (auth)

24676 (LA-DC-8138) NUMERICAL EVALUATION OF SEPARABLE POTENTIALS FOR THE SINGLET ($J = 0$) AND TRIPLET ($J = 1$) PARTIAL WAVES OF THE NUCLEON-NUCLEON SYSTEM. MacKenzie, James J. (Minnesota Univ., Minneapolis. School of Physics. Los Alamos Scientific Lab., N. Mex.). [1968]. Contract W-7405-eng-36. 30p. Dep. CFSTI.

The results of numerical calculations for separable potentials which will fit the singlet ($J = 0$) and triplet ($J = 1$) partial waves of the nucleon-nucleon system are presented. Although no unique set of potentials was found, it is shown that the principal differences in the solutions are at high energies. The deuteron wave function and its quadrupole moment and D state probability are also presented for several mixing parameters. (auth)

24678 POSSIBLE METHOD TO DISCRIMINATE STATISTICAL HYPOTHESES AT CLOSE VALUES OF χ^2 AND ITS APPLICATION TO THE PHASE SHIFT ANALYSIS OF NUCLEON-NUCLEON SCATTERING. Kazarinov, Yu. M.; Kiselev, V. S.; Rozanova, A. M.; Silin, I. N. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 7: 340-8(Feb. 1968). (In Russian).

A method to estimate the probability of the first class error P is proposed when rejecting one of the hypotheses with the account of the correlation of its χ^2 with the χ^2 value of the best of the hypotheses. The method is reasonable for application in the case when one of the hypotheses cannot be rejected using the conventional χ^2 criterion. The estimate of P was used to discriminate solutions in the phase shift analysis of nucleon-nucleon scattering at 630 MeV. (auth)

24680 PARITY-VIOLATING NUCLEON-NUCLEON POTENTIAL. Lacaze, R. (Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro). Nucl. Phys., B4: 657-70(1968).

A static parity-violating nucleon-nucleon potential due to the two-pion exchange is constructed, assuming the current-current and CVC hypotheses for weak interactions. Rescattering terms as well as the $\pi\pi$ P-wave in the strong π -N vertex are taken into account. The results differ from those obtained by Blin-Stoyle in a perturbation calculation for the strong interaction; namely, the range of our potentials is longer and this might modify Partovi's results for the asymmetry coefficients in photodisintegration of the deuteron. (auth)

24681 SIMULTANEOUS PHASE SHIFT ANALYSIS OF 210 MeV NUCLEON-NUCLEON SCATTERING. Janout, Z.; Kazarinov, Yu. M.; Lehar, F.; Winternitz, P. (Joint Inst. for Nuclear Research, Dubna, USSR). Nucl. Phys., B4: 527-33(1968).

Phase-shift analysis at 210 MeV was performed taking $l_{\max} = 5$. New data on the differential cross section, polarization and triple scattering parameters were used and the procedure leads to a unique solution. The angular dependences of experimental quantities are shown in diagrams. (auth)

24683 MESON-NUCLEON COUPLING CONSTANTS FROM NUCLEON-NUCLEON FORWARD DISPERSION RELATIONS. Bugg, D. V. (Rutherford High Energy Lab., Chilton, Eng.). Nucl. Phys., B5: 29-46(1968).

Forward dispersion relations are applied to four spin-dependent nucleon-nucleon elastic scattering amplitudes. Data are taken from

pp and pn phase shift analyses up to 630 MeV lab kinetic energy. Suitable combinations of amplitudes are chosen to separate singlet and triplet NN contributions from the u-channel. The former is dominated by the pion, but after this is removed there remains a significant effect from exchange of something heavier and of negative parity. The most likely source for this appears to be the 3π cut, although η exchange might account for some of it. The triplet NN contributions are dominated by ρ , ω , and σ mesons and are consistent with the absence of other contributors. If ρ alone contributes to the NN $I = 1$ discontinuity, $(g_{\rho 1} + g_{\rho 2})^2 = 23.0 \pm 1.0$ for a ρ mass of 750 MeV/c². The data are rather insensitive to the ratio $f_\rho = g_{\rho 2}/g_{\rho 1}$, and give $f_\rho = 2.5^{+0.8}_{-0.5}$. If f_ρ is not to be considerably different from the value 3.7 predicted from the electromagnetic structure of the nucleon, the pn data require that contributions from exchange of 0^+ and 1^+ mesons with $I = 1$ should be small. Under the assumption that $g_{\omega} = 0$, the pp data give $g_{\omega 1}^2 = 13.5 \pm 1.7$, and $g_{\omega 2}^2 = 14.1 \pm 1.5$, $m_\omega = 613$ MeV/c². Two parameters of the deuteron may be determined by fitting the deuteron pole term. The effective range r_e of the deuteron is found to be 1.69 ± 0.02 fm, and the asymptotic ratio, ρ , of the D and S waves is 0.032 ± 0.005 . (auth)

24684 PION EXCHANGE IN n-p SCATTERING AND PHOTO-PRODUCTION. Wilson, Richard. Comments Nucl. Particle Phys., 2: 41-7(Mar.-Apr. 1968).

A brief historical review is given of the experimental and theoretical study of pion exchange in n-p scattering and photoproduction of π^+ and π^0 . (L.B.S.)

24688 QUARK-MODEL INEQUALITY FOR NUCLEON-NUCLEON TOTAL CROSS SECTIONS. Pinski, G. (Drexel Inst. of Tech., Philadelphia). Nuovo Cim., 54A: 495-6(Mar. 21, 1968).

It is pointed out that a strict inequality for nucleon-nucleon total cross sections follows from the additive quark model with only charge independence for quark amplitudes. The limiting energy below which the inequality is violated is also noted. (L.B.S.)

24707 (JINR-P2-3716) POLYARIZATSIONNYE OPYTY PO PROVERKE T- I CPT-INVARIANTNOSTI V NUKLON-NYKLON-NOM I NUKLON-ANTINUKLONNOM RASSEYANII. (Polarization Experiments on the T- and CPT-Invariance Test in Nucleon-Nucleon and Nucleon-Antinucleon Scattering). Bilen'ki, S. M.; Lapidus, L. I.; Ryndin, R. M. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1968. 20p. (In Russian). Dep.

The experiments of the T-invariance test in elastic N-N scattering are discussed. The results of the experiments performed are given. The possible experiments on the CPT-invariance test in elastic proton-antiproton scattering are also considered. (auth)

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872 SMALL-ANGLE PROTON-PROTON POLARIZATION AND CROSS SECTION AT 213 MeV. Marshall, J. F.; Brown, C. N.; Lobkowitz, F. (Univ. of Rochester, N. Y.). Contract AT(30-1)-875. Phys. Rev., 150: 1119-22 (Oct. 28, 1966). (UR-875-144).

This experiment was a simultaneous measurement of the proton-proton cross section and polarization for the angular range $8.9^\circ - 38.7^\circ$ cm at 213 ± 6 MeV. An experimental normalization of the cross section of $\pm 1.3\%$ accuracy was obtained. The results agree with the predictions of the latest phase-shift analyses except for $\theta_{cm} \lesssim 15^\circ$. (auth)

924 HIGH-ENERGY CROSS SECTIONS IN A "QUARK-DROPLET" MODEL. Woo, Ching-hung (Univ. of Maryland, College Park). Contract AFOSR-500-64. Phys. Rev., 150: 1372-6 (Oct. 28, 1966).

The following experimental information is available about the high-energy scattering of pp (pn), $\bar{p}p$ ($\bar{p}n$), π^+p , and K^+p : (a) the total cross sections, (b) the coefficients b and c in the small-angle parametrization of the differential cross section $d\sigma/dt = Ae^{(bt+ct^2)}$, (c) the ratios of elastic to total cross sections, and (d) the qualitative feature of whether or not the diffraction peak shrinks for the different processes. At the highest available energy, the dependence of these characteristics on the energy becomes relatively weak. A study is made of their dependence on the quantum numbers of the particles involved; that is, how these characteristics are interrelated for the different processes. A "quark-droplet" model is introduced for this purpose. In the approximation where the small differences between pn and $\bar{p}p$ scattering and between π^+p and π^-p scattering are neglected, a three-parameter model gives a good description of the relative magnitude of the total cross sections and the absolute magnitudes of b. It gives a poorer but still reasonable description of the relative magnitudes of (σ_{el}/σ) , and the absolute magnitudes of c. It is shown how a small energy dependence of the three parameters can lead to an increase or decrease of b with energy for the different processes, and how a further splitting of the three parameters can satisfactorily account for the differences between pn and $\bar{p}p$, and between π^+p and π^-p . The difference between this analysis and the Regge-pole analysis is discussed. A few unsettled points requiring further experimental check are summarized at the end. (auth)

933 (LA-3558) A MONTE CARLO SIMULATION OF A PROTON-PROTON SPIN CORRELATION EXPERIMENT. Bryant, H. C.; Jarmie, Nelson (Los Alamos Scientific Lab., N. Mex.). Aug. 2, 1966. Contract W-7405-eng-36. 43p. Dep. mn. CFSTI \$2.00 cy, \$0.50 mn.

A FORTRAN IV Code is described that simulates in detail the results to be expected from a proton-proton spin correlation measurement for various assumed values for the correlation coefficient C_{mm} . The life history of a successful event is described with explanations of the more important computational algorithms. Multiple scattering, relativistic, and energy cut-off effects are included. Plots of many of the more significant variable distributions and a listing of the code, CNNJ9, are presented. (auth)

934 NUCLEON-NUCLEON SCATTERING IN THE FRAMEWORK OF SU_4 SYMMETRY. Zech, Hans-Juergen (Univ., Hamburg). Z. Phys., 196: 222-39 (1966). (In German).

As a consequence of SU_4 -invariance, spin singlet and spin triplet phase shifts should be equal for nucleon-nucleon scattering at even angular momenta. The usefulness of assuming SU_4 -symmetry is tested by calculating, with the use of the Hamada-Johnston potential model for nucleon-nucleon interaction considering only the SU_4 -invariant central part of the potential, the phase shifts in the energy region from 20 to 320 Mev for $l = 0, 2, 4$ and by computing with the use of the Born series the corrections to these phase shifts arising from the residual parts of the potential. Although the approximate quality of the singlet phase with one of the triplet phases persists for $l > 0$, the results obtained do not show promise of great usefulness of the hypothesis of SU_4 -invariance for discussing nucleon-nucleon interactions. (auth)

935 NEAR-PERIPHERAL p-p SCATTERING FROM SIMPLE ONE-BOSON-EXCHANGE CONTRIBUTIONS. Bryan, R. A.; Arndt, R. A. (Univ. of California, Livermore). Phys. Rev., 150: 1299-1307 (Oct. 28, 1966). (UCRL-14297-T (Rev. 1)).

The non-S-wave p-p amplitude is fitted over the 0- to 345-MeV range with three pole terms utilized in a simple fashion; the pole terms are equated with the real part of the scattering amplitude. The imaginary part is then specified by elastic unitarity. The pole terms which give the fit are due to vector-meson exchange ($gv^2 = 2.3$, $fv/gv =$

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2.3; $m_\pi = 770$ MeV), scalar-meson exchange ($g_\sigma^2 = 1.6$, $m_\sigma = 390$ MeV), and pion exchange ($g_\pi^2 = 12.3$, $m_\pi = 135$ MeV). The coupling constants and masses were found with an automatic search routine on an IBM 7094 or CDC 3600 computer. For experiment the single-energy phase-shift analyses of Arndt and MacGregor at 25, 50, 95, 142, 210, and 310 MeV were taken. The pole parameters are consistent with other independent experiments to within the accuracy of the model. The scalar meson is postulated, but may be responsible for the $T = 0$, S-wave $\pi\pi$ correlation observed in the reaction $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ at low energies. (auth)

1016 (UCRL-16991) PROTON-PROTON SCATTERING BETWEEN 4.2 AND 10 MeV AND THE S_0 SHAPE DEPENDENT SCATTERING PARAMETERS. Slobodrian, R. J.; Conzett, H. E.; Shield, E.; Tivol, W. F. (Lawrence Radiation Lab., Univ. of California, Berkeley), July 1966. Contract W-7405-eng-48. 12p. (CONF-660906-30). Dep. mn. CFSTI \$1.00 cy, \$0.50 mn.

From International Conference on Nuclear Physics, Gatlinburg, Tenn.

Proton-proton scattering angular distributions were measured at 6.141, 8.097, and 9.981 MeV (laboratory energy) in an experiment designed to achieve an absolute accuracy better than 1%. A phase-shift analysis has produced preliminary values for the S_0 phase shifts, as well as split P and D_0 phase shifts. With this new information it is possible to reach substantially less ambiguous conclusions concerning the shape-dependent parameters P and Q than was possible before. (auth)

2455 SCATTERING PHASE SHIFTS AT HIGH ENERGIES. Higuchi, Yoshio; Machida, Shigeru (Rikkyo Univ., Tokyo). Progr. Theoret. Phys. (Kyoto), 36: 313-36 (Aug. 1966).

The real and imaginary parts of the partial wave phase shifts for elastic pp , π^+p and $\bar{p}p$ scattering are evaluated from the experimental data on the total cross section, differential cross section and the ratio of the real to the imaginary part of the forward scattering amplitude, assuming no spin dependence. In the case of $\bar{p}p$ scattering the calculated values of the ratio of the real to the imaginary part of the forward scattering amplitude are used, because there are no experimental data available. The results obtained depend mainly on the contribution of the diffraction scattering, and it is shown that the contributions from the intermediate and large angle scattering are quite small numerically. It is also shown, by examining several reasonable forms of the t dependence of the ratio of the real to the imaginary part of the scattering amplitude, that it does not affect the results appreciably. (L.B.S.)

2480 MESON-NUCLEON COUPLING CONSTANTS FROM EMPIRICAL NUCLEON-NUCLEON SCATTERING. Koepp, G.; Soeding, P. (Univ., Hamburg). Phys. Lett., 23: 494-6 (Nov. 21, 1966).

From a fit of the forward scattering amplitude and of the partial-wave amplitudes with $J \geq 2$ in proton-proton scattering, the following values for the vector meson-proton coupling constants are obtained: $g_\rho^2 = 1.2 \pm 0.2$, $g_\omega^2 = 4.7 \pm 2.1$ and $g_f^2 = 0$. (auth)

2481 UNAMBIGUOUS PHASE-SHIFT ANALYSIS OF THE NUCLEON-NUCLEON SCATTERING AT 23.1 MeV. Bilenkaya, S. I.; Kazarinov, Yu. M.; Legar, F.; Janout, Z. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 892-5 (Oct. 1966). (In Russian).

The phase-shift analysis of NN-scattering has been carried out taking new data on the polarization correlation in np- and pp-collisions and on the asymmetry tensor element $\mathcal{H}_{pp}$ at 23.1 MeV into account. A unique solution with negative mixing parameter $\epsilon_1 = -4.86 \pm 1.39$ was obtained for $l_{\max} = 2$. The phase-shifts are given for $l_{\max} = 2$ and 3 as well as plots of the experimentally measurable quantities $\mathcal{H}_{ss}$ for pp- and np-scattering. (auth)

2483 DISPERSION THEORETIC CALCULATION OF THE TWO-PION-EXCHANGE CONTRIBUTION IN NUCLEON-NUCLEON SCATTERING: II. DETAILED INVESTIGATION BY COMPARISON WITH THE OBEC AMPLITUDE. Furuichi, Susumu; Watari, Wataro (Rikkyo Univ., Tokyo; Osaka City Univ.). Progr. Theoret. Phys. (Kyoto), 36: 348-65 (Aug. 1966).

Uncorrelated 2π -exchange contributions to the nucleon-nucleon scattering are investigated in detail by comparing the proper 2π contributions with appropriate one-boson-exchange amplitudes. It is shown that (i) the isospin non-flip amplitude shows a behavior similar to the contribution from the exchange of a single (isoscalar) scalar boson, mainly owing to the effect of the (33) resonance; (ii) the behavior of the isospin flip amplitude is also very similar to that of the contribution from the exchange of a single (isovector) vector boson, and the contribution from the nucleon-pole term is dominant in this amplitude. Furthermore, the relation of the approach to the potential model is discussed, and it is shown that the two-pion-exchange process produces a strong attractive central force and a rather strong negative LS force. The LS force gives a splitting of the 3P_1 amplitudes roughly equal to the observed one. However, the central force seems too strong. The case of cutoff of the high momentum part of the contribution of the exchanged two pions is also examined. By the cutoff procedure, the contribution from the 33 part is considerably suppressed, and the suppression becomes larger as the orbital angular momentum of the two nucleons becomes smaller. (auth)

2503 STUDIES ON INVARIANCE PRINCIPLES IN ELEMENTARY PARTICLE PHYSICS AND PROTON-PROTON BREMSSTRAHLUNG. Ueda, Yoshiaki. (Rochester, N. Y., Univ. of Rochester, 1966). 123p. Thesis.

The testing and application of invariance principles is discussed. The effects of time reversal invariance violation in $K \rightarrow 3\pi$ decay was investigated. In a linear energy approximation for the decay matrix elements, it can be proven using the TCP theorem alone that the partial decay rate of the τ (or τ' or θ) mode for the K^+ meson is nearly equal to that for the K^- meson, provided that contributions from the final state $I = 3$ pion configuration can be neglected. Also, effects of final state pion-pion interactions are computed by extending the dispersion-theoretical treatment of Khuri-Treiman. Next as an application of invariance principles a general theory of relativistic angular correlations for successively decaying particles is developed. Relativistic invariance is guaranteed by the use of the helicity formulation. As examples, the Ξ and Σ^0 are investigated in detail. The proton-proton bremsstrahlung is also investigated by using a field theory as opposed to a potential model. The one pion exchange model is adopted and part of the matrix element is related to the photopion production matrix element, which is expressed in terms of dispersion relations. A

detailed analysis shows that the Born approximation diagrams give the dominant contribution and that the diagrams involving N^* or ρ resonances are negligible for the energy considered. It was found that the results, unlike those of the potential model, seem to give satisfactory agreement with experimental data. (Dissertation Abstr.)

2524 COMPARISON OF THE FORMAL THEORY OF SCATTERING WITH THE CHANNEL APPROACH. Dolinszky, Tamas. Magyar Tud. Akad. Kozp. Fiz. Kut. Int. Kozlem., 14: 287-97(1966). (In Hungarian).

The scattering amplitude is defined by analytical expressions formulated differently in terms of the theory of scattering and in terms of the channel approach. The comparison of the analog concepts shows that the transition matrix element of the formal theory of scattering is fully reproduced by the collision matrix element of the channel approach in the case of elastic scattering by a finite range central force. For nuclear reactions the matrix elements are seen to differ even for two-nucleon interactions of finite range. The difference between the two matrix elements is presented in an analytical form, and it is shown to be due to the presence of polarization forces in the external region. (auth)

3977 (JINR-E1-2952) SPECIFICATION OF THE N-N PHASE SHIFT ANALYSIS AT 23.1 MeV. Kazarinov, Yu. M.; Legar, F.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 7p. Dep. mn.

The N-N phase shift analysis at 23.1 MeV was specified on the basis of new experimental data on the measurement of C_{pp} parameter and P_{pp} polarization at the angle 140° (cms). It is shown that the addition of new data within the errors does not change the solution found previously. (auth)

3978 (JINR-E1-2969) PHASE-SHIFT ANALYSIS AND PLANNING OF EXPERIMENTS AT 18.2 AND 9.7 MeV. Kazarinov, Yu. M.; Legar, F.; Ulegla, I.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1966. 24p. Dep. mn.

The simultaneous phase-shift analysis of np and pp data is performed at 18.2 and 9.7 MeV. Three and four sets of phase shifts are obtained, respectively. Previously obtained nuclear potentials for nonmixing states of two-nucleon system are used to calculate the maximum error in the simultaneous phase-shift analysis, due to the assumption on the additivity of the Coulomb and nuclear phase-shifts. Optimal experiments are planned for a further specification of the phase-shift analysis. The angular distributions of the experimental quantities are given on graphs. (auth)

3984 EXPERIMENTAL ASPECTS OF THE USE OF CARBON-HYDROGEN POLARIZED PROTON TARGETS. Cahill, Th. A. (Univ. of California, Los Angeles). Nucl. Instrum. Methods, 42: 327-8(July 1966).

The experimental aspects of the use of carbon-hydrogen polarized proton targets for proton-proton scattering experiments in the medium energy region are discussed. Comparisons are made to standard double nitrate polarized proton targets, based on $\text{La}_2\text{Mg}_3(\text{NO}_3)_{12} \cdot 24\text{H}_2\text{O}$. (B.G.D.)

4058 (JINR-E1-2953) SPECIFICATION OF THE N-N PHASE SHIFT ANALYSIS AT 147 MeV. Kazarinov, Yu. M.; Legar, F.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 31p. Dep. mn.

Specification of the N-N phase shift analysis at 147 MeV was performed by using all data available at the energies near to 147 MeV. The data on effective cross section of np- and pp-scattering and pp-scattering polarization were normalized to this energy. The angular dependences of the experimental quantities were calculated and are presented. (auth)

4060 P-P AND N-p SCATTERING BASED ON TRANSVERSE MOMENTUM DISTRIBUTION AND MANDELSTAM REPRESENTATION. Chavda, L. K.; Narayan, D. S. (Tata Inst. of Fundamental Research, Bombay). pp 535-45 of Proceedings of the Ninth Symposium on Cosmic Rays, Elementary Particle Physics, and Astrophysics. Neelakantan, K. A. (ed.). Bombay, Department of Atomic Energy, 1966.

For the study of proton-nucleon scattering a representation of the angular dependence is modified such that a scattering amplitude can be derived from it which has the Mandelstam singularity structure and which leads to the empirically observed transverse momentum dependence for small and large values of the angular distribution. This result is then generalized to obtain the full scattering amplitude for p-p scattering involving both spin-flip and nonspin-flip parts of the amplitude. Finally the treatment is extended to obtain the amplitude for n-p direct and charge exchange scattering. The agreement with experiment of this model shows that the same pattern of interaction and the same forces responsible for the p-p scattering also determine the n-p direct and charge exchange scatterings. (J.F.P.)

4064 DYNAMICAL CONDITIONS IN A SIMPLE SOLUBLE MODEL. Eftimiu, C. (Univ., Bonn). Nuovo Cimento (10), 45A: 1033-7(Oct. 21, 1966).

The relation between the conditions characterized by the vanishing of the form factor and the vanishing of the proper vertex under which an elementary particle appearing among the intermediate states of a scattering process turns into a dynamical Regge-like particle is investigated in a simple soluble model. (L.B.S.)

4065 RELATIVISTIC RECONSTRUCTION OF N-N SCATTERING MATRIX. Bilenkii, S. M.; Lapidus, L. I.; Ryndin, R. M. (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksp. Teor. Fiz., 51: 891-906(Sept. 1966). (In Russian).

It is shown how the nucleon-nucleon scattering matrix can be reconstructed from the experimental data at fixed values of the angle and energy in the relativistic case. Different reconstruction procedures are considered. Relativistic formulae were obtained for reconstructing the nucleon-nucleon scattering matrix in the state with total zero isospin from the np and pp-scattering data. (auth)

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4334 FORMAL TREATMENT OF n-p INTERACTIONS IN HEAVY NUCLEI. I. Prosperi, D. (Centro di Studi Nucleari, Casaccia, Italy. Univ., Rome). Nuovo Cimento (10), 44B: 199-203 (July 11, 1966).

A formalism for the treatment of n-p interactions is outlined. The formalism does not require the introduction of isotopic-spin co-ordinates. (D.C.W.)

4335 FORMAL TREATMENT OF n-p INTERACTIONS IN HEAVY NUCLEI. II. Prosperi, D. (Centro di Studi Nucleari, Casaccia, Italy. Univ., Rome). Nuovo Cimento (10), 44B: 204-9 (July 11, 1966).

A many-body theory based on "two-operator coefficients" is outlined. The theory can be used to describe odd-odd nuclei. (D.C.W.)

7456 (JINR-P-2861) AMPLITUDE UPGRUGOGO RASSEYANIYA NUKLONOV NUKLONAMI. (Elastic N-N-Scattering Amplitudes). Golovin, B. M.; Rozanova, A. M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 46p. Dep. mn.

On the basis of the previously published data on the phase-shift analysis, the elastic N-N scattering amplitudes are calculated for energies in the range 23 to 630 MeV. Some peculiarities of the amplitudes are mentioned. The values obtained for spinless terms are compared with the predictions based on dispersion relations. (auth)

7507 MODEL FOR ELASTIC SCATTERING AT HIGH ENERGY AND LARGE MOMENTUM TRANSFER. Contogouris, A. P. (Faculte des Sciences, Orsay, France). Phys. Lett., 23: 698-701 (Dec. 19, 1966).

A model is presented, in which the variation of the differential cross section at large momentum transfer is determined in terms of experimentally known quantities. (auth)

9697 (AERE-Bib-149) NUCLEON-NUCLEON SCATTERING (EXPERIMENTAL ASPECTS). A Bibliography, 1961-1966. Hall, J. L. (Atomic Energy Research Establishment, Harwell (England)). Aug. 1966. 48p. Dep. mn. BIS \$1.40. HMSO 7s.

The bibliography includes published articles and unclassified reports on the experimental aspects of nucleon-nucleon (p-p and n-p) scattering at all energies, for the period covered by abstracting journals published between August, 1961 and June, 1966. Antiparticles are not included. (B.G.D.)

9722 STATISTICAL SCATTERING AND THE OREAR FORMULA. Sisakyan, I. N.; Feinberg, E. L.; Chernavskii, D. S. (Lebedev Inst. of Physics, Moscow). JETP Lett. (USSR) (Engl. Transl.), 4: 290-3 (Nov. 15, 1966).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 4: 432-6 (Nov. 15, 1966). It is found that the universal Orear formula can be interpreted as the result of a combination of the statistical scattering and dif-

fraction due to all statistical processes. Also since large-angle elastic scattering is governed, in general, not only by statistical scattering but also by diffraction statistical scattering, it follows that elastic p-p scattering at low energies is asymmetrical about 90°, in agreement with experiment. The appearance of symmetry is expected when the angle, at which the differential and statistical scatterings are equal, becomes smaller than 90° with increasing energy. (J.F.P.)

9745 THEORY OF PROTON-PROTON BREMSSTRAHLUNG. Cromer, A. H. (Northeastern Univ., Boston); Sobel, M. I. Phys. Rev., 152: 1351-6 (Dec. 23, 1966).

The proton-proton bremsstrahlung cross section is derived to first order in the electromagnetic interaction and the nucleon-nucleon t matrix. The cross section is expressed in terms of the nucleon-nucleon phase shifts and the quasi-phase parameters needed to describe t off the energy shell. The formulas are given in a form suitable for calculation. (auth)

9810 SUBSIDIARY REGGE TRAJECTORIES WITH SINGULAR RESIDUES. NUCLEON-NUCLEON SCATTERING. Durand III, Loyal (Univ. of Wisconsin, Madison). Phys. Rev. Lett., 18: 58-62 (Jan. 9, 1967).

It is pointed out that the existence of secondary Regge trajectories with intercepts $\alpha(0)$ which differ by integers from that of the leading trajectory at $t = 0$, and residues which are singular at that point, is a very general phenomenon which should occur both in the scattering of particles with spin, and in the scattering of particles of unequal mass. Rules are given for determining if such trajectories exist, and for determining their properties. The case of nucleon-nucleon scattering is discussed as an example. (auth)

9811 UNITARITY CORRECTIONS AND A FOUR-POLE FIT TO PERIPHERAL p-p SCATTERING BELOW 350 MeV. Arndt, R. A.; Bryan, R. A.; MacGregor, M. H. (Univ. of California, Livermore). Contract W-7405-eng-48. Phys. Rev., 152: 1490-1504 (Dec. 23, 1966). (UCRL-14807-T).

Proton-proton partial-wave amplitudes for $l \geq 1$ and for lab kinetic energies below 350 MeV are fitted with a collection of single-particle exchanges taken in Born (fixed-pole) approximation. Since the Born terms are real, and consequently nonunitary, a correction term is added which makes the full amplitude unitary, and which at the same time satisfies the appropriate dispersion relation and threshold condition. The nature of this correction term and of its association with a strip approximation to the Mandelstam representation are discussed. The particle parameters were fitted to a reduced matrix representation of the p-p data, as described by Arndt and MacGregor in another publication. The S-wave dependence was removed in a manner also discussed by these authors. The gross structure of the partial-wave amplitudes is found to be approximately given by a sum of four meson-exchange poles, those corresponding to a π meson ($J^P = 0^-, I = 1, g_\pi^2 = 14, M_\pi = 135$ MeV), a σ meson ($J^P = 0^+, I = 0, g_\sigma^2 = 2.9, M_\sigma = 450$ MeV) an ω meson ($J^P = 1^-, I = 0, g_\omega^2 = 4, (f/g)_\omega = 0, M_\omega = 783$ MeV), and a ρ meson ($J^P = 1^-, I = 1, g_\rho^2 = 1.2, (f/g)_\rho = 4, M_\rho = 763$ MeV). The searched parameters were $g_\pi^2, g_\sigma^2, g_\omega^2, g_\rho^2$, and M_σ ; the remaining parameters were fixed at their "physical" values. It is further found that the relatively small unitarizing corrections play an essential role in determining the goodness of fit, but they do not appreciably alter the pole parameters determined from the search. Studies were also undertaken to determine the manner in which this (obviously

low-energy) model becomes quantitatively worse as low-angular-momentum and high-energy contributions are added to the calculation. (auth)

9813 APPROXIMATION METHOD FOR DOUBLE-SCATTERING INTEGRALS. Sobel, M. I. (Brooklyn Coll.). Phys. Rev., 152: 1385-9 (Dec. 23, 1966).

A method is suggested for approximately evaluating matrix elements for double-scattering processes. The method of performing integrals is illustrated in the cases of inelastic p-d scattering and p-p bremsstrahlung. The correction to p-p bremsstrahlung is found to be not greater than 7%. (auth)

11776 CALCULATION OF THE PARTIAL-WAVE ABSORPTIONS AND OF THE MODULI OF THE ELASTIC AMPLITUDES IN NUCLEON-NUCLEON SCATTERING BELOW 1.4 GeV. Amaldi, U. Jr.; Biancastelli, R.; Francaviglia, S. (Istituto Superiore di Sanita, Rome). Nuovo Cimento (10), 47A: 85-112 (Jan. 1, 1967).

The usual procedure to compute partial-wave absorptions in pion-pion and pion-nucleon scattering from the knowledge of inelastic processes is extended to the nucleon-nucleon case and applied to the range 550 to 1400 MeV of laboratory kinetic energies. One-pion production, which is the only important inelastic channel, is described by means of the well-known peripheral model modified by the introduction of form factors. Contrary to general belief, the results show that this model does not violate any of the unitarity conditions, which in the present case are not at all trivial due to the nondiagonal character of the S-matrix in the angular momentum representation. From the computed absorptions the moduli of the partial-wave elastic matrix elements are obtained. After a careful discussion, which shows that the results are trustworthy in the 800 to 1400 MeV energy range, the absorptions are compared with the data of a published phase shift analysis performed at 970 MeV and suggestions are made on the best starting point of future phase shift searches. Finally the possible use of absorptions as known inelasticities to be introduced in partial-wave dispersion relations is outlined. It must be stressed that the results do not depend upon the interpretation of the cut-off function appearing in the inelastic matrix elements as true pionic form factor. (auth)

11778 ELASTIC pp-SCATTERING PHASE SHIFT ANALYSIS AT 657 MeV WITH ACCOUNT OF ONE-BOSON EXCHANGE AND RELATIVISTIC COULOMB EFFECTS. Azhgirei, L. S. Yadern. Fiz., 4: 1248-50 (Dec. 1966). (In Russian).

The phase shift analysis of experimental data on the elastic pp-scattering near to 660 MeV was performed, taking relativistic corrections and proton form factors into account in the Coulomb scattering. The exchange of a scalar boson and two vector ones was taken into account, besides the one pion exchange, in calculating the phase shifts of higher states in the pp system. The one-boson exchange proves to be significant for a description of the proton polarization data at small angles. (auth)

11779 REGGE CUT IN PROTON-PROTON SCATTERING. Huang, K.; Jones, C. E.; Teplitz, V. L. (Massachusetts Inst. of Tech., Cambridge). Phys. Rev. Lett., 18: 146-8 (Jan. 23, 1967).

It is pointed out that a break recently discovered in the differential cross section for p-p scattering as a function of energy at $\Theta = 90^\circ$ may be explained in terms of a Regge cut. An attempt is made to see whether a mechanism can be found that leads naturally to the observed phenomena. A model is developed assuming first that the scattering amplitude is given by a Regge formula without the background term. A comparison between experiment and theory is shown. (L.B.S.)

12027 (UCRL-50001-66-2) PHYSICS DEPARTMENT REPORT, JUNE-SEPTEMBER 1966. (California Univ., Livermore. Lawrence Radiation Lab.). Contract W-7405-eng-48. 63p. Dep. mn. CFSTI \$3.00 cy, \$0.65 mn.

Theoretical studies were made of N-N scattering, electron scattering by polyatomic molecules, A-N interaction, $\Lambda\Lambda$ He⁴, the four-nucleon system, Σ -N interaction, and π - π scattering amplitudes. The fission cross sections of ^{241m}Am and ²³⁵U were measured from 0.02 eV to 6 MeV and from 0.004 to 2 keV, respectively. Threshold photoneutron cross sections for Fe and Be were also measured, as were the photoneutron cross sections of ⁸⁹Y, ⁹⁰Zr, ⁹¹Zr, ⁹²Zr, and ⁹⁴Zr up to photon energies of 30 MeV. Cross sections for the reaction ¹⁴N(n,p)¹⁴C were obtained from measurements of the cross section of the reaction ¹⁴C(p,n)¹⁴N. The reaction ¹⁴C(p,n)¹⁴N was investigated at proton energies between 7 and 14 MeV; the angular distributions at the highest energies were analyzed using a finite-range DWBA formalism. Angular distributions for the reaction ¹⁹F(α ,t)²⁰Ne were analyzed using a zero-range DWBA formalism. Differential cross sections for (α ,n) reactions on ¹¹O and ¹⁸O were measured at 9.8, 11.6, and 12.2 MeV; and evidence was also obtained for the (n, γ) reaction on ²³⁸Pu for slow neutrons. The neutron scattering cross sections of ²⁴¹Pu and ²³⁵U from 2 to 32 eV and from 2 to 22 eV, respectively, were studied further. Data were also obtained on the de-excitation γ rays following (γ ,n) and (γ ,p) reactions on ¹⁶O; and the spontaneous fission half life of ^{242m}Am was measured, as were the thermal-neutron capture cross sections of Ca, ⁴²Ca, ⁴³Ca, and ⁴⁴Ca. Neutron diffraction studies of the magnetic transition in NiS as a function of composition were carried out. Bounds on the fugacity and virial series of the pressure in matter were obtained, and the magnetization and conductivity of Fe were studied from 300 to 1250 kbar. Equation-of-state measurements were carried out on rare-earth metals, and elastoplastic wave structure generated in Al by a tangentially accelerated flying plate was studied. A diffusion approximation to the inertial energy transfer in isotropic turbulence was developed; and atmospheric focusing and refraction of blast waves were studied, as was plasma production using multiple laser beams. The effects of various parameters on the output energy from a Q-spoiled ruby oscillator were also studied, and the rate of energy transfer between electrons and ions in a plasma was calculated. (D.C.W.)

12084 (UCRL-16322) EXTENDED CHARGE EFFECTS ON LOW ENERGY PROTON-PROTON SCATTERING. Slobodrian, R. J. (California Univ., Berkeley. Lawrence Radiation Lab.). Aug. 1965. Contract W-7405-eng-48. 13p. Dep. mn. CFSTI \$3.00 cy, \$0.65 mn.

A nonnegligible correction to the proton-proton scattering parameters was found to arise from a consideration of the extended charge distribution of the proton, far beyond the errors quoted in the recent literature. Using the physical picture

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given, it is concluded that the p-p nuclear potentials should be less attractive than is currently assumed. This is due to a fictitious singular electrostatic potential, which simulates a repulsive core inside the nuclear potential well. (S.F.L.)

13699 RELATION BETWEEN CHARGE-EXCHANGE AND QUASI-ELASTIC SCATTERING AND DYNAMICS OF MULTIPLE MESON PRODUCTION IN HIGH ENERGY REGION. Fukuda, Hiroshi; Iso, Chikashi (Tokyo Inst. of Tech.). Progr. Theoret. Phys. (Kyoto), Suppl., Nos. 37-38, 255-74(1966).

The relation between angular distribution and energy dependence of $A + B \rightarrow C + D$ type scattering cross section and dynamical behaviors of multiple-meson wave produced in high-energy collision is analyzed through unitarity relation. Assuming that the most energetic particle in inelastic channel has the same quantum number as that of the incident particle in the same direction, the various behaviors of quantum-number exchange scattering can be explained semi-quantitatively, i.e., energy dependence and angular distribution of $\pi^+p \rightarrow \pi^+n$, $\pi^+p \rightarrow \eta p$, $pp \rightarrow pN^*$, $\bar{p}p \rightarrow \bar{\Sigma}^-\Sigma^+$ etc., as well as elastic scattering. Also under the above assumption a factorization theorem can be shown for energy dependence and angular distribution of $A + B \rightarrow C + D$ type scattering; this theorem is very useful to compare various two body processes. The results are different in some processes from that deduced by Regge-pole theorem. (auth)

13713 (SLAC-PUB-256) INFORMATION ABOUT THE TWO AND THREE NUCLEON SYSTEMS OBTAINED AND OBTAINABLE FROM THE USE OF POLARIZED TARGETS AND BEAMS. Noyes, H. Pierre (Stanford Linear Accelerator Center, Stanford Univ., Calif.). Jan. 1967. Contract AT(04-3)-515. 51p. (CONF-661205-2). Dep. mn. CFSTI \$3.00 cy, \$0.65 mn.

From Conference on Polarized Targets and Sources, Saclay, France.

Review of recent experiments and theory makes it clear that the spin structure of the three-nucleon system is too complicated to allow a direct determination of the scattering matrix in the near future. In order to provide more readily applicable tools for experimental analysis, the rigorous three-body theory provided by the Faddeev equations should be articulated to provide a low energy n-d theory comparable to effective range theory, a unitary parameterization for the coupled elastic scattering and breakup problems comparable to phase shift analysis, and a theory of high angular momentum states based on the deuteron wave function analogous to one-pion-exchange for the N-N system. As physical input both better nucleon-nucleon scattering measurements, particularly in the n-p system, and a method for extending these results to the energy-momentum regions allowed by the uncertainty principle in the three-nucleon system are also required. Whether it is attempted to derive this extension from electromagnetic measurements of the two-nucleon wave functions, or directly from two-nucleon scattering, it is found that this extension requires understanding of the coupling of the nucleon-nucleon system to other elementary particles. Thanks to the high precision of recent nucleon-nucleon scattering measurements provided by polarization techniques, it is found that all the characteristic features of the two-nucleon interaction can in fact be interpreted as arising from the exchange of known bosons and boson resonances, and hence that this extension can possibly be made in a physically reasonable way. It is concluded that the three-nucleon problem should be approached both phenomenologically and from the point of view of elementary particle physics, and that the coupling of these two approaches offers great promise, if kept in close contact with experiment, and if full use is made of the new polarized target and polarized beam techniques. (auth)

13801 NON-COPLANARITY IN PROTON-PROTON BREMSSTRAHLUNG AT 157 MeV. Gottschalk, B.; Shlaer, W. J.; Wang, K. H. (Harvard Univ., Cambridge, Mass.). Nucl. Phys., A94: 491-501(1967).

The dependence on coplanarity of the reaction $p + p \rightarrow p + p + \gamma$ was investigated for outgoing protons at symmetric angles of 30 and 35° to the beam. The cross section falls off, approximately linearly, as the non-coplanarity of the final state approaches the limit set by kinematics. The coplanar cross sections at $\theta = 30$ and 35° are 10.6 and 14.0 $\mu\text{b}/\text{sr} \pm 20\%$, respectively, consistent with previous results. (auth)

15260 MEASUREMENT OF THE SPIN-CORRELATION PARAMETER C_{NN} IN PROTON-PROTON SCATTERING AT 680 MeV. Dost, Helmut E.; Arens, John F.; Betz, Frederick W.; Chamberlain, Owen; Hansroul, Michel J.; Holloway, Leland E.; Schultz, Claude H.; Shapiro, Gilbert (Univ. of California, Berkeley). Contract W-7405-eng-48. Phys. Rev., 153: 1394-6(Jan. 25, 1967). (UCRL-11877(Rev.)).

Using a polarized beam and polarized target the spin-correlation parameter C_{NN} was measured in proton-proton scattering for an incident-proton laboratory-system kinetic energy of 680 MeV. The polarized beam was made by scattering unpolarized protons from the 184-in. cyclotron in an external first target of liquid hydrogen, resulting in a polarization of 0.44. To reverse the beam polarization, the incident-proton scattering angle was reversed. The target protons were polarized by a solid-state technique called "dynamic polarization" to 0.40 on the average. The elastic proton-proton interactions involving the polarized protons were kinematically separated from other interactions by counting both protons in coincidence. The angular region covered by the 13 data points extends from 51.2 to 88.7 deg in the center-of-mass system. The results show that C_{NN} rises in this region from about 0.5 to 0.9 with a typical standard deviation of 0.1. (auth)

15264 MEASUREMENT OF THE PROTON-PROTON CROSS SECTION AND POLARIZATION IN THE COULOMB INTERFERENCE REGION AT 213 MeV. Marshall, James Franklin. Rochester, N. Y., Univ. of Rochester, 1966. 114p.

Thesis.

This experiment was a simultaneous measurement of the proton-proton differential cross section and polarization at an incident energy of 213 ± 8 MeV over the angular range $8.9 - 37.8^\circ$ cm. In separate runs liquid hydrogen targets of 0.46 and 0.69 gm cm^{-2} were bombarded with a well collimated 90% polarized proton beam and the angular distribution of scattered protons was measured to the right and left of the incident beam line by means of two triple coincidence scintillation telescopes, the defining apertures of which subtended solid angles of 0.00471 and 0.00235 steradians at 30° in the cm system. The counters were mounted on a rotating frame so that they could be shifted frequently from one side of the beam axis to the other during the data runs in order to cancel out instrumental asymmetries. The angular resolution was $\pm 0.6^\circ$ cm for the first run and $\pm 0.7^\circ$ cm for the second run. The angular range was chosen to overlap the range of previous measurements at this energy of the relative cross section and polarization which were for cm angles of $30 - 90^\circ$. An absolute normalization of the cross section was obtained to 1.3% accuracy. Important features of this normalization measurement included the use of a fast scintillation telescope to monitor the incident beam and a careful determination of the effective target thickness. An experimental normalization was obtained for the polarization by measuring the left-right asymmetry of p-carbon scattering with the liquid hydrogen target replaced by a carbon target. The data agree well

with the predictions of recent phase shift analyses except at angles smaller than 15° cm where somewhat weaker interference effects are indicated by the data. (Dissertation Abstr.)

15265 MEASUREMENT OF THE PROTON-PROTON BREMSSTRAHLUNG CROSS SECTION AT 204 MeV. Rothe, Kenneth Warren. Rochester, N. Y., Univ. of Rochester, 1966. 114p. Thesis.

A survey experiment to measure cross sections and angular distributions for proton-proton bremsstrahlung at 204 MeV was completed. Spark chambers were used to determine energy and direction of the two outgoing protons. A detector with good angular resolution determined the direction of the gamma rays and set a lower cutoff of 20 MeV on the gamma energy. Three gamma ray angles were investigated ($\theta_{lab} = 90^\circ, 135^\circ, 45^\circ$) giving a total of 513 good bremsstrahlung events. Proton center of mass angular distributions indicate the strong presence, in the final two proton system, of angular momentum states with $L > 0$. In addition, the protons prefer to come off in a plane containing the gamma ray and the incident beam. Proton polarization data agree well in sign with the elastic polarization although the average inelastic polarization is smaller than the elastic value at 210 MeV. The shape of the polarization depends on gamma angle and at $\theta_{lab} = 90^\circ$ differs significantly in shape from the elastic curve. Gamma asymmetries average -0.146 ± 0.044 (all events included) where the negative sign indicates preference to scatter such that $\vec{P}_{inc} \times \vec{P}_\gamma$ lies antiparallel to the beam polarization and $\vec{P}_{inc}$ is the incident beam momentum. Measured cross sections ($d^2\sigma/d\Omega dE_\gamma$) agree in shape with those predicted by Ueda although not in magnitude (the calculations give cross sections ~ 1.5 times higher than those observed). A comparison with cross sections measured by Gottshalk et al., at 158 MeV indicates that the cross sections are larger than theirs by approximately the factor of three predicted by Duck and Pearce. An invariant mass plot $m_{\gamma, p}$ gives an upper limit for the production cross section of 55 nanobarns for any resonant state $P^* \rightarrow P + \gamma$ in the $950 \leq \text{mass} \leq 1050$ MeV region with lifetimes $\tau \cdot 10^{-22} \leq \tau \leq 10^{-10}$ sec. (Dissertation Abstr.)

15332 HEAVY PARTICLE PAIR PRODUCTION. Sisakyan, I. N.; Feinberg, E. L.; Chernavskii, D. S. Zh. Eksp. Teor. Fiz., 52: 545-56 (Feb. 1967). (In Russian).

An important result obtained in recent years is discovering that such high-energy hadron-interaction processes exist which pass through the compound state ("head-on collisions"). Such processes do not only determine binary scattering $A + B \rightarrow C + D$ involving a large 4-momentum transfer $\sqrt{-t} > 1$ GeV, but as shown, pp and dd heavy pair production also. In this case one may differentiate between pair production in NN collisions involving the formation of other particles, such as pions, and processes of the type $A + \bar{A} \rightarrow B + \bar{B}$ which do not involve other particles. An example of the latter case is heavy pair production by γ -quanta when the form factor F of the $\gamma\bar{\gamma}$ vertex is determined by formation of the compound state. Application to the cross section σ_q for $q\bar{q}$ quark pair production in NN and $N\bar{N}$ -collisions shows that if the quarks interact with hadrons at distances $m_N^{-1} - \mu^{-1}$ as strongly as the hadrons interact between themselves, then σ_q should be extremely small and decrease exponentially with the mass m_q . If, however, the interaction is weaker σ_q may be large and approach the geometric cross section. This result is practically true for any type of generation mechanism. The same reasoning is employed for estimating the time-like form factor for the $\gamma\bar{\gamma}$ vertex. The result is compared with the experiments on $p\bar{p} \rightarrow e^- e^+ (\mu^- \mu^+)$ annihilation. (auth)

15354 REGGE-POLE FORMULAS FOR DIFFERENTIAL CROSS SECTIONS OF QUASI-TWO-BODY πN AND NN INTERACTIONS. Wang, Ling-lie (Univ. of California, Berkeley). Contract W-7405-eng-48. Phys. Rev., 153: 1664-72 (Jan. 25, 1967). (UCRL-17053).

Regge-pole formulas for differential cross sections of some quasi-two-body πN and NN interactions, which can have one or two meson trajectories exchanged, are given. The reactions treated are: $\pi N \rightarrow \pi\Delta(1236)$, $\pi N \rightarrow \omega\Delta(1236)$, $\pi N \rightarrow A_2 N$, $\pi N \rightarrow \eta N$, $\pi N \rightarrow \eta\Delta(1236)$, $\pi N \rightarrow \rho N$, $\pi N \rightarrow \rho\Delta(1236)$, $NN \rightarrow N\Delta(1236)$, $NN \rightarrow NN^*(1500, \frac{3}{2}^-)$, $NN \rightarrow NN^*(1480, \frac{1}{2}^+)$. (auth)

15417 OPTICAL POTENTIAL FOR HIGH-ENERGY PHYSICS: THEORY AND APPLICATIONS. Arnold, Richard C. (Argonne National Lab., Ill.). Phys. Rev., 153: 1523-46 (Jan. 25, 1967).

A field-theoretic exact two-body optical potential V^0 is defined, corresponding to the exact pseudopotential in nuclear physics. A small-angle, high-energy approximation for scattering amplitudes in the absence of resonances or bound states is suggested, based largely on investigations of Torgerson in a fairly realistic model field theory. This approximation, which corresponds to the eikonal or linearized WKB approximation in a nonrelativistic limit, involves only mass-shell values of V^0 and can be discussed in the framework of dispersion relations and analyticity. The longest range contributions to V^0 are one-pion exchange (when allowed) and the multiperipheral diagrams of Amati, Fubini, and Stanghellini; these contributions are termed "multiperipheral optical potential" (MOP). One possibility for the asymptotic high-energy limit of MOP brings in Regge poles through the multiperipheral diagrams. At energies which are not asymptotic, but are high enough to ensure the usefulness of the eikonal formalism, important non-pole contributions to V^0 are discussed. The difference between $\bar{p}p$ and pp elastic scattering is explained in such an energy region. As a natural consequence of the picture presented, one obtains distorted-wave Born-approximation (DWBA) correction formulas applicable to any small contributions in V_0 ; e.g., real part, spin flip, and charge exchange. A special case is the absorptive correction to the ρ Regge-pole expression for charge exchange in $\pi^+ p \rightarrow \pi^0 n$, which has been discussed in a previous paper. The Serber potential which accommodates large- t behavior (although only $-t/s \ll 1$ can be properly described by the eikonal expression) is shown to be a special case of MOP. If MOP is dominated by the Pomeranchuk Regge pole (P) in elastic pp scattering above 10 BeV/c, and if is ignored spin, a real part of the forward scattering amplitude for this case is obtained, which agrees in sign with the observed value, but is too small in magnitude; it has an energy dependence $[\ln s/s_0]^{-1}$. The $\bar{p}p$ results should become identical to the pp ones for energies which are asymptotic for $\bar{p}p$ also. Similar results for the real part hold for all two-body reactions. In πp scattering, a formalism incorporating spin properly into the eikonal method is presented, and in the asymptotic limit with no "anomalous-moment" terms in the Born approximation (as suggested by a Pomeranchuk pole), a spin-orbit coupling is obtained corresponding to use of the Dirac equation with a 4-vector static central potential. The resulting πp spin-flip amplitude decreases with increasing energy like $s^{-1/2}$ relative to nonflip terms, but is presumably dominated by effects of secondary Regge poles such as P' . To describe multichannel reactions, and to obtain absorptive correction formulas including reactive damping, an exact multichannel optical potential V_{ij}^0 is defined, and a matrix eikonal mass-shell approximation is proposed. Such a method is valid only when certain commutation relations are satisfied for the matrix Born approximation; these are satisfied, for example, if the t dependence of all elements of this matrix is the same, which can be true in many cases if mass differences are ignored. Regge poles and the Byers-Yang model are considered in this context. To include resonances in the s channel, possibilities for extend-

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ing the eikonal formalism are discussed. A method of formulation utilizing dispersion relations for phase shifts allows an alternative, purely S-matrix approach to the eikonal approximation, but is physically more obscure than the field-theoretic and static-potential-theory approaches. Singularities in complex J of the MOP-eikonal approach are explored. It is found that infinite numbers of branch cuts in J correspond to absorptive (DWBA) corrections when Regge poles are used in MOP. An apparent paradox concerning results of Mandelstam on cancellation of cuts is discussed and a possible avenue of resolution, involving treating external particles as Regge poles with signature, is described. (auth)

15618 (ORO-1316-28) NUCLEON-NUCLEON BREMSSTRAHLUNG. Pearce, William A.; Gale, William A.; Duck, Ian M. (Rice Univ., Houston, Tex.). Feb. 7, 1967. Contract AT(40-1)-1316. 20p. (CONF-670302-1). Dep. mn. CFSTI \$3.00 cy. \$0.65 mn.

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla.

Cross sections for bremsstrahlung production in N-N interactions were calculated using the Tabakin separable potentials. The results were compared with experimental observations. (D.C.W.)

17036 ASYMMETRY IN THE EMISSION OF π^+ MESONS IN 612 MeV pp-COLLISIONS WITH A POLARIZED PROTON BEAM. Borisov, A. A.; Kuznetsov, A. S.; Lukashov, V. E.; Nurushev, S. B.; Solov'yakov, V. L. Yadern. Fiz., 5: 348-53 (Feb. 1967). (In Russian).

Experiments are described determining the azimuthal asymmetry in the production of π^+ -mesons in proton-proton collisions, using a 612 MeV polarized proton beam. The measurements were performed in the region of l.s. angles 85 to 125° using a scintillation hodoscopic device. For fixed angles the asymmetry was determined for three values of the π^+ -meson emission energy. The experimental results are compared with the predictions of the one-meson approximation model. (auth)

17037 MEASUREMENT OF THE TRIPLE SCATTERING PARAMETER R_{pn} AT 70° CMS AND THE PHASE SHIFT ANALYSIS AT 630 MeV. Kazarinov, Yu. M.; Legar, F.; Pisarev, A. F.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 5: 140-5 (Jan. 1967). (In Russian).

The parameter R_{pn} and the polarization in the elastic 605-MeV pn scattering were measured at 70°, with the result $R_{pn} = 0.09 \pm 0.19$ and $P_{pn} = -0.05 \pm 0.18$. These data were used to perform a phase shift analysis at 630 MeV, to calculate the experimentally measurable quantities and to plan further experiments, determining the parameters D_{pn} , R_{pn} , A_{pn} , C_{pn}^{Re} and A_{pn}^{Im} . The planning showed, that within the given experimental possibilities, a measurement of the parameters D_{pn} and A_{pn} will be the most efficient way to discriminate between the two remaining sets of phase shifts. (auth)

17038 SPIN CORRELATION IN THE ELASTIC SCATTERING OF POLARIZED 605 MeV PROTONS ON PROTONS. Golovin, B. M.; Zulkarneev, R. Ya.; Kiselev, V. S.; Medved, S. V.; Nikanorov, V. I.; Pisarev, A. F.; Semashko, G. L. (Joint Inst.

for Nuclear Research, Dubna, USSR). Yadern. Fiz., 5: 146-9 (Jan. 1967). (In Russian).

The spin correlation coefficients in the elastic pp-scattering were measured at 90° cms, using a polarized 605 MeV proton beam. Spark chambers controlled by scintillation counters were used in the measurements. The following values of the coefficients were determined: $C_{nn} = 0.56 \pm 0.18$, $C_{kp} = 0.27 \pm 0.18$, $C_{qk} = 0.92 \pm 0.38$. (auth)

17039 NEUTRON-PROTON SMALL ANGLE SCATTERING AT 14.1 MeV. Suhani, A.; Fox, R. (Technion-Israel Inst. of Tech., Haifa). Phys. Lett., 24B: 173-4 (Feb. 20, 1967).

The neutron-proton differential cross section was measured at an energy of 14.1 MeV for angles between 12 and 90° c.m. A least-squares fit of the data to a straight line has a slope of $2 \pm 4\%$ between the measured angles. This slope is in agreement with the predicted isotropy as calculated by Nakamura from the theory of Hamada and Iwadare. (auth)

17112 (CERN-67-3) SOME REMARKS CONCERNING THE PROTON STRUCTURE. Schopper, H. (European Organization for Nuclear Research, Geneva (Switzerland)). Feb. 16, 1967. 10p. Dep. mn.

A determination of whether the e-p and p-p results are consistent with each other and the general conclusions about the proton which can be drawn on this basis is made. It is emphasized that both the e-p and the p-p data can be fitted by two almost phenomenological expressions. This is connected with the difficulty in accelerating the various parts of the nucleon without breaking it up, and this difficulty is independent of the specific process. If, on the other hand, an optical potential is used to interpret the form factors and cross sections, it implies that the proton consists of two shells with radii of 0.8 and 0.35 f approximately. (J.F.P.)

17134 (AECD-TP-15) PHASE SHIFT CALCULATIONS FOR REAL AND REALISTIC POTENTIALS. Ali, Shamsheer; Islam, Mozaharul (Atomic Energy Centre, Dacca (Pakistan)). Sept. 1966. 14p. Dep. mn.

Real and central potentials are considered in the program presented and a procedure for phase shift calculations is developed which can be readily used for all types of realistic potentials. This program also incorporates the calculation of the low-energy effective range parameters, namely, scattering length and effective range. (J.F.P.)

17135 (JINR-P4-3135) OPISANIE UPRUGOGO NUKLON-NUKLONOGO RASSEYANIYA V MEZONNOI MODELI YADER-NYKH SIL. (Description of Elastic NN-Scattering in Meson Model of Nuclear Forces). Babikov, V. V.; Kiselev, V. S. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1967. 16p. (In Russian). Dep. mn.

The phase shifts of elastic NN-scattering with the orbital momenta $L \geq 1$ for the energy range of $E_{lab} \approx 330$ MeV are calculated on the basis of an assumption that the external region of nuclear forces is determined by the exchange of the lightest π , η , ρ , ω , δ mesons. The momentum dependence of the potentials is calculated

in the Born approximation. The constants of meson-nucleon coupling are found which lead to a satisfactory description of experimental P, D, F, G scattering phase shifts. It is shown that these values agree with those of the coupling constants, determined from other experimental data. (auth)

17136 (JINR-P4-3136) SOVREMENNYE MODELI YADER-NYKH SIL. (Modern Nuclear Force Models). Babikov, V. V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1967. 10p. (In Russian). Dep. mn.

Different models of nucleon-nucleon interaction, used in nuclear physics, are discussed. (auth)

17138 ONE-BOSON-EXCHANGE MODEL PARAMETERS AND NN-SCATTERING PHASE SHIFTS. Azhgirel, L. S.; Chizhikov, V. I. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 5: 405-10 (Feb. 1967). (In Russian).

The parameters of a one-boson-exchange model are determined from the nucleon-nucleon scattering phase shifts in the region 25 to 310 MeV, using the method of least squares. In a four-pole model, allowing for the exchange of scalar (σ), pseudoscalar (π) and two vector (ω and ρ) mesons, the best description of the nucleon-nucleon scattering corresponds to the following values of the parameters: $g_{\sigma}^2 = 2.1 \pm 0.5$; $f_{\omega}/g_{\omega} = 0.5 \pm 0.1$; $m_{\omega} = 422 \pm 18$ MeV; $g_{\rho}^2 = 2.9 \pm 0.4$; $m_{\rho} = 373 \pm 13$ MeV; $g_{\pi}^2 = 13.1 \pm 0.2$; $g_{\pi}^2 = 0.1 \pm 0.3$; $f_{\rho}/g_{\rho} = -5.4 \pm 7.0$; $m_{\rho} = 800 \pm 140$ MeV. The energy dependences of the phase shifts, calculated using these parameters, are compared with the results of phase shift analyses at 435 and 657 MeV. (auth)

17139 SPIN CORRELATION TENSOR IN THE SCATTERING OF POLARIZED NUCLEONS BY POLARIZED PROTON TARGET. Winternitz, P.; Legar, F.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 5: 201-3 (Jan. 1967). (In Russian).

Experiments to measure the tensor of spin correlation from the scattering of a polarized nucleon beam by a polarized proton target are discussed. Relativistic formulas for measurable quantities are obtained. A construction of the scattering matrix with experimentally measurable quantities is performed. (auth)

17296 (UCRL-16864) DETERMINATION OF THE NEUTRON-NEUTRON SCATTERING LENGTH. Shield, Edward (California Univ., Berkeley. Lawrence Radiation Lab.). Dec. 19, 1966. Contract W-7405-eng-48. 72p. Dep. mn. CFSTI \$3.00 cy, \$0.65 mn.

Thesis.

Measurements on the reaction $T(d,^3\text{He})2n$ at 32.7-MeV incident deuteron energy were used to determine the n-n scattering length. Watson's theory of final-state interactions provides a theory with which the experimental data giving the number of ^3He at 6 and 8° vs energy can be compared. Comparison is made with numbers of ^3He near the maximum energy, in which case the neutrons go off with little relative energy under the influence of a final-state s-wave interaction. The best fit of the data to theory gives $a_{nn} = -16.1 \pm 0.1$ F. The applicability of this method is proved by measurements on the reaction $^3\text{He}(d,t)2p$, which give a value for a_{pp}

equal to the accepted value within the experimental errors. Comparisons of the results with other measurements of a_{nn} are given. (auth)

18893 (AD-635017) THE POLARIZATION PARAMETER IN ELASTIC PROTON-PROTON SCATTERING FROM .75 TO 2.84 GeV. Neal, Homer A. Jr. (Michigan Univ., Ann Arbor. Dept. of Physics). Apr. 1966. Contract Nonr-1224(23). 114p. (TR-2303106-23-T). CFSTI \$3.00 cy, \$0.65 mn.

A double-scattering technique was employed to measure the polarization parameter in elastic proton-proton scattering at .75, 1.03, 1.32, 1.63, 2.24, and 2.84 GeV. An external proton beam from the Brookhaven Cosmotron was focussed on a three-inch-long liquid hydrogen target and the elastic recoil and scattered protons were detected in coincidence by scintillation counters. The polarization produced in the scattering process was inferred from the azimuthal asymmetry exhibited in the scattering of the recoil beam from a carbon target. This asymmetry was measured by a set of two scintillation counter telescopes which symmetrically viewed the carbon target. The analyzing power of this arrangement was previously determined in an independent experiment employing a 40% polarized proton beam. The corrected values of the polarization parameter are exhibited as a function of the center-of-mass scattering angle for each incident beam energy. The prediction of the Regge theory that the polarization parameter in elastic proton-proton scattering is related to the total proton-proton and proton-antiproton cross sections was found to be consistent with the experimental results. (auth)

18896 (JINR-P1-3167) IZMERENIE PARAMETRA R I FAZOVYI ANALIZ p-p RASSEYANIYA PRI 600 MeV. (Measurement of the R Parameter and the Phase-Shift Analysis of pp-Scattering at 600 MeV). Golovin, B. M.; Zul'karneev, R. Ya.; Kiselev, V. S.; Medved, S. V.; Nikanorov, V. I.; Pisarev, A. F.; Semashko, G. L. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1967. 10p. (In Russian). Dep. mn.

The triple scattering parameter R was measured in the scattering of 605-MeV protons on protons with spark chambers controlled by scintillation counters. The phase-shift analysis of experimental data was performed at ~600 MeV. (auth)

18898 (SLAC-PUB-238) THE ABSOLUTE VALUE OF $A_{xx}(90^\circ)$ FOR PROTON-PROTON SCATTERING AT 11.4 MeV. Noyes, H. Pierre (Stanford Linear Accelerator Center, Stanford Univ., Calif.). Dec. 1966. Contract AT-(04-3)-400. 10p. (CONF-661210-2). Dep. mn. CFSTI \$3.00 cy, \$0.65 mn.

From American Physical Society Meeting, Stanford, Calif. Because of the deterioration of the target under proton bombardment, Catillon, Chapellier, and Garreta normalize their measurements of the proton-proton scattering parameters $A_{xx}(90^\circ)$ and $A_{yy}(90^\circ)$ at 11.4, 19.15, 23.45, and 26.5 MeV to the value of $A_{xx}(90^\circ)$ at 11.4 MeV. In order to provide an absolute normalization for these experiments, it is noted that at 90° the value of A_{xx} is related to the ratio A_{yy}/A_{xx} by the equation $1 + A_{xx} = (1 - A_{yy}/A_{xx}) / [(|c|^2/|e|^2) + 1 - A_{yy}/A_{xx}]$ where c and e are two of the four triplet p-p helicity amplitudes defined by Raynal. This result is independent of the singlet amplitude, and further, the unknown ratio $|c|/|e|$ is shown to be well approximated by $(1 + r)/(1 - r)$, where r is $\frac{1}{2}$ of the ratio of L · S to tensor contributions of the ^3P phase shifts. It is known from p-p phase shift analyses at

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higher energy that the $L \cdot S$ interaction is of short range compared to the known one-pion-exchange tensor interaction, and this ratio is expected to be small. Conservative limits at this energy are set by existing p-p models fitted to the higher energy scattering, and in this way r is found to lie between 0.087 and 0.162. The corresponding uncertainty in A_{xx} is ± 0.0019 , which is negligible compared to the experimental uncertainty of ± 0.013 in the measurement of A_{yy}/A_{xx} . It is concluded that $A_{xx}(90^\circ) = -0.984 \pm 0.009$ at 11.4 MeV. (auth)

18976 CHIRAL SYMMETRY FOR REGGE RESIDUES. Mitter, P. K.; Sawyer, R. F. (Univ. of California, Santa Barbara). Phys. Rev., 154: 1382-6 (Feb. 25, 1967).

It is assumed that the octet Regge trajectories of baryon number zero belong to $(8,1) \pm (1,8)$ representations of chiral $U(3) \otimes U(3)$. The relations among residues at zero momentum transfer which follow from this assumption are studied. Predictions are made for the $\frac{1}{2}^+$ -isobar forward-production cross section in baryon-baryon and meson-baryon scattering. The prediction (at sufficiently high energies) $(d\sigma/d\Omega)_{\theta=0} (p + p \rightarrow p + N^{*+}) = 8/9 (d\sigma/d\Omega)_{\theta=0} (p + n \rightarrow n + p)$ seems to be in reasonable agreement with experiment. The $U(3) \otimes U(3)$ group is also found useful in exploring the possible dynamic origin and consequences of exchange degeneracy (degeneracy of odd- and even-signature trajectories). (auth)

19021 DETERMINATION OF THE NUCLEON-NUCLEON ELASTIC-SCATTERING MATRIX. V. NEW RESULTS AT 25 MeV. Arndt, Richard A.; MacGregor, Malcolm H. (Univ. of California, Livermore). Phys. Rev., 154: 1549-57 (Feb. 25, 1967). (UCRL-70075).

Analyses of N-N experiments at 25 MeV have been hampered by a lack of complete scattering data, especially for the scattering states with isotopic spin $T = 0$. In particular, there is an ambiguity in the single-energy $T = 0$ solutions at 25 MeV. This ambiguity, which is discussed here in detail, is partly resolved by the addition of new (n,p) data. Some new (p,p) data were also added. The resulting phases more closely resemble the values expected from potential models—with which they are compared. The new selection of data permits a determination of the pion-nucleon coupling constant ($g_\pi^2 = 14.3 \pm 1.3$), whereas the older selections did not. An investigation of the parabolic approximation for each of the phases indicates the extent to which one can believe the uncertainties as given by an error-matrix calculation. The energy-dependent analyses in this energy region were improved by having the S phases extrapolate to the scattering length and effective-range expansions at low energies. The resulting phases give excellent fits to the data at 10 MeV as well as at 25 MeV. Experiments that would further improve the analysis at 25 MeV are suggested. The present results are in some disagreement with a recently released Dubna analysis at 23 MeV. (auth)

19023 MODEL FOR HIGH-ENERGY SINGLE-PION PRODUCTION. Fraser, G. M. (Imperial Coll. of Science and Tech., London); Roberts, R. G. Nuovo Cimento (10), 47A: 339-42 (Jan. 21, 1967).

A possible mechanism for the background production of single mesons (π) in high-energy reactions is investigated. The background production considered is direct production, that is, without any intermediate resonance or bound state being formed which may subsequently decay to give an indirect production process.

The processes considered are $\pi^+ + p \rightarrow \pi^+ + \pi^0 + p$, $\pi^+ + p \rightarrow \pi^+ + \pi^+ + n$, and $p + p \rightarrow p + p + \pi^0$. Several features which would be exhibited by all these reactions over a range of incident meson (π) momenta are presented. (J.F.P.)

19173 DIFFERENTIAL CROSS SECTION OF 40-MeV NEUTRONS SCATTERED FROM PROTONS. Tagliaferri, Edward Jr. Los Angeles, Univ. of California, 1966. 128p.

Thesis.

The purpose of the experiment was to measure the differential cross section of 40-MeV neutrons scattered from protons. The neutrons were produced by inserting a hollow probe cooled with D_2O into the circulating proton beam of the UCLA 50-MeV cyclotron. The neutrons from the deuteron break-up in the heavy water were collimated into a beam and scattered from protons in a piece of plastic scintillator. The recoil proton was detected in this scintillator, in coincidence with the scattered neutron, which was detected by another scintillation counter placed at the desired scattering angle. The energy of the scattered neutron was determined by measuring its time-of-flight from the target to the neutron detector. Four neutron detectors were used simultaneously during the experiment, with anti-coincidence scintillation counters placed in front of each one to prevent charged particles originating in the target counter from registering as valid scattering events. One counter remained at 25° to the neutron beam throughout the experiment to continuously monitor the energy and intensity of the incident neutrons. Two corrections were made to the results. The data taken at 40° in the center of mass had to be adjusted upward by 33.2% because part of the pulse-height spectrum of the recoil protons from neutrons scattered at this angle was cut off by the discriminator on the target counter. The second correction was a downward adjustment of the data at center of mass scattering angles from 90 to 140° . This correction had to be made because at these angles, it was energetically possible for an incident neutron to cause the break-up of a carbon nucleus in the target counter into three detectable α particles and still have enough energy left over so that its velocity was the same as it would have been had it scattered from a proton. The corrections increased in size with increasing scattering angle, ranging from $1.7 \pm 0.3\%$ at 90° to $29 \pm 7\%$ at 140° . The corrected data were normalized to the differential scattering cross section measured by the Harwell group with 42.5-MeV neutrons. The normalized data from the three neutron detectors were then averaged. The average data were fitted by the method of least squares to a polynomial of the form $d\sigma/d\Omega = a_0 + a_1 \cos \theta + a_2 \cos^2 \theta$ where θ is the neutron scattering angle. The values obtained for a_0 , a_1 , and a_2 were 13.04 ± 0.38 , -2.98 ± 1.15 , and 7.11 ± 1.62 , respectively. The corresponding coefficients for a similar fit made to the data taken by the Harwell group are 14.20 ± 0.28 , 0.16 ± 0.49 , and 4.49 ± 0.73 . (Dissertation Abstr.)

19296 (UCRL-50001-66-1, pp 1-40) NUCLEAR AND ATOMIC STRUCTURE. (Lawrence Radiation Lab., Univ. of California, Livermore).

Summaries are given of research on: vector mesons in a Coulomb potential; elementary excitations in an interacting Bose gas; theoretical existence of the $\Sigma^{-}nn$ hyperfragment; phenomenological Λ -nucleon potentials; a one-boson exchange model for p-p elastic scattering (0 to 400 MeV) in the context of a strip approximation to the corresponding Mandelstam representation; one-boson exchange models and nucleon-nucleon scattering; potential energy of the hydrogen atom; kinematic singularities introduced by partial-wave projection for the scattering of particles with spin and unequal masses; the $^{18}O(p,d)^{19}O$ and $^{18}O(p,t)^{19}O$ reactions at

18.5 MeV; development of a Moxon-Rae-type gamma detector which has an efficiency which is proportional to the total energy of the incident photons; calculation of fast-neutron inelastic scattering cross sections; a two-nucleon DWBA analysis of data from the $^{15}\text{F}(d,\alpha)^{17}\text{O}$ reaction; reactions $^3\text{He}, d$ and $(\text{He}-3,t)$ on isotopes of carbon, nitrogen, and oxygen with 17.8-MeV ^3He ions; angular distributions of the $^{18}\text{F}(\alpha,t)^{20}\text{Ne}$ reaction to the ground state and various excited states using 28.5-MeV α particles; measurement of photoneutron cross sections just above the neutron binding energy for iron and bismuth; comparison of mirror nuclei resulting from photoexcitation of ^{16}O ; measurement of $\bar{\nu}$ (the average number of neutrons released per fission) for neutron fission of ^{240}Am ; cross sections for the (γ,n) and $(\gamma,2n)$ reactions with ^7Li ; characteristic x-ray production in single crystals of Al and Cu by proton bombardment at 70 to 100 keV; the $^{26}\text{Mg}(p,n)^{26}\text{Al}$ and $^{26}\text{Mg}(p,n)^{26}\text{Al}$ reactions to assess the applicability of a strong coupling deformed isospin model in describing the (p,n) charge-exchange reaction; the two-body force by the $^{14}\text{C}(p,n)^{14}\text{N}$ reaction; elastic scattering of 7- to 14-MeV neutrons from nitrogen; the x-rays from the fission of ^{235}U with a bent-crystal spectrometer; secondary standard γ -ray energies; and neutron production cross sections using protons of 7.5- to 14.0-MeV energy. (S.F.L.)

21137 USE OF A POLARIZED PROTON TARGET FOR THE STUDY OF LOW-ENERGY NUCLEON-NUCLEON INTERACTIONS. Lehar, Frantisek (Czech Technical Univ., Prague); Winternitz, Pavel. *Cesk. Cas. Fys.*, 17: 158-211(1967). (In Czech).

The possible use of a polarized proton target in the investigation of low-energy nucleon-nucleon interactions is reviewed. The reconstruction of the scattering matrix and verification of P-, T- and isotopic invariance are briefly discussed. Possible sources and detectors of polarized particles are discussed. All possible experimental quantities determined from the phase shift analysis are given in graphs for energies of 14.5 and 23.1 MeV. (auth)

21234 DOUBLE RESONANCE PRODUCTION AT HIGH ENERGIES: CORRELATIONS BETWEEN THE DECAY DISTRIBUTIONS OF RESONANCES IN THE QUARK MODEL. Bialas, A. (Jagellonian Univ., Krakow. Inst. of Nuclear Physics, Krakow); Gula, A.; Muryn, M. *Phys. Lett.*, Part B, 24: 428-31(Apr. 17, 1967).

The correlations between the decay distributions of resonances produced in the processes $\pi p \rightarrow \rho N^* K p \rightarrow K^* N^*$ and $\bar{p} \bar{p} \rightarrow N^* \bar{N}^*$ are investigated in the framework of the quark model. It is found that the discussed predictions of the quark model are in good agreement with the existing data, and they are similar to the result of the absorption model calculations. (auth)

21250 (UCSD-10P10-21) MESON THEORY OF NUCLEON-NUCLEON INTERACTION. Wong, David Y. (California Univ., La Jolla, San Diego). Feb. 1967. Contract AT(11-1)-Gen-10. 26p. (CONF-670302-2). Dep. mn. CFSTI \$3.00 cy, \$0.65 mn. From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla.

It is found that a nucleon-nucleon potential can be constructed in terms of the exchange of six mesons: π , σ , η , ρ , ω , and ϕ . The calculation of the potential and the methods for solving for the scattering amplitudes are considered. It is found that a simple

model of nuclear forces based on the exchange of correlated mesonic systems is in good agreement with experimental data on nucleon-nucleon scattering. Such a model can be used as a basis for the detailed phenomenological analysis of the data; and it also leads to a qualitative understanding of the nuclear forces in terms of nucleon-nucleon and meson-meson interactions. (J.F.P.)

21252 THE NUCLEON-NUCLEON INTERACTION AND EXCHANGE OF THE π SYSTEM. Gauron, P.; Lacombe, M.; Vinh Mau, R. (Facultes des Sciences de Paris et d'Orsay. Institut de Physique Nucleaire, Orsay, France). *Nuovo Cim.* (10), 47A: 924-8(Feb. 21, 1967). (In French).

The results of an attempt to treat the nucleon-nucleon interaction using the analyticity and unitarity properties of the scattering amplitude are given. A determination is made of the part of the nucleon-nucleon potential associated with a (π,η) system for a comparison with the contributions obtained previously. These results show that the exchange of the ω or π system constitutes only some corrections to the exchange of one or two mesons (π), this exchange being necessary to improve the model used for the calculation of the latter contribution. (J.F.P.)

21256 SUPERCONVERGENCE SUM RULES IN NUCLEON-NUCLEON SCATTERING. D'Auria, R.; de Alfaro, V. (Univ., Turin. Istituto Nazionale di Fisica Nucleare, Turin). *Nuovo Cimento* (10), 48A: 284-8(Mar. 1, 1967).

The case of nucleon-nucleon scattering is examined in order to establish the possible sum rules, and the problem of saturation is discussed. It is found that saturation of the sum rules in the nucleon-antinucleon channel by the lowest intermediate states yields relations which are consistent with the known values of the coupling constants. It is stressed that the only sensible indication derives from the relative order of the magnitude and sign of the various contributions. (J.F.P.)

21257 MESON-NUCLEON COUPLING CONSTANTS FROM NUCLEON-NUCLEON FORWARD DISPERSION RELATIONS. Carter, A. A. (Cambridge Univ., Eng.). *Nuovo Cimento* (10), 48A: 15-22(Mar. 1, 1967).

The coupling constants of the ω , η , σ mesons were estimated using the proton-proton forward dispersion relation. The calculations were performed as a function of the σ mass, upon which limits were placed. The ratio of the real to the imaginary part of the elastic proton-proton scattering amplitude was evaluated. (auth)

21258 OPTICAL-MODEL, HIGH-ENERGY p-p SCATTERING AND STRUCTURE OF THE NUCLEON. Islam, M. M. (Brown Univ., Providence). *Nuovo Cimento* (10), 48A: 251-7(Mar. 1, 1967). (NYO-2262TA-140).

An exact derivation of the eikonal description of the scattering amplitude, a discussion of some of the questions raised by Byers and Yang, and an indication of what the semiphenomenological results may imply about the structure of the nucleon are presented. (J.F.P.)

21322 (JINR-P1-3189) IZMERENIE POLYARIZATSII PUCHKA PROTONOV S ENERGIEI 635 MeV. (Measurement of 635 MeV Proton Beam Polarization). Zul'karneev, R. Ya.; Nadezhdin, V. S.; Satarov, V. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 6p. (In Russian). Dep. mn.

The results are reported of polarization measurements of the proton beam obtained by scattering on a Be target inside the synchrocyclotron and used in scattering experiments beginning from 1960. A method and the procedure of experimental measurements of azimuthal asymmetry for 350, 596, 635 MeV in pp-scattering at various angles are described. Possible contributions of false asymmetries into experimentally found values are analyzed. The weighted mean over all the beam polarization measurements was obtained by the time-invariant method and turned out to be 0.425 ± 0.013 . (auth)

21414 SPIN CORRELATION PARAMETERS IN PROTON-PROTON SCATTERING BETWEEN 10 AND 26 MeV. Catillon, P.; Chapellier, M.; Garreta, D.; Thirion, J. (CEN, Saclay, France). pp 293-4 of Proceedings of the 2nd International Symposium on Polarization Phenomena of Nucleons. Huber, P.; Schopper, H. (eds.). Basel and Stuttgart, Birkhaeuser Verlag, 1966.

Spin correlation parameters for p-p scattering between 10 and 26 MeV were obtained by measuring the cross sections for the scattering of polarized proton beams by a polarized target. (D.C.W.)

21415 MEASUREMENTS OF C_{NN} IN 140-MeV P-P SCATTERING USING A POLARIZED TARGET. Brogden, T. W. P.; Jarvis, O. N.; Orchard-Webb, J.; Wigan, M. R. (Atomic Energy Research Establishment, Harwell, Eng.). pp 298-300 of Proceedings of the 2nd International Symposium on Polarization Phenomena of Nucleons. Huber, P.; Schopper, H. (eds.). Basel and Stuttgart, Birkhaeuser Verlag, 1966.

The spin correlation parameter in p-p scattering at 140 MeV was measured using a polarized target of hydrated lanthanum magnesium nitrate. Both scattered and recoil protons were recorded in coincidence using three counter telescopes for scattering angles of $\pm 30^\circ$ and 45° . (D.C.W.)

21416 RE-EVALUATION OF OLD VALUES AND REMEASUREMENT OF POLARIZATION IN P-P SCATTERING AT 140 MeV. Jarvis, O. N. (Atomic Energy Research Establishment, Harwell, Eng.); Rose, B.; Scanlon, J. P.; Eaton, G. H.; Cox, G. F.; van Zyl, C. P. pp 301-3 of Proceedings of the 2nd International Symposium on Polarization Phenomena of Nucleons. Huber, P.; Schopper, H. (eds.). Basel and Stuttgart, Birkhaeuser Verlag, 1966.

The polarization of two proton beams obtained from a synchrocyclotron was measured as was the asymmetry in the elastic scattering of both polarized beams by Al at 10° . The polarization in p-p scattering at 140.5 MeV was measured using a liquid hydrogen target. (D.C.W.)

21417 PROTON-PROTON SCATTERING AT 600 MeV USING A POLARIZED TARGET. PRELIMINARY RESULTS. Coignet, G. (CEN, Orsay, France); Cronenberger, D.; Kuroda, K.; (and others). pp 304-7 of Proceedings of the 2nd International Symposium on Polarization Phenomena of Nucleons. Huber, P.; Schopper, H. (eds.). Basel and Stuttgart, Birkhaeuser Verlag, 1966.

The polarization for p-p scattering at 600 MeV was measured using a polarized target. The spin correlation parameter was measured at 585 MeV using a polarized beam and a polarized target. (D.C.W.)

21418 MEASUREMENT OF THE DEPOLARIZATION IN N-P SCATTERING AT 2.6 MeV. Pursér, F. O.; Sawers, J. R.; Walter, R. L. (Duke Univ., Durham, N. C.). pp 311-13 of Proceedings of the 2nd International Symposium on Polarization Phenomena of Nucleons. Huber, P.; Schopper, H. (eds.). Basel and Stuttgart, Birkhaeuser Verlag, 1966.

Triple-scattering asymmetries were measured for neutron elastic scattering by hydrogen (polyethylene), Fe, and Zr using polarized neutrons from the $^{12}\text{C}(d,n)^{13}\text{N}$ reaction. The depolarization parameter for n-p scattering was obtained. (D.C.W.)

21615 ANALYSIS AND INTERPRETATION OF THE NEW NUCLEON-NUCLEON MEASUREMENTS NEAR 24 MeV. Noyes, H. P. (Stanford Univ., Calif.). pp 238-43 of Proceedings of the 2nd International Symposium on Polarization Phenomena of Nucleons. Huber, P.; Schopper, H. (eds.). Basel and Stuttgart, Birkhaeuser Verlag, 1966.

The results of a phase-shift analysis of p-p and n-p scattering near 25 MeV are compared with the predictions of several potential models. It is noted that the inclusion of data obtained with polarized beams and polarized targets moves the $T = 1$ phases closer to the values predicted by the models. The predictions of certain models are compared with experimental data. (D.C.W.)

23306 (JINR-E01-3194) THE $A(\theta)$ ASYMMETRY IN ELASTIC 635-MeV pp-SCATTERING. Kiselev, V. S.; Nadezhdin, V. S.; Satarov, V. I.; Zul'karneev, R. Ya. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 8p. Dep. mn.

The results of the $A(\theta)$ asymmetry measurements of elastic pp-scattering are described as being completely due to the totally polarized beam. The measurements were performed at 635 MeV in the angle range from 28 to 90° (cms). Earlier pp-scattering phase shifts are improved by using both the results and those of other experiments. In searching for solutions beginning from random values three solutions with $l_{\max} = 5$ and two solutions with $l_{\max} = 4$ are obtained. Thus, in the energy range analyzed, no evidence for the existence of a single phase-shift solution is obtained. (auth)

23307 (JINR-E1-3066) THE DESIGN OF SPECIFYING AND DISCRIMINATING NN-SCATTERING EXPERIMENTS. Fedorov, V. V.; Pazman, A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Computing Techniques and Automation). [1966]. 16p. Dep. mn.

Some expressions are obtained which made it possible to use

a sequential design of regression experiments (design with finite time) instead of the continuous design. A new method is proposed for the design of discriminating experiments. A comparison with other methods is given. (auth)

23308 (UCRL-17433) HIGH-ENERGY-PHYSICS EXPERIMENTS WITH POLARIZED TARGETS. Chamberlain, Owen (California Univ., Berkeley, Lawrence Radiation Lab.). Dec. 1966. Contract W-7405-eng-48. 56p. (CONF-661206-3). Dep. mn. CFSTI \$3.00 cy, \$0.65 mn.

From Conference on Polarized Targets and Sources, Saclay, France.

Experiments with polarized proton targets are reviewed in detail. These experiments include both proton-proton and meson (π)-proton interactions. Such experiments are undertaken in order to obtain knowledge of the spin dependence of the forces in strong interactions. (J.F.P.)

23314 (BNL-994, pp 70-102) PHYSICS. (Brookhaven National Lab., Upton, N.Y.).

Experimental and theoretical studies concerned with the structure and fundamental properties of matter are described. Descriptions of various experiments carried out on particle physics at the Cosmotron and the AGS are given, and the theoretical aspects of particle physics, instrumentation, and data processing are discussed. Other areas of physics considered are solid state, nuclear structure, theoretical physics, neutron physics, and atomic and molecular physics. (J.F.P.)

23403 (LA-DC-8639) LOW ENERGY NEUTRON-PROTON POLARIZATION EXPERIMENTS. Simmons, J. E. (Los Alamos Scientific Lab., N. Mex.). [1966]. Contract W-7405-eng-36. 16p. (CONF-670302-4). Dep. mn. CFSTI \$3.00 cy, \$0.65 mn.

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla.

The status of n-p scattering and polarization experiments near 25 MeV is reviewed. Recent data on polarization and spin correlation observables are discussed in relation to phase-shift analyses, with some emphasis on the role of the s-d coupling parameter. (auth)

23405 (UCRL-70376) CONCEPT FOR AN ENERGY DEPENDENT NEUTRON-NEUTRON SCATTERING EXPERIMENT USING A NUCLEAR EXPLOSION. Dickinson, W. C.; Bowman, C. D. (California Univ., Livermore, Lawrence Radiation Lab.). Mar. 17, 1967. Contract W-7405-eng-48. 11p. (CONF-670302-3). Dep. mn. CFSTI \$3.00 cy, \$0.65 mn.

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla.

An experiment that could be used to determine the n-n scattering length using a nuclear explosion as the neutron source is proposed. The experimental geometry is discussed in detail. (D.C.W.)

25229 (CEA-R-3193) MESURE DES COEFFICIENTS DE CORRELATION DE SPINS A_{xx} ET A_{yy} DANS LA DIFFUSION p-p DE 11 A 26 MeV. (Spin Correlation Parameters A_{xx} and A_{yy} Measurements in p-p Scattering From 11 to 26 MeV). Catillon, Philippe; Chapellier, Maurice; Garreta, Denis (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Mar. 1967. 75p. (In French). Dep.

The A_{xx} and A_{yy} spin correlation coefficients of the proton-proton scattering were measured at the laboratory energies of 11.40, 19.15, 23.45, and 26.50 MeV for the center of mass scattering angle 90° . These measurements were made by scattering a polarized proton beam on a polarized proton target. (auth)

25231 PLANNING OF np-SCATTERING EXPERIMENTS ABOVE THE MESON PRODUCTION THRESHOLD. Legar, F.; Fedorov, V. V.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 5: 887-90 (Apr. 1967). (In Russian).

The optimal experiment, necessary to determine the most probable of two phase shift sets at 400 and 630 MeV, is designed. Experiments determining the quantities D , R , A , C_{nn} and A_{nn} in pn-scattering are considered. It is shown that the most effective experiment is the measurement of the parameter D_{pn} . The measurements must be performed at 60 and 115° (c.m.s.) for 400 and 630 MeV, respectively. (auth)

25232 SPIN CORRELATION IN PROTON-PROTON SCATTERING AT 27 MeV. Jarmie, Nelson (Los Alamos Scientific Lab., N. Mex.); Brolley, J. E.; Kruse, Herald; Bryant, Howard C.; Smythe, R. Contract W-7405-eng-36. Phys. Rev., 155: 1438-43 (Mar. 25, 1967). (LA-DC-7494).

The spin-correlation parameter C_{nn} for proton-proton scattering was measured at $90.00 \pm 0.25^\circ$ c.m. angle and 27.05 ± 0.10 MeV. The value obtained is $C_{nn} = -0.689 \pm 0.070$. The construction and operation of the apparatus is described, detailing the cryogenic targets and fast electronic logic. The analysis of the data is explained. Related experiments and the significance of this measurement in the investigation of nucleon-nucleon scattering are briefly discussed. (auth)

25287 DYNAMICS OF ELEMENTARY PARTICLES AND THE PION-NUCLEON INTERACTION. COURSE A. Lectures Given at the Niels Bohr Institute and NORDITA, Copenhagen by J. Hamilton. Copenhagen, Nordisk Institut for Teoretisk Atomfysik, 1966. 233p.

The processes discussed are $\pi + \pi \rightarrow \pi + \pi$, $\pi + N \rightarrow \pi + N$, $N + N \rightarrow N + N$, and similar processes in which a γ -ray replaces one pion. The basis of the dynamical theory is considered, not to so deep a level as axiomatic field theory, but to one sufficiently deep to give confidence in the reliability of the theory. Forward and near forward dispersion relations are dealt with, and some applications to the pion-nucleon system are shown. Also the application of the Mandelstam representation is treated. (DENM)

v.21 (1967)

25314 (JINR-P02-3188) OBMEN TENZORNYMI MEZ-ONAMI V UPRUGOM NN-RASSEYANII. (Exchange of Tensor Mesons in Elastic NN-Scattering). Azhgirei, L. S.; Chizhikov, V. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Computing Techniques and Automation). 1967. 15p. (In Russian). Dep. mn.

The N-N scattering matrix amplitudes for the exchange of tensor ($J = 2^+$) and pseudotensor ($J = 2^-$) mesons are obtained. A partial wave decomposition is made and the expressions for the partial wave amplitudes are given. (auth)

25315 (JINR-P2-3253) DISPERSIONNYE PRAVILA SUMM DLYA NN- I NN-RASSEYANIYA. (Dispersion Sum Rules for NN- and NN-Scattering). Pisarenko, V. G. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1967. 13p. (In Russian). Dep.

By help of dispersion sum rules the parameters of the high energy NN- and NN-scattering are connected with the cross section integrals in the low and middle energy region. (auth)

25316 MONTE CARLO SIMULATION OF A PROTON-PROTON SPIN CORRELATION EXPERIMENT. Bryant, Howard C. (Univ. of New Mexico, Albuquerque); Jarmie, Nelson. Contract W-7405-eng-36. Phys. Rev., 155: 1444-7 (Mar. 25, 1967). (LA-DC-8180).

A FORTRAN IV program is described that simulates in detail the results to be expected from a proton-proton spin correlation measurement for various assumed values for the correlation coefficient C_{nn} . The life history of a successful event is described which includes multiple scattering, relativistic, and energy cutoff effects. Plots of many of the more significant variable distributions are presented, and the advantages of the method are discussed. (auth)

25317 HIGH-ENERGY NUCLEON-NUCLEON SCATTERING FROM REGGE POLES. Flores-Maldonado, Victor (Univ. of California, Berkeley). Contract W-7405-eng-48. Phys. Rev., 155: 1773-84 (Mar. 25, 1967). (UCRL-16918).

A phenomenological study of N-N scattering is made according to the Regge-pole theory. The p-p, $\bar{p}$ -p, p-n, and $\bar{p}$ -n elastic processes, and p-n and $\bar{p}$ -n charge-exchange scattering are considered. The purpose of this work is twofold: first, to see if there is agreement between a simple Regge-pole model and the existing experimental data, such as measurements of α , $d\sigma/dt$, polarizations, the ratio of the real to the imaginary part of the amplitude, and other inferences from π -N scattering. Second, if agreement is found, the behavior of the trajectories and residue functions is investigated. It is found that a Regge-pole model which includes the contributions of the trajectories P, P', ω , ρ , and R can account for the data. The agreement is better above 15 (GeV)². Below this energy, discrepancies between this model and experimental data begin to be noticed. This happens, in particular, in processes in which ρ and R are the principal contributors. We find that the zero-momentum-transfer data are in good agreement with an ω intercept of 0.5; with P, P', and ω residues almost equal in value; and with comparatively small ρ and R residues. The study of the data at invariant momentum transfers less than zero indicates that the trajectories are straight lines or have a small curvature. They seem to follow the trend of the Chew-Frautschi diagram. Poor agreement is obtained with trajectories that tend asymptotically to the axis $\alpha = 0$. The residues of the trajectories of even signature, P, P', and R, behave similarly. They remain greater than or equal

to zero, the zero value being attained at the point at which the corresponding trajectory crosses the axis $\alpha = 0$. In contrast, the residues of the trajectories of odd signature, ω and ρ , pass to the negative side of the plane at momentum transfers of about -0.1 (GeV)². They remain less than or equal to zero, the zero value being attained at the point at which the corresponding trajectory crosses the axis $\alpha = -1$. The physical constraints of unitarity, spin structure, factorization, and the assumption of real analyticity of the residues are imposed. (auth)

25319 INELASTIC PROCESS AND THE ONE BOSON EXCHANGE MODEL. 2. Kikugawa, Masayoshi (Hiroshima Univ.); Sawada, Shoji. Progr. Theoret. Phys. (Kyoto), 37: 88-106 (Jan. 1967).

The proton-proton scattering and one pion production in proton-proton collision at 0.97 GeV are analyzed in terms of the one-boson-exchange model. The pion production is assumed to proceed through the (3-3) resonance production. The one π , one ρ , one ω and one scalar meson exchange are taken for the elastic proton-proton scattering amplitudes T_A^0 , and the one π and one ρ exchange for the (3-3) resonance production amplitudes T_B^0 . In order to satisfy the unitarity condition these one-boson exchange amplitudes are related with the S matrix by $S = [1 + (i/2) T^0/1 - (i/2) T^0]$, where T^0 is the matrix formed by T_A^0 , T_B^0 and the elastic nucleon-(3-3) resonance scattering amplitude T_C^0 as $T^0 = [T_A^0 \ T_B^0 / T_C^0 \ T_C^0]$. The matrix element T_C^0 is taken as free parameters. The observed energy distribution of recoil neutrons in the one pion production process can be successfully reproduced by this model, almost independently of the parameters T_C^0 . There the pomeron factor is not necessarily required. (auth)

25320 MANDELSTAM BRANCH POINTS AND SCATTERING OF PARTICLES AT HIGH ENERGIES AND LARGE MOMENTUM TRANSFERS. Anselm, A. A.; Dyatlov, I. T. (Institute of Physics and Tech., Leningrad). Phys. Lett., 24B: 479-82 (May 1, 1967).

An attempt is made to determine the behavior of the elastic cross section at high energy s and large momentum transfer t by considering the contribution of Mandelstam branch points in the complex angular momentum plane. Outside the diffraction cone, but for $|t| \ll s$, the cross section $d\sigma/dt$ decreases exponentially with $\sqrt{-t}$ (which is in qualitative agreement with Ozer's formula) and also exhibits oscillations. The possibilities of experimental investigation of these oscillations are discussed. (auth)

25325 LARGE-ANGLE SCATTERING AT VERY HIGH ENERGIES AND UNITARY SYMMETRIES. Kastrup, H. A. (Univ., Bern). Nucl. Phys., B1: 309-16 (1967).

Recent experimental results in high-energy large-angle scattering are compared with a statistical soft-meson model combined with unitary symmetries. This model is able to account for a number of observed properties. In particular it follows that all elastic and inelastic cross sections are dominated by an SU_6 -invariant exponential factor which leads to the observed universality for SU_2 -invariant reactions, but which may be sensitive to symmetry breaking in the case of SU_3 . A method for extracting that part of the cross section which should not be sensitive to symmetry breaking is discussed. (auth)

25356 STATISTICAL POTENTIAL MODEL. Machida, Shigeru (Kyoto Univ.); Namiki, Mikio. *Progr. Theoret. Phys.* (Kyoto), 37: 107-16 (Jan. 1967).

The statistical-potential model for high energy elastic scattering is proposed in order to account for large-angle scattering in a unified framework describing the real part of the forward elastic scattering amplitude. The whole amplitude is considered to be decomposed into two parts: one is the pure imaginary shadow scattering amplitude and the other the statistical potential scattering amplitude. The statistical potential scattering amplitude $T^{(c)}$ is formulated under the assumption that many scattering centers are produced when the central collision occurs, and that the distribution of these scattering centers is determined by a distribution function subject to some statistical law. The amplitude $T^{(c)}$ can be treated in analogy to the theory of neutron scattering by crystal. Some empirical formulas can be reproduced from rather natural assumptions on the correlation function of the above system of scattering centers. (auth)

25422 (JINR-P01-3215) POLYARIZATSIONNYE EFFEKTY PRI NEUPRUGOM Nd-RASSEYANII. 3. KVAZIUPRUGOE pp-RASSEYANIE. (Polarization Effects by Inelastic Nd-Scattering. 3. Quasi-Elastic pp-Scattering). Golovin, B. M.; Kulyukina, L. A. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1967. 6p. (In Russian). Dep. mn.

On the basis of the nonrelativistic impulse approximation, polarization parameters are calculated for the "normal total experiment" on quasi-pp scattering in N-d collisions. (auth)

27302 PROTON-NEUTRON QUASI-ELASTIC SCATTERING AT 991 MeV. Murray, T. A.; Riddiford, L.; Grayer, G. H.; Jones, T. W.; Tanimura, Y. (Univ. of Birmingham, Eng.). *Nuovo Cim.* (10), 49A: 261-72 (May 21, 1967).

The proton-proton and proton-neutron elastic-scattering angular distributions were measured at 1.69 GeV/c (=991 MeV) from 14.5 to 150° c.m.s. using fast scintillation counters in conjunction with magnetic-momentum analysis. In both cases, the forward elastic cross sections are considerably in excess of their respective optical-theorem minima, the results being consistent with the existence of a real part in the $T = 0$ scattering amplitude together with spin dependence in both interactions. The proton-neutron angular distribution is more strongly asymmetric about 90° c.m.s. than it is at lower energies, indicating the onset of diffraction scattering and increased interference between the scattering amplitudes in the $T = 0$ and $T = 1$ I-spin states. At the larger center-of-mass angles, the data suggested that substantial corrections were necessary because of the inapplicability of the impulse approximation as a result of multiple nuclear scattering in the deuteron, necessitating a measurement of the ratio of quasi-elastic to elastic proton-proton scattering from 100 to 150° c.m.s. (auth)

27303 NEUTRON-PROTON BREMSSTRAHLUNG AT 197 MeV. Koehler, P. F. M.; Rothe, K. W.; Thorndike, E. H. (Univ. of Rochester, N. Y.). *Phys. Rev. Lett.*, 18: 933-6 (May 22, 1967).

A more reliable npy cross section measurement is provided. The experiment was performed using a proton beam and a target of almost free neutrons in deuterium. The proton-deuteron radiative processes are interpreted by an extension of the spectator model. Inferred free n-p bremsstrahlung cross sections are given. (J.F.P.)

27342 (JINR-P2-3251) RASSHCHEPLENIE TRAEKTORI REDZHE I SOOTNOSHENIYA MEZHDU SECHENIYAMI PRI VYSOKIH ENERGIYAKH. (Regge Trajectory Splitting and Relations Between High Energy Cross Sections). Kadyshevskii, V. G.; Mir-Kasimov, R. M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1967. 11p. (In Russian). Dep.

A number of relations are obtained between the cross sections for meson-nucleon and nucleon-nucleon collisions at high energies in the framework of a model unifying the Regge pole theory and the broken $SU(3)$ symmetry scheme. (auth)

27382 AN IMPACT PARAMETER CUT-OFF MODEL FOR NUCLEON ISOBAR EXCITATION IN INELASTIC pp SCATTERING. Rotsstein, A. (McGill Univ., Montreal). *Nucl. Phys.*, B1: 655-67 (1967).

A simple model is presented to account for the energy and momentum transfer dependence, at small scattering angles, of the production differential cross sections in the reactions $p + p \rightarrow N + N^*$. N is a nucleon and N^* represents a nucleon isobar. The study is applied to the isospin $T = \frac{1}{2}$ isobar at 1238 MeV and to the $T = \frac{1}{2}$ isobars at 1400, 1512, 1688, and 2190 MeV respectively. Partial waves below an impact parameter cut-off b_c are suppressed, while for $b > b_c$ the partial waves are given by the Born one-pion exchange contribution for the 1238-MeV isobar and by a Gaussian distribution with a radius characteristic of elastic pp scattering for the $T = \frac{1}{2}$ isobars. The results of the calculations are in good agreement with the data. (auth)

27383 NUCLEON-NUCLEON AND NUCLEON-ANTINUCLEON ELASTIC SCATTERING AT HIGH MOMENTUM TRANSFERS. Bialas, A. (Jagellonian Univ., Krakow. CERN, Geneva); Czyzewski, O. *Nuovo Cim.* (10), 49A: 273-9 (May 21, 1967).

The discussion of the present data on $\bar{p}p$ and np elastic scattering at high momentum transfers is given. It is shown that (i) the Orear formula can be used for the description of these data, (ii) the data are in disagreement with the statistical model of compound elastic scattering, (iii) the data suggest that the elastic interaction of nucleons and antinucleons at high momentum transfers is roughly independent of the kind of particles involved. (auth)

27384 METHOD FOR SOLVING THE NAMBU-SALPETER-BETHE EQUATION AND ITS APPLICATION TO NUCLEON-NUCLEON SCATTERING IN THE 3P_1 STATE. Ito, Hitoshi (Kinki Univ., Osaka); Mizouchi, Masayoshi; Murota, Toshiyuki; Nakano, Tadao; Noda, MatuTarow; Tanaka, Fujio. *Progr. Theoret. Phys.* (Kyoto), 37: 372-97 (Feb. 1967).

A method for numerically solving the Nambu-Salpeter-Bethe equation in realistic cases is investigated. The method is based on a variational principle and can be applied to all energy regions. By this method the 3P_1 phase shifts in nucleon-nucleon scattering at 10, 100, 205, and 270 MeV incident energies are calculated in the ladder approximation of PS(PS) coupling. Information on the accuracy of solutions is also obtained. The numerical solutions in the case of neglecting the virtual nucleon pair effects are close to the results of the 3-dimensional nonstatic calculation with the one-pion-exchange potential. It is shown that nucleon pair effects are not large. (auth)

27388 BREMSSTRAHLUNG OF SOFT γ QUANTA IN $p + p \rightarrow p + p + \gamma$ AND $\pi^- + p \rightarrow \pi^0 + n + \gamma$ REACTIONS. Starodubtsev, G. P.; Shekhter, L. Sh. (Saratov State Univ., USSR). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 3, 146-50 (1966). (In Russian).

The Low theorem for soft γ -quantum emission was applied to the reactions $p + p \rightarrow p + p + \gamma$ and $\pi^- + p \rightarrow \pi^0 + n + \gamma$. The first two terms of differential cross section expansion in the processes by photon energies (for the proton scattering at ultrarelativistic threshold) were obtained. (tr-auth)

27515 (INP-534/PL) DIFFRACTION OF HIGH ENERGY NUCLEONS ON NUCLEI AND THE REAL PART OF THE NUCLEON-NUCLEON SCATTERING AMPLITUDE. Czyz, W.; Lesniak, L. (Institute of Nuclear Physics, Krakow (Poland)). Feb. 1967, 14p. (CONF-670207-4). Dep.

From 2nd International Conference on High Energy Physics and Nuclear Structure, Rehovoth, Israel.

A method of analyzing high-energy nucleon-nucleus scattering in terms of nucleon-nucleon elastic scattering amplitude is presented and the results compared with the recent experimental data. (auth)

27519 MEASUREMENT OF THE DIFFERENTIAL CROSS SECTION IN PROTON-PROTON SCATTERING AT 49.41 MeV. Baty, C. J. (Rutherford High Energy Lab, Eng.); Griffith, T. C.; Inrie, D. C.; Lush, G. J.; Robbins, L. A. Nucl. Phys., A98: 489-502 (1967).

The differential cross section for proton-proton elastic scattering at 49.41 MeV was measured at 30 angles between 13 and 90° (cms) with an absolute precision of 0.5 to 0.7% over most of the angular range. The 90° cms cross section is compared with other data near 50 MeV. (auth)

27629 PROTON-PROTON PHASE SHIFTS AT 50 MeV. Perling, J. K. (Atomic Energy Research Establishment, Harwell, Eng.). Nucl. Phys., A99: 241-5 (1967).

The p-p scattering data near 50 MeV, including a recent accurate set of cross-section measurements, are analyzed in terms of phase shifts. Only the S-, P-, and D-phases are found to differ significantly from the one-pion-exchange values. The results are more accurate than those obtained previously and are more consistent with results at other energies. (auth)

27444 SPIN CORRELATION PARAMETER A_{xx} AND A_{yy} MEASUREMENTS IN p-p SCATTERING FROM 11 MeV TO 26 MeV. Catillon, P.; Chapellier, M.; Garreta, D. (CEN, Saclay, Gif-sur-Yvette, France). Nucl. Phys., B2: 93-109 (1967).

The A_{xx} and A_{yy} spin correlation coefficients of proton-proton scattering were measured with an accuracy better than 2% at lab energies of 11.4, 19.15, 23.45 and 26.5 MeV for the center-of-mass scattering angle of 90°. The measurements were made by scattering a polarized proton beam on a polarized proton target. (auth)

29450 TWO-PROTON FINAL-STATE INTERACTIONS IN THE REACTIONS $D(^3\text{He}, t)2p$ AND $^3\text{He}(d, t)2p$ AT A CENTER-OF-MASS ENERGY OF 21 MeV. Morton, B. J.; Gross, E. E.; Malanify, J. J.; Zucker, A. (Oak Ridge National Lab., Tenn.). Phys. Rev. Lett., 18: 1007-9 (June 5, 1967). (ORNL-P-3000).

Triton spectra were measured at 0 and 3° for the reaction $D(^3\text{He}, t)2p$ and at 5° for the reaction $^3\text{He}(d, t)2p$ at the same c.m. energy (21 MeV). The results were compared with predictions of the Watson-Migdal final-state interaction theory, and the proton-proton scattering length a_p was determined for each reaction. Although the overall fit for the first reaction is poor, the best fit to the high-energy region of the data is obtained for $a_p = -12.6 \pm 0.6$ F. For the second reaction, $a_p = -7.3 \pm 0.6$ F gives a reasonably good overall fit. (auth)

29518 MULTIPARTICLE PRODUCTION IN HIGH-ENERGY COLLISIONS. Huang, Kerson (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Phys. Rev., 156: 1555-63 (Apr. 25, 1967). (MIT-2098-284).

The "incoherent-droplet" model proposed earlier is solved for the general case of multiparticle production in high-energy hadron collisions. For small transverse momenta the result is equivalent to taking the invariant square matrix element to be $C \exp \{-(n/Nk_0) \sum_{i=1}^n q_i^2\}$, where q_i is the magnitude of the transverse momentum of the i th final particle, n is the total number of particles in the final state, N is an increasing function of energy, otherwise unspecified, and k_0 is a constant. Independent of the choice of parameters in the model, it is found that in the high-energy limit two of the heaviest final particles share equally almost all of the available energy. Parameters of the model can be so chosen as to reproduce the experimental constancy of the average transverse momentum and the total cross section. The simplest choice leads to the prediction that the average multiplicity increases logarithmically with the total cm energy. Illustrative examples of energy and angular distributions are given. (auth)

29522 REGGE POLES AND THE ALGEBRA OF CURRENTS. Cabibbo, N. (CERN, Geneva, Univ., Aquila, Italy). pp 359-77 of Strong and Weak Interactions. Present Problems. Zichichi, A. (ed.). New York, Academic Press, 1966.

The theory of high-energy strong interactions is discussed based on the identification of an algebra of scalar and vector currents in the structure of the residue functions associated with Regge trajectories. (J.F.P.)

29533 HIGH-ENERGY np CHARGE-EXCHANGE SCATTERING AND ONE-PION EXCHANGE. Byers, Nina (Univ. of California, Los Angeles). Phys. Rev., 156: 1703-7 (Apr. 25, 1967).

It is shown that the "droplet" model with long-range π exchange included can account for the observed np charge-exchange differential cross sections in the GeV region for $0 < -t < 0.5$ (GeV/c)². The very steep rise in $d\sigma/dt$ for $-t < 0.02$ (GeV/c)² is due to long-range π exchange and is similar to the steep rise near $t = 0$ in elastic scattering of charged particles due to the Coulomb interaction. From the droplet-model viewpoint, π exchange can be identified only in large-impact-parameter collisions. For smaller-impact-parameter collisions, the model differs from the absorptive OPE model; however, the resulting amplitudes also have the one-pion pole at $t = \mu^2$. The reaction $np \rightarrow pn$ in the GeV region is re-

markable in that it may be the only reaction in which the effect of long-range π exchange can be easily seen. In elastic scattering, long-range π^0 exchange scattering is small compared to diffraction scattering, and is masked by Coulomb effects. It might be observed in high-precision measurements of np elastic scattering. In $\bar{p}p \rightarrow \bar{n}n$, the effect of long-range π^- exchange is likely to be more accessible to experimental observation. The anomaly near $t = 0$ due to π exchange may tend to vanish at high energies, due to the rapid decrease of the π -exchange amplitude with increasing energy. Fits to the data in the region $0.1 < -t < 0.5$ (GeV/c)² indicate strong spin dependence in np and $\bar{p}p$ charge exchange. (auth)

29541 REGGE POLES IN HIGH-ENERGY SCATTERING. Phillips, R. J. N. (Atomic Energy Research Establishment, Harwell, Eng.). pp 268-314 of Strong and Weak Interactions. Present Problems. Zichichi, A. (ed.). New York, Academic Press, 1966.

Regge phenomenology is considered. The Regge poles are postulated, and their predictions are examined and compared with experiment. Moving poles, the Sommerfeld-Watson transformation, signature, high-energy kinematics, t-channel poles, πN scattering, characteristic Regge properties, and properties of other models are discussed. Also discussed are non-Regge effects, the one-pole cases of $\pi^- + p \rightarrow \pi^0 + n$, and $\pi^- + p \rightarrow \eta^0 + n$, the two-pole case for KN and $\bar{K}N$ charge exchange, SU(3) for π , η , K, and $\bar{K}$, and other interactions with boson Regge poles. (J.F.P.)

29558 STRUCTURE OF THE HIGH ENERGY CURRENTS. Frahm, C. P.; Ne'eman, Y.; Yellin, Joel (Tel-Aviv Univ., Israel). pp 2-14 of Symmetry Principles at High Energy. Perlmutter, Arnold; Kursunoglu, Behram (eds.). San Francisco, W. H. Freeman and Co., 1967.

The algebra of vertex strengths in factorized Regge residues is applied to high-energy meson-baryon elastic forward scattering and to nucleon-nucleon elastic cross sections. The structure of the high-energy currents, which satisfy the commutation relation of $[U(3) \times U(3)]_B$ and the coupling of the 2^+ mesons to $(1,1) \Theta_{\mu\nu}$ are investigated. (L.B.S.)

29562 (JINR-P1-3268) DISKRIMINATSIYA STATISTICHESKIKH GIPOTEZ PRI BLIZKIKH ZNACHENIYAKH χ^2 . (Discrimination of Statistical Hypotheses of the Values of χ^2 of the Same Order). Kazarinov, Yu. M.; Kiselev, V. S.; Rozanova, A. M.; Silin, I. N. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1967. 19p. (In Russian). Dep.

A method was suggested for evaluating the probability of a first type error if one rejects the hypothesis of a larger value of χ^2 with the χ^2 difference of two hypotheses $\Delta\chi^2 \geq 10$ with a larger number of freedom degrees when the probabilities of hypotheses on the χ^2 -criterion are of the same order. The problem is solved in two stages. First, in formulating the problem according to Neumann-Pirson the probability of the first type error is estimated for the case of fixed hypotheses (without the fitted parameters). Further, this result is used to obtain the majorized estimate of the probability of the first type error in the case of linear dependence of the hypotheses on the fitted parameters for which the ignorance of the exact hypothesis turns out to be unessential. The result can be used in the case of quasi-linear hypotheses as well. It was shown that for fixed hypotheses the probability P of the first type error does not exceed half of the probability of the fact

that χ^2 with one freedom degree will not exceed the difference χ^2 of the hypotheses. In the case of hypotheses with linear dependence on the fitted parameters for P the estimate was obtained which takes into account the probability of additional fluctuation for the χ^2 minima difference due to the unknown parameters determined by the mathematical structure of the hypotheses. P can be evaluated analytically either by the Monte Carlo method or by the method presented. The evaluation of P was used to discriminate between solutions in the phase-shift analysis of nucleon-nucleon scattering at 630 MeV. In this case two of the three solutions obtained earlier were rejected with a $P \leq 0.1\%$ probability. The difference χ^2 of these solutions with χ^2 for the best of the solutions turned out to be 13.56 and 19.10 for the number of freedom degrees as large as 207. (auth)

29563 (UCRL-17571) BOUNDS FOR THE CORRECTION TO THE BORN TERM AND APPLICATIONS TO p-p SCATTERING FOR A GENERALIZED DISPERSION MODEL. Binstock, Judith (California Univ., Berkeley, Lawrence Radiation Lab.). May 3, 1967. Contract W-7405-eng-48. 41p. Dep. CFSTI.

Thesis.
A generalized dispersion model for the unitarizing correction to the Born term is given. (Only equal-mass, elastic scattering is considered.) The upper and lower bounds on this correction are explicitly given, in terms of the experimentally available direct-channel phase shifts. This model is shown to include as special cases the Chew-Arndt, MacGregor-Arndt (J_0 even), Scotti-Wong, and Kantor models. The main features of the model are analyticity (except for cuts from unitarity and crossing), specifications both of the number of fluctuations of the left-hand-discontinuity (LHD) of the correction term and of the asymptotic behavior of the correction term, and unitarity of the full partial-wave amplitude. A similar exploitation of the analyticity and unitarity of the full partial-wave amplitude is shown to yield a consistency condition relating the number of fluctuations of the LHD of the full partial-wave amplitude to the direct-channel phase shifts. The consistency condition is shown to have power as well as rigor, in that its application to p-p scattering data yields new information. (auth)

29619 O(4) SYMMETRY AND REGGE-POLE THEORY. Freedman, Daniel Z.; Wang, Jiunn-Ming (Univ. of California, Berkeley). Phys. Rev. Lett., 18: 863-7 (May 15, 1967).

A more general and elegant explanation of families of Regge trajectories is studied. According to this explanation, the existence of Regge families follows because, as a general consequence of Lorentz invariance, scattering amplitudes at zero values of the Mandelstam invariants have a special invariance property. The little group of the Poincaré group is considered for the process in which momenta $p_1 + p_2 \rightarrow p'_1 + p'_2$. It is shown that a much simpler formation of the symmetry can be given in terms of the compact group O(4), which is identified as the little group in the unphysical region $t = 0$, $0 \leq s \leq 4m^2$. The general formulation of the O(4) symmetry in the presence of spin and its specific application to NN scattering are outlined. (J.F.P.)

29875 BREMSSTRAHLUNG PRODUCTION IN p-p COLLISIONS AT 30 MeV. Thompson, J. C. (Univ. of Manitoba, Winnipeg); Naqvi, S. I. H.; Warner, R. E. Phys. Rev., 156: 1156-8 (Apr. 20, 1967).

The proton-proton bremsstrahlung production cross section was

v.21 (1967)

measured at 30-MeV incident proton energy and at 35° in the Harvard geometry. Using the same assumptions about the dependence of the cross section on noncoplanarity as were made in previous work at low energies, a value of $1.85 \mu\text{b}/\text{sr}^2$ is obtained, with a statistical error of $0.25 \mu\text{b}/\text{sr}^2$ and a total error estimated to place an upper limit of about $4 \mu\text{b}/\text{sr}^2$ on the cross section. This upper limit disagrees with Signell and Marker's prediction of about $15 \mu\text{b}/\text{sr}^2$. (auth)

29969 (UCRL-17299) NUCLEAR CHEMISTRY DIVISION ANNUAL REPORT, 1966. Cunningham, B. B.; Reynolds, F. L.; Stephens, F. S. (eds.) (California Univ., Berkeley. Lawrence Radiation Lab.). Jan. 1967. Contract W-7405-eng-48. 419p. Dep. CFSTI.

30046 NOTE ON THE OFF-SHELL SCATTERING AMPLITUDES. Tanaka, Hiromi (Saga Univ., Japan). Progr. Theoret. Phys. (Kyoto), 37: 469-70 (Feb. 1967).

The accuracy of off-shell amplitudes for nucleon-nucleus scattering obtained for incident energies below about 100 MeV assuming a spin-dependent Gaussian potential with the Serber exchange character for the two-nucleon interaction is studied. An investigation is made of how the accuracy of this procedure is influenced by the existence of the hard core in the two-nucleon interaction. It is concluded that while the change of the magnitudes of the off-shell amplitudes by taking account of the hard core is appreciable especially in their imaginary part, it does not cause such a serious effect as to make the use of this procedure invalid for small scattering angles. (J.F.P.)

31609 DOUBLE-SCATTERING CONTRIBUTIONS TO THE PROTON-PROTON DIFFERENTIAL CROSS SECTION IN THE QUARK MODEL. Harrington, David R.; Pagnamenta, Antonio (Rutgers-The State Univ., New Brunswick, N. J.). Phys. Rev. Lett., 18: 1147-50 (June 19, 1967).

It is pointed out that the double scattering effects in the quark model shown previously by Franco provides a natural explanation for the sharp break in the high-energy proton-proton differential cross section at a momentum transfer square of about $0.6 \text{ GeV}^2/c^2$. An attempt is made to make semiquantitative estimates of the double scattering contribution to the proton-proton differential cross section assuming a quark-model description of the protons. The elastic scattering of two high-energy protons in the cms system is considered. It is assumed that each proton is composed of three quarks and may be described by a nonrelativistic completely antisymmetric spatial wave function. (J.F.P.)

31630 PREDICTIONS OF THE TWELVE-DIMENSIONAL GROUPS AND NUCLEON-NUCLEON SCATTERING. Arndt, R. A.; Moravosik, M. J.; Wright, R. M. (Univ. of California, Livermore). Nuovo Cim. (10), 49A: 806-13 (June 21, 1967). (UCRL-70054).

Predictions of the various twelve-dimensional groups such as SU_{12} , M_{12} , $\bar{U}_{12}$, and of the hybrid coplanar subgroup $U_3 \times U_3$ for the vanishing of one of the invariant amplitudes of nucleon-nucleon scattering are compared directly with the values of that invariant amplitude at a large range of energies and angles, as obtained from

the energy-dependent modified analysis of nucleon-nucleon scattering data. There is a complete disagreement between the prediction of group theory and the experimental values. (auth)

31642 DISPERSION MODEL OF SCATTERING AT SMALL PULSE TRANSMISSION AND HIGH ENERGIES. Azimov, S. A.; Arushanov, G. G.; Rasulkulov, M. S.; Khalmuradov, R. S. (Inst. of Nuclear Physics, Tashkent). Izv. Akad. Nauk Uz. SSR, Ser. Fiz.-Mat. Nauk, No. 2, 68-9 (1967). (In Russian).

A dispersion model of elastic scattering at low-momentum transfer and high energy using the scattering amplitude $F(s,t)$ was studied. The experimental data showed that $t_0 \approx 0.2 (\text{GeV}/c)^2$ in the case of pp scattering and $t_0 \approx 0.3 (\text{GeV}/c)^2$ in the case of $\bar{p}p$ scattering. It is shown that the suggested dispersion mode is more real than that of the P. T. Matthews et al. (Nuovo Cim. 21, 1963, 823). (R.V.J.)

33401 PROTON-PROTON BREMSSTRAHLUNG AT 204 MeV WITH A POLARIZED BEAM. Rothe, K. W.; Koehler, P. F. M.; Thorndike, E. H. (Univ. of Rochester, N. Y.). Phys. Rev., 157: 1247-58 (May 25, 1967).

A proton-proton bremsstrahlung experiment was completed using 204-MeV, 90% polarized protons incident on a liquid-hydrogen target. The gamma ray was detected in a threshold counter. The two protons were observed in a spark-chamber array giving energy and direction information. Cross sections and gamma ray and proton asymmetries due to the polarized beam were measured. The cross sections obtained agree with the theoretical calculations of Sobel and Cromer, and Duck and Pearce. Ueda's calculation is high by a factor near 2, but properly describes the shape of $(d^2\sigma/d\Omega dE_\gamma)$ versus E_γ . Proton asymmetries agree in sign and magnitude with the elastic 210-MeV values. Gamma-ray asymmetries are of the same sign and magnitude as those obtained in our measurements of $p + a \rightarrow d + \gamma$ which agree with photodisintegration calculations. An upper limit of 35 nb was placed on the production of $p + p \rightarrow p + p^* (\bar{p}^* \rightarrow p + \gamma)$ decaying to a gamma and a proton for lifetimes $10^{-22} \leq \tau \leq 10^{-16} \text{ sec}$. (auth)

33605 THE POLARIZATION PARAMETER IN ELASTIC PROTON-PROTON SCATTERING FROM 0.75 TO 2.84 GeV. Neal, Homer Alfred Jr. Ann Arbor, Univ. of Michigan, 1966. 118p.

Thesis.

A double-scattering technique was employed to measure the polarization parameter in elastic proton-proton scattering at .75, 1.03, 1.32, 1.63, 2.24 and 2.84 GeV. An external proton beam from the Cosmotron was focussed on a three-inch-long liquid hydrogen target, and the elastic recoil and scattered protons were detected in coincidence by scintillation counters. The polarization produced in the scattering process was inferred from the azimuthal asymmetry exhibited in the scattering of the recoil beam from a carbon target. This asymmetry was measured by a set of two scintillation counter telescopes which symmetrically viewed the carbon target. The corrected values of the polarization parameter are exhibited as a function of the center-of-mass scattering angle for each incident beam energy. The prediction of the Regge theory that the polarization parameter in elastic proton-proton scattering is related to the total p-p and p- $\bar{p}$ cross sections was found to be consistent with the experimental results. (TSS) (Diss. Abstr.)

33682 INTERACTION MECHANISMS OF TWO BODIES AT HIGH ENERGY. Sonderegger, P. (CEN, Saclay, France). J. Phys. (Paris), Colloq., 27: C4.11-22(Nov.-Dec. 1966). (In French).

The distinction is made between diffraction scattering, which includes a class of inelastic reactions, and exchange scattering. The exchange processes are in good agreement with the Regge-pole model, while the connection between this model and the diffraction mechanism is still obscure. The quark model is quoted as a promising outlook. (auth)

33703 THE POSSIBILITY OF CHECKING THE $\Delta T = 1/2$ RULE IN REACTIONS OF SINGLE PRODUCTION OF STRANGE PARTICLES. Delavin, A. A.; Kobzarev, I. Yu. JETP Lett. (USSR) (Engl. Transl.), 5: 226-8(Apr. 15, 1967).

Translated from Zh. Eksp. Teoret. Fiz., Pis'ma Redakt., 5: 277-9(Apr. 15, 1967).

Attention is called to the fact that interactions with single production of strange particles and formation of the isobar Δ (1246) and (or) isoscalar mesons may turn out to be more convenient for checking the $\Delta T = 1/2$ rule than previously proposed interactions. Relations, resulting from the $\Delta T = 1/2$ rule, between the cross sections for the proposed interactions are presented. (J.F.P.)

33706 FORM FACTORS AND THE ABSORPTIVE ONE-PION-EXCHANGE MODEL. Yock, P. C. M.; Gordon, David (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Phys. Rev., 157: 1362-71(May 25, 1967). (MIT-2098-258).

The one-pion-exchange model, corrected for absorption in the initial and final states, is examined for those two-body reactions involving the production of high-spin particles. It is found that the inclusion of form factors brings the theory into agreement with experiment. By consideration of a number of reactions, explicit expressions for the $N\pi N^*(1238)$ and $\pi\pi\pi$ vertex function form factors are obtained. It is shown that these form factors do not require the existence of any as yet undiscovered mesons. Implications of these form factors in two-pion-exchange calculations are also discussed. (auth)

33718 EXCITED-DROPLET MODEL FOR $pp \rightarrow pN^*$ AT HIGH ENERGIES. Arnold, Richard C. (Argonne National Lab., Ill.). Phys. Rev., 157: 1292-5(May 25, 1967).

A surface-excitation droplet model for N^* production in pp collisions at high energy and small momentum transfer is proposed which explains the Δ^2 dependence of the first two observed $I = 1/2$ isobars. (auth)

33720 NUCLEON-NUCLEON ELASTIC SCATTERING AMPLITUDES. Golovin, B. M.; Rozanova, A. M. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 5: 1283-5(June 1967). (In Russian).

The coefficients of the pp elastic scattering, pp scattering without Coulomb interaction and np scattering amplitudes are calculated on the basis of the phase-shift analysis of the elastic pp and np scattering data at the energies 23, 40, 52, 68, 95, 147, 210, 310, 400 and 630 MeV. Some features are indicated concerning the pp

scattering amplitude with and without Coulomb interaction. Data concerning the spin independent terms in the pp scattering without Coulomb interaction and np scattering amplitudes are compared with the theoretical predictions based on dispersion relations. (auth)

33721 RELATIVISTIC NUCLEON-NUCLEON INTERACTIONS. Green, A. E. S.; Sawada, T. (Univ. of Florida, Gainesville). Nucl. Phys., B2: 267-81(1967).

One-boson-exchange interactions are derived for pseudoscalar (P), vector (V), scalar (S), axial vector (A) and anti-symmetric tensor (T) mesons. The Schrödinger-Pauli limit is obtained for a general combination of such Diracian OBE interactions. Besides the static terms, the reduced interactions contain relativistic central, spin-spin, tensor, spin-orbit and velocity-dependent terms as well as velocity-dependent, tensor operators. The relativistic interactions V_p and $V_v + V_s$ are pursued in detail. Singularity difficulties are dealt with by using "regularized" fields. The phase shifts for $N-N$ scattering are calculated for a purely relativistic model with two adjustable constants and a "broken" model with eight. The fits to the experimental phase shifts are presented. (auth)

33745 SCATTERING AND INFINITE DIMENSIONAL SYMMETRY SCHEMES. Stern, J. (Czech Technical Univ., Prague). Czech. J. Phys., 17: 391-9(1967).

The recently proposed non-trivial binding of the Poincaré group with internal symmetry groups, which leads to mass splitting without symmetry breaking, from the point of view of scattering. A very general realization is given of the corresponding infinite dimensional Lie algebra in the Fock space of asymptotic states built from two scalar nucleons. Assuming that the algebra describes the exact symmetry of the S -matrix it is concluded that no elastic NN scattering exists. (auth)

33806 (RHEL/R-129, pp 11-44) HIGH ENERGY PHYSICS DIVISION. (Rutherford High Energy Lab., Chilton (England)).

Various elementary particle interaction experiments performed at NIMROD are described, and the operation and instrumentation for NIMROD are discussed. The development of wire spark chambers is also mentioned. (J.F.P.)

33807 (RHEL/R-129, pp 45-77) NIMROD DIVISION. (Rutherford High Energy Lab., Chilton (England)).

The discussion of the NIMROD accelerator includes its operation and development, the accelerated beam utilization, beam transport components, and the development of polarized proton targets. The experimental beam lines are also discussed. (J.F.P.)

33808 (RHEL/R-129, pp 97-106) PROTON LINEAR ACCELERATOR DIVISION. (Rutherford High Energy Lab., Chilton (England)).

Experiments performed using the proton linear accelerator are briefly described. These studies cover proton reactions with light and heavier nuclei. The operation and development of the proton linear accelerator are also discussed. (J.F.P.)

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33872 (ORNL-4122) ELECTRONUCLEAR DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING DECEMBER 31, 1966. (Oak Ridge National Lab., Tenn.). May 1967. Contract W-7405-eng-26. 136p. Dep. CFSTI.

Progress was made on many experiments, notably on proton-proton bremsstrahlung, on proton-proton interactions at very low energies, on shell-model structure studies through pickup of nucleons and through charge exchange, and on characterization of the optical model by the interaction of protons with complex nuclei. Work at high resolution was accomplished using the Elbek spectrometer. Theoretical work continued in close association. In the field of accelerator development, the experimental prototype 4-MeV Separated-Orbit Cyclotron was advanced in design, and earlier prototypes for the 50-MeV SOC were completed and tested. A new polarized source for the ORIC is under construction. (auth)

35258 (AD-650156) POLARIZATION PARAMETER IN ELASTIC PROTON-PROTON SCATTERING FROM 0.75 TO 2.84 GeV. Neal, Homer A.; Longo, Michael J. (Michigan Univ., Ann Arbor, Dept. of Physics). Mar. 1967. Contract Nonr-1224(23). 52p. (TR-27-03106-27-T; ORA-03106). CFSTI.

The polarization parameter in elastic proton-proton scattering was measured at 0.75, 1.03, 1.32, 1.63, 2.24, and 2.84 GeV by employing a double-scattering technique. An external proton beam was focused on a three-inch long liquid hydrogen target and the elastic recoil and scattered protons were detected in coincidence by scintillation counters. The polarization of the recoil beam was determined from the azimuthal asymmetry exhibited in its scattering from a carbon target. Values of the polarization parameter as a function of the center-of-mass scattering angle are given for each incident beam energy. The predictions of the Regge theory for polarization in elastic proton-proton scattering and recently published phase shift solutions are compared with the experimental results. Surprisingly good agreement with the Regge predictions is found despite the low energies involved. (auth) (TAB)

35295 (AD-651038) A REGGE-QUARK MODEL OF HADRON SCATTERING. James, P. B.; Logan, R. K. (Illinois Univ., Urbana, Dept. of Physics). 1967. Contract N00014-66-C-00010-A05. 10p. CFSTI.

One of the unique features of the quark model is that one obtains relations between baryon-baryon cross sections and meson-baryon cross sections. A Regge quark model analysis was recently performed in which agreement between these relations and experiment was obtained only after a scale factor was introduced (N. Ahmadzadeh, Phys. Letters v22 p96 1966) in the N-N amplitude. It is now shown how this agreement may be obtained without introducing such a factor. (auth) (TAB)

35298 DISPERSION ANALYSIS OF ELASTIC SCATTERING OF HIGH-ENERGY PARTICLES. Barashnikov, V. S. (Joint Inst. for Nuclear Research, Dubna, USSR). Fortsch. Phys., 14: 741-69(1966).

The discussion of the dispersion analysis of high energy elastic scattering includes the zero-angle elastic scattering amplitude, the behavior of the cross sections in the high energy region, elastic $\pi^- + p$ scattering with charge exchange at zero angle, and the real part of the elastic $\pi^+ + p$ scattering amplitude. The scattering of protons and antiprotons on protons is also considered. (J.F.P.)

35305 IS THERE A PION CONSPIRACY? Phillips, R. J. N. (Atomic Energy Research Establishment, Harwell, Eng.). Nucl. Phys., B2: 394-407(1967).

A possible conspiracy, between the pion Regge pole and an opposite-parity pole, is considered. It would help to reconcile theory with experiment, for high-energy NN and NN charge exchange, where there are severe difficulties otherwise. The conspirator pole is arranged to give no light 0^+ meson, but may give a heavy 2^+ meson. (auth)

35314 (COO-1112-104) DIFFRACTION MODEL FOR STRONG INTERACTIONS AND THE SHRINKAGE OF THE DIFFRACTION PEAK. Kriech, A. D. (Michigan Univ., Ann Arbor. Harrison M. Randall Lab. of Physics). [1966]. Contract AT(11-1)-1112. 17p. Dep. CFSTI.

The diffraction model for strong interactions at high energies is considered. A model with a spherically symmetric interaction probability density which is squashed down in the direction of the motion by the Lorentz contraction is assumed. This model leads to the prediction that the differential elastic scattering cross section $d\sigma/dt$ should depend only on $\beta^2 P_t$. When the $p + p$ and $\pi + p$ elastic data are plotted against this variable, the energy dependence is removed. Thus this model seems to offer a kinematic explanation for the well-known shrinkage of the diffraction peak. (J.F.P.)

35315 (JINR-E1-3420) EFFECT OF TENSOR MESON EXCHANGE ON N-N SCATTERING. Azhgirei, L. S.; Chizhikov, V. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Computing Techniques and Automation). 1967. 7p. Dep.

The coupling constants of the scalar (σ), pseudoscalar (π), vector (ω and ρ) and tensor (f) mesons are determined by the least squares method from the elastic nucleon-nucleon scattering phase shifts. It is shown that the account of the tensor meson in terms of one-boson-exchange model leads to a better description of the experimental $^3P_{0,1,2}$ and 3D_1 phase shifts of N-N scattering in the energy region of 25-330 MeV. (auth)

35316 (JINR-E2-3345) SIMULTANEOUS PHASE SHIFT ANALYSIS OF 210 MeV NUCLEON-NUCLEON SCATTERING. Yanout, Z.; Kazarinov, Yu. M.; Legar, F.; Winternitz, P. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 34p. Dep.

A phase-shift analysis at 210 MeV was performed with $l_{\max} = 5$. New data on the differential cross section, polarization and triple scattering parameters were used. A single solution was obtained as a result of it. The angular dependence of experimental values are shown in diagrams. Relativistic formulas for recoil particle triple scattering parameters are given. (auth)

35317 HARD CORE AND ABSORPTION IN A TWO-CHANNEL MODEL FOR PROTON-PROTON COLLISION. Hida, Gyo; Sawada, Shoji; Yano, Tadashi; Yonezawa, Minoru (Hiroshima Univ. Univ. of Nagoya, Japan). Progr. Theor. Phys. (Kyoto), 37: 692-701(Apr. 1967).

The effect of hard core on absorption in proton-proton collision up to a few GeV is examined by a spinless two channel model with

$p + p \rightarrow p + p$ and $p + p \rightarrow p + N^*$. It is shown that the strong s-wave absorption can be obtained for the energy near the inelastic threshold even in the presence of hard core. The importance of the non-local real potential due to the competing inelastic processes is emphasized on the problem of hard core. (auth)

35318 BARYON-BARYON REACTIONS AND SU3 SYMMETRY. De Souza, Patrick David. University Park, Md., Univ. of Maryland, 1966. 90p.

Thesis.

SU(3) symmetry has been used in order to obtain relations between the cross-sections for baryon-baryon reactions in the $^1S^0$ and $^3S^1$ states. The modifications of these relations for higher angular momentum states are derived and it is shown that the possible existence of strong coupling of the $^3D^1$ state to the $^3S^1$ state does not invalidate the above derived relations. In order to investigate the effect of mass splitting on these results a potential model calculation is carried out in order to verify the predicted equality of $^3S^0$ n-p and Σ^+-p cross-sections. The calculation indicates that this relationship is indeed satisfied and that further Σ^+-n system has a possible bound singlet state with a binding energy ≤ 1 MeV. The multichannel Σ^+-p reactions are investigated with an SU(3) invariant K-matrix using the Λ -p parameters of Burnstein and Alexander. A calculation of Σ^+-p cross sections is carried out for center of mass energies < 10 MeV. The results of this calculation are not in agreement with experiment. (Dissert. Abstr.)

35351 THE UNITARITY CONDITION OF THE S-MATRIX FOR HIGH ENERGY ELASTIC SCATTERING. Kobayashi, Kozo (Saitama Univ., Urawa, Japan). Progr. Theor. Phys. (Kyoto), 37: 904-15(May 1967).

The inelasticity of the intermediate states in the unitarity condition of the S-matrix is investigated for high energy elastic scattering of strongly interacting particles. The inelastic process is treated as the multiple production of mesons, for which we have assumed statistical independence. The energy-momentum conservation law in the intermediate states is derived in terms of the meson momentum distribution, and it is shown that the effective intermediate states are in general varied with the elastic scattering angles. The property of the intermediate states is discussed with existing experimental data on the multiple meson production. In high energy accelerator researches and analyses of cosmic ray jet, it has been revealed that the momentum distribution of the secondaries is sharply peaked in the longitudinal direction and the average transverse momentum is constant independent of the incident energies. From these experimental results, it is shown that the inelasticity of the intermediate states responsible for large angle elastic scattering is quite small compared with that for small angle elastic scattering. (auth)

35410 POTENTIAL MODEL CALCULATION OF PROTON-PROTON BREMSSTRAHLUNG. Sobel, M. I. (City Univ. of New York, Brooklyn); Cromer, A. H. Phys. Rev., 158: 1157-60 (June 20, 1967).

The cross section $da/d\Omega d\Omega_1 d\Omega_2$ for proton-proton bremsstrahlung is calculated for various energies and geometries, using the Yale potential and the Hamada-Johnston potential. The results are compared with the experimental data at 200, 158, and 48 MeV. Good agreement is obtained with the 158-MeV data, though the calculated cross sections are somewhat too large in the forward direction (of the scattered photon) and somewhat too small in the

backward direction. The integrated cross section $da/d\Omega d\Omega_1$ is in fair agreement with the data at 200 MeV, but at 48 MeV the experimental cross section is three to four times smaller than the calculated values. This could be because of the acceptance of non-coplanar events in the experiment. (auth)

37653 (UCLA-34P106-1) ANNUAL PROGRESS REPORT (ON PARTICLE PHYSICS), MAY 10, 1966-MAY 24, 1967. (California Univ., Los Angeles. Dept. of Physics). Contract AT(11-1)-34. 17p. Dep. CFSTI.

Work performed by the UCLA particle physics group from May 10, 1966 to the present is reported. The major effort during the preceding year has been spent on three separate experiments. At the time of the 1966 report the $K^0(\mu^3)$ polarization experiment was in a background study stage. This experiment was completed during the summer. The second effort was a second data run on the γ experiment to supplement information obtained in the preceding year. Data taking was terminated in the fall, followed by extensive work to measure the absolute efficiency of our neutron counters in the neutron beam at the LRL 184" cyclotron and to measure the absolute efficiency of the γ -ray counters using the γ -ray monochromator at Cal Tech's synchrotron. Thirdly, a new experiment has been prepared and data taking will begin about June 15. The experiment is a study of the differential cross section of the reaction $n + p \rightarrow \gamma + d$. This reaction, in conjunction with its inverse reaction, constitutes a direct test of time reversal invariance in photo-meson reactions. A collaboration including the University of Michigan and the Moyer group at LRL was formed to carry out this project. Work on the analysis of data taken in preceding years has been continued. This includes work on K^0 decay experiment, $2\pi\gamma$ experiment, and K^0 decay experiments. Investigation of proton polarization in frozen toluene and other hydrocarbons has been continued. And finally, the design of an experiment to measure the electromagnetic form factor of the ρ meson has been pursued. These experiments are discussed in detail. Chapter III is devoted to equipment constructed in the past year. Chapter IV contains a bibliography of published work and reports. (auth)

37680 EXPERIMENTAL INVESTIGATIONS OF THE NUCLEON-NUCLEON INTERACTION AT 600 TO 650 MeV. Kazaninov, Yu. M. (Joint Inst. for Nuclear Research, Dubna, USSR). Rev. Mod. Phys., 39: 509-12(July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

The upper boundary of the unambiguous phase-shift analysis as is known, is at 310 MeV. Above the meson production threshold this unambiguity is absent. In the range from 600-650 MeV where physicists have worked during recent years the scattering amplitude was determined ambiguously and not very reliably. In this connection all the experiments for studying nucleon-nucleon scattering being carried out have two purposes: first, the more accurate determination and improvement of the phase-shift analysis and second, the discrimination of the obtained phase-shift sets for the determination of the most probable set of them. A short survey of some of experiments performed with the above purpose at Dubna in recent years is presented. (auth)

37681 EXPERIMENTAL ASPECTS OF NUCLEON-NUCLEON SCATTERING NEAR 210 MeV: A CRITICAL REVIEW. Thorne-dike, Edward H. (Univ. of Rochester, N. Y.). Contract AT(30-

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1)-875. Rev. Mod. Phys., 39: 513-22(July 1967). (UR-875-194).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

Data bearing on the nucleon-nucleon interaction near 210 MeV are reviewed. Proton-proton elastic scattering, neutron-proton elastic scattering (both free and from neutrons bound in deuterium), nucleon-nucleon bremsstrahlung, and tests of invariance principles are discussed. Three-nucleon experiments are mentioned briefly. Some revisions to published N-N scattering data are suggested, and complete tables of data are given. (auth)

37682 A SURVEY OF EXPERIMENTAL RESULTS ON NUCLEON-NUCLEON SCATTERING WORK DONE BY THE ORSAY GROUP. Michalowicz, A. (Institut de Physique Nucléaire, Orsay, France). Rev. Mod. Phys., 39: 523-5(July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

This report presents experimental results obtained by the Orsay group in France. Firstly, experiments of differential cross section polarization and depolarization in pp scattering at 150 MeV are given. Secondly, polarization and correlation measurements in pp scattering at 600 MeV are given. (auth)

37683 NUCLEON-NUCLEON SCATTERING EXPERIMENTS AT INTERMEDIATE ENERGIES IN BERKELEY. Cheng, David (Univ. of California, Berkeley). Rev. Mod. Phys., 39: 526-30 (July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

Recent experiments at Berkeley on nucleon-nucleon systems at intermediate energies are discussed. Comparison of experimental results for measurements of parameters using polarized targets agree well with results of experiments not using polarized targets. The advantages and disadvantages of these different methods are discussed briefly. (auth)

37684 POLARIZATION AND C_{NN} MEASUREMENTS BETWEEN 0.6 AND 1.2 GeV. Ducros, Y. (Department de Physique des Particules Elementaires, Saclay, France). Rev. Mod. Phys., 39: 531-3 (July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

The polarization parameter P was measured at Saclay, at 7 energies, and the C_{NN} parameter at 3 energies. A polarized target and the extracted beam of the synchrotron "Saturne" were used. The beam momentum was known at $\pm 1\%$. The beam intensity was limited at 10^7 protons in 400 sec. (auth)

37685 SPIN-CORRELATION PARAMETERS IN p-p SCATTERING. Catillon, P. (SPNME, CEN, Saclay, France). Rev. Mod. Phys., 39: 534-5(July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

Experiments which were done to measure spin-correlation parameters in nucleon-nucleon scattering are summarized, and results compared with phase-shift models. (auth)

37686 MEASUREMENTS OF C_{NN} IN PROTON-PROTON SCATTERING. Beretvas, A. (Univ. of Chicago); Booth, N. E.; Dolnick, C.; Esterling, R. J.; Hill, R. E.; Scheid, J.; Sherden, D.; Yokosawa, A. Rev. Mod. Phys., 39: 536-7(July 1967).

The spin-spin correlation parameter C_{NN} for p-p scattering was measured at 5 energies between 305 and 415 MeV. Measurements were made over the angular range of 50 to 90° in the cm system. A polarized beam, produced by scattering of the internal proton beam of the Chicago cyclotron, and the Argonne polarized proton target were used for the experiment. Results obtained for $C_{NN}(90^\circ)$ are: 0.52 ± 0.08 at 305 MeV, 0.48 ± 0.08 at 330 MeV, 0.50 ± 0.05 at 358 MeV, 0.46 ± 0.06 at 386 MeV, and 0.42 ± 0.04 at 415 MeV. Comparisons with other experimental results and with theoretical and phenomenological models will be made. (auth)

37687 PRESENT AND FUTURE WORK WITH THE HARWELL SYNCHROCYCLOTRON. Whitehead, C. (Atomic Energy Research Establishment, Harwell, Eng.). Rev. Mod. Phys., 39: 538-41(July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

A brief description of present work at Harwell is given. The final results of the C_{NN} measurements at 73.5, 98, and 142 MeV are given and the status of the precision measurements at 100 MeV is presented. The results of the measurement of the forward cross section for the reaction $d(p,n)2p$ at 95.7 and 143.9 MeV are given and mention is made of recent p, n reaction results. Finally a description is given of the recent 50-MeV p, p differential cross section measurement made at the proton linear accelerator. (auth)

37688 LOW-ENERGY NEUTRON-PROTON POLARIZATION EXPERIMENTS. Simmons, J. E. (Los Alamos Scientific Lab., N. Mex.). Rev. Mod. Phys., 39: 542-5(July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

The status of N-P scattering and polarization experiments near 25 MeV is reviewed. Recent data on polarization and spin correlation observables are discussed in relation to phase-shift analyses, with some emphasis on the role of the S-D coupling parameter. (auth)

37690 RECENT p-p MEASUREMENTS AT INS, TOKYO, AND p-p PHASE SHIFTS AT 50 MeV: PRELIMINARY RESULTS. Hoshizaki, Norio (Kyoto Univ.). Rev. Mod. Phys., 39: 548-9 (July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

The p-p differential cross section was remeasured at 52.3 MeV within 1% accuracy by Sanada et al. A phase-shift analysis was made by using these new data and those on C_{NN} , C_{pp} , P , D , R , and A . All of these data were normalized at 50.0 MeV. The solution is 1S_0 39.00 ± 0.35 , 1D_2 1.97 ± 0.15 , 3P_0 12.57 ± 0.52 , 3P_1 -7.86 ± 0.27 , 3P_2 5.98 ± 0.13 , ϵ_1 -1.90 ± 0.19 , 3F_2 0.43 ± 0.18 (in degrees). The solution shows that the parameters ϵ_1 and $\delta(^3F_2)$ are given essentially by the OPE forces. Other features of the solution are similar to those of the previous one. The values of the $\delta(^1S_0)$ and $\delta(^3P_0)$ of the present solution are larger by about three standard deviations than those given from the Hamada-Johnston potential. (auth)

37691 PHASE-SHIFT ANALYSIS AT HARWELL. Perring, J. K. (Atomic Energy Research Establishment, Harwell, Eng.). *Rev. Mod. Phys.*, 39: 550-5 (July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

Results of recent analyses of proton-proton and neutron-proton data in the 140-MeV region and of proton-proton data at 50 MeV are reported. The existing neutron-proton data in the 25-MeV region are examined and suggestions for experiments are made. It is argued that in fact the available data in this region tell one very little about the interaction. (auth)

37693 n-p TRIPLE-SCATTERING PARAMETER D_t AT 197 MeV. Spalding, D.; Thomas, A. R.; Thorndike, E. H. (Univ. of Rochester, N. Y.). *Phys. Rev.*, 158: 1338-42 (June 25, 1967). (UR-875-185).

The n-p triple-scattering parameter D_t was measured at 197 MeV at three angles. The measurements were made by bombarding a liquid-deuterium target with polarized protons, and spin-analyzing high-energy neutrons recoiling into forward angles. Spin analysis was accomplished by a charge-exchange scattering on CH_2 . The measurements are related to the D_t parameter for free n-p scattering through an impulse-approximation calculation which includes the s-wave final-state interaction between the incident proton and the proton in the deuteron. Values obtained for the free np D_t parameter are: $+0.095 \pm 0.068$, -0.014 ± 0.071 , and $+0.058 \pm 0.103$ at free n-p center-of-mass scattering angles of 147.4° , 138.6° , and 126.9° , respectively. These values are compared with the phase-shift solutions YLAN of Breit and collaborators, and the energy-independent solution of Arndt and MacGregor. Solutions YLAN 0, 1, 2, 2M, 3, and the Arndt-MacGregor solution do not agree with the data. Solutions YLAN 3M and 4M fit the data quite well. (auth)

37734 INTERNATIONAL CONFERENCE ON THE NUCLEON-NUCLEON INTERACTION, HELD AT UNIVERSITY OF FLORIDA, GAINESVILLE, MARCH 23-25, 1967. Green, A. E. S.; MacGregor, M. H.; Wilson, R. (eds.). *Rev. Mod. Phys.*, 39: 495-717 (July 1967). (CONF-670302).

The conference includes 35 papers. Separate abstracts were prepared for all papers. (J.F.P.)

For abstracts of individual papers see: 37680-37691, 37794, 37793, 37845-37863, 37892, and 37893.

37794 ANTINUCLEAR FORCES. Phillips, R. J. N. (Atomic Energy Research Establishment, Harwell, Eng.). *Rev. Mod. Phys.*, 39: 681-8 (July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

Theoretical models of the nucleon-antinucleon interaction are surveyed in the few-hundred MeV region. Their relation to the nucleon-nucleon interaction, and any light they may shed on it, are discussed. (auth)

37802 (JINR-P2-3374) О ВОССТАНОВЛЕНИИ АМПЛИТУД МАТРИЦЫ РАССЕЙАНИЯ ВПЕРЕД. (On the Reconstruction

of the Forward Scattering Matrix Amplitude). Lapidus, L. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 12p. (In Russian). Dep.

The comparison with the dispersion relations, sum rules, etc. require the determination of the amplitudes of meson-nucleon, N-N and γ -N forward scattering. The formulas were obtained for this procedure at $\theta = 0^\circ$. The functions $a(0)$ and $b(0)$ contained in the amplitude of meson-nucleon scattering are determined by the measurements of the cross sections as well as the values of $P_0/\sin \theta$, R and A. In order to determine the amplitudes $u(0)$, $v(0)$, and $h(0)$ contained in the N-N-scattering amplitude it is necessary to measure total cross sections and also to analyze particle polarization after scattering. The determination of the spin-orbital amplitude $c(\theta)/\sin \theta$ at $\theta = 0^\circ$ is given. The amplitude of the nucleon Compton-effect is reduced at $\theta = 0^\circ$. An expression was obtained for the cross section of the polarized photon interaction with polarized nucleons. The determination of the imaginary parts of the amplitudes is made. The real parts are determined by measuring the differential cross sections. (auth)

37815 REGGE POLES AND HIGH-ENERGY SINGLE-PARTICLE PRODUCTION. Roberts, R. G. (Univ. of Durham, Eng.); Fraser, G. M. *Phys. Rev.*, 159: 1297-1303 (July 25, 1967).

A formalism is presented for the analysis of the high-energy production process $a + b \rightarrow 1 + 2 + 3$, where the participating particles may have any general spin. Its distinguishing feature is that no assumption is made of a quasi-two-particle intermediate state. The method consists of a consideration of the behavior in the crossed channel $a + \bar{b} \rightarrow \bar{1} + 2$ when the amplitudes are dominated by a finite number of Regge Poles. The general problem of obtaining crossing relations for three-particle amplitudes is discussed, and finally examples are presented of the application of the formulas to the processes $\pi + N \rightarrow 2\pi + N$ and $pp \rightarrow pp\pi^0$. (auth)

37835 PHASE-SHIFT CALCULATIONS FOR REAL AND REALISTIC POTENTIALS. Ali, Shamsher; Islam, Mozaharul (Atomic Energy Centre, Dacca, Pakistan). *J. Natur. Sci. Math.*, 6: 169-75 (Oct. 1966).

A numerical method of calculation of phase shifts was outlined. This method can also be used to calculate the low-energy effective range parameters, namely the scattering length and the effective range. The zero energy parameters calculated for various potentials with this method were compared with the ones calculated for the same potentials but by other independent methods and were found to be quite satisfactory. The accuracy of the method was also verified. (auth)

37841 DETERMINATION OF THE NUCLEON-NUCLEON ELASTIC SCATTERING MATRIX. VI. NEW RESULTS NEAR 50 MeV. Wright, Robert M.; MacGregor, Malcolm H.; Arndt, Richard A. (Univ. of California, Livermore). *Phys. Rev.*, 159: 1322-6 (July 25, 1967). (UCRL-70075(Rev.)).

A previous phase-shift analysis at 50 MeV has been improved by increasing the completeness of the data set. Since no new data have become available at this energy, it was necessary to expand the range of energies. Reasonable values are for the ϵ_1 phase shift and for the pion-nucleon coupling constant g^2 . Certain ways of handling the data result in an ambiguity in the $T = 0$ phase shifts, which were explored in detail. It is concluded that no precise, reliable values for the $T = 0$ phases can as yet be derived from existing data near 50 MeV, although the present solutions must be in the neighborhood of the correct solution. (auth)

37843 CONTRIBUTIONS OF REGGE CUTS TO FORWARD NUCLEON-NUCLEON SCATTERING. Branson, D.; Nussinov, S.; Treiman, S. B.; Weisberger, W. I. (Palmer Physical Lab., Princeton, N. J.). Phys. Lett., 25B: 141-3(Aug. 7, 1967).

Empirical consequences of possible contributions to the asymptotic behavior of forward nucleon-nucleon scattering from cuts in the angular momentum plane are discussed. The model used for investigating the presence of cuts is the iteration of the scattering amplitude via elastic unitarity in the s-channel. (L.B.S.)

37844 MODEL-INDEPENDENT CONTRIBUTION IN PROTON PROTON BREMSSTRAHLUNG. Nyman, E. M. (Stanford Univ., Calif.). Phys. Lett., 25B: 135-8(Aug. 7, 1967).

Part of the invariant amplitude for p-p bremsstrahlung can be shown to be independent of the off-shell behavior of the p-p interaction. The corresponding cross section agrees with the measured values. The model-independent terms are computed in a fully covariant and gauge-independent fashion, employing the best available representation of the elastic p-p scattering amplitude. (auth)

37845 THE N-N INTERACTION, 1967: AN OVERVIEW AND CONFERENCE SUMMARY. Green, Alex E. S. (Univ. of Florida, Gainesville); MacGregor, Malcolm H.; Wilson, Richard. Rev. Mod. Phys., 39: 498-508(July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

A summary is given of our state of knowledge of the nucleon-nucleon interaction as derived from the invited and contributed papers and the informal discussions. It appears that much progress has been made since 1960 and that despite the use of widely divergent formalisms current theoretical models have much of the same physical substance. The informal discussions of the conference, particularly those related to the experimental, phenomenological, and theoretical aspects of the nucleon-nucleon interaction in the elastic scattering region are summarized. (auth)

37846 DETERMINATION OF THE p-p ELASTIC SCATTERING MATRIX. MacGregor, Malcolm H. (Univ. of California, Livermore). Rev. Mod. Phys., 39: 556-9(July 1967). (UCRL-70403; CONF-670302-5).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

A phase-shift analysis of p-p scattering data from 10 to 400 MeV is presented. Phase-shift energy-dependent forms having a plausible analytic structure are used, and matrix techniques are employed for the search procedure. An interaction process was used to arrive at a self-consistent p-p data set. This analysis is being extended to higher energies and to the n-p system. (auth)

37847 PHENOMENOLOGICAL PHASE-PARAMETER FITS TO N-N DATA AT INTERMEDIATE ENERGIES. Breit, G. (Yale Univ., New Haven). Contract AT(30-1)-1807. Rev. Mod. Phys., 39: 560-70(July 1967). (YALE-1807-42).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

New p-p and n-p phase-parameter multiple energy fits (Y-IV)

intended for the energy range from ~8 MeV to ~340 MeV employing 947 measurements for p-p and 1023 for n-p are discussed. Improvements over older work include: more careful joining to low-energy data involving phase searches beginning at 1.397 MeV for p-p and 3.205 MeV for n-p; inclusion of triple scattering and polarization data at 430 MeV; data lumping in smaller groups than previously; increased accuracy of one-pion-exchange (OPE) phases; graded introduction of OPE treatment. Related matters include: effects of Coulomb field corrections and of corrections for the apparent violation of short-range charge independence for the new fits and the older YRB1(K₀)-YLAN4M; effects of varying the difference between the p-p and n-p effective ranges within its uncertainty limits; analyses of mockups of experiments designed to improve knowledge of the difference just mentioned; comparisons of values of the pion-nucleon coupling constant g_0^2 derived from p-p and n-p data in relation to the long-range charge independence of N-N interactions. (auth)

37848 PHASE-SHIFT ANALYSIS OF DATA ON NUCLEON-NUCLEON SCATTERING AT LOW ENERGIES. Kazarinov, Yu. M.; Lehar, F.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna, USSR). Rev. Mod. Phys., 39: 571-3(July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

The use of a polarized proton target (PPT) in experiments below 30 MeV opens new possibilities for investigating deviations from pure S scattering, occurring at these energies. It seems highly probable, that a detailed investigation of P- and D-state nucleon interactions at 10-20 MeV, will make it possible to extend the region, in which the scattering amplitude is determined unambiguously to energies, at which the nucleons interact practically only in the S state, so that the phase-shift analysis is considerably simpler. It is therefore important to perform a phase-shift analysis of the existing experimental data in order to obtain information necessary for the planning of future experiments. This was done at 9.7, 14.5, and 18.2 MeV. (auth)

37849 NEUTRON-NEUTRON INTERACTION. Slaus, Ivo (Ruđer Boskovic Inst., Zagreb). Rev. Mod. Phys., 39: 575-83(July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

The present status of the problem of charge dependence is discussed. The information about the neutron-neutron interaction derived from the two-neutron system, three-nucleon systems, final-state interactions in multiparticle reactions, and peripheral processes is critically evaluated. The experimental data indicate the breakdown of charge independence by about 3-5%. Evidence concerning the violation of charge symmetry is inconclusive, but it seems that most of the data are consistent with the assumption that charge symmetry is satisfied within 0.5-1%. The most suitable studies which might improve the knowledge of the neutron-neutron forces are indicated. (auth)

37850 INTERACTION OF TWO NUCLEONS AT LOW ENERGIES. I = 1. Heller, Leon (Los Alamos Scientific Lab., N. Mex.). Contract W-7405-eng-36. Rev. Mod. Phys., 39: 584-90(July 1967). (LA-DC-8606).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

A summary of the knowledge of the low-energy interaction of two nucleons with one unit of isobaric spin is presented. The single-energy analyses of accurate low-energy proton-proton scattering data are discussed with emphasis upon the electromagnetic effects which were included and those which should be. The phase shifts which result are presented and discussed in terms of the effective range expansion and potentials. A brief discussion of charge symmetry and independence in terms of potentials and dispersion relations is given. The equality of the neutron-neutron and proton-proton nuclear interactions, which seems to be established, may not be sufficient for understanding the problem of mirror nuclei. The question of charge independence is much more difficult. (auth)

37851 PION INSTABILITY IN NUCLEON-NUCLEON SCATTERING. Lassila, K. E. (Iowa State Univ. of Science and Technology, Ames. Research Inst. for Theoretical Physics, Helsinki); Peltola, E. I. Rev. Mod. Phys., 39: 591-2(July 1967).
From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

Pion instability effects are inserted into the OPEP part of the Hamada-Johnston and Yale potentials to determine if any observables are affected by these corrections. A contribution of 0.030 F to the observed neutron-neutron and singlet state neutron-proton scattering length difference is found. (auth)

37852 MESON THEORETIC N-N INTERACTIONS FOR NUCLEAR PHYSICS. Green, A. E. S.; Sawada, T. (Univ. of Florida, Gainesville). Rev. Mod. Phys., 39: 594-610(July 1967).
From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

One-boson-exchange interactions are derived for pseudoscalar (P), vector (V), scalar (S), axial vector (A), and antisymmetric tensor (T) mesons. The Schrödinger-Pauli-Breit limit is obtained for a combination of such Diracian OBE interactions. The phase shifts are calculated for the purely relativistic π - 5ω model and it is found possible to fit the S-wave phase shifts by adjusting one coupling constant and one regularization parameter. Then by breaking this model slightly several accurate representations of the N-N interaction are developed for all waves with a moderate number of adjustable parameters, several of which are fixed by external considerations. A physical interpretation of the results particularly the velocity-dependent interactions is presented. Finally the results are discussed in relation to other PVS models. (auth)

37853 NUCLEON-NUCLEON INTERACTION CONSISTENT WITH THEORY AND EXPERIMENT. Lomon, E.; Feshbach, H. (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Rev. Mod. Phys., 39: 611-21(July 1967). (MIT-2098-308).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

The nucleon-nucleon data are fitted by a boundary condition model interaction determined largely by theoretical forms. One- and two-pion, ρ , ω , and η meson exchange adiabatic local potentials determine the interaction outside $r_0 \approx \frac{1}{2} \mu^{-1}$. Only the two-pion-exchange contribution contains a degree of ambiguity measured by the parameters ξ and λ for the pion ladder and nucleon pair diagrams, respectively. The interaction is determined at r_0 by an energy-independent boundary condition for those par-

tial waves sensitive to the short-range interaction. A very good fit to the p-p data and a good fit to the n-p data below 350-MeV nucleon laboratory energy, are obtained, comparable to the best phenomenological fits. The optimum or fixed values of exchange particle masses and coupling constants corresponds to their known physical values, and the λ and ξ parameters optimize in their theoretical range. The value attained by r_0 corresponds to that predicted by the theory of the boundary condition model. There remain 19 boundary condition parameters, freely fitted, to which the data are sensitive. These may in principle be related to pion-nucleon amplitudes. Rescattering and ϕ meson exchange contributions to the potential remain to be investigated, as does the effect of coupling to inelastic channels. (auth)

37854 MESON THEORY OF NUCLEON-NUCLEON INTERACTION. Wong, David Y. (Univ. of California, San Diego, La Jolla). Rev. Mod. Phys., 39: 622-8(July 1967).
From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

Exchange of π , η , ρ , ω , ϕ mesons and a pair of pions in the relative s state can account for all the important features of the nucleon-nucleon interaction. The method of dispersion relation is employed to calculate nucleon-nucleon phase shifts starting from the relativistic single-particle-exchange Feynman diagrams. Validity of the method is tested in the nonrelativistic limit where the solution of the dispersion relation is compared to the solution of the Schrödinger equation for a superposition of Yukawa potentials. For potentials that contain a long-range attraction and a strong short-range repulsion there is little difference between the two solutions. In the meson model, the attraction comes primarily from the π and the s-wave two-pion exchange. The exchange of ω and ϕ produces the required short-range repulsive force. Two approaches to the nucleon-nucleon scattering problem were considered. The meson model was taken to be the basis of a detailed fit to the scattering data. A total of 12 adjustable parameters were introduced and a fit to the pp and np data was obtained. The accuracy is comparable to that of pure phenomenological potentials with considerably more parameters. The number of parameters in the meson model is minimized using approximate symmetry considerations to clarify the physical significance of the model. With only four adjustable parameters, all the important features of the phase shift are reproduced. These results lend support to the idea that the strongly correlated multimeson systems ρ , ω , and ϕ play a dominant role in the inner part (≤ 0.3 F) of the nucleon-nucleon potential while the exchange of two pions in a relative s-state accounts for the gross feature of the medium-range attraction. (auth)

37856 NUCLEON-NUCLEON SCATTERING, PION-NUCLEON SCATTERING, AND THE NUCLEON FORM FACTORS. Signell, Peter; Durso, John (Michigan State Univ., East Lansing). Rev. Mod. Phys., 39: 635-9(July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

The one-pion and two-pion-exchange contributions to pion-nucleon scattering, nucleon-electron scattering (nucleon electromagnetic form factors), and nucleon-nucleon scattering are examined using as closely similar methods as possible. These contributions are compared to experimental phase shifts which do not depend on the exchange of more than two pions. (auth)

v.21 (1967)

37857 MESON-NUCLEON COUPLING CONSTANTS FROM LOW-ENERGY PROTON-PROTON SCATTERING. Koepp, G. (Technische Hochschule, Aachen). Rev. Mod. Phys., 39: 640-7 (July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

Coupling constants of various scalar and vector mesons to the nucleon are determined from empirical proton-proton partial wave amplitudes of high angular momenta. Various fits are described and compared with predictions of unitary symmetry schemes. (auth)

37858 PION-PRODUCTION AMPLITUDES AND NUCLEON-NUCLEON INTERACTION. Amaldi, U. Jr. (Istituto Superiore di Sanita, Rome). Rev. Mod. Phys., 39: 649-56 (July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

The present knowledge of the partial-wave proton-proton absorptions due to pion production below 1.5 GeV of laboratory kinetic energy is summarized. The three models which were used for obtaining this kind of information from inelastic data are discussed: the Mandelstam model, the one-pion-exchange model, and the K matrix, or damping, model. Although there is some disagreement, in the near future one can hope to obtain reasonably trustworthy values for partial wave absorptions as a function of energy from the threshold of pion production to about 1.5 GeV. This information will be useful not only to reduce the number of parameters in high-energy phase-shift analysis, but also to be introduced as known inelasticities in partial wave dispersion relations. (auth)

37860 NUCLEON-NUCLEON INTERACTION AT HIGH ENERGIES. Leader, E. (Cambridge Univ., Eng.). Rev. Mod. Phys., 39: 663-9 (July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

The present situation in the understanding of high-energy physics is reviewed. In high-energy physics there is a plethora of theories, which often look quite incompatible, but which share one grand claim. For each of them it has been possible to find at least one set of experimental data with which they agree. The outstanding experimental features which are discernible in the nucleon-nucleon system at energies above about 3-GeV/c laboratory momentum are summarized. Some of the main theoretical ideas are considered, and it is examined to what extent they are compatible with the experimental properties described. (auth)

37861 PHENOMENOLOGICAL ANALYSIS OF PROTON-PROTON SCATTERING IN THE INELASTIC REGION. Hoshizaki, Norio (Kyoto Univ.). Rev. Mod. Phys., 39: 700-5 (July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

A survey of recent works concerning the phase-shift analysis of p-p scattering in the energy region from 400 MeV to a few GeV is presented. The method of analysis and results are described. Physical implications of them are also discussed. A new scheme of analysis is proposed. It modifies the previous method in fixing the imaginary phase shifts to the values from the one-pion model with unitarity. Reanalysis of the p-p data at 970 MeV shows the validity of the new scheme. (auth)

37862 PHASE-SHIFT ANALYSIS OF DATA AND THE DETERMINATION OF THE SCATTERING AMPLITUDE IN THE NUCLEON ENERGY REGION ABOVE PION-PRODUCTION THRESHOLD. Kazarinov, Yu. M. (Joint Inst. for Nuclear Research, Dubna, USSR). Rev. Mod. Phys., 39: 706-9 (July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

Historically it has become a habit that the phase-shift analysis is carried out by the experimenters. Thus, each experimental investigation is completed by improving the earlier results of the phase-shift analysis and thus, the phase-shift analysis may be considered as an original method for the treatment of experimental data. The phase-shift analysis turns out to be a means first, to test how well new experimental results agree with the whole collection of earlier known data and, second, to more accurately plan further experiments. In these conditions a phase-shift analysis program is used at one energy. The program implies the following assumptions: There is a charge independence of nuclear forces. Nucleon interaction in states with high orbital momenta is correctly described with a one-pion Feynman diagram. Orbital momenta, beginning from those for which a one-pion approximation can be justified, are determined keeping in mind that in the one-pion approximation, polarization in nucleon-nucleon scattering is equal to 0. Pions are produced, mainly, from initial states with total isotopic spin 1. Results of the analyses will be given. (auth)

37863 PHASE-SHIFT REPRESENTATION FOR NUCLEON-NUCLEON SCATTERING ABOVE PION-PRODUCTION THRESHOLD. Arndt, Richard A. (Univ. of California, Livermore). Rev. Mod. Phys., 39: 710-15 (July 1967). (UCRL-70542).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

A number of questions relating to phase-shift representations of nucleon-nucleon scattering in an energy range where inelastic channels are open and may contribute significantly to such representations are discussed. While attention will be directed specifically toward nucleon-nucleon scattering above 400 MeV, the relevance is seen of such questions being applied to similar strongly interacting systems. (auth)

37864 RELATIVISTIC TREATMENT OF MUON CAPTURE IN DEUTERIUM. APPLICATION TO THE DETERMINATION OF NEUTRON-NEUTRON SCATTERING LENGTH AND EFFECTIVE RANGE. Cremmer, E. (Laboratoire de Physique Theorique et Hautes Energies, Orsay, France). Nucl. Phys., B2: 409-23 (1967).

A relativistic calculation of muon capture in deuterium is given. The important effect of hyperfine structure is treated relativistically. A determination of neutron-neutron scattering length and effective range is made. Vertex functions are used to describe the proton-neutron-deuteron vertex and the Omnes method to compute the final-state interaction. It is shown that an accuracy of 2.5% in spectrum and capture rate must allow a determination of r_{nn} and a_n with an accuracy of, respectively, ± 0.2 fm and ± 0.7 fm. (auth)

37865 MESON MIXING AND THE CHARGE ASYMMETRY OF THE N-N INTERACTION. Downs, B. W. (Univ. of Colorado, Boulder); Nogami, Y. Nucl. Phys., B2: 459-69 (1967).

Electromagnetic mixing of isospin eigenstates for the neutral

mesons leads to charge-asymmetry effects in the N-N interaction. This is discussed in terms of a single-meson-exchange model in which the coupling constants are taken from SU₃ and from phenomenological estimates. Mixing of the vector mesons is considerably more important than mixing of the pseudoscalar mesons. The difference ($a_{nn} - a_{pp}$) between scattering lengths for the strong n-n and p-p interactions could be about -1.5 fm, when the n-p mass difference (which contributes about -0.5 fm) is also considered. Other charge-asymmetry effects which were estimated are much smaller. (auth)

37892 TWO-NUCLEON INTERACTION AS A RESEARCH TOOL IN PARTICLE PHYSICS. Moravcsik, Michael J. (Harvard Univ., Cambridge, Mass. Univ. of California, Livermore), *Rev. Mod. Phys.*, 39: 670-80 (July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

Knowledge of the two-nucleon interaction can be used as a proving ground for general theories of elementary particles. Within this context three aspects of the nucleon-nucleon problem are examined: the tests of some group theoretical schemes through the nucleon-nucleon interaction; a summary of the status of test of general conservation laws; and an attempt to investigate the general analyticity structure of the S matrix through the two-nucleon interaction. (auth)

37893 IDEAS ON NEW EXPERIMENTS ON POLARIZED TARGET. Lapidus, L. I. (Joint Inst. for Nuclear Research, Dubna, USSR), *Rev. Mod. Phys.*, 39: 689-94 (July 1967).

From American Physical Society, Nucleon-Nucleon Interaction Conference, Gainesville, Fla. See CONF-670302.

A possible application of polarized proton targets and polarized proton and antiproton beams to the direct testing of T, P, C invariance and the CPT theorem is considered. Procedure for direct determination of the T-violated amplitude T from experimental data is given. Deviations from symmetry properties for polarization tensors in elastic scattering due to the bremsstrahlung effect are considered. The P invariance can be tested both in the up-down asymmetry measurement and in the total cross section measurements using the polarized beam and the polarized target. The measurement of the total polarization cross section σ_{p1p2} is of interest for testing higher isotopic symmetries. (auth)

38224 STUDIES OF THE PROTON-PROTON BREMSSTRAHLUNG PROCESS AT THE UNIVERSITY OF MANITOBA. Thompson, J. C. (Univ. of Manitoba, Can.), *Phys. Can.*, 23: No. 3, 6-12 (Summer 1967).

A new experimental technique is described for studying low-energy (~50 MeV) proton-proton bremsstrahlung processes. The technique uses wire spark chambers and a small on-line computer for data handling. Some advantages of the system include increase in counting rate while maintaining good geometry, complete removal of slit scattered protons since each detected proton is traced back to its origin, and possibility of investigating events where the outgoing protons are not coplanar with the incident beam direction. (S.F.L.)

38234 (LA-DC-8856) p-p SCATTERING AT THE INTERFERENCE MINIMUM, AND APPLICATIONS OF THE ABSOLUTE VELOCITY GAUGE TECHNIQUE. Seagrave, John D. (Los Alamos Scientific Lab., N. Mex.), [1966]. Contract W-7405-eng-36, 22p. (CONF-670629-2), Dep. CFSTI.

From Symposium on Light Nuclei, Few Body Problems, and Nuclear Forces, Brela, Yugoslavia.

The unique rationale of a recent experiment to determine the nuclear s-wave phase shift at the low-energy Coulomb-interference minimum is described together with the absolute velocity gauge instrumentation developed for this purpose, which made possible proton energy measurements to the accuracy of one part in 10⁴ and the location of the interference minimum at 382.43 ± 0.20 keV. Energy determinations with the velocity gauge of the ¹⁹F(p,α)¹⁶O resonance at 340.45 ± 0.04 keV, of the ²¹Al(p,γ)²⁴Si resonance at 991.912 ± 0.043 keV, and of the ⁷Li(p,n)⁷Be threshold at 1880.617 ± 0.078 keV are compared with previous measurements that they supersede. The special property of the gauge response which permits differential energy transduction concurrently with absolute average energy measurement has not yet been exploited, and a number of applications are suggested. (auth)

38405 POSSIBLE OBSERVATION OF VACUUM POLARIZATION EFFECTS IN THE ¹S₀ p-p STATE. Slobodrian, R. J. (Univ. of California, Berkeley), *Phys. Lett.*, 25B: 89-90 (Aug. 7, 1967).

The effects of vacuum polarization on the "line shape" of the ¹S₀ p-p state are calculated and are shown to be measurable with present experimental techniques. (auth)

38416 COMPARISON OF MODERATE-ENERGY PROTON-PROTON MODELS. III. Noyes, H. Pierre (Stanford Univ., Calif.); Signell, Peter; Yoder, N. R.; Wright, Robert M. Contract W-7405-eng-48. *Phys. Rev.*, 159: 789-92 (July 20, 1967). (UCRL-70349; SLAC-PUB-269).

The predictions of 12 proton-proton models and phase-shift representations are compared to a selected but comprehensive set of 9 to 330-MeV scattering data. The best fit was found to be produced by a quadratic interpolation of Arndt and MacGregor's phase-shift table, with a ratio of χ^2 to its expected value of 1.4. The best potential is that of Hamada and Johnston, with a ratio of 3.1. The ratio for the Tabakin potential is 28. (auth)

39260 HIGH RESOLUTION NUCLEAR STRUCTURE STUDIES USING 1 GeV PROTONS. Friedes, J. L. (Brookhaven National Lab., Upton, N. Y.); Sutter, R.; Palevsky, H.; Bennett, G.; Igo, G.; Simpson, W. D.; Stearns, R. L.; Corley, D. M. *Nucl. Instrum. Methods*, 54: 1-12 (Sept. 1967). (BNL-11241).

The experimental apparatus used to perform nuclear reaction experiments with 1 GeV incident protons is described. The main element of the system is a magnetic spectrometer which uses digital wire spark chambers and has an energy resolution of 3 MeV fwhm. An on-line computer system, which presents the experimenter with an instantaneous scope display of the data being recorded, is indispensable to this experimental technique. The results of 1 GeV proton-proton scattering are presented to demonstrate the performance of the equipment. (auth)

40175 REMARKS ON EXCITATION FUNCTION OF THE N_{15}^* (1688). Namiki, Mikio (Waseda Univ., Tokyo). Progr. Theor. Phys. (Kyoto), 37: 1344-5 (June 1967).

It is shown that the excitation function of the N_{15}^* (1688), obtained by the missing mass method in the processes $\gamma + p \rightarrow N^*$, $e + p \rightarrow e + N^*$, $p + p \rightarrow p + N^*$, and others, should be strengthened by some factor due to the existence of the doublet N_{15}^* (1688⁺) and N_{15}^* (1688⁻). It is concluded that the excitation function of the N_{15}^* (1688) is larger than that of the N_{15}^* (1688⁺), in the absence of the N_{15}^* (1688⁻), by the factor $(1 + A^2)$. (J.F.P.)

40222 SHRINKING NATURE OF DIFFRACTION AMPLITUDES DUE TO PERIPHERAL INELASTIC PROCESSES. Ino, T.; Kikugawa, M.; Yonezawa, M. (Hiroshima Univ.). Nuovo Cim. (10), 50A: 960-2 (Aug. 21, 1967).

An intuitive discussion on the shrinking nature due to the one-meson-exchange-dominated inelastic process which is behind the discussions of the nature of the diffraction scattering in connection with the Regge-type behavior of the scattering amplitude at high energies is given. In order to examine the magnitude of the shrinkage due to this mechanism, the diffraction due to the inelastic processes $K^+ + p \rightarrow K^+ + p$ and $p + p \rightarrow N_{15}^* + p$ in the spinless model are calculated. (J.F.P.)

40235 (LPHE-TH-209) NONRELATIVISTIC SUM RULES AND THE BINDING ENERGY OF THE DEUTERON. Chadan, K.; Montes Lozano, A. (Paris Univ., Orsay (France). Laboratoire de Physique Theorique et Hautes Energies). July 1967. 16p. Dep.

Nonrelativistic sum rules in potential scattering with potentials of finite radius are used to calculate in a very simple way the deuteron binding energy from neutron-proton triplet-S phase-shift. In order to use these sum rules, the imaginary zeros in the k-plane ($k = \sqrt{E}$), of the regular solution $\phi_i(k, r)$ of the radial Schrödinger equation are studied in detail for an arbitrary potential (whether having a finite radius or not), and their properties are established. It is found that these zeros are closely related to the bound states. In particular, their number is the same as the number of bound states. If the zeros are denoted by $i \gamma_j(r)$, $j = 1, \dots, n$, it can be shown that each $\gamma_j(r)$ is an increasing function of r , and has a finite limit for $r \rightarrow \infty$, which corresponds to a bound state of energy $E_j = -\gamma_j^2(\infty)$. These facts, together with the sum rules, enable the bound state energies to be calculated in a very simple and direct manner from the phase-shift and the interaction radius, which is an arbitrary parameter in the sum rules and may be chosen as large as necessary in order to be sure that one is really outside the range of the interaction. The method is applied to the deuteron, assuming that the n-p interaction in 3S_1 state has a radius of the order of the triplet scattering length ($a_t = 5.4$ fermi), i.e., more than three times the triplet effective range ($r_{ot} = 1.73$ fermi). The result is 2.30 MeV, in good agreement with the experimental value 2.224 MeV. This particular example shows that, although, in general, the phase-shift and the binding energies are, except for the Levinson theorem, independent of each other, it may be possible, for interactions of short range, to calculate the latter from the former in a simple way by making the physically reasonable assumption that the interaction vanishes identically beyond some radius, which may be taken as large as necessary. Some possible applications of the sum rules are briefly indicated at the end. (auth)

40242 REFINEMENT OF THE PHASE ANALYSIS OF NN-SCATTERING AT THE ENERGY 147 MeV. Kazarinov, Yu. M.; Legar, F.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 6: 174-7 (July 1967). (In Russian).

The refinement of the phase analysis of NN scattering at the energy 147 MeV is made with the use of all available data at close energies. The experimental results for the np- and pp-scattering effective cross section and pp-scattering polarization were normalized to the energy 147 MeV. (auth)

40432 (WASH-1074) REPORTS TO THE AEC NUCLEAR CROSS SECTIONS ADVISORY GROUP MEETING, HELD AT BROOKHAVEN, NEW YORK, APRIL 13-14, 1967. Motz, H. T. (comp.) (European-American Nuclear Data Committee). Contract W-7405-eng-36. 153p. (EANDC(US)-99U; INDC(US)-9U). Dep. CFSTI.

CHROMIUM—neutron scattering at 0.35 to 0.965 MeV, differential cross section and polarization for

SAMARIUM-153—energy level at 35 keV, from samarium-152 neutron capture

SAMARIUM-152—neutron capture by, γ spectra from thermal

PLATINUM-196—energy-level transition widths from platinum-

195 neutron capture

PLATINUM-195—neutron capture by, γ spectra and transition widths for

ERBIUM-166—neutron capture by, direct

CARBON-13—neutron separation energy from carbon-12 neutron capture

CARBON-12—neutron capture by, neutron separation energy for

HAFFNIUM-177—neutron capture by, γ spectra from resonance

HAFFNIUM-178—energy levels from hafnium-177 neutron resonance capture

THULIUM-169—neutron capture by, resonance widths for

URANIUM-238—neutron capture by, γ spectra and resonance widths for

HOLMIUM-165—neutron capture by, γ spectra from

HOLMIUM-166—energy levels from holmium-165 neutron capture

TUNGSTEN-183—energy levels from tungsten-182 neutron capture

TUNGSTEN-185—energy levels from tungsten-184 neutron capture

TUNGSTEN-187—energy levels from tungsten-186 neutron capture

ARSENIC-75, BROMINE-81, COPPER-65, GERMANIUM-76,

GERMANIUM-74, SELENIUM-80, ZINC-70—proton reactions

(p,n) with, isobaric analog resonances in

ERBIUM-164, ERBIUM-168, ERBIUM-170—neutron resonance parameters at 0.030 to 4.245 keV

ERBIUM-167—neutron resonance parameters at 8 to 373 eV

ERBIUM-166—neutron resonance parameters at 0.01 to 2.89 keV

OXYGEN-17—energy levels of, calculations using shell model

CALCIUM-48, BISMUTH-209—neutron total cross section at 100 to 600 keV

SILICON-30—deuteron differential elastic scattering cross sections at 3.2, 3.7, and 3.9 MeV

SILICON-31—energy levels from silicon-30 (d,p) reactions, branching ratios for

SILICON-30—deuteron reactions (d,p) with, angular correlations and γ spectra from

RHENIUM-185, -187—neutron resonance parameters at 2 to 99 eV

ZIRCONIUM-91—neutron resonance parameters at 0.24 to 1.54 keV

SCANDIUM-45—neutron total cross section at 0.02 to 8000 eV

- SCANDIUM-45—neutron absorption cross section for, thermal
 SCANDIUM—use as neutron filter
 NEPTUNIUM-239—energy-level transitions from americium-243 alpha decay
 AMERICIUM-243—alpha decay of, γ - γ coincidence spectra from
 FISSION FRAGMENTS—range-energy relations for gases and nickel foil
 GASES—fission-fragment range-energy relations for
 RARE GASES—fission-fragment range-energy relations for
 NICKEL—fission-fragment range-energy relations for foils of
 SODIUM-25—energy level at 90 keV, lifetime of
 OXYGEN-16—triton reactions (t, α) and (t,p) at 1 to 3 MeV, excitation functions for
 CARBON-12—triton reactions (t,p) at 1 to 3 MeV, excitation functions for
 URANIUM-238—neutron capture at 0.04 to 1.90 keV, radiative widths for
 DEUTERIUM, TRITIUM—neutron differential elastic scattering cross sections at 6 to 23 MeV
 NEUTRONS—interactions n + p at 11 to 30 MeV, polarization in
 URANIUM-238—neutron fission cross section at 1 to 23 MeV
 URANIUM-235—neutron fission cross section at 2 to 21 MeV
 LITHIUM-7—deuteron reactions (d,He-3) at 22 MeV, angular distribution of energy spectra from
 LITHIUM-7—triton reactions (t, α) at 22 MeV, angular distribution of energy spectra from
 CARBON-12—triton reactions (t, α) at 6 MeV, γ spectra from
 THORIUM-232—neutron fission cross section at 12 to 18 MeV
 STRONTIUM-87—neutron inelastic scattering at 2 to 15 MeV, activation cross sections for
 BORON-10—neutron reactions (n, α) up to 505 keV, cross sections for fast and thermal
 CALCIUM-40—neutron total cross section and resonance parameters at 1 to 2 MeV
 ALUMINUM, IRON, NICKEL, SODIUM—neutron capture resonances at 1 to 100 keV
 FLUORINE—neutron capture resonances at 1 to 300 keV
 LEAD—neutron capture resonances at 1 to 300 keV
 LEAD-206—neutron capture resonances at 1 to 300 keV
 LEAD-207—neutron capture resonances at 1 to 300 keV
 MAGNESIUM—neutron capture resonances at 1 to 300 keV
 SULFUR—neutron capture resonances at 1 to 300 keV
 RHODIUM—neutron scattering resonances at low energy
 ETHYLENE POLYMERS—neutron differential inelastic scattering cross section at 0.33, 0.65, and 1.02 eV
 WATER—neutron differential inelastic scattering cross section at 0.15, 0.23, 0.33, 0.50, and 0.63 eV
 ZIRCONIUM HYDRIDES—neutron differential inelastic scattering cross section at 0.24, 0.40, 0.57, and 0.67 eV
 NIOBIUM HYDRIDES—neutron differential inelastic scattering cross section at 0.238 eV
 URANIUM OXIDES UO_2 —neutron differential cross sections at 0.134 and 0.341 eV
 IRON—neutron spectra in, time of flight measurements of fast
 DEUTERIUM—proton reactions (p,pn) at 9 MeV, cross section and spectra for
 DEUTERONS—interactions p + d, bremsstrahlung production cross section for
 DEUTERIUM—proton reactions (p,2p) at 11 MeV, spectra from
 DEUTERIUM—deuteron reactions (d,dp) at 11 MeV, spectra from
 LITHIUM-6—proton reactions (p,d α), (p,p α), and (p,pd) at 9 MeV, coincidence spectra from
 CALCIUM-40—proton differential elastic scattering cross sections at 6 to 13 MeV, angular distributions of
 HELIUM-3—proton elastic scattering at 4 to 11 MeV by polarized, asymmetries in
 NUCLEONS—interactions N + N, bremsstrahlung production cross sections for
 NUCLEAR REACTIONS—theory of elastic scattering of spin- $\frac{1}{2}$ particles on spin- $\frac{1}{2}$ targets, using spin-orbit, spin-spin, and tensor forces
 SILICON-30—deuteron differential elastic scattering cross sections at 3.2, 3.7, and 3.9 MeV
 SILICON-31—energy levels from silicon-30 (d,p) reactions, branching ratios for
 SILICON-30—deuteron reactions (d,p) with, angular correlations and γ spectra from
 RHENIUM-185, -187—neutron resonance parameters at 2 to 99 eV
 ZIRCONIUM-91—neutron resonance parameters at 0.24 to 1.54 keV
 SCANDIUM-45—neutron total cross section at 0.02 to 8000 eV
 SCANDIUM-45—neutron absorption cross section for, thermal
 SCANDIUM—use as neutron filter
 NEPTUNIUM-239—energy-level transitions from americium-243 alpha decay
 AMERICIUM-243—alpha decay of, γ - γ coincidence spectra from
 FISSION FRAGMENTS—range-energy relations for gases and nickel foil
 GASES—fission-fragment range-energy relations for
 RARE GASES—fission-fragment range-energy relations for
 NICKEL—fission-fragment range-energy relations for foils of
 SODIUM-25—energy level at 90 keV, lifetime of
 OXYGEN-16—triton reactions (t, α) and (t,p) at 1 to 3 MeV, excitation functions for
 CARBON-12—triton reactions (t,p) at 1 to 3 MeV, excitation functions for
 URANIUM-238—neutron capture at 0.04 to 1.90 keV, radiative widths for
 DEUTERIUM, TRITIUM—neutron differential elastic scattering cross sections at 6 to 23 MeV
 NEUTRONS—interactions n + p at 11 to 30 MeV, polarization in
 URANIUM-238—neutron fission cross section at 1 to 23 MeV
 URANIUM-235—neutron fission cross section at 2 to 21 MeV
 LITHIUM-7—deuteron reactions (d,He-3) at 22 MeV, angular distribution of energy spectra from
 LITHIUM-7—triton reactions (t, α) at 22 MeV, angular distribution of energy spectra from
 CARBON-12—triton reactions (t, α) at 6 MeV, γ spectra from
 THORIUM-232—neutron fission cross section at 12 to 18 MeV
 STRONTIUM-87—neutron inelastic scattering at 2 to 15 MeV, activation cross sections for
 BORON-10—neutron reactions (n, α) up to 505 keV, cross sections for fast and thermal
 CALCIUM-40—neutron total cross section and resonance parameters at 1 to 2 MeV
 ALUMINUM, IRON, NICKEL, SODIUM—neutron capture resonances at 1 to 100 keV
 FLUORINE—neutron capture resonances at 1 to 300 keV
 LEAD—neutron capture resonances at 1 to 300 keV
 LEAD-206—neutron capture resonances at 1 to 300 keV
 LEAD-207—neutron capture resonances at 1 to 300 keV
 MAGNESIUM—neutron capture resonances at 1 to 300 keV
 SULFUR—neutron capture resonances at 1 to 300 keV
 RHODIUM—neutron scattering resonances at low energy
 ETHYLENE POLYMERS—neutron differential inelastic scattering cross section at 0.33, 0.65, and 1.02 eV
 WATER—neutron differential inelastic scattering cross section at 0.15, 0.23, 0.33, 0.50, and 0.63 eV
 ZIRCONIUM HYDRIDES—neutron differential inelastic scattering cross section at 0.24, 0.40, 0.57, and 0.67 eV
 NIOBIUM HYDRIDES—neutron differential inelastic scattering cross section at 0.238 eV
 URANIUM OXIDES UO_2 —neutron differential cross sections at 0.134 and 0.341 eV
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 DEUTERIUM—proton reactions (p,pn) at 9 MeV, cross section and spectra for
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 DEUTERIUM—proton reactions (p,2p) at 11 MeV, spectra from

DEUTERIUM—deuteron reactions (d,dp) at 11 MeV, spectra from
 LITHIUM-6—proton reactions (p,d α), (p,p α), and (p,pd) at 9 MeV, coincidence spectra from
 CALCIUM-40—proton differential elastic scattering cross sections at 6 to 13 MeV, angular distributions of
 HELIUM-3—proton elastic scattering at 4 to 11 MeV by polarized, asymmetries in
 NUCLEONS—interactions N + N, bremsstrahlung production cross sections for
 NUCLEAR REACTIONS—theory of elastic scattering of spin- $\frac{1}{2}$ particles on spin- $\frac{1}{2}$ targets, using spin-orbit, spin-spin, and tensor forces
 CARBON-12—photon reactions (γ ,n) at 23 to 65 MeV, neutron time-of-flight, spectra from
 OXYGEN-16—photon reactions (γ ,n) at 23 to 65 MeV, neutron time-of-flight spectra from
 DEUTERIUM—photodisintegration at 40 and 50 MeV, differential cross sections for
 OXYGEN-16—photon reactions (γ ,p) at 18 to 25 MeV, proton spectra from; photon reactions (γ ,n) and (γ ,p) in giant resonance region, gamma spectra from
 OXYGEN-15—energy-level transitions from oxygen-16 (γ ,n) reactions in giant resonance region
 NITROGEN-15—energy-level transitions from oxygen-16 (γ ,p) reactions in giant resonance region
 NUCLEAR REACTIONS—theory of giant dipole resonances in photon-induced
 YTTRIUM-89—energy levels from electron inelastic scattering
 ZIRCONIUM-90—electron inelastic scattering at 60 MeV, angular distributions for
 BISMUTH-209—energy levels from electron inelastic scattering
 LEAD-206—energy levels from electron inelastic scattering
 LEAD-207—energy levels from electron inelastic scattering
 LEAD-208—energy levels from electron inelastic scattering (D.C.W.)

42258 HIGH-PRECISION MEASUREMENT OF PROTON-PROTON POLARIZATION BETWEEN 10 AND 20 MeV. Slobodrian, R. J.; McKee, J. S. C.; Bichsel, H.; Tivol, W. F. (Univ. of California, Berkeley). *Phys. Rev. Lett.*, 19: 704-6 (Sept. 18, 1967).

The p-p polarization asymmetry was measured at 9.6-, 15.6-, and 19.7-MeV laboratory energy with accuracy down to ± 0.003 . The interpretation of our results requires a significant spin-orbit term in the interaction. (auth)

42259 EXPERIMENTS AT LOW ENERGY. Catillon, P. (CEN, Saclay, France). pp 297-307 of *Polarized Targets and Ion Sources*. Gif-sur-Yvette, France, Centre d'Etudes Nucleaires de Saclay, [1967].

From Conference on Polarized Targets and Sources, Saclay, France, Dec. 5-9, 1966. See CONF-661205.

A description of the three experiments that have been performed at low energy using polarized targets is given. These experiments, performed at Los Alamos, Harwell, and Saclay, involve the nucleon-nucleon interactions. (W.H.K.)

42260 THE REAL PART OF THE SPIN-INDEPENDENT FORWARD SCATTERING AMPLITUDE IN ELASTIC NUCLEON-NUCLEON COLLISIONS. Dutton, L. M. C.; Howells, R. J. W.;

Jafar, J. D.; Van Der Raay, H. B. (Univ. of Birmingham, Eng.). *Phys. Lett.*, 25B: 245-8 (Aug. 21, 1967).

Elastic pp and pd scattering in the Coulomb interference region were studied using a sonic spark chamber technique. Analyses of these data yield $\alpha_p = 0.10 \pm 0.16$ and $\alpha_n = -0.50 \pm 0.15$ at 1.69 GeV/c in good agreement with dispersion relation calculations, the value of $\alpha_p = -0.30 \pm 0.09$ obtained at 1.54 GeV/c is however not consistent with these calculations. (auth)

42367 RELATIVISTIC TREATMENT OF STRUCTURE IN THE COULOMB INTERFERENCE PROBLEM. Locher, M. P. (CERN, Geneva). *Nucl. Phys.*, B2: 525-31 (1967).

The effect of form factors on the Coulomb phase angle in elastic high-energy scattering of charged particles is discussed. The influence of the angular dependence of the strong interaction part on the phase is included. Essentially the nonrelativistic result of Bethe turns out to be correct. (auth)

42384 EXPERIMENTAL TESTING OF THE ANALYTICITY STRUCTURE OF THE S-MATRIX. Arndt, R. A.; Moravcsik, M. J. (Univ. of California, Livermore). *Nuovo Cim.* (10), 51A: 108-17 (Sept. 1, 1967).

A tentative experimental test of the analyticity structure of the S-matrix in low-energy nucleon-nucleon scattering is performed by showing that among an appreciable number of functions describing the energy dependence of phase shifts in proton-proton scattering dynamics, satisfying various threshold and asymptotic requirements, those having qualitatively the proper analytic structure give somewhat better fits to experimental data than those with "improper" analytic structure. Statements are also made about the relative merits of various approximation schemes. (auth)

42385 ANGULAR MOMENTUM DEPENDENT POTENTIALS IN NUCLEON-NUCLEON SCATTERING. Crönström, C. Kgl. Danske Vidensk. Selsk., Det. Mat.-Fys. Medd., 35: 1-23 (1967).

We investigate the general properties of the most general local, angular momentum dependent nucleon-nucleon potential. We generalize the arguments of a previous paper on angular momentum dependent potentials, to take into account the complications which arise because of the spin of the nucleons. As an example we consider a scalar boson exchange potential, and show that the conventional approximation methods for obtaining local potentials from field theory are completely misleading in this case. (auth) (DENM)

42388 TWO-PARTICLE INELASTIC REACTIONS AND MOVING BRANCH POINTS IN ANGULAR-MOMENTUM PLANE. Ansel'm, A. A.; Dyatlov, I. T. (Ioffe Inst. of Physics and Tech., Leningrad). *JETP Lett. (USSR) (Engl. Transl.)*, 5: 330-2 (June 1, 1967).

Translated from *Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu*, 5: 404-6 (June 1, 1967).

The contribution of branch points to the asymptotic amplitudes of two-particle inelastic interactions at large momentum transfers $|t| \gg m^2$, but at $|t| \ll s$ (where s is the square of the total cms energy and m is the nucleon mass) is considered. (J.F.P.)

42396 THEORY OF THE NEUTRON-PROTON CAPTURE. Bebel, D.; Kaschlunn, F.; Lewir, K. (Humboldt-Univ., Berlin). Monatsber. Deut. Akad. Wiss. Berlin, 8: 705-8(1966). (In German).

In the theoretical calculation of the total cross section for the neutron-proton capture $n + p \rightarrow d + \gamma$ it is essential that the quantum mechanical results be used as the contribution of the direct γN interaction and not the values obtained by means of dispersion theory approximation. The origin of the inaccuracy obtained in the dispersion theory calculations occurs not in the dispersion theory approach but in supplementary approximations. The total cross section can also be obtained by means of the form independence approximation. It is shown that the introduction of form dependence corrections changes the result only slightly within the limits of error. (J.S.R.)

42613 (NP-16992) ANNUAL REPORT, APRIL 1966-MARCH 1967. (Tokyo Univ. (Japan). Inst. for Nuclear Study). 154p. Dep.

TIN-118—proton reactions (p,t) at 55 MeV, differential cross sections for
ZINC-68—proton reactions (p,t) at 55 MeV, differential cross sections for
ZINC-67—proton reactions (p,d) at 55 MeV, differential cross sections for
CADMIUM-110 and -114—proton differential inelastic scattering cross sections at 55 MeV
SAMARIUM-150, -152, and -154—proton reactions (p,t) at 55 MeV, triton energy spectrum and angular distributions for
ZIRCONIUM-90—proton reactions (p,d) at 55 MeV, zirconium-89 energy levels from
ZIRCONIUM-90—proton reactions (p,t) at 55 MeV, zirconium-88 energy levels from
ZIRCONIUM-91—proton reactions (p,d) at 55 MeV, zirconium-90 energy levels from
ZIRCONIUM-91—proton reactions (p,t) at 55 MeV, zirconium-89 energy levels from
PROTONS—reactions (p,t) with zirconium-91 at 55 MeV, zirconium-89 energy levels from
YTTRIUM-89—proton reactions (p,d) at 55 MeV, yttrium-88 energy levels from
NIOBIUM-93—proton reactions (p,d) at 55 MeV, niobium-92 energy levels from
ALUMINUM-27—energy levels from proton elastic and inelastic scattering at 55 MeV
BERYLLIUM-9 and CARBON-12—proton reactions (p,p' α) at 55.3 MeV, angular correlation distribution for
PROTONS—interactions with protons at 52.34 MeV, differential cross sections for; interactions with protons at 50 MeV, spin correlation parameters for
STRONTIUM-83—beta and electron-capture decay of, gamma spectrum from
RUBIDIUM-83—electron-capture decay of, gamma spectrum from
RHODIUM-100—beta and electron-capture decay of, ruthenium-100 energy levels from
CESIUM-136—beta decay of, beta-gamma delayed coincidence study of,
SYNCHROTRONS—design and operation at Tokyo University
PROTONS—interactions $\gamma + p \rightarrow p + \eta$ at 890 MeV, polarization recoil protons in
DEUTERONS—interactions $\gamma + d \rightarrow \pi^0 + d$ at 650 to 820 MeV, differential cross sections for
TIN-117, -118, -119, and LEAD-208—proton reactions (p,d) at 55 MeV, differential cross sections for (S.F.L.)

42699 NUCLEAR FORCES. I. Feshbach, H.; Kerman, A. K. (Massachusetts Inst. of Tech., Cambridge). Comments Nucl. Particle Phys., 1: 132-8(July-Aug. 1967).

The importance of nucleon-nucleon forces in the understanding of nuclear structure is reviewed, and the use of nucleon-nucleon scattering experiments to study these forces is briefly discussed. Results are outlined which have been obtained using incident nucleons with energies ranging up to approximately 350 MeV laboratory energy. The one-pion exchange potential is discussed. (S.F.L.)

44269 POLARIZATION PARAMETER IN ELASTIC PROTON-PROTON SCATTERING FROM 0.75 TO 2.84 GeV. Neal, Homer A.; Longo, Michael J. (Univ. of Michigan, Ann Arbor). Contract Nonr-1224(23). Phys. Rev., 161: 1374-83(Sept. 25, 1967).

The polarization parameter in elastic proton-proton scattering was measured at 0.75, 1.03, 1.32, 1.63, 2.24, and 2.84 GeV by employing a double-scattering technique. An external proton beam from the Brookhaven Cosmotron was focused on a 3 in.-long liquid-hydrogen target and the elastic recoil and scattered protons were detected in coincidence by scintillation counters. The polarization of the recoil beam was determined from the azimuthal asymmetry exhibited in its scattering from a carbon target. This asymmetry was measured by a pair of scintillation-counter telescopes which symmetrically viewed the carbon target. The analyzing power of this system was previously determined in an independent calibration experiment employing a 40%-polarized proton beam at the Carnegie Institute of Technology synchrocyclotron. False asymmetries were cancelled to a high order by periodically rotating the analyzer 180° about the recoil beam line. Spark chambers were utilized to obtain the spatial distribution of the beam as it entered the analyzer; this information allowed an accurate determination of the corrections necessary to compensate for any misalignment of the axis of the analyzer relative to the incident-beam centroid. Values of the polarization parameter as a function of the center-of-mass scattering angle are given for each incident beam energy. The predictions of the Regge theory for polarization in elastic proton-proton scattering and recently published phase-shift solutions are compared with the experimental results. Surprisingly good agreement with the Regge predictions is found despite the low energies involved. (auth)

44272 NEUTRON-PROTON ELASTIC SCATTERING AT 15.7 MeV. Morton, W. T. (Univ. of Glasgow). Proc. Phys. Soc. (London), 91: 899-902(Aug. 1967).

The angular distribution of neutrons with an incident energy of 15.7 MeV elastically scattered from protons was measured in the angular range between 180 and 60° in the center-of-mass system using the nuclear emulsion technique. The results are consistent with the previous measurements at 14 MeV and yield a value of $\sigma(180^\circ)/\sigma(90^\circ) = 1.07 \pm 0.02$. By combining the present results with others at 14 MeV and fitting to an equation of the form $d\sigma/d\Omega = A + B \cos \theta + C \cos^2 \theta$, values were obtained of $B/A = -0.033 \pm 0.022$ and $C/A = 0.042 \pm 0.026$. (auth) (UK)

44351 (ORNL-TM-1945) GRAPHS OF SCATTERED PARTICLE ENERGIES VS SCATTERING ANGLES, AND GRAPHS OF CENTER-OF-MASS SCATTERING ANGLES VS LABORATORY SCATTERING ANGLES FOR NUCLEON-NUCLEON REACTIONS FROM 25 TO 3500 MeV AND FOR PION-NUCLEON REACTIONS FROM 25 TO 2500 MeV. Bertini, Hugo W.; Guthrie, Miriam P.;

Pickell, Elsie H. (Oak Ridge National Lab., Tenn.). Aug. 18, 1967. Contract W-7405-eng-26. 37p. Dep. CFSTI.

Graphs are presented illustrating the laboratory energy of the scattered nucleon vs the laboratory energy of the incident nucleon where the scattering angle is a parameter for incident nucleon energies ranging from 25 to 3500 MeV. The same types of data are presented for pion-nucleon reactions with energies from 25 to 2500 MeV. Graphs of the scattering angle in the center-of-mass system vs the scattering angle in the laboratory system at various reaction energies for the same reactions and over the same energy ranges are presented. The data are applicable to the checking and the understanding of the results from an intermediate-energy intranuclear-cascade calculation. (auth)

44380 REGGE-POLE MODEL FOR THE SCATTERING MAXIMA IN πN AND NN SCATTERING AND THE NO-COMPENSATION MECHANISM. Chiu, Charles B.; Chu, Shu-yuan; Ling-lie (Univ. of California, Berkeley). Contract W-7405-eng-48. Phys. Rev., 161: 1563-70 (Sept. 25, 1967). (UCRL-17302).

The dip-bump structure in the low-energy πp elastic differential cross section was studied. It is found that a zero in the helicity nonflip amplitude of the P' trajectory gives a natural explanation of this structure. At the same time the high-energy πp total and differential cross sections, the πp polarizations, and the πp charge-exchange differential cross-section data were consistently fitted. The helicity nonflip amplitude of the P' trajectory will vanish at $\alpha_{P'} = 0$ if the P' trajectory chooses what we call the no-compensation mechanism. Consistent with the πp solution, the pp and $\bar{p}p$ total and differential cross sections can also be well fitted. The secondary maximum in the low-energy $\bar{p}p$ differential cross section is reproduced. (auth)

44389 EFFECT OF HIGHER BARYON RESONANCES ON THE TWO-PION EXCHANGE CONTRIBUTION TO NN SCATTERING. Durso, John W. (Michigan State Univ., East Lansing). Contract AT(11-1)-1051. Phys. Rev., 161: 1636-9 (Sept. 25, 1967). (COO-1051-6).

The consistency of πN and NN scattering demonstrated in a previous paper is reexamined by reparametrizing the Bowcock-Cottingham-Lurie model for πN scattering to include the effects of baryon resonances beyond the well-known $\Delta_2(1236)$. The reparametrization, though unphysical in the sense of requiring a negative width for the $N_2(1518)$ to achieve a best fit to low-energy πN data, reduces the χ^2 of the model by a factor of 8.6. Used as input for the NN calculations, this new parametrization is found to yield essentially the same results as when only the N and $\Delta_2(1236)$ are included in the πN model. Arguments are presented to explain the apparent insensitivity of the NN predictions to the fine details of the πN model. (auth)

44391 ON PROTON-PROTON BREMSSTRAHLUNG. Felsner, G. (CERN, Geneva). Phys. Lett., 25B: 290-2 (Sept. 4, 1967).

The cross section for proton-proton bremsstrahlung was calculated for soft photons in a model independent way. Comparison with experiments was made. (auth)

44421 NEW TEST OF T INVARIANCE IN $p-p$ SCATTERING. Handler, R.; Wright, S. C. (Univ. of Chicago). Phys. Rev. Lett., 19: 933-6 (Oct. 16, 1967).

A test of T invariance in $p-p$ triple scattering was performed at 430 MeV. The difference in two polarizations which are identical if T is valid was found to be 0.0006 ± 0.0028 . The T-nonconserving amplitude was found to be less than $1/4\%$ of the T-conserving amplitude. The T-nonconserving phase was found to be less than 0.06 of its maximum value. (auth)

44555 ${}^4\text{He}(p,t)2p$, ${}^4\text{He}(p,{}^3\text{He})pn$ AND ${}^4\text{He}(p,{}^3\text{He})d$ REACTIONS AT 156 MeV AND THE FINAL-STATE INTERACTION. Bernas, M.; Lee, J. K.; Bachelier, D.; Brissaud, I.; Detraz, C.; Radvanyi, P.; Roy, M. (Institut de Physique Nucleaire, Orsay, France). Phys. Lett., 25B: 260-2 (Sept. 4, 1967).

The $p-n$ and $p-p$ final-state interaction in the $(p,{}^3\text{He})$ and (p,t) reactions on ${}^4\text{He}$ at 156 MeV was measured for several t and ${}^3\text{He}$ angles and was analyzed in terms of the Watson-Migdal theory. Agreement is rather good for the shapes of the energy spectra, but not for their relative magnitudes. The differential cross section of ${}^4\text{He} + p \rightarrow d + {}^3\text{He}$ was measured from $\theta_d = 4$ to 177° c.m. (auth)

44529 RESONANCES AND ANTISHRINKAGE OF DIFFRACTION PEAK. Hasebe, Katsuya (Nagoya Univ., Japan). Progr. Theor. Phys. (Kyoto), 38: 202-9 (July 1967).

An attempt is made to account for the energy dependence of the slope (shrinkage or antishrinkage) of differential cross section in $p-p$ and $p-\bar{p}$ diffraction scattering. It is assumed that the effective interaction is described by a potential around the black sphere and that the potential is repulsive or attractive for the $p-p$ or the $p-\bar{p}$ system, respectively. π^+p and K^+p scattering are also discussed in connection with resonances. (auth)

44546 HIGH-ENERGY NUCLEON SCATTERING. Wilson, Richard. Comments Nucl. Particle Phys., 1: 160-3 (Sept.-Oct. 1967).

Some of the recent refinements in high-energy nucleon scattering experiments are discussed. Various features of the Pomeronhuk theorem, dispersion relations, and large-momentum transfers for πp and pp scattering are pointed out. (L.B.S.)

44548 PROTON-PROTON BREMSSTRAHLUNG. Reitan, Arne (Norges Tekniske Høgskole, Trondheim, Norway). Nucl. Phys., B3: 147-54 (1967).

The differential and total cross section for the reaction $p + p \rightarrow p + p + \gamma$ are evaluated by using a transition operator consisting of the standard electromagnetic interaction plus a part arising from exchange of pions between the two nucleons. The latter processes are treated by a simple semiphenomenological model. Only transitions to the final 1S_0 state are considered. The results are compared with experiments at 200 MeV incident laboratory energy. (auth)

46551 PROTON-PROTON BREMSSTRAHLUNG. Reitan, Arne. (Norges Tekniske Høegskole, Trondheim, Norway). Ark. Fys. Seminar Trondheim, No. 9, 16p.(1967).

The differential and total cross section for the reaction $p + p \rightarrow p + p + \gamma$ are evaluated by using a transition operator consisting of the standard electromagnetic interaction plus a part arising from exchange of pions between the two nucleons. The latter processes are treated by a simple semiphenomenological model. Only transitions to the final 1S_0 state are considered. The results are compared with experiments at 200 MeV incident laboratory energy. (auth)

46553 VELOCITY DEPENDENT OBEP AND NUCLEON-NUCLEON SCATTERING PHASE SHIFT IN THE BORN APPROXIMATION. Sharma, Ravi D.; Green, A. E. S. (Univ. of Florida, Gainesville). Nucl. Phys., B3: 33-46(1967).

Relativistic OBEP containing important velocity dependent terms in the Schrödinger-Pauli limit are treated in the Born approximation. The N-N elastic scattering phase shifts are calculated and the results are compared with exact calculations of the phase shifts. It is found that the Born approximation can be relied upon for D and higher waves and gives reasonable trends for the P-waves. Two methods of treating the velocity dependence in the Born approximation are discussed. It is shown that direct Born approximation treatment of velocity-dependent potentials is valid when the effective mass method breaks down. Three different OBEP arising from different treatments of a vector meson field are studied in detail and are found to give similar results for D-waves and higher but differ significantly in the 1P_0 phase shift. (auth)

46555 DEUTERON VERTEX FUNCTION IN DISPERSION THEORY. Harkness, Richard Long Jr. Bloomington, Ind., Indiana Univ., 1965. 52p.

Thesis.

Form factors are shown to arise in practical applications of S-matrix theory, and are used to restore the effects of certain neglected terms which account for the structure of one or more particles participating in a scattering process. These ordinarily neglected terms are shown to be especially important in the case of a weakly bound composite particle, for in this case they contribute a so-called "anomalous threshold." The reaction $p + p \rightarrow p + D$ is analyzed and a family of terms which appear in the amplitude is isolated and defined to be the form factor of the deuteron. The resulting form factor is essentially the vertex function of field theory. Neglecting spin and postulating unsubtracted dispersion relations, a first order approximation to the deuteron vertex function is explicitly evaluated. The approximation amounts to assuming that the deuteron is bound by single pion exchange. The first order expression is shown to generate an anomalous threshold when the binding energy is decreased sufficiently. The mechanism by which the a.t. arises are thoroughly explored. The non-relativistic limit of the anomalous term in the vertex function is shown to correspond to the Schroedinger wave function of the deuteron calculated with a Yukawa potential for single pion exchange. This correspondence is interpreted in terms of the large size of the deuteron compared to a pion Compton wavelength, and is further demonstrated by showing that the anomalous term in the vertex function determines the low energy properties of the relativistic deuteron photodisintegration amplitude in the same way that the wave function of the deuteron influences the nonrelativistic calculation of the same amplitude in the impulse approximation. Finally the same form factor is evaluated again, this time incorporating spin in a fully relativistic formalism and using rho as well as pion

exchange in the model of the deuteron in an effort to fit an empirical form factor of the deuteron derived elsewhere. The empirical form factor shows strong evidence of a hard core in the deuteron and provides an acid test of any theory of deuteron structure at small distances. (Disser. Abstr.)

46661 (ORNL-TM-1914) TWO-PROTON FINAL-STATE INTERACTIONS IN THE REACTIONS $^3\text{He}(d,t)2p$, $d(^3\text{He},t)2p$, $^3\text{He}(^3\text{He},^4\text{He})2p$, AND $p(^3\text{He},d)2p$. Morton, Bobby Joe (Oak Ridge National Lab., Tenn.). Sept. 1967. Contract W-7405-eng-26. 82p. Dep. CFSTI.

Thesis. Submitted to Univ. of Tennessee, Knoxville.

The energy spectra of the observed particles for the reactions $^3\text{He}(d,t)2p$, $D(^3\text{He},t)2p$, $^3\text{He}(^3\text{He},^4\text{He})2p$, and $^4\text{He}(^3\text{He},d)2p$ were measured at forward angles using the 36-MeV deuteron beam and the 53- and 74-MeV ^3He beams from the Oak Ridge Isochronous Cyclotron. Each of the spectra was characterized by a peak in the high-energy region corresponding to the two unobserved protons having a low relative energy. These peaks were attributed to the enhancement of the cross section in this energy region by the final-state interaction of the two protons. The data were analyzed using the final-state interaction theory of Watson and Migdal. This theory gave an adequate representation of the data for the reactions $^3\text{He}(d,t)2p$ and $^3\text{He}(^3\text{He},^4\text{He})2p$ using the known proton-proton interaction. However, for the other reactions, $D(^3\text{He},t)2p$ and $^4\text{He}(^3\text{He},d)2p$, the observed peaks were much narrower than the theoretical predictions. For the reaction $D(^3\text{He},t)2p$, the narrower peak could be explained by assuming the primary reaction mechanism is a charge-exchange process and calculating this effect using the impulse approximation. (auth)

46665 UNIQUE DETERMINATION OF THREE PROTON-PROTON SCATTERING PARAMETERS AT 9.69 MeV. Noyes, H. Pierre; Lipinski, H. M. (Stanford Univ., Calif.). Contract AT(04-3)-515. Phys. Rev., 162: 884-9(Oct. 20, 1967). (SLAC-PUB-268).

The well-established fact that the spin-orbit interaction is of short range compared to one-pion-exchange (OPE) interaction causes the phase-shift combination $\Delta_{15} = (-2\delta_{1,0} - 3\delta_{1,1} + 5\delta_{1,2})/12$ to be small compared to $\Delta_T = 5(2\delta_{1,0} - 3\delta_{1,1} + \delta_{1,2})/12$ at low energy. It is found that this makes it impossible to carry through an unambiguous phase-shift analysis of existing data near 10 MeV for δ_0 and $\delta_{1,1}$, but it also makes it possible to show that the ratio Δ_{15}/Δ_T must lie between 0.07 and 0.15 at 9.69 MeV. Using this result, one can then uniquely determine δ_0^π , Δ_T , and $\Delta_C = (\delta_{1,0} + 3\delta_{1,1} + 5\delta_{1,2})/9$ and obtain $\delta_0^\pi = 55.6^\circ \pm 0.28^\circ$, $\Delta_T = 0.91^\circ \pm 0.28^\circ$, $\Delta_C = -0.020^\circ \pm 0.029^\circ$ with relative correlations $(OT) = -0.96$, $(OC) = 0.47$, $(TC) = -0.30$. The result is stable against variation of Δ_{15}/Δ_T over the full physically allowable range, against the extrapolation needed to include $[\Lambda_{\pi\pi}/\Lambda_{\pi\pi}]$ (90°) at 11.4 MeV in the data set, against vacuum polarization corrections, and against whether or not phases with $J > 2$, 3F_2 , and (marginally) ϵ_2 are dropped or given their OPE values. The data require 1D_2 to be within 30% of the OPE prediction, and the value of Δ_T given above also agrees with this prediction to the same accuracy. This is important as it shows conclusively that p-p differential cross sections below 10 MeV can be analyzed uniquely and stably for only two nuclear parameters (δ_0^π and Δ_C) by using the OPE prediction multiplied by the Coulomb-barrier penetration factor for all other nuclear scattering parameters. The small value of Δ_C is presumably due to the delicate cancellation between the weakly repulsive OPE central P-wave interaction and the strongly attractive intermediate-range attraction arising from the exchange

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of two interacting pions in the $I = 0$ $\pi\text{-}\pi$ S state. A single (model-dependent) parameter measuring the strength of this attraction relative to OPE will account both for this value of Δ_C and for the four values previously determined at 3 MeV and below. The value of δ_0^E again confirms the predicted OPE shape correction in the 1S_0 state to modest accuracy and, taken together with results below 3 MeV and near 27 MeV, establishes the existence of the shape correction beyond reasonable doubt. (auth)

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994 (JINR-P-2332) **PLANIROVANIJE EKSPERIMEN-TOV PO n-p-RASSEYANIYU DLYA OPREDELENIYA NAIBOLEE VEROYATNOGO NABORA FAZOVYKH SDVI-GOV.** (Planning of n-p Scattering Experiments for Determining the Most Probable Set of Phase Shifts). Lehar, F.; Fedorov, V. V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 13p. Dep. mn.

The optimal experiment is planned to distinguish between three sets of phase shifts in n-p scattering at 630 Mev. (auth)

1029 **TWO-PION EXCHANGE CONTRIBUTION TO THE HIGHER ANGULAR MOMENTUM NUCLEON-NUCLEON PHASE SHIFTS [Thesis].** Dursio, John William. University Park, Pa., Pennsylvania State Univ., 1964. 108p.

The two-pion exchange contribution to the higher ($l > 2$) angular momentum phase shifts in nucleon-nucleon scattering is calculated using the single dispersion relation approximation to the Mandelstam representation developed by Cini and Fubini. Only the singularities in the scattering amplitude nearest the physical region of the kinematic variables are taken exactly into account while the effect of more distant singularities is absorbed into arbitrary constants. A simple model for the complete pion-nucleon amplitude is assumed and is related to the amplitude for nucleon-antinucleon annihilation into two pions by use of the crossing symmetry of the Mandelstam representation. The single spectral functions in the Cini-Fubini approximation are then calculated by application of the unitarity condition of the S-matrix in the nucleon-antinucleon channel. The contribution to the scattering amplitude in the nucleon-nucleon channel is obtained by further application of crossing symmetry. The calculated two-pion contribution yields reasonable corrections to the one-pion exchange phase shifts. (TCO)

2520 (IA-920) **RESEARCH LABORATORIES SEMI-ANNUAL REPORT FOR THE PERIOD JULY-DECEMBER 1963.** (Israel Atomic Energy Commission, Yavne; Soreq Research Establishment). 196p. Dep. mn.

Progress and trends in the research program are reported, and operational services are described. Information is included on operation of the IRR-1 Reactor and isotope production. Research progress is reported on

elementary particle theory, reactor physics, nuclear physics, solid state physics, inorganic chemistry, radiation chemistry, nuclear chemistry, analytical chemistry, and applications technology. Biological and medical research are summarized. Results of research on nuclear hazards are presented along with research progress on nuclear and mechanical instrumentation. A bibliography of reports and papers associated with the project is included. (JRD)

2685 (LA-DC-7250) **A MEASUREMENT OF C_{NN} IN NEUTRON-PROTON SCATTERING AT 23 Mev.** Bendt, P. J.; Malanify, J. J.; Roberts, T. R.; Simmons, J. E. (Los Alamos Scientific Lab., Univ. of California, N. Mex.). [1964]. Contract W-7405-eng-36. 5p. (CONF-650928-10). Dep. mn; CFSTI \$1.00 cy, \$0.50 mn.

From International Conference on Polarization Phenomena of Nucleons, Karlsruhe.

Results of an experiment to measure the neutron-proton correlation function, C_{NN} , at 180° c.m. and $E_n = 23$ Mev are described. The experiment consists in measuring differences in the intensity of scattered particles when a polarized beam of neutrons is incident on a polarized proton target. (M.O.W.)

2701 **A MEASUREMENT OF POLARIZATION IN NEUTRON-PROTON SCATTERING IN THE ENERGY RANGE 20-120 Mev.** Langsford, A. (Atomic Energy Research Establishment, Harwell, Eng.); Bowen, P. H.; Cox, G. C.; Huxtable, G. B.; Riddle, R. A. J. Nucl. Phys., 74: 241-60(1965). (AERE-R-4973).

The values of the polarization in neutron-proton scattering were measured in eleven energy bands between 20 and 120 Mev in the angular range 20 to 160° cm, using time-of-flight techniques. The accuracy of the measurement is greatest, typically 2 to 3%, in the middle of the energy range where little other data are available. There is fairly good agreement between experiment and the YLAN4M phase-shift analysis predictions in the general angle and energy dependence of the polarization values. Attention is drawn to the fact that some discrepancies exist which exceed the combined experimental and phase-shift prediction errors. (auth)

2726 RANGE OF VALIDITY OF THE ONE-BOSON-EXCHANGE MODEL. Hamu, Yojiro; Hoshizaki, Norio (Kyoto Univ.). *Progr. Theoret. Phys. (Kyoto)*, **34**: 455-61 (Sept. 1965).

The validity of the one-boson-exchange model is discussed in connection with the nucleon-nucleon scattering. From a consideration of the asymptotic behavior of the phase shifts calculated with this model as the incident energy goes to infinity, it is shown that an appropriate limitation in energy must be imposed in order that the theory does not present contradiction with the Levinson theorem. A practical limit of applicability of the model is effectively established in terms of the impact parameter whose critical value is fixed to be $0.4 \sim 0.6 \hbar/\mu_{\pi c}$; for those values of the impact parameter smaller than this, the theory does not work. An alternate estimate of the critical value is given in terms of the ranges of the forces due to the exchange of each boson, showing a reasonable agreement with the former value. A discussion concerning the inclusion of other bosons not yet discovered is also given. (auth)

4588 (UCRL-11565) POLARIZATION PARAMETER IN PROTON-PROTON SCATTERING FROM 328 TO 736 Mev [Thesis]. Betz, Frederick William (Lawrence Radiation Lab., Univ. of California, Berkeley). Aug. 11, 1964. Contract W-7405-eng-48. 90p. Dep. mn; CFSTI \$3.00 cy, \$0.75 mn.

The polarization parameter in elastic proton-proton scattering was measured at several energies and angles. The unpolarized external proton beam from the 184-inch synchrocyclotron was made incident upon a polarized target. The full energy of the beam was degraded by means of copper absorber to obtain beams with laboratory kinetic energies of 328, 614, 679, and 736 Mev. The elastic proton-proton scatterings were kinematically separated from background events by detection of both protons in coincidence with the use of scintillation counters. Measurements were made in the center-of-mass angular region from 33 to 110 degrees (at smaller angles the slower proton lacked sufficient range to emerge from the target). The target was polarized by means of a technique called dynamic nuclear orientation. Its polarization was measured by monitoring the nuclear magnetic resonance signal of the free protons in the target. This signal was calibrated in terms of absolute magnitude of polarization by measurement of the temperature of the proton system and the frequency of its resonance when the polarization of the target was enhanced. The experimental procedure was to count the number of elastic scatterings into a solid angle with the polarization of the target parallel to the normal to the scattering plane and then, under identical conditions, to count the elastic scatterings with the direction of the polarization of the target reversed. The measured values of the polarization parameter are presented as a function of angle for each incident proton energy. (auth)

4590 (UCRL-11926) NUCLEON-NUCLEON POLARIZATION AT 700, 600, 500, AND 400 Mev [Thesis]. Cheng, David (Lawrence Radiation Lab., Univ. of California, Berkeley). July 1, 1965. Contract W-7405-eng-48. 105p. Dep. mn; CFSTI \$4.00 cy, \$0.75 mn.

The polarization parameters for the two-nucleon systems were measured at the 184-in. cyclotron at beam energies of

700, 600, 500, 400 and 310 Mev. They are measured for both the pp and pn systems by means of a polarized proton beam initially produced by scattering the external proton beam on a carbon target at ± 6 deg, and then scattered in a liquid hydrogen target or a liquid deuterium target. The asymmetry is measured by reversing the sign of the beam polarization by reversing the pC scattering angle. The angular range treated is between 30 and 150 deg in the center-of-mass system, and involves measurements at eight angular positions at each energy. In order to calibrate the beam polarization, the polarization parameter for pC is also measured at the above energies in the forward direction between 6 and 14 deg in the laboratory frame. When fitting both the differential cross section, I_0 , and polarization, P , with all the data available in this energy region, in terms of power series, the differential cross sections in both the pp and pn systems were found to vary with energy to a greater extent than the polarization parameters. From these fits, I_0 and P , for the isotopic spin singlet ($I = 0$) state of the 2-nucleon system is also calculated. (M.O.W.)

4597 DIRECT NUMERICAL INTEGRATION OF THE TWO-NUCLEON SCHRÖDINGER EQUATION WITH TENSOR FORCES. Lovitch, Lionel (Istituto Nazionale di Fisica Nucleare, Pisa, Italy); Rosati, Sergio. *Phys. Rev.*, **140**: B877-82 (Nov. 22, 1965).

The technique of middle-point matching accompanied by an iterative application of suitable correction formulas for trial values of corresponding parameters is considered in integrating a two-channel Schrödinger equation. In the case of the deuteron wave equations, when tensor forces are taken into account, a correction formula for improving an initial energy value is used in obtaining the binding energy and the corresponding wave functions, the formula giving quadratic convergence. The extension of the method to nucleon-nucleon scattering states is straightforward and the variable quantities are, in that case, the parameters of a phenomenological potential. (auth)

4599 M(12) PREDICTIONS FOR pp SCATTERING. Freund, P. G. O.; Lo, S. Y. (Univ. of Chicago). *Phys. Rev.*, **140**: B927-8 (Nov. 22, 1965). (COO-264-265).

The relations $A = -R'$, $A' = R$, $C_{KP} = 0$, $C_{PP} = C_{KK}$ and $C_{NN}(\theta) = D(\theta) + D(\pi - \theta) - 1$ between the standard parameters of pp scattering are derived from M(12) invariance and compared with experiment. The applicability of M(12) invariance to scattering processes is discussed. (auth)

4603 ASYMPTOTIC BEHAVIOR OF THE FORWARD-SCATTERING AMPLITUDE. Banerjee, Haridas (Univ. of Delhi). *Phys. Rev.*, **140**: B989-91 (Nov. 22, 1965).

It is argued on the basis of unitarity and analyticity properties of the scattering amplitude that the total cross section in high-energy scattering should be bounded by $s^{-1/2} \ln^2 s$, where s is the square of the center-of-mass energy. The high-energy accelerator data on pp scattering and cosmic-ray data on pp scattering are quite consistent with the law $\sigma_{\text{tot}} \propto s^{-1/2}$ asymptotically. If it is further assumed that in the asymptotic limit particle and

antiparticle cross sections are identical, the ratio α of the real and the imaginary parts of the forward scattering amplitude in the asymptotic limit is obtained as the value $\alpha \approx -0.4$, which is in fairly good agreement with the results of recent experiments on pp scattering. (auth)

4605 COMPARISON OF NUCLEON-NUCLEON SCATTERING DATA WITH THE PREDICTIONS OF $SU(12)_F$. Kantor, P. B.; Kuo, T. K.; Peterls, Ronald F.; Trueman, T. L. (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 140: B1008-12 (Nov. 22, 1965). (BNL-9295).

The form of the nucleon-nucleon scattering amplitude is determined subject to the restriction that baryon-baryon scattering be invariant under $SU(12)_F$ transformations. The results are found to disagree with experiment. The possibility that $SU(12)_F$ may be a "leading approximation" to a true S-matrix theory is discussed briefly. (auth)

4613 EXPLICIT WAVE FUNCTIONS FOR ANY SPIN. Frishman, Y. (Weizmann Inst., Rehovoth, Israel); Gotsman, E. Phys. Rev., 140: B1151-6 (Nov. 22, 1965). (IA-1040).

A general method is given for calculating the exact form of the helicity eigenstates of a wave function for any spin. Explicit expressions of the wave functions for spin $S = 1, \frac{3}{2}, 2$, and $\frac{5}{2}$ are listed. Examples of helicity amplitudes for the production of $S = \frac{3}{2}^+$ and $S = \frac{5}{2}^+$ isobars in proton-proton scattering are computed. (auth)

4637 NEW POSSIBILITIES FOR INVESTIGATING NUCLEON, PION AND GAMMA-QUANTA REACTIONS ON POLARIZED HYDROGEN TARGETS. Lapidus, L. I. (Joint Inst. for Nuclear Research, Dubna, USSR). pp 232-6 of Physics and Techniques of Low Temperatures. Prague, Publishing House of the Czechoslovak Academy of Sciences, 1964.

A short survey is given of new experimental possibilities with elementary particles, especially at high energies, using polarized hydrogen targets. These new possibilities belong to an important branch of research, the investigation of polarization effects, a source of much new information difficult to obtain in any other way. Examples of such possibilities are discussed. One of these is elastic scattering in which the polarization of initially unpolarized particles is equal to the asymmetry in the scattering cross section on a polarized target, thus the cross section asymmetry, which is simpler, may be studied in order to find this polarization. Other examples include meson (π)-nucleon, nucleon-nucleon scattering, the scattering of γ quanta on protons and nuclei, and scattering of high-energy electrons on protons. (J.F.P.)

4849 (UCRL-14360, pp 1-50) NUCLEAR AND ATOMIC PHYSICS. (Lawrence Radiation Lab., Univ. of California, Livermore).

The experimental and theoretical studies carried out

during the period in elementary-particle and nuclear physics are summarized, together with observations on the magnetic properties of KO_2 , PuO_2 , $NiSe$, NiS , and $FeTe$. (D.C.W.)

6046 PROTON-PROTON BREMSSTRAHLUNG AT 158 Mev. Gottschalk, B.; Shlaer, W. J.; Wang, K. H. (Harvard Univ., Cambridge, Mass.). Nucl. Phys., 75: 549-60 (1966).

The reaction $p + p \rightarrow p + p + \gamma$ was investigated for coplanar protons with symmetric angles of 30, 32.5, 35, 37.5, and 40°. The cross sections integrated over all γ -ray angles are respectively 7.8, 10.1, 12.4, 13.3, and 23.8 $\mu b/sterad^2 \pm 20\%$. For each proton angle, the angular distribution of the emitted γ ray was inferred and was found to be almost uniform with a slight tendency to forward peaking. (auth)

6049 CALCULATION OF s-WAVE NUCLEON-NUCLEON SCATTERING PARAMETERS IN THE $I = 0, S = 1$ STATE BY THE N/D METHOD. Bose, Sudesh (Univ., Delhi). Nucl. Phys., 75: 682-6 (1966).

Balázs' method of approximating the N function by two poles is applied to calculate the scattering length and effective range for s-wave nucleon-nucleon scattering in the $I = 0, S = 1$ state. The residue of the poles is determined by matching the scattering amplitude and its derivative with those obtained from the fixed s dispersion relation. Only the contributions of π, η, ρ , and ω poles are retained in the fixed s dispersion relation. The agreement between the calculated and the experimental values is found to be reasonably good. (auth)

6053 ON A BREMSSTRAHLUNG THEORY FOR THE MULTIPLE PRODUCTION OF MESONS. Blasas, A.; Ruijgrok, T. (CERN, Geneva). Nuovo Cimento (10), 39: 1061-81 (Oct. 16, 1965).

The bremsstrahlung theory of multiple meson production in very-high-energy nucleon-nucleon collisions is considered. The motion of the nucleons is represented by an orbit, chosen in such a way that the energy and momentum loss are in rough agreement with the observed values of the inelasticity K and the transverse momentum q . The field equation for the meson field is then solved in the natural scalar meson approximation. Assuming that there is no other mechanism for the production of mesons it is then possible to calculate for the final state the average number of mesons for each momentum value. From this, the following quantities were computed; the average multiplicity, the width of the diffraction peak for elastic scattering, the distributions of longitudinal and transverse momentum, and the distributions of $\log \cotg \theta/2$ and of the azimuthal angle. Where possible a comparison with the experimental results was made. Qualitatively the comparison is quite encouraging. The conclusion is that a more realistic version of the bremsstrahlung theory is likely to explain many features of multiple meson production at very high energies. (auth)

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6056 MEASUREMENT OF PROTON-PROTON TRIPLE SCATTERING AT 430 Mev. Roth, R. (Princeton Univ., N. J.); Engels, E. Jr.; Wright, S. C.; Kloeppel, P.; Handler, R.; Pondrom, Lee G. Phys. Rev., 140: B1533-40 (Dec. 20, 1965). (COO-881-53).

The polarization parameters P , D , R , A , and A' were measured at seven scattering angles between 30 and 120° in the center-of-mass system with an incident energy of 430 Mev. A 56% polarized beam was prepared by scattering on an internal beryllium target. A liquid-hydrogen target was used for the p-p scattering, and the outgoing polarization was analyzed with a third scattering in the carbon plates of a spark chamber. The scattering asymmetry ϵ was determined by fitting the data to a distribution $1 + \epsilon \cos \theta$ by the maximum-likelihood method. The analyzing power of the spark chamber as a function of energy was measured in beams of known polarization. The beam polarization before and after the p-p scattering was manipulated with a solenoid and two bending magnets. The measurements are compared with the extrapolations of several phase-shift and resonance analyses of experimental data at higher and lower energies. (auth)

7785 (GA-6712) PARTIALLY INELASTIC TWO-BODY COLLISIONS. Rothbart, G. B. (General Atomic, San Diego, Calif. John Jay Hopkins Lab. for Pure and Applied Science). Oct. 27, 1965. Contract AT(04-3)-167. 13p. Dep. mn; CFSTI \$1.00 cy, \$0.50 mn.

Theoretical expressions were derived in order to more fully understand experimental observations and to prepare optimum experimental conditions in which neutrons experience partially inelastic collisions. (M.O.W.)

7788 (JINR-E-2440) NUCLEON-NUCLEON POTENTIAL WITH A SOFT CORE FOR THE 1S_0 STATE IN THE ENERGY REGION 0.17-310 Mev. Bystritskii, I.; Legar, F.; Ulegla, I. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1965. 6p. Dep. mn.

Nucleon-nucleon potentials with a soft core, giving a good description of the energy dependence of the 1S_0 state phase shifts in elastic p-p and n-p scattering, are found. However, at low energies the simultaneous description of p-p and n-p scattering in the 1S_0 state with the help of a single potential is in disagreement with the experimental data. (auth)

7789 (JINR-P-2349) TENZOR POLYARIZATSI PRI RASSEYANII POLYARIZOVANNYKH NUKLONOV NA POLYARIZOVANNOI PROTONNOI MISHENI. (The Polarization Tensor in Scattering of Polarized Nucleons on a Proton Target). Bilenkaya, I.; Vinternits, P.; Legar, F.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1965. 114p. Dep. mn.

The tensor components were calculated and discussed according to the phase shift data in the energy range 23.1 to 630 Mev. (auth)

7791 (JINR-P-2382) OBRAZOVANIE π -MEZONOV V REAKTSII $NN \rightarrow NN\pi$ NA POLYARIZOVANNYKH NUKLONAKH V MODELI ODNOPIONNOGO OBMENA. (Pion Production in the $N + N \rightarrow N + N + \pi$ Reaction on Polarized Nucleons in the OPE Model). Nurusev, S. B.; Solovyanov, V. L. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 22p. Dep. mn.

Assuming that inelastic nucleon-nucleon interaction involving single pion production can be described by the one-pion exchange diagram a calculation is made of energy spectra and left-right asymmetry in pion emission by collisions of 600 Mev polarized protons with unpolarized target protons. The results of calculations are in quantitative agreement with experimental data on positive pion production in the $pp \rightarrow pn\pi^+$ reaction. (auth)

7796 (JINR-P-2407) TENZOR SPINOVOI KORRELYATSI PRI RASSEYANII POLYARIZOVANNYKH NUKLONOV NA PROTONNOI POLYARIZOVANNOI MISHENI. (Spin Correlation Tensor in the Scattering of Polarized Nucleons on a Polarized Proton Target). Winternits, P.; Legar, F.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1965. 40p. Dep. mn.

Experiments concerning the spin correlation tensor C in the scattering of polarized nucleons on polarized nucleons are discussed. Relativistic formulas are derived for the experimental quantities. Components of C are predicted for the energies 23.1, 40, 52, 95, 147, 210, 310, 400, and 630 Mev on the basis of various sets of phase shifts, and are given on graphs. The scattering matrix is directly reconstructed with the help of experimentally measured quantities. (auth)

7818 THE 720 Mev S-WAVE π - π RESONANCE AND THE ONE-BOSON EXCHANGE MODEL OF N-N SCATTERING. Kikugawa, M. (Hiroshima Univ.); Sawada, S.; Yonezawa, M.; Ueda, T.; Watari, W. Nuovo Cimento (10), 40A: 647-9 (Nov. 21, 1965).

It is pointed out that the recently reported $I = 0$, $J^P = 0^+$ π - π resonance with mass ~ 720 Mev and width ~ 50 Mev may be the scalar meson predicted by the one-boson exchange (OBE) model of N-N scattering. Discrepancies between the predicted mass for this unitary singlet and the observed mass are discussed. The possibility that the observed resonance may be part of the 0^+ triplet or the 0^+ octet is also considered. The relation of the S-wave scalar meson predicted by the OBE model to the behavior of the π -N scattering length and phase shift is discussed. (M.J.T.)

7840 APPLICATION OF THE DASHEN-FRAUTSCH METHOD TO THE CALCULATION OF THE DIFFERENCE BETWEEN THE nn AND np SINGLET SCATTERING LENGTHS. Goldberg, H. (Faculte des Sciences, Orsay, France). Nuovo Cimento (10), 40B: 243-66 (Nov. 11, 1965).

The difference between the 1S_0 np and nn scattering lengths is calculated by a method due to Dashen and Frautschi. In the calculation the driving term used is the change in the one-pion exchange contribution between the

two channels due to differences in the charged and neutral pion masses which are exchanged, in the charged and neutral π - N coupling constants, and in the external proton and neutron masses. The split in the coupling constants is also estimated with the same formalism and constitutes an independent result. The over-all result obtained is $a_{nn} - a_{np} = -(3.8 \pm 3.4)$ fermi, if the elementary-particle physics definition of scattering length is used. This is in qualitative agreement with recent experimental findings. (auth)

7841 ON THE DETERMINATION OF THE PROTON-PROTON 1S_0 SHAPE PARAMETER. Slobodrian, R. J. (Univ. of California, Berkeley). Nuovo Cimento (10), 40B: 443-5 (Dec. 11, 1965).

It is shown that the 1S_0 shape parameter for proton-proton scattering cannot be determined with certainty on the basis of shape-dependent fits to the five accurately-known experimental phase shifts (at 0.38 to 3.04 Mev lab), with and without the vacuum polarization correction. The effects of fits at only four or three points are also considered. Results of a least squares fit to the data are summarized. It is concluded that existing data do not confirm as yet the validity of the vacuum polarization correction. (M.J.T.)

7870 ON THE POSSIBILITY OF USING NUCLEAR REACTORS IN COSMIC SPACE FOR DIRECT MEASUREMENTS OF nn SCATTERING CROSS SECTIONS. Bondarenko, I. I.; Kovalev, V. P.; Zolotukhin, V. G. Yadern. Fiz., 2: 839-42 (Nov. 1965). (In Russian).

An analysis of an experiment for the direct measurement of the n - n scattering cross section in the singlet state is performed. For the measurement of the cross section, a pulsed nuclear reactor having a negative temperature coefficient and located in cosmic space at an altitude of 400 to 500 km is proposed. It is shown that the scattering length can be determined with an error of $\pm 10\%$. (auth)

7874 MEASUREMENT OF THE POLARIZATION IN pp SCATTERING AT 667 Mev. Azhgirei, L. S.; Kumeikin, Yu. P.; Meshcheryakov, M. G.; Nurushev, S. B.; Solovyanov, V. L.; Stoletov, G. D. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 2: 892-6 (Nov. 1965). (In Russian).

The polarization in p - p scattering was studied in a double scattering experiment. For large angles, renormalization of the data at 635 Mev was performed. The polarization was observed to increase with energy from 602 to 656 Mev. The angular distribution of the polarization of 667 Mev shows a considerable contribution from the triplet states with orbital momenta up to $l = 5$. A set of phase shifts that describe the polarization and other experimental data in the region near 660 Mev is included. (D.C.W.)

7882 THE PHYSICS OF ELEMENTARY PARTICLES. Muirhead, H. New York, Pergamon Press, 1965. 751p. \$20.00.

The physical principles that are used to describe the properties and behavior of the elementary particles are discussed. The topics included are the discovery and classification of elementary particles, intrinsic properties of particles, quantized field theory, quantum theory of noninteracting fields, symmetry properties of free fields, field interactions, S -matrix, invariance properties, dispersion relations, and electromagnetic, weak, and strong interactions. (C.E.S.)

7883 POLARIZATION PARAMETER IN PROTON-PROTON SCATTERING FROM 328 TO 736 Mev [Thesis]. Betz, Frederick William. Berkeley, Calif., Univ. of California, 1965. 91p.

The polarization parameter in elastic proton-proton scattering was measured at several energies and angles. The unpolarized external proton beam from the 184-inch synchrocyclotron was made incident upon a polarized target. The full energy of the beam was degraded by means of copper absorbers to obtain beams with laboratory kinetic energies of 328, 614, 679, and 736 Mev. The elastic proton-proton scatterings were kinematically separated from background events by detection of both protons in coincidence with the use of scintillation counters. Measurements were made in the center-of-mass angular region from 33 to 110 degrees (at smaller angles the slower proton lacked sufficient range to emerge from the target). The target was polarized by means of a technique called dynamic nuclear orientation. Its polarization was measured by monitoring the nuclear magnetic resonance signal of the free protons in the target. This signal was calibrated in terms of absolute magnitude of polarization by measurement of the temperature of the proton system and the frequency of its resonance when the polarization of the target was unenhanced. The experimental procedure was to count the number of elastic scatterings into a solid angle with the polarization of the target parallel to the normal to the scattering plane and then, under identical conditions, to count the elastic scatterings with the direction of the polarization of the target reversed. The measured values of the polarization parameter are presented as a function of angle for each incident proton energy. (Dissertation Abstr.)

9727 SPIN CORRELATION EXPERIMENTS IN PROTON-PROTON SCATTERING AT 380 Mev. Allaby, J. V.; Chisholm, A.; Eades, J.; James, A. N. (Univ. of Liverpool). Nucl. Phys., 77: 449-64 (1966).

Measurements of the spin correlation parameters C_{nn} and C_{kp} for 45° center-of-mass proton-proton scattering are described. The measurements were made using counter techniques to detect asymmetries following simultaneous rescattering of both protons in carbon polarization analyzers. The results obtained were $C_{nn} = +0.30 \pm 0.10$ and $C_{kp} = +0.10 \pm 0.08$. (auth)

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9728 MONTE CARLO CALCULATIONS OF SPURIOUS ASYMMETRIES IN SPIN CORRELATION EXPERIMENTS. Eades, J. (Univ. of Liverpool). Nucl. Phys., 77: 465-71(1966).

A Monte Carlo calculation of the instrumental asymmetry in correlation experiments described previously is given. This calculation includes the effect of multiple scattering material in the path of the lower energy proton from the p-p scattering. As expected, the result was to reduce the value of the instrumental asymmetry. (auth)

9746 MESON-NUCLEON COUPLING CONSTANTS FROM PROTON-PROTON SCATTERING ANALYSIS. Kocpp, G.; Kramer, G. Phys. Lett., 19: 593-5(Dec. 15, 1965).

An attempt to determine the nucleon coupling constants of the well established vector mesons ρ , ω and ϕ , the meson (η) and a recently discovered scalar $I = 0$ meson, called s by a best fit to partial wave scattering matrix elements obtained from phase shift analysis of experimental proton-proton scattering data below 300 Mev, is described. It is assumed that unitarity is not important for the small partial wave amplitudes of large angular momenta and that these are entirely given by the one-particle exchange contribution of the mesons with low mass. The main results are summarized. First a $J = 0$ $\pi\pi$ contribution around 400 Mev must be present and second the constants g_{ω_1} and g_{ρ_1} come out in agreement with the SU(6) relation $g_{\omega_1}/g_{\rho_1} = 3$. (J.F.P.)

9777 ON THE PHASE-SHIFT ANALYSIS OF THE NUCLEON-NUCLEON SCATTERING ABOVE 1 Gev. Hama, Yogi; Hoshizaki, Norio (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 34: 584-93(Oct. 1965).

A method for analyzing nucleon-nucleon scattering experiments in the Bev-energy region is proposed. The new scheme is based on an explicit inclusion, in the intermediate-angular-momentum states, of contributions from one-boson-exchange processes and on an assumption that the absorption coefficients can be represented by a smooth function of the orbital angular momentum l , taken as a continuous variable. The phase shifts with higher l are assumed as usual to be represented by OPEC, and those with lower l are determined from the experimental data by the least-squares method. The reliability of the new approach is checked by applying it to an analysis of the p-p scattering data at 970 Mev. The previously found solutions of peripheral- and central-absorption types are obtained again: this fact suggests that the method works well. A discussion on the range of validity of the one-boson-exchange model is given, by which the previously obtained conclusion that its use must be restricted to the region where the impact parameter is larger than some critical value $b_{crit} \sim 0.5\hbar/\mu_{\pi}c$ is confirmed. (auth)

9778 DISPERSION THEORETIC CALCULATION OF TWO-PION-EXCHANGE CONTRIBUTION IN NUCLEON-NUCLEON SCATTERING. I. FORMULATIONS AND GENERAL RESULTS OF NUMERICAL CALCULATION.

Furutchi, Susumu; Watari, Wataro (Rikkyo Univ., Tokyo. Osaka City Univ.). Progr. Theoret. Phys. (Kyoto), 34: 594-631(Oct. 1965).

The two-pion-exchange contribution without pion-pion correlation in nucleon-nucleon scattering is investigated in detail using the partial-wave dispersion relation. With the aim to clarify the contribution the amplitude is divided into the contributions corresponding to the fourth order perturbation (N-part) and the additional effect from the pion-nucleon resonance in the (33) state (33 part), and each part is further divided with respect to the angular momentum of the exchanged two pions, L , so that the characteristics of quantities appearing in the intermediate steps of calculation such as the effective mass distribution functions may be presented in a somewhat concrete way. Through the investigation of the effective mass distribution functions, it is found that (i) the 33 part contributes mostly to the $L = 0$ and 1 parts, which are the lowest L contributions to $h^{(a)}$ and $h^{(b)}$ respectively, where the whole amplitude is described as $h^{(a)} + \tau^{(1)}\tau^{(2)}h^{(b)}$ for the isospin freedom; (ii) the relative order of magnitude of 33 part to N part shows that the (33) effect is considerably large for $L = 0$ part at the large effective mass region. This means that the effects of (33) πN resonance in the two-pion-exchange contribution for the nucleon-nucleon scattering have a very similar behavior to the one-scalar-boson exchange contributions, where relatively large effective masses are assumed. Consequently, such features of the 33 part is likely to specify the characteristics of the two-pion-exchange contributions. In fact, the (33) effect is generally very large for lower partial wave amplitudes than the F wave, in the form of "proper" 2π contribution. Comparison with other calculations and discussions of related problems are also given. (auth)

9786 PROPOSED TECHNIQUE FOR NEUTRON-PROTON ANGULAR DISTRIBUTION MEASUREMENTS IN THE 15 TO 30 Mev RANGE. Benenson, R. E. (City Coll. of New York, New York. Columbia Univ., New York). 16p. (CONF-650653-7). ORINS. Gmelin, AED-CONF-65-170-24.

From American Physical Society, Summer Meeting, New York.

A system of radiator, magnet field, and high resolution detector is proposed as an approach to high accuracy neutron-proton differential cross section measurements. A single detector serves as an array with an azimuthal angle spread defined by the detector height. Some geometrical considerations of the magnetic field and some practical considerations in the fabrication of the magnet are presented. In addition to neutron-proton scattering, this technique could also find application with either neutrons or charged particle beams for other target materials in solid form as long as the highest particle momenta do not exceed limitations imposed by the magnetic field. (J.F.P.)

11544 (JINR-P-2462) OBRAZOVANIE π -MEZONOV V (n-p)-STOLKNOVENIYAKH PRI ENERGII 600 Mev. (Pion Production in (n-p) Collisions at 600 Mev). Kazarinov, Yu. M.; Simonov, Yu. N. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 18p. Dep. mn.

Angular distributions of charged pions and total production cross sections of neutral pions generated in n-p collisions at 600 $\pm$ 10 Mev were measured. It was found that $\sigma_{\pi^0}(\theta) = [(0.115 \pm 0.005) + (0.004 \pm 0.013) \cos \theta + (0.04 \pm 0.02) \cos^2 \theta] \times (1.073 \pm 0.104) \times 10^{-27} \text{ cm}^2/\text{sterad}$, in the cms of the colliding nucleons. The total cross sections of the reactions are $\sigma(np \rightarrow \pi^0) = (4.6 \pm 0.6) \times 10^{-27} \text{ cm}^2$ and $\sigma(np \rightarrow \pi^+) = \sigma(np \rightarrow \pi^-) = (1.68 \pm 0.17) \times 10^{-27} \text{ cm}^2$. The obtained data do not contradict the hypothesis of charge independence of nuclear forces. The cross sections for pion production in collisions of two nucleons in states with total isotopic spin $T = 0$ and $T = 1$ are equal to $(4.4 \pm 0.6) \times 10^{-27}$ and $(10.85 \pm 0.42) \times 10^{-27} \text{ cm}^2$, respectively. (auth)

11617 RE-NORMALIZATION OF POLARIZATION IN n-p SCATTERING AT MEDIUM ENERGIES. Rose, B. (Atomic Energy Research Establishment, Harwell, Eng.). Phys. Lett., 20: 86-8 (Jan. 15, 1966).

Published data on polarization in n-p scattering at medium energies are reconsidered, and certain renormalizing factors and normalization errors are proposed. (D.C.W.)

11622 DETERMINATION OF THE NUCLEON-NUCLEON ELASTIC-SCATTERING MATRIX. IV. COMPARISON OF ENERGY-DEPENDENT AND ENERGY-INDEPENDENT PHASE-SHIFT ANALYSES. Arndt, Richard A.; MacGregor, Malcolm H. (Univ. of California, Livermore). Phys. Rev., 141: 873-88 (Jan. 1966). (UCRL-14252-T).

(p,p) and (n,p) scattering data in six energy bands centered at 25, 50, 95, 142, 210, and 330 Mev. were analyzed. First an energy-dependent analysis was carried out. Then phase-shift energy derivatives were extracted from this analysis and used in carrying out accurate energy-independent analyses. The energy-dependent phase-shift forms were chosen to have a singularity structure consistent with the requirements of partial-wave dispersion equations. A very rapid search procedure was utilized. The isotopic spin-1 scattering matrix was accurately determined over the energy range under consideration. The isotopic spin-0 scattering matrix was also determined, but not to the same accuracy, because of the incompleteness of the (n,p) data selection. The phase-shift analyses were carried out, and the pion-nucleon coupling constant g^2 was determined, using first (p,p) and then (p,p) plus (n,p) data selections. The results were a further substantiation of the charge independence hypothesis. Matrix methods used for the search procedures are discussed, and it is shown how the data normalization constants can be eliminated from the search. A discussion is also included of the use of the inverse error matrix in obtaining quantitative fits with theoretical models. (auth)

11624 MEASUREMENT OF THE N^{*-} - N^{*++} MASS DIFFERENCE. Gidal, George; Kernan, Anne; Kim, Sedong (Univ. of California, Berkeley). Phys. Rev., 141: 1261-7 (Jan. 1966). (UCRL-16096; UCRL-16096(Rev.)).

A measurement of the N^{*-} - N^{*++} mass and width differences is described, where N^* is the nucleon resonance with $(J^P) = 3/2(1/2^+)$ and mass approximately 1240 Mev. The

resonances were produced in the inelastic reactions $n n \rightarrow p n \pi^-$ and $p p \rightarrow n p \pi^+$, which are known to proceed almost entirely via N^{*-} and N^{*++} production, respectively, in the observed energy region. A comparison of the $(n\pi^-)$ and $(p\pi^+)$ effective-mass distributions gives a mass difference of 7.9 ± 6.8 Mev and a width difference of 25 ± 23 Mev for N^{*-} - N^{*++} . This result agrees with predictions based on the SU(3) and SU(6) symmetry schemes. (auth)

11642 PRODUCTION AND ABSORPTION OF S-WAVE PIONS AT LOW ENERGY BY TWO NUCLEONS. Koltun, D. S.; Reitan, A. (Univ. of Rochester, N. Y.). Phys. Rev., 141: 1413-18 (Jan. 1966). (UR-875-88).

The cross sections for the reactions $p + p \rightarrow d + \pi^+$ and $p + p \rightarrow p + p + \pi^0$ are calculated for s-wave pions at threshold. The meson (π) is produced by either nucleon, and emitted directly or rescattered in an s wave by the second nucleon, through a modified static interaction. The two nucleons interact through a phenomenological potential. For the Hamada-Johnston potential both calculated cross sections agree with experimental results. Application of the method of calculation to the nuclear absorption of s-wave pions is discussed. (auth)

11652 DYNAMICAL INELASTICITY AND HIGH-ENERGY p-p SCATTERING. Islam, M. M. (Brown Univ., Providence). Phys. Rev., 141: 1524-8 (Jan. 1966).

A recently proposed method for calculating partial-wave inelasticity dynamically is applied to the high-energy p-p scattering. The two nucleons are considered spinless. Their left-hand-cut contribution is calculated by making a δ -function approximation of the absorptive part in the crossed channel. Partial waves with $l \leq l_2$ are taken to be completely imaginary and those with $l > l_2$ are considered to be given by the Born term. Certain interesting features of the present model are discussed. (auth)

11671 DOUBLE NN SCATTERING WITH A POLARIZED BEAM AND A POLARIZED TARGET. Bilenski, S. M.; Lapidus, L. I.; Ryndin, R. M. (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksp. Teor. Fiz., 49: 1653-63 (Nov. 1965). (In Russian).

Possible experiments for measuring the polarization of nucleons produced as a result of scattering of a polarized beam by a polarized proton target are discussed. In such experiments it should be possible for the first time to determine the components of the third rank polarization tensor M_{ijk} . Polarization correlation is also considered in the case when one of the initial particles is polarized. Relativistic formulas for measurable quantities are derived. The problem of reconstructing the scattering matrix is discussed. (auth)

11965 (JINR-P-2426) PRIMENENIE POLYARIZOVANNOI POLYARIZOVANNOI PROTONNOI MISHENI DLYA IS-SLEDOVANIYA NUKLON-NUKLONNOGO VZAIMODEIST-

VIIA PRI NIZKIKH ENERGIYAKH. (Use of Polarized Proton Target in the Investigation of Low-Energy Nucleon-Nucleon Interactions). Winternitz, P.; Legar, F. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics. Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 168p. Dep. mn.

The possible use of a polarized proton target in the investigation of low-energy nucleon-nucleon interactions is reviewed. The reconstruction of the scattering matrix and verification of P-, T-, and isotopic invariance are briefly discussed. Possible sources and detectors of polarized particles are discussed. Detailed tables of experimental values are listed for the polarization of nucleons scattered on nucleons and complex nuclei and in nuclear reactions for energies from 0.1 to 25 Mev. All possible experimental quantities determined from the phase shift analysis are given in graphs, for the energy 23.1 Mev. 175 references. (auth)

13453 (JINR-P-2511) OBRAZOVANIE ZARYAZHEN-NYKH π -MEZONOV V SODARENIIYAKH NEITRONOV S PRONAMI PRI ENERGIH NEITRONOV 600 Mev. (Charged Meson Production in Neutron-Proton Collisions at 600 Mev Neutron Energy). Dzhelepov, V. P.; Kiselev, V. S.; Oganesyan, K. O.; Flyagin, V. B. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 24p. Dep. mn.

The production of mesons (π^+) in n-p interactions at about 600 Mev was investigated using a multichannel magnetic spectrometer. An analysis of the results shows that in spite of the dominating role of resonance pion production, it is necessary to take into account the non-resonance transfer contributions in phenomenological considerations. (D.C.W.)

13455 (UCRL-14240-T) THE SPIN STRUCTURE OF NUCLEON-NUCLEON SCATTERING. Moravcsik, Michael J. (Lawrence Radiation Lab., Univ. of California, Livermore). [nd]. Contract W-7405-eng-48. 26p. (CONF-650928-14). Dep. mn. CFSTI \$2.00 cy, \$0.50 mn.

From International Conference on Polarization Phenomena of Nucleons, Karlsruhe, Ger.

Nucleon-nucleon scattering is discussed in terms of form factors. The information that can be obtained on the dynamics of the two-nucleon interaction by an experimental determination of the form factors is stressed. (D.C.W.)

13470 THE DETERMINATION OF THE IMAGINARY PART OF PHASE SHIFTS IN ELASTIC pp-SCATTERING AT 655 Mev. Vovchenko, V. G. (Ioffe Inst. of Physics and Tech., Leningrad). Dokl. Akad. Nauk SSSR, 163: 1348-51 (Aug. 21, 1965). (In Russian).

Phase analysis of the elastic pp scattering under consideration of the meson formation data allowed the determination of only those pp systems in which the meson formation and absorption coefficients were also taken into account.

Making use of S. Mandelstam's resonance model, the production cross section of π mesons may be calculated from the original state of the pp system. Examination of the angular distribution of π mesons from the $p + p \rightarrow \pi^+ + d$ reaction at the production threshold and at $E_p = 660$ Mev indicated that the reaction goes from the 1D_2 state with an S divergence. In order to determine the parameters at an emitted proton energy of 655 Mev, the meson spectra changes at an angle of 30° in the laboratory system were used. The admixture of μ mesons and electrons in the system was small. The differential cross section of the $p + p \rightarrow \pi^+ + p + n$ reaction was calculated to be $(11.1 \pm 1.1) \times 10^{-27}$ cm². The total cross section was found to be $(3.0 \pm 0.23) \times 10^{-27}$ cm² for $\sigma(\pi^+pn)/4\pi$ and $\sigma(\pi^+d)$. Values were also obtained for the meson production cross section from other reactions. (TTT)

13489 NUCLEON-NUCLEON POTENTIAL WITH A SOFT CORE FOR THE 1S_0 STATE IN THE ENERGY REGION 0.17 - 310 Mev. Bystritskii, L.; Legar, F.; Ulegla, I. (Joint Inst. of Nuclear Research, Dubna, USSR). Phys. Lett., 20: 186-7 (Feb. 1, 1966).

A nucleon-nucleon potential with a soft core is found which describes well the energy dependence of the 1S_0 phase shift in elastic p-p and n-p scattering. However, a simultaneous description of p-p and n-p scattering consistent with the experimental data could not be made with the same potential. (auth)

13493 THE REAL PART OF THE PROTON-NEUTRON FORWARD SCATTERING AMPLITUDE. Carter, A. A. (Cavendish Lab., Cambridge, Eng.); Bugg, D. V. Phys. Lett., 20: 203-5 (Feb. 1, 1966).

The real part of the proton-neutron forward scattering amplitude was evaluated from a dispersion relation. The low energy contribution from the unphysical region may be fitted with a ρ pole alone. (auth)

13500 NEUTRON-PROTON DIFFERENTIAL CROSS SECTION AT 129 AND 150 Mev. Measday, David F. (Harvard Univ., Cambridge, Mass.). Phys. Rev., 142: 584-90 (Feb. 18, 1966).

The differential cross section for neutron-proton scattering was measured from 70 to 180° (center-of-mass system) at energies of 129 ± 1 and 150 ± 1 Mev. A neutron beam was used with an energy width of 6 Mev. The data have relative errors of from 3 to 4%. They were normalized to total-cross-section data with the aid of phase-shift analysis; differences between various solutions imply an uncertainty in the absolute value of these cross-section data of as much as 6.5%. The data at 150 Mev are shown to be more reasonable than previous data in this energy region. The data at 129 Mev agree well with earlier work. (auth)

13512 COMPARISON OF EFFECTIVE RANGES OF n-p AND p-p INTERACTIONS. Brett, G.; Friedman, K. A.; Seamon, R. E. (Yale Univ., New Haven). [Progr. Theoret. Phys. (Kyoto), 34: Suppl., 449-91(1965)]. (YALE-1807-28).

The effective ranges r_0 in 1S_0 states of n-p and p-p interactions are compared on the basis of available data. The results of H. Pierre Noyes regarding the $(r_0)_{n-p}$ being about 10% or more smaller than $(r_0)_{p-p}$ are confirmed provided the comparison is made for the most probable values of these quantities in the sense of a statistical analysis employing the current values of measured quantities with their small statistical uncertainties such as used by Noyes. Sources of systematic errors in the interpretation of experiments from which the experimental values have been derived are discussed. Among them are dynamic effects of molecular electrons for experiments above the epithermal energy region, effects of molecular binding and intermolecular interactions in experiments on the coherent n-p scattering cross section and possible deviations from the effective range approximation, the meaning of which for the $^3S_1 + ^3D_1$ state is discussed. A numerical analysis shows that combinations of systematic errors of a reasonable magnitude can result in reducing the difference $(r_0)_{p-p} - (r_0)_{n-p}$ to a much smaller value than 10%. An alternative less elaborate analysis employing a potential for all but the 1S_0 states also admits the possibility of the smaller $(r_0)_{p-p} - (r_0)_{n-p}$ difference. (auth)

13516 PHASE-SHIFT ANALYSIS OF NUCLEON-NUCLEON SCATTERING AT 400 Mev. Kazarinov, Yu. M.; Kiselev, V. S.; Simonov, Yu. N. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 2: 1095-1102 (Dec. 1965). (In Russian).

The phase-shift analysis of the nucleon-nucleon scattering at the energy close to 400 Mev was made. Five solutions satisfactorily describing the experimental data are found. Only one of these solutions seems to agree with the set of phase shifts obtained by the interpolation of the solutions for 300 and 600 Mev. (auth)

15310 (JINR-P-2608) SECHENIE ODRAZOVANIYA ZARYAZHENNYKH π -MEZONOV V (n,p)-SOUDARENIYAKH PRI EFFEKTIVNOI ENERGII NEITRONOV 585 Mev. (Production Cross Section of Charged Pions in (n,p) Collisions at the Effective Neutron Energy of 585 Mev). Basiladze, S. G.; Ermolov, P. F.; Oganessian, K. O. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 7p. Dep. mn.

Using a scintillation telescope and a liquid hydrogen target Dewar vessel, the production cross section of charged pions in neutron-proton collisions was measured at 585 Mev. The value of the cross section was found. (auth)

15321 INTEGRAL REPRESENTATIONS FOR SCATTERING AMPLITUDES. II. APPLICATION. Predazzi, E. (Univ. of Chicago). Contract AT(11-1)-264. Ann. Phys. (N. Y.), 36: 250-66(Feb. 2, 1966). (COO-264-284).

The formalism developed previously is applied to a phenomenological analysis of high energy proton-proton elastic scattering. The general experimental features appear to be satisfactorily reproduced by a simple empirical spectral function. Spin effects are neglected; for this reason the numerical comparison given here has to be taken simply as a qualitative indication and no least squares analysis has been carried on. Restricting ourselves to a potential picture and solving the inversion problem in the W.K.B. approximation, the potential is roughly reconstructed from the empirical scattering amplitude and is found to be an energy dependent generalization of a Yukawa potential whose Fourier transform is exponentially damped for large values of the momentum variable. (auth)

15356 DEVIATIONS FROM CHARGE INDEPENDENCE IN n-p AND n-n SCATTERING LENGTHS BY S-MATRIX METHODS. Biswas, S. N. (Univ. of Delhi); Kumar, Aditya; Saxena, R. P. Phys. Rev., 142: 1141-4(Feb. 25, 1966).

The difference between the zero-energy 1S_0 n-p and n-n scattering lengths is calculated, using the dispersion-theoretic method of Dashen and Frautschi, originally employed for calculating electromagnetic mass splittings. It is assumed that the deviation is due to the perturbative effect of (i) magnetic interaction between nucleons, (ii) electromagnetic mass shifts between exchange bosons, and (iii) electromagnetic mass difference between neutron and proton. The calculation predicts $a(np) - a(nn) = 3.58 F$, if the definition $\lim_{q \rightarrow 0} (q \cot \delta)^{-1} = 1/a$ is used. The result is in qualitative agreement with the experimental value $a(np) - a(nn) = 7.28 \pm 1.9 F$. The effects of the $\rho^+ - \rho^0$ mass difference and the vertex corrections, which were ignored in the calculation, may, hopefully, account for the remaining deviation. (auth)

15817 MESON RESONANCES AND NUCLEAR FORCES. Barker, Bruce M.; Gupta, Suraj N.; Haracz, Richard D. (Wayne State Univ., Detroit). Phys. Rev., 142: 1144-9 (Feb. 25, 1966).

The effect of η^- , ω^- , and ρ -meson resonances on nuclear forces is investigated with special attention to the $\eta + \pi$ exchange contribution, which requires extensive calculations. The exact relativistic results are expressed in terms of the W matrix, which was employed earlier for the one- and two-pion-exchange nucleon-nucleon interactions. It is pointed out that the relativistic approach is necessary for the treatment of nucleon-nucleon scattering up to 310 Mev, and an application of the present results to the experimental scattering data should enable us to estimate the coupling constants for the meson resonances. (auth)

17337 (AERE-R-6138) TESTS FOR T-INVARIANCE IN N-N SCATTERING. Phillips, R. J. N. (Atomic Energy Research Establishment, Harwell (England)). Jan. 1966. 12p. Dep. B19 \$0.50, HMW 2n, 6d.

Expressions are given for the polarization tensors of nucleon-nucleon scattering, assuming time-reversal (T) invariance does not hold. Some pairs of tensors, apparently related by T, prove to be equal regardless of T-invariance; others offer genuine tests of T-invariance. (auth)

17345 (JINR-P-2531) PRIMENENIE UNITARNOI SIMMETRII K MNOZHESTVENNOMU ROZHDENIYU MEZONOV. (Application of Unitary Symmetry to Multiple Meson Production). Dalbog, E. I. (Joint Inst. for Nuclear Research, Dubna (USSR), Lab. of Theoretical Physics). 1965. 7p. Dep. mn.

It is shown that the Watson theorem concerning the ratio of the average number of charged and neutral mesons in multiple production is generalized to $SU(3)$. The ratio of the number of π pions to that of π^0 and η^0 , produced by high-energy nucleon collisions is calculated. A comparison with experiment was made. (auth)

17350 (N-65-19395) THE nn SCATTERING LENGTH. Goldberg, Hyman (Paris Univ., Orsay (France). Laboratoire de Physique Theorique et Hautes Energies). Jan. 1965. 20p. (TH-85).

The contribution of the $\pi^+\pi^0$ mass difference to the difference in the 1S_0 np and nn scattering lengths is calculated by a method due to Dashen and Frautschi. In the calculation only the one-pion-exchange contribution is retained; and the difference $a_{nn} - a_{np} = -4.80F$ is obtained. The deviation of the coupling constants is also estimated, and this is shown to give negligible contribution to the difference. (STAR)

17353 THE PROTON-PROTON SINGLET S-STATE INTERACTION. Olsen, J. M.; Skavlem, S. Arbok Univ. Bergen, Mat.-Nat. Ser., No. 3, 1-11(1964).

The low energy proton-proton scattering data are described by means of a three-parameter nonmonotonic potential that is a superposition of two Yukawa potentials. The wave equation is solved by means of a variational method, and the results are tested by numerical integrations for some values of the potential parameters. Corresponding values of admissible potential parameters are plotted graphically. A parabolic relation seems to exist between two of the parameters. The low energy potentials do not fit the 310 Mev proton-proton scattering results. (auth)

17378 HIGH-ENERGY BEHAVIOR OF THE REAL PART OF THE SCATTERING AMPLITUDES AND SOME CONSEQUENCES FROM SU_3 . Igi, K.; Kawai, T. (Tokyo Univ. of Education). Nuovo Cimento (10), 41A: 609-12 (Feb. 21, 1966).

The dynamical model admitting Regge cuts to Regge poles, which was used to investigate the asymptotic behavior of the real over the imaginary part of the forward scattering amplitude, is applied to calculations of the ratios for high-energy scattering. These ratios are compared with experiment for pp and $\pi^+\pi$ scatterings, and predictions are made of these values for $p\bar{p}$, $K^+\pi$, $K^+\eta$ which are not measured experimentally. Also it is shown that a predicted relation appears to hold where the values are calculated by the same method. (J.F.P.)

17381 ONE-PARTICLE EXCHANGE MODEL FOR INELASTIC PROTON-PROTON SCATTERING. Yock, P. C. M. (Massachusetts Inst. of Tech., Cambridge). Nuovo Cimento (10), 41A: 635-7(Feb. 21, 1966). (MIT-2098-209).

The energy dependences of those proton-proton collisions which can be interpreted as the excitation of an isobar in the final state: $p + p \rightarrow N^{*+} + p$ are examined. In particular the production of the nucleon isobars with masses equal to 1238, 1430, 1512, and 1688 Mev are considered. The observed energy dependences are compared with the theoretical value obtained on the assumption of spin-zero exchange. The production angular distributions are also discussed. (J.F.P.)

17413 ON THE POSSIBILITY OF INVESTIGATING WEAK NUCLEON-NUCLEON INTERACTIONS. Lobashev, V. M. (Ioffe Inst. of Physics and Tech., Leningrad). Yadern. Fiz., 2: 957-9(Nov. 1965). (In Russian).

The reaction $n^0 + p^1 \rightarrow D^2 + \gamma$ is proposed as a means of studying a weak nucleon-nucleon interaction. A neutron trap in the active zone of a reactor would serve as a strong source of gamma quanta from the above reaction. It is estimated that a collimated beam of 10^{10} to 10^{11} quanta per second could be produced by this reaction. In principle it should be possible to measure a circular polarization on the order of 10^{-7} within a reasonable length of time. In this way it is possible to observe the contribution from a weak nucleon-nucleon interaction. By reversing the magnetic field in polarization counter at a definite frequency it should be possible to detect circularly polarized gamma quanta by electronic means. The fundamental nature of the results justifies the expenditure of a considerable amount of work required to overcome the experimental difficulties. (TTT)

17449 ANALYTICITY PROPERTIES OF THE SCATTERING AMPLITUDE FOR A VELOCITY-DEPENDENT POTENTIAL. Cirelli, R.; Montaldi, E.; Prosperi, G. M. (Univ., Milan. Istituto Nazionale di Fisica Nucleare, Milan). Nuovo Cimento (10), 41A: 456-80(Feb. 21, 1966).

A method developed in a preceding paper is applied to the study of the analyticity properties of the scattering amplitude relative to a kind of velocity-dependent potential, $V = V_0(r) - \frac{1}{2}[\Delta_2 V_1(r) + V_1(r)\Delta_2]$, which has raised some interest for the description of the low-energy nucleon-nucleon interaction. (auth)

17461 HIGH-ENERGY LARGE-MOMENTUM-TRANSFER PROCESSES AND ANALYTICITY IN COORDINATE SPACE. Wu, Tai Tsun (Harvard Univ., Cambridge, Mass.). Phys. Rev., 143: 1117-34(Mar. 25, 1966).

In nonrelativistic scattering theory, analytic potentials lead to exponentially decreasing differential cross sections for large momentum transfers. An attempt is made to adopt this connection for strong interactions. Since the differential cross section for proton-proton elastic scattering with large momentum transfers decreases exponentially with the momentum transfer, it is postulated that the wave functions of strongly interacting particles are analytic func-

tions of the coordinate variables. This assumption leads in a natural way to an exponential dependence on the transverse momentum transfer. On the basis of this, speculations are made about various scattering processes involving a total of four strongly interacting particles, two incoming and two outgoing. The results are, in some cases, less specific than those of the previous consideration. Since it is natural to consider not only two-particle but also three-particle wave functions, the speculation is also extended to some processes where three particles are produced. (auth)

19273 (BNL-929, pp 3-43) PHYSICS. (Brookhaven National Lab., Upton, N. Y.).

Research efforts devoted to particle physics, atomic and molecular physics, neutron physics, nuclear structure, and solid state physics are summarized. (J.R.D.)

19441 (JINR-E-2560) MEASUREMENT OF THE PARAMETER R IN THE ELASTIC pn -SCATTERING AT 605 Mev AND THE NUCLEON-NUCLEON PHASE SHIFT ANALYSIS. Janout, Z.; Kazarinov, Yu. M.; Lehar, F.; Pisarev, A. F.; Simonov, Yu. N. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 20p. Dep. mn.

The triple scattering parameter and the polarization in p - n scattering at 605 Mev were measured using spark chambers. Measurements were made at 90 and 125°. (D.C.W.)

19442 (JINR-E-2609) UNAMBIGUOUS PHASE-SHIFT ANALYSIS OF THE NUCLEON-NUCLEON SCATTERING AT 23.1 Mev. Bilenkaya, S. I.; Janout, Z.; Kazarinov, Yu. M.; Lehar, F. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 18p. Dep. mn.

The phase shift analysis of NN scattering was carried out with account of new data on polarization correlation in (n-p) and (p-p) collisions and of the element of the asymmetry tensor a_{33} at 23.1 Mev. The unique solution with negative mixing parameter was found to be $\epsilon_1 = -4.86 \pm 1.39$ for $l_{\max} = 2$. The phase shifts are given for $l_{\max} = 2$ and $l_{\max} = 3$ as well as the plots of the experimentally measurable quantities a_{33} for (p-p) and (n-p) scatterings. (auth)

19452 (UR-875-126, Paper 4) NUCLEON-NUCLEON BREMSSTRAHLUNG AT 200 Mev. Rothe, K. W.; Koehler, P. F. M.; Thorndike, E. H. (Rochester Univ., N. Y. Dept. of Physics and Astronomy). 18p.

An incident beam of 204-Mev protons strikes a $3''$ hydrogen target; the resulting γ -ray is detected in coincidence with two protons. The γ production cross sections are presented along with other pertinent reaction kinematics. (M.O.W.)

19453 (UR-875-126, Paper 5) NEUTRON-PROTON INTERACTIONS AT 205 Mev. Thorndike, E. H.; Reay, N. W.; Spalding, D.; Thomas, A. R. (Rochester Univ., N. Y. Dept. of Physics and Astronomy). 12p.

The neutron-proton interaction was investigated by bombarding deuterons with 205-Mev polarized protons, and observing high energy neutrons recoiling into forward angles. The parameters P and R_1 were measured. The polarization parameter P was obtained by measuring the up-down asymmetry of the recoiling neutrons. The neutrons were detected in a counter consisting of a polyethylene converter and a multi-element range telescope. Measurements were made at neutron laboratory angles between 10 and 30°. Statistical errors were typically ± 0.017 . Measurements of R_1 were made at angles between 0 and 20°, to an accuracy of typically ± 0.09 . (M.O.W.)

19454 (YALE-1807-33) NUCLEON-NUCLEON SCATTERING. Breit, G. (Yale Univ., New Haven, Conn.). Feb. 9, 1966. Contract AT(30-1)-1807. 24p. (CONF-660209-1). Dep. mn. CFSTI \$2.00 cy, \$0.50 mn.

From Conference on Intermediate Energy Physics, Williamsburg, Va.

The discussion is confined to energies at which meson production has a negligible effect. Scattering can then be described by means of real phase shifts and coupling parameters. Various aspects of nucleon-nucleon interactions are discussed, and a review of corresponding data is presented. (M.O.W.)

19477 A PERIPHERAL MODEL WITH ABSORPTION FOR THE PROCESS $N + N \rightarrow N + N^*$. Margolis, B.; Rotsstein, A. (McGill Univ., Montreal). Nuovo Cimento (10), 42A: 179-84 (1966).

The peripheral model recently introduced by Clegg for the process $N + N \rightarrow N + N^*$ is modified to include absorptive effects due to competition from other inelastic channels. The modified model is applied to the three nucleon isobars at 1238 Mev, 1512 Mev and 1688 Mev. With absorption, one finds that the theoretical values of the cross sections are in much better agreement with the experimental data. The results also justify the frequently used approximation that the complex phase shifts describing elastic scattering in the entrance and exit channels are the same and furthermore the value of the absorption parameter ν associated with these complex phase shifts is in excellent agreement with that obtained from the study of the elastic pp and $p\bar{p}$ scattering cross sections. (auth)

19494 ESTIMATE OF QUARK PRODUCTION IN HIGH-ENERGY NUCLEAR INTERACTIONS. Domokos, G.; Fulton, T. (John Hopkins Univ., Baltimore). Phys. Lett., 20: 346-8 (Mar. 15, 1966).

A statistical model estimate is made of quark production in p - p collisions. The cross section is given as a function of quark mass as well as the counting rate of production by cosmic rays, assuming that the primaries consist entirely of protons. (auth)

v.20 (1966)

19496 NUCLEAR BREMSSTRAHLUNG FROM p-p AND p-d INTERACTIONS NEAR 140 Mev. Edgington, J. A. (Cambridge Univ., Eng.); Rose, B. Phys. Lett., 20: 552-3(Mar. 15, 1966).

Differential cross sections for bremsstrahlung were measured for p-p and p-d interactions near 140 Mev. The total cross sections are, respectively, -0.01 ± 0.06 μ b and 8 ± 1 μ b for photon energies above 30 Mev and -0.06 ± 0.05 μ b and 4.0 ± 0.3 μ b for photon energies above 40 Mev. These results are compared with those of other experimenters and with theoretical predictions. (auth)

19502 POLARIZATION IN p-p ELASTIC SCATTERING FROM 0.75 TO 2.8 Gev. Longo, Michael J.; Neal, Homer A.; Overseth, Oliver E. (Univ. of Michigan, Ann Arbor). Contract NONR 1224(23). Phys. Rev. Lett., 16: 536-8(Mar. 21, 1966).

The polarization parameter in p-p elastic scattering was measured at six energies in the range from 0.75 to 2.80 Gev. The results were compared with other experimental data. (D.C.W.)

19504 REAL PART OF THE PROTON-NEUTRON SCATTERING AMPLITUDE FROM AN SU(3) REGGE-POLE MODEL. Barger, V.; Olsson, M. (Univ. of Wisconsin, Madison). Contracts AT(11-1)-881; COO-881-59. Phys. Rev. Lett., 16: 545-8(Mar. 21, 1966).

The contributions to the real part of the forward elastic-scattering amplitude $f(s,0)$ were investigated. It was shown that the condition $\rho_{pp} \approx \rho_{pn}$ ($\rho = \text{Re } f(s,0)/\text{Im } f(s,0)$) is in essential agreement with the prediction of a Regge-pole model. (D.C.W.)

19512 2^+ MESONS AND HIGH-ENERGY SCATTERING. Desai, Bipin R. (Univ. of California, Riverside); Freund, Peter G. O. Phys. Rev. Lett., 16: 622-5(Apr. 4, 1966).

A discussion is presented on whether the SU(3) nonet of the nine $J^P = 2^+$ mesons in existence explains the experimental behavior of the sum of the particle and antiparticle total cross sections in the elastic scattering process $A + B \rightarrow A + B$, where A stands for baryons and B stands for baryons or mesons, or whether additional Regge trajectories are needed. (B.G.D.)

19521 INFLUENCE OF PION RESONANCES ON LOW ENERGY PROTON-PROTON SCATTERING. Koepp, G. (II. Institut fuer Experimentalphysik, Hamburg). Z. Phys., 191: 273-301(1966). (In German).

Coupling constants of various scalar and vector mesons to the nucleon are determined from empirical proton-proton partial wave amplitudes of high angular momenta. Various fits are described and compared with predictions of unitary symmetry schemes. (auth)

21590 (CERN-66-2) MESURE DES PARAMETRES DE POLARISATION ET DE CORRELATION DE SPIN DANS LA DIFFUSION PROTON-PROTON A 600 Mev A L'AIDE D'UNE CIBLE DE PROTONS POLARISES. (Measurement of Polarization Parameters and Spin Correlation in Proton-Proton Scattering at 600 Mev by Means of a Target of Polarized Protons). Coignet, G. (European Organization for Nuclear Research, Geneva (Switzerland)). Jan. 19, 1966. 65p. Dep. mn.

The general formalism of proton-proton scattering and its relation to different experiments is reviewed. The experiments are also compared to those made without a polarized target. The beam, the polarized proton target, and the experimental detection installation used are described. A beam of protons capable of easily being transformed into a polarized beam with intensity and polarization sufficient for experimentation was constructed. The beam made it possible to evaluate the analysis capacity of carbon at 575 Mev at 1 angles. By the use of this beam with a target of polarized protons the angular distribution of the parameters of polarization P^0 and of correlation C_{XX} was measured in proton-proton scattering at 600 Mev. (J.S.R.)

21610 (CERN-65-32, pp 181-94) STUDY OF THE FEASIBILITY OF AN EXPERIMENT TO OBSERVE THE W PRODUCED IN STRONG INTERACTIONS. Good, R. H.; Mehlihop, W. A. W.; Piccioni, O.; Swanson, R. (California Univ., La Jolla, San Diego).

A feasibility study using the AGS to investigate the existence of an intermediate W boson to about 6 Bev mass value is presented. The reaction $p + p \rightarrow d + W$ followed by $W \rightarrow \mu + \nu$ is considered. The expected production cross section of the reaction is summarized along with the apparatus proposed for this study. (B.G.D.)

21617 (JINR P 2546) OB ODNOM PRIDLIZHENNOM METODE V ZADACHE DVUKH NUKLONOV. (On an Approximate Method in a Two-Nucleon Problem). Efimov, V. N. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Neutron Physics). 1966. 17p. Dep. mn.

The application of the well-known Bubnov-Galerkin's method to solving integral equations is considered. Use is made of orthogonal polynomials with weight determined by the radial dependence of the potential. An approximate factorized expression was obtained for the t-matrix off the energy surface. The Yukawa potential is considered as an example. (auth)

21621 (JINR-P-2584) OPREDELENIE PARAMETROV ODNODOZONNOI OBMENNOI MODELI PO FAZOVYM SDVIGAM UPYUGOGO NUKLON-NUKLONNOGO RASSEYANIYA. (Determination of One-Boson Exchange Model Parameters by Elastic Nucleon-Nucleon Scattering Phase Shifts). Ashgirdi, L. S.; Chizhikov, V. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 20p. Dep. mn.

The least squares method is used to determine one-

boson exchange model parameters from the nucleon-nucleon phase shifts in the energy range of 25 to 310 Mev. Different methods for the explicit unitarization of the Born partial-wave amplitudes are compared. The K-matrix unitarization is shown to give the best fit to the pp-phase shifts. For an exchange of a scalar meson (σ), a pseudo-scalar meson (π), and two vector mesons (ω and ρ) a best fit to the NN-scattering was obtained with the following parameters: $g_\sigma^2 = 2.9 \pm 0.4$; $m_\sigma = 373 \pm 13$ Mev; $g_\pi^2 = 13.1 \pm 0.2$; $g_\omega^2 = 2.1 \pm 0.5$; $f_\omega/g_\omega = 0.5 \pm 0.1$; $m_\omega = 422 \pm 18$ Mev; $g_\rho^2 = 0.1 \pm 0.3$; $f_\rho/g_\rho = -5.4 \pm 7.0$; $m_\rho = 800 \pm 120$ Mev. The energy dependencies calculated by the above parameters are compared with the results of phase shift analyses at 435 and 657 Mev. (auth)

21622 (JINR-P-2585) FAZOVYĬ ANALIZ UPUGOGO pp-RASSEYANIYA PRI 657 Mev S UCHETOM ODNOROZONNOGO OBMENA I RELYATIVISTSKIKH KULONOVSKIKH EFFEKTOV. (Elastic pp-Scattering Phase Shift at 657 Mev With Account of One-Boson Exchange and the Relativistic Coulomb Effects). Azhgirei, L. S. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 7p. Dep. mn.

The phase shift analysis of the data on elastic pp-scattering was performed in the neighborhood of 660 Mev taking into consideration relativistic corrections in the Coulomb scattering. In calculating the phase shifts of higher states of pp-system account was also taken, besides the one-pion exchange, of the scalar and two vector bosons. The one-boson exchange turns out to be essential for describing data on small-angle proton polarization. (auth)

21635 BOUNDS FOR THE CORRECTION TO THE BORN TERM AND APPLICATIONS TO p-p SCATTERING FOR A GENERALIZED DISPERSION MODEL. Binstock, Judith (Univ. of California, Berkeley). Ann. Phys. (N. Y.), 36: 435-57 (Feb. 18, 1966). (UCRL-16174).

The unitarizing corrections to the Born term, as given by the Chew-Arndt, MacGregor-Arndt (j_0 even), and Scotti-Wong models, are shown to be bounded above and below. The bounds follow from the mathematical forms of the models, to all of which forms a theorem (proved in this paper) applies. The correction bounds are given for several p-p amplitudes for the range 0 to 300 Mev. The results are shown to explain why the apparently different models mentioned above give similar Born terms after subtraction of the correction from the experimentally determined (p-p) amplitude. A generalization of these models for the unitarizing correction is proposed, which has properties leading to partial-wave dispersion relations, and which has a specified relationship between the asymptotic behavior and the fluctuation of the sign of the left-hand discontinuity. Upper and lower bounds are found for the correction term prescribed by this generalized model (which is not restricted, in its application, to nucleon-nucleon scattering). (auth)

21637 ON A CERTAIN NONLOCAL POTENTIAL. De La Cruz, V.; Orman, B. A.; Razavy, M. (Univ. of Alberta, Edmonton, Canada). Can. J. Phys., 44: 629-36 (Mar. 1966).

A solvable example of a class of nonlocal potentials, whose kernels are related to Green's functions of second-order differential equations, is examined. This solvable example is applied to a few standard problems and, in particular, acceptable numerical results are obtained for p-p scattering in the 1S state. (auth)

21680 APPLICATIONS OF A COULOMB-MODIFIED s-WAVE DISPERSION RELATION. Heller, Leon; Rich, Marvin (Univ. of California, Los Alamos, N. Mex.). Contract W-7405-eng-36. Phys. Rev., 144: 1324-38 (Apr. 29, 1966). (LA-DC-7565).

Low-energy proton-proton and neutron-neutron scattering is compared through the use of a Coulomb-modified dispersion relation. Basing the analysis upon a Jost-Bargmann potential, for which the s-wave amplitude in the uncharged case contains a single interaction pole at $q = \frac{1}{2} i\mu$, it is shown that the corresponding amplitude in the charged case contains a sequence of branch points at $q = \frac{1}{2} n i\mu$. However, a small region near the highly singular $n = 1$ point still dominates the dispersion relation. The low-energy phase shifts obtained from the solution of the dispersion relation are in excellent agreement with those obtained directly from the Schroedinger equation both for the charged and uncharged cases. In a similar analysis based upon a Yukawa potential, the convergence of the method is much slower as higher Born-approximation singularities are fed in. A technique is presented for extracting the singular parts of individual Born terms arising from superpositions of Yukawa potentials, and, serves as the basis for computing the input to the dispersion relation. This procedure does not require explicit integration of the terms of the Born series. It is also shown that the integral equation used, which was originally derived by Wong and Noyes by studying the analytic properties of the effective-range function, is identical to the D equation in the N/D method. (auth)

21689 GENERAL EFFECTIVE-RANGE FORMULA AND THE COMPOSITENESS OF THE DEUTERON. Ida, Masakuni (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 35: 104-16 (Jan. 1966).

In order to discuss the compositeness of the deuteron, experimental data on the low-energy n-p scattering in the 3S_1 state are summarized into two features by the use of a general effective-range formula introduced in a previous work. If expressed conventionally, they are: (i) $a/R - 1 = 0.25$, (ii) the effective range approximation is valid in the low-energy region. Conditions under which (ii) is true are investigated. Weinberg's argument is found to be insufficient to exclude the possibility that the deuteron is elementary. It is shown by general considerations and by an analysis in terms of a one-pole model that the features, (i) and (ii), strongly favor the deuteron to be composite. (auth)

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24017 (UCRL-11985) EXCHANGE PROCESSES AND 1S_0 n-p SCATTERING LENGTH. Shield, E.; Slobochian, R. J. (Lawrence Radiation Lab., Univ. of California, Berkeley). Mar. 10, 1965. Contract W-7405-eng-48. 7p. Dep. mn. CFSTI \$1.00 cy, \$0.50 mn.

Neutron-proton scattering is described by a wave function with a short range potential and a wave function without any defined symmetry which satisfies Schroedinger's equation. The individuality of the proton and neutron is questioned and a theory is derived for the scattering length of the 1S_0 interaction. (M.O.W.)

24018 (AERE-Trans-1047) THE PLANNING OF n-p SCATTERING EXPERIMENTS FOR DETERMINING THE MOST PROBABLE SET OF PHASE SHIFTS. Lehar, F.; Fedorov, V. V. Translated by D. L. Allan (Atomic Energy Research Establishment, Harwell (England)), from JINR Preprint R-2332. 1965. 13p. Dep. BIS \$0.50. HMSO 2s. 6d.

An optimal experiment is planned to distinguish between three sets of phase shifts in n-p scattering at 630 Mev. (auth)

24020 INVESTIGATION OF NEUTRON-PROTON SCATTERING AT 14.1 Mev WITH HIGH-PRESSURE DIFFUSION CHAMBERS. Greiner, E.; Karge, H. (Friedrich-Schiller-Univ., Jena, Ger.). Ann. Phys. (7), 16: 354-9 (1965). (In German).

The angular distribution of neutron-proton scattering at 14.1 Mev was determined in the region $180^\circ \geq \theta \geq 90^\circ$ with a high-pressure diffusion chamber. The approximation of the midpoint by a $\cos^2\theta$ -distribution yielded an anisotropy factor $\sigma(180^\circ)/\sigma(90^\circ)$ of 1.074 ± 0.04 . The results are compared with previous experimental and theoretically obtained distributions. In particular, the angular distribution measurements with a diffusion chamber are discussed. (tr-auth)

24024 ANALYSIS OF ENERGY CHARACTERISTICS OF HIGH-ENERGY NUCLEAR REACTIONS IN PHOTOEMULSIONS. Zhdanov, G. B.; Cheremiskina, A. V. Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 1938-41 (Oct. 1965). (In Russian).

Methods for determining the energy of nuclear interactions in emulsions in the presence of a fixed energy threshold are evaluated, using data on about 50 primary and 135 secondary interactions. The method of Castagnoli, $E = 2\gamma_c^2 M$, where γ_c is the cms Lorentz factor and M is the nucleon mass, is shown to be the least accurate of all existing methods. Three other methods are considered: $E = E_\gamma/K_{lab}^0$, where E_γ is the energy of the soft component of a shower and K_{lab}^0 is the corresponding coefficient of inelasticity in the lab system; $E = \bar{P}_\perp \epsilon \theta_1^{-1}/K_{lab}^0$, where $\bar{P}_\perp$ is the average transverse momentum, θ_1 is the angle of emission of the secondary particles, and K_{lab}^0 is the corresponding coefficient of inelasticity; $E = \bar{P}_\perp/\theta_0$, where θ_0 is the angle of flight of the original particle relative to the direction of the particle inducing the preceding interaction. The energy spectra of primary and secondary interactions,

calculated using these formulas, are shown and compared with experimental values. (M.J.T.)

24029 IS ABSORPTION NECESSARY IN HIGH-ENERGY INELASTIC PROCESSES? Selleri, F. (Univ., Bologna). Nuovo Cimento (10), 42: 835-43 (Apr. 21, 1966).

Two arguments are presented against the presence of important absorptive effects in high-energy physics. The first comes from the phenomenological analysis of single-pion production in pp collisions and the second from the application of the random phase approximation to the unitarity condition for an inelastic process. (auth)

24030 PION PRODUCTION IN PROTON-PROTON COLLISIONS AT 610 Mev. Busza, W. (London Univ.); Davis, D. G.; Duff, B. G.; (and others). Nuovo Cimento (10), 42: 871-7 (Apr. 21, 1966).

The process $pp \rightarrow pp\pi^0$ was studied at 610 Mev for low four-momentum transfer collisions. The angular distributions of the outgoing protons are compared with the one-pion exchange peripheral model. It is found that the form factor derived from pion production at higher energies gives good agreement between the observed and theoretical angular distributions. (auth)

24054 DIRECT MEASUREMENT OF NEUTRON-NEUTRON SCATTERING. Kuchowicz, Bronislaw. Postepy Fiz., 17: 67-9 (1966). (In Polish).

An idea was developed for an experimental accomplishment of n-n scattering. The experiment can be realized in cosmic space. The neutron source can be a pulse reactor containing enriched uranium fuel. The detector (an ionization chamber filled with ^3He) is shielded from direct neutrons and it can detect only the neutrons scattered on other neutrons from the beam. The calculations are presented for the case of 8.6×10^{17} neutrons per pulse. In this case the background is approximately 18 per cent. (auth)

24061 APPLICATION OF THE CONICAL FUNCTION AND MEAN VALUE THEOREM TO THE PROBLEMS OF SCATTERING. Liu, Yao-yang. Wu Li Hsueh Pao, 21: 1889-96 (Nov. 1965). (In Chinese).

Based on the dispersion relation, an approximate method is suggested to obtain the scattering amplitudes. In principle this method can be applied to the study of the amplitude behavior of low- and high-energy scattering. For high energy π^+p , K^+p , and pp scattering, the primary comparison with experiments is made by two parameters. It is found that the theory agrees with experiments. (auth)

24360 (UCRL-16580, pp 107-48) NUCLEAR REACTIONS AND SCATTERING. (Lawrence Radiation Lab., Univ. of California, Berkeley).

Research progress is reported on analysis of (p,t) reactions; theory and descriptions of scattering reactions; $^4\text{He}(p,d)^3\text{He}$ reactions with polarized protons; determination of proton-proton 1S_0 shape parameter; alpha scattering on ^{56}Fe ; ^{40}Ca scattering of ^3He and ^4He ; deuteron cross sections; charge effects on proton-proton scattering; and ^6Li and ^7Li proton reactions. (J.R.D.)

25785 (JINR-P-2582) DISPERSIONNYI ANALIZ UPRUGOGO RACCEYANIYA CHASTITS V OBLASTI VYSOKIKH ENERGII. (Dispersion Analysis of Elastic Scattering of High-Energy Particles). Barashnikov, V. S. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 45p. Dep. mn.

Experimental data on measurement of the real part of the elastic nN and NN scattering amplitude at zero angle are discussed. The experiment is compared with the results of dispersion calculations. (auth)

25786 (JINR-P-2630) RELYATIVISTSKOE VOSSTANOVLENIE MATRITSY N-N RASSEYANIYA. (Relativistic Reconstruction of N-N Scattering Matrix). Bilen'kil, S. M.; Lapidus, L. I.; Ryndin, R. M. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1966. 25p. Dep. mn.

It is shown how the nucleon-nucleon scattering matrix can be reconstructed from the experimental data at fixed values of the angle and energy in the relativistic case. Different reconstruction procedures are considered. Relativistic formulas were obtained for reconstructing nucleon-nucleon scattering matrix in the state with total non-zero isospin from the $n-p$ and $p-p$ scattering data. (auth)

25807 CROSS SECTION FOR PRODUCTION OF CHARGED PIONS IN $n-p$ COLLISIONS AT A NEUTRON EFFECTIVE ENERGY 585 Mev. Basiladze, S. G.; Ermolov, P. F.; Oganesyan, K. O. (Joint Inst. of Nuclear Research, Dubna, USSR). JETP Lett. (USSR) (Engl. Transl.), 3: 103-5 (Feb. 15, 1966).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redakt., 3: 163-6 (Feb. 15, 1966).

The cross section for the production of charged pions in $n-p$ interactions with $E_n = 585$ Mev was measured using a scintillation telescope placed at 90° to the neutron beam. The cross section obtained was in agreement with those obtained previously. (G.O.Y.)

25821 EXTENDED ELECTROMAGNETIC STRUCTURE EFFECTS ON LOW-ENERGY PROTON-PROTON SCATTERING. Slobodrian, R. J. (Univ. of California, Berkeley). Phys. Rev., 145: 766-71 (May 20, 1966). (UCRL-16322).

The corrections to low-energy 1S_0 $p-p$ scattering parameters, arising from the extended electromagnetic structure of the proton, are calculated in the context of nuclear-interaction models without a static core, with a soft core, and also with a hard core of radius $r_c = 0.40$ F. A comparison

of the corrected 1S_0 $p-p$ scattering length "neutralized" with an approximate formula (a_p) is made with the 1S_0 $n-n$ scattering length a_n , recently determined by reliable experimental methods with reasonable accuracy. (auth)

25832 ELECTROSTATIC EFFECTS IN NUCLEON-NUCLEON SCATTERING AT INTERMEDIATE ENERGIES. Seamon, R. E.; Friedman, K. A.; Breit, G. (Yale Univ., New Haven). Phys. Rev., 145: 779-86 (May 20, 1966). (YALE-1807-31).

Making use of a local static potential model of the nucleon-nucleon interaction, estimates are made of the effect of the electrostatic interaction on tests of long-range charge independence, with special reference to data analyses in which the $l = 1$ phase shifts are assumed to be the same in $p-p$ and $n-p$ scattering at bombarding energies above 10 Mev. The major effect found is caused by a combination of the changes in the expected values of the observables produced by the changes in the phase-parameters of the searched low- L set of $l = 1$ phases, and the associated shifts of the $l = 0$ phase-parameters of the searched low- L set that result from their adjustment to compensate for the change of the $l = 1$ set that is caused by the Coulomb corrections when a minimum of χ^2 is looked for. These effects cause an increase in the pion-nucleon coupling constant derived from $n-p$ scattering on the basis of the YRB1(K_0), YLAN4M searches by 5 to 7%, depending on details of the calculations. The violation of charge independence known to exist at very low energies in the 1S_0 state, when extrapolated to the 10-350 Mev energy range for that state by means of the model, reduces the above change by roughly 1% of g_0^2 . The direct effect of the Coulomb corrections on the one-pion-exchange (OPE) set of phases in $p-p$ scattering is to increase $(g_0^2)_{p-p}$ by an amount estimated not to be greater than 1% of g_0^2 . The values of $(g_0^2)_{p-p}$ and $(g_0^2)_{n-p}$ obtained in Yale searches of the YRB1(K_0), YLAN4M series come closer together by about 3 or 4% of g_0^2 as a result of the combined effect of corrections mentioned. Electrostatic corrections of $p-p$ phase-parameters give values of the total scattering cross section σ_{n-n} on the assumption of charge symmetry of nucleon-nucleon forces; these values are compared with recent measurements of Mensday and Palmieri. The applicability of multiple-scattering corrections of Glauber to $n-d$ scattering at the relatively low energies of the experiments is briefly discussed. In view of the uncertainties in these as well as in the electrostatic corrections, there appears to be no reason for doubting charge symmetry. On account of the schematic character of the model used, all of the electrostatic corrections reported here have qualitative significance only, having been intended for general orientation only. (auth)

25850 PLANNING OF np SCATTERING EXPERIMENTS FOR DISCRIMINATION BETWEEN VARIOUS SETS OF PHASE SHIFTS. Legar, F.; Fedorov, V. V. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 3: 693-6 (Apr. 1966). (In Russian).

An optimal experiment is planned to discriminate between the sets of phase shifts in np -scattering at 630 Mev. (auth)

25863 RECONSTRUCTION OF THE $N + N \rightarrow \pi + d$ REACTION AMPLITUDE. Shekhter, L. Sh. (Joint Inst. for Nuclear Research, Dubna, USSR). *Yadern. Fiz.*, 3: 739-51 (Apr. 1966). (In Russian).

The reconstruction of the $N + N \rightarrow \pi + d$ reaction amplitude for a given energy and scattering angle, is discussed. It is shown that it is necessary to measure the following quantities, so as to reconstruct directly the amplitude up to a common phase-factor: differential cross section for an unpolarized beam and target, left-right asymmetry for a polarized beam, left-right asymmetry for a polarized target, addition to cross section due to various orientations of the beam and target polarizations, deuteron polarization for unpolarized, transversally and longitudinally polarized initial proton beams. (auth)

25866 SPIN EFFECTS IN HIGH-ENERGY NUCLEON-NUCLEON SCATTERING. Kaidalov, A. B.; Karnakov, B. M. (Inst. of Theoretical and Experimental Physics, State Atomic Energy Commission, USSR. Moscow Engineering Physics Inst.). *Zh. Eksp. Teor. Fiz.*, 50: 691-3 (Mar. 1966). (In Russian).

Polarization of finite nucleons in NN-scattering is considered under the assumption that the main singularities in the complex j plane possess definite quantum numbers. An experimental possibility is mentioned for checking the hypothesis that the vacuum state determines the behavior of the scattering amplitude at high energies. (auth)

27816 TRANSVERSE-MOMENTUM DISTRIBUTION, MANDELSTAM REPRESENTATION AND OPTICAL POTENTIAL FOR p - p SCATTERING. Chavda, L. K.; Narayan, D. S. (Tata Inst. of Fundamental Research, Bombay). *Nuovo Cimento* (10), 43A: 382-96 (May 21, 1966).

The experimental angular distribution of particles in p - p scattering seems to depend essentially on a single variable $p_t = q \sin \theta$ instead of depending separately on the momentum q and the angle of scattering θ . For small values of p_t , the angular distribution can be represented as a Gaussian in p_t as $\exp[-ap_t^2]$ and for large values of p_t , as an exponential in p_t as $\exp[-bp_t]$. Using this empirical information a scattering amplitude which has the Mandelstam singularity structure and which leads at the same time to the empirically observed transverse momentum dependence for small and large p_t is constructed. The relevant spectral functions are calculated and the scattering amplitude expressed as the usual integrals over the spectral functions. It is shown that for spinless identical particles, the ratio of the real part to the imaginary part of the scattering amplitude in the forward direction goes to zero at high energies and that this ratio in nonforward directions is smaller than that in the forward direction. From the scattering amplitude suggested an optical potential is derived which would give approximately the observed p - p scattering. (auth)

27817 HIGH-ENERGY LARGE-ANGLE SCATTERING AND FORCES AT SMALL DISTANCES. Cottingham, W. N.; Dombey, N. (Rutherford High-Energy Lab., Chilton, Eng.).

Nuovo Cimento (10), 43A: 397-412 (May 21, 1966).

Complex potential models of proton-proton high-energy large-angle scattering are investigated. It is found that there are two essentially different kinds of potential which generate exponentially small scattering amplitudes. The potentials must be very singular at the origin or else bounded and also smooth. Experimental tests to distinguish between them are proposed. (auth)

27830 ONE-BOSON-EXCHANGE MODELS AND THE NUCLEON-NUCLEON PROBLEM. Arndt, R. A.; Bryan, R. A.; MacGregor, M. H. (Univ. of California, Livermore). *Phys. Lett.*, 21: 314-18 (May 15, 1966). (UCRL-14687-T).

The four-pole boson exchange model is fit to nucleon-nucleon data, using a matrix representation for the data. The coupling parameters thus obtained do not depend markedly on unitarity corrections applied to the model. (auth)

27856 PROTON-PROTON BREMSSTRAHLUNG. Ueda, Yoshiaki (Indiana Univ., Bloomington). *Phys. Rev.*, 145: 1214-28 (May 27, 1966).

Proton-proton bremsstrahlung is investigated by using a field-theory, as opposed to a potential, model. The one-pion-exchange model is adopted, and part of the matrix element is related to the photon-pion production matrix element, which is expressed in terms of dispersion relations. A detailed analysis shows that the Born-approximation diagrams give the dominant contribution and that the diagrams involving N^* or ρ resonances are negligible for the energy considered. The results, unlike those of the potential model, seem to give satisfactory agreement with experimental data. (auth)

27863 VECTOR-MESON COUPLINGS TO THE BARYONS. Sugawara, H.; von Hippel, Frank (Cornell Univ., Ithaca, N. Y.). *Phys. Rev.*, 145: 1331-7 (May 27, 1966).

Some arguments are presented by which the couplings of the vector mesons to the baryons are fixed. These arguments amount to an extension of the nonet scheme which has already been successfully applied by Okubo and by Glashow and Socolow to the 1^- and 2^+ mass formulas and decays. It is found that, using the vector-meson couplings obtained and the physical vector masses, the following experimental observations are largely accounted for: the proportionality of the electric and magnetic nucleon form factors to each other and to the p -($N_{3/2}^+$) $^+$ magnetic-dipole transition form factor; the suppression of backward ϕ production in K^- - p experiments; the over-all suppression of ϕ production in π - p experiments; and the isospin independence of the hard core in nucleon-nucleon scattering. The relative leptonic decay rates of the ρ , ω , and ϕ are also estimated, and it is predicted that there will be suppressions in $f'(1500)$ production corresponding to those observed in ϕ production. (auth)

27892 STUDIES OF NUCLEON-NUCLEON INTERACTION USING NONLINEAR SPINOR THEORY. Dhar, J. Munich, Univ., 1963. 49p. \$2.00 Gmelin, AED-Diss. 63-817.

Nucleon-nucleon interactions are investigated by means of dispersion relations. Only the π and η meson contributions to scattering amplitude are taken into account. Coupling constants π -nucleon and η -nucleon are calculated. Results are in agreement with experimental data. (Gmelin Inst.)

28321 SYMMETRY DEFECTS IN POLARIZATION MEASUREMENT. Libert, J. (Institut Interuniversitaire des Sciences Nucleaires, Mons, Belg.). Nucl. Instrum. Methods, 41: 348-54(1966). (In French).

The result of a polarization determination depends on the possible influence of symmetry defects due to an imperfect experimental set-up. This problem is presented in a general way. The usual methods of measurement are discussed and their properties, appearing in the literature in an unprecise and incomplete manner, are established rigorously. (auth)

29985 (CONF-640509(Pt.1), Paper 1) POLE CONTRIBUTIONS TO N-N SCATTERING BELOW PION PRODUCTION. Bryan, R. (Paris Univ., Orsay (France). Laboratoire Joliot-Curie de Physique Nucleaire). 29p. It is shown that the essential features of N-N scattering over the 0- to 300-Mev energy range are embodied in the one-meson-exchange terms due to the ω , ρ , η , π , and σ , where the latter symbol stands for a $T = 0$, $J = 0^+$ meson of mass near that of the neutrino. A detailed theoretical discussion is presented. (M.O.W.)

29999 CROSS SECTION OF QUARK GENERATION. Maksimenko, V. M.; Sisakyan, I. N.; Feinberg, E. L.; Chernavskii, D. S. (Lebedev Inst. of Physics, Moscow). JETP Lett. (USSR) (Engl. Transl.), 3: 219-21(Apr. 15, 1966).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiya, 3: 340-4(Apr. 15, 1966).

The absence of quarks from p-N collisions in accelerators or cosmic rays has led to the conviction that their mass m_q is much higher than their generation threshold; it is further assumed that their generation cross section σ_q can not be much smaller than $\sim (10^{-3} - 10^{-4})\sigma_0$, where $\sigma_0 \approx 30$ mb is the cross section of inelastic NN collision. It is shown that independent experiment and theory lead to $\sigma_q \sim \exp(-2 m_q/\mu)$, where μ is the pion mass, so that any increase of m_q by an amount equal to m_π reduces σ_q by ~ 5 orders of magnitude. (B.G.D.)

30001 INTERACTION STRENGTHS OF THE NEUTRON AND PROTON. Daniel, H. (Max-Planck-Institut fuer Kernphysik, Heidelberg). pp 160-3 of Kolloquium Ueber β -Zerfall und Schwache Wechselwirkungen. Heidelberg, Max-Planck-Instituts fuer Kernphysik, 1965.

Evidence is accumulated to show that there is a universal difference in the interaction strengths of the neutron and proton. The interactions considered are weak interaction, strong interaction, and electromagnetic interaction. (J.S.R.)

30004 NEUTRON-PROTON TOTAL CROSS SECTIONS NEAR 20, 24, AND 28 Mev. Groce, D. E.; Sowerby, B. D. (Australian National Univ., Canberra). Nucl. Phys., 83: 199-208(1966).

The neutron-proton total cross section is measured at three neutron energies in a good geometry transmission experiment using a pressurized gaseous sample. The resulting cross sections are 493.3 ± 2.4 mb at a laboratory neutron energy of 19.565 ± 0.026 Mev, 397.2 ± 1.7 mb at 23.951 ± 0.017 Mev and 337.6 ± 2.1 mb at 27.950 ± 0.013 Mev. (auth)

30038 "INCOHERENT DROPLET" MODEL OF HIGH-ENERGY LARGE-ANGLE SCATTERING. Huang, Kerson (Inst. for Advanced Study, Princeton, N. J.). Phys. Rev., 146: 1075-9(June 24, 1966).

The high-energy large-angle scattering between two hadrons is thought of as incoherent scattering between two objects of complicated internal structure. A model is proposed whereby the incoherence is simulated by a simple recipe. Consequences of the model can be deduced simply. The salient feature of the result is that transverse momentum transfer is strongly inhibited for kinematical reasons. Orcair's empirical fit for large-angle p-p scattering is obtained. (auth)

30082 CHARGE ASSYMETRY OF MESONS CREATED IN PROTON-NEUTRON INTERACTIONS. Rob, L. (FTJF, Prague). pp 80-4 of International Conference on High-Energy Physics. Budapest, Central Research Inst. of Physics, 1963.

Angular distributions of π^+ and π^- mesons produced in proton interactions with neutrons and protons in a nuclear emulsion stack were measured. 117 p-n interactions and 165 p-p interactions were found. Methods of measurement and identification of the fast and slow secondary particles are briefly discussed. The cms angular distributions from the p-n interactions exhibited a pronounced asymmetry; the coefficients were found to be $K(\pi^+) = +0.78 \pm 0.18$ and $K(\pi^-) = -0.75 \pm 0.40$. For p-p interactions, $K(\pi^+) = -0.001 \pm 0.180$ and $K(\pi^-) = -0.06 \pm 0.25$. (L.B.S.)

31997 BREMSSTRAHLUNG PRODUCTION IN 48-Mev p-p COLLISIONS. Warner, Robert E. (Univ. of Manitoba, Winnipeg). Can. J. Phys., 44: 1225-37(June 1966).

Measurements of the cross section $d^2\sigma/d\Omega_1 d\Omega_2$ for the bremsstrahlung reaction $p + p \rightarrow p + p + \gamma$ were made with 48 $\pm$ 1 Mev incident protons. Both final protons were detected in coincidence at equal angles on either side of the beam and coplanar with the beam, and bremsstrahlung events were identified kinematically. Cross sections of

32004 CALCULATION OF CROSS SECTIONS FOR DEUTERON PHOTODISINTEGRATION AND NEUTRON CAPTURE BY A PROTON FOR THE CASE OF A NONLOCAL POTENTIAL. Dotsenko, B. B.; Salasyuk, V. M. (Kiev State Univ.). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 5, 80-5 (1965). (In Russian).

The processes of photodisintegration of a deuteron by a gamma quantum and of radiative capture of a neutron by a proton with emission of a gamma quantum are examined. The interaction between the nucleons is described by a non-local potential of the Yamaguchi type but with the repulsion caused by the nucleon cores taken into account. The Schrödinger equation for the proposed potential is solved exactly. The values of the parameters of the potential are determined more precisely in comparison with previously obtained values. The effective photodisintegration and radiative-capture cross sections are calculated. The calculations show that the proposed potential allows the processes of photodisintegration at low energies (up to 20 Mev) to be described sufficiently well. The calculated radiative-capture cross section agrees somewhat better with experiment than that determined for other potentials. (tr-auth)

32008 DISPERSION THEORY CALCULATIONS FOR NUCLEON-NUCLEON SCATTERING. Feldman, K. S.; Hochberg, S. (Imperial Coll. of Science and Tech., London). Nucl. Phys., 83: 645-65 (1966).

The nucleon-nucleon interaction is investigated using the dispersion formalism of Goldberger, Grisaru, MacDowell and Wong. The contributions due to the exchange of one and two pions are included. The N/D method is employed and the resulting sets of integral equations are solved to a desired degree of accuracy by digital computer techniques. Scattering phase shifts and coupling parameters are calculated for values of the total angular momentum $J = 0, \dots, 5$ at laboratory energies up to 400 Mev. Fair agreement with experiment is obtained for $J \geq 3$. A short discussion of the deuteron is incorporated and its binding energy estimated. (auth)

32016 POLARIZATION AND SPIN CORRELATION PARAMETER MEASUREMENTS IN 600-Mev PROTON-PROTON SCATTERING USING A POLARIZED PROTON TARGET. Colnet, G. (Institut du Radium, Orsay, France); Cronenberger, D.; Kuroda, K.; Michalowicz, A.; Olivier, J. C.; Poulet, M.; Teillac, J.; Borghini, M.; Ryter, C. Nuovo Cimento (10), 43A: 708-15 (June 1, 1966).

Using a polarized or unpolarized proton beam previously described and a polarized proton target (70%) the parameters $P(\theta)$ and $C_{LL}(\theta)$ were measured in the angular interval from 23 to 104° in the center-of-mass system at about 600 Mev. The experimental set-up and the way in which the data were carried out are discussed. Results are presented and compared to those already obtained in the same energy region. (auth)

32030 CHARGE-DEPENDENT EFFECTS IN NUCLEON-NUCLEON 1S_0 SCATTERING LENGTHS BY THE DASHEN-FRAUTSCHI METHOD. Duck, I.; Khanna, F. (Rice

Univ., Houston, Tex.). Nuovo Cimento (10), 43A: 1047-61 (June 21, 1966). (TID-22556).

The dispersion relation of Dashen and Frautschi was used in conjunction with the nucleon-nucleon scattering amplitudes of Scotti and Wong, and the nucleon electromagnetic form factors to calculate the charge dependence of the nucleon-nucleon 1S_0 scattering lengths due to single-photon exchange and to the charge dependence of the pion mass and coupling constants. The contribution of the one-photon exchange is considerably enhanced over what one would expect from a potential calculation using hard cores. (auth)

32048 CONSIDERATION OF n-p DIRECT AND CHARGE-EXCHANGE SCATTERING BASED ON TRANSVERSE MOMENTUM DISTRIBUTION AND MANDELSTAM REPRESENTATION. Narayan, D. S. (Tata Inst. of Fundamental Research, Bombay). Nuovo Cimento (10), 44A: 213-17 (July 1, 1966).

The n-p direct and charge-exchange scattering was considered according to a recent model of Chavda and Narayan based on transverse-momentum distribution and Mandelstam representation, and the results are compared with the available experimental data. (auth)

32059 PROTON-PROTON BREMSSTRAHLUNG WITH THE TABAKIN POTENTIALS. Duck, I.; Pearce, W. A. (Rice Univ., Houston, Tex.). Phys. Lett., 21: 669-71 (July 1, 1966). (TID-22804).

p-p- γ cross sections calculated with the Tabakin potentials are found to be in good agreement with experimental results at $E_p = 158$ Mev. A discrepancy persists at $E_p = 50$ Mev. (auth)

32062 PROTON-PROTON BREMSSTRAHLUNG AT 204 Mev. Rothe, K. W.; Koehler, P. F. M.; Thorndike, E. H. (Univ. of Rochester, N. Y.). Phys. Rev. Lett., 16: 1118-21 (June 13, 1966).

The gamma energy spectra, the angular distributions in the two-nucleon cms and the gamma and p-p asymmetries due to an initially polarized, 204-Mev proton beam are presented. (G.O.Y.)

32073 PION-PION CORRELATION EFFECT IN TWO-PION-EXCHANGE CONTRIBUTION FOR NUCLEON-NUCLEON SCATTERING. Furuichi, Susumu (Rikkyo Univ., Tokyo); Watanabe, Keiji. Progr. Theoret. Phys. (Kyoto), 35: 408-15 (Mar. 1966).

The pion-pion correlation effect is investigated, starting from the pion-pion scattering phase shifts which show the presence of a ρ meson in the $I = L = 1$ state and a strong attraction without resonance in the $I = L = 0$ state. By comparing with the one boson exchange contribution amplitude, the roles of the pion-pion correlation and the normalization $f_4^{(+)}(0) = C_0$ in nucleon-nucleon scattering are clarified. Comparison with the empirical phase shifts in the isotriplet

state shows that $C_0 \sim 0$ and a rather small value of g_ρ^2 are probable and not inconsistent with the analysis of pion-nucleon scattering. (auth)

32173 IMPACT PARAMETER FORMALISM. II. HIGH-ENERGY ELASTIC SCATTERING. Adachi, Toshimi (Tokyo Metropolitan Technical Coll.). Progr. Theoret. Phys. (Tokyo), 36: 463-94 (Mar, 1966).

The mathematical structure of the impact parameter formalism proposed by Kotani and Adachi is discussed. The formalism is regarded as a counterpart of the partial wave expansion of the scattering amplitude. An impact parameter amplitude is defined as a function of impact parameter and total energy. This amplitude has two characteristic features, corresponding to particle-like and wave-like pictures. The latter nature has not been taken into account in previous impact parameter formalisms. In order to investigate the character of the impact parameter amplitude, this formalism is applied to high energy elastic scattering. A phenomenological analysis of the diffraction scattering is characterized by two parameters. Various expressions for the impact parameter amplitudes which are connected with the large angle proton-proton scattering are derived. The absorption coefficients for each partial wave are obtained. The Lommel function of two variables is widely used in the diffraction scattering, just as it has been employed in the diffraction theory of classical light waves. (auth)

34151 (ISS-66/15) CALCULATION OF PARTIAL-WAVE ABSORPTIONS AND OF THE MODULI OF THE ELASTIC AMPLITUDES IN NUCLEON-NUCLEON SCATTERING BELOW 1.4 Gev. Amaldi, U. Jr.; Biancastelli, R.; Francaviglia, S. (Istituto Superiore di Sanita, Rome (Italy). Laboratori di Fisica). Apr. 16, 1966. 58p. Dep. mn.

A general procedure is outlined for obtaining the absorptions in each partial wave when the amplitudes for the production of any number of particles in nucleon-nucleon interactions at a given baricentric energy are known. This procedure is then applied to single pion production in nucleon-nucleon interactions at 0.8 to 1.4 Bev. (B.G.D.)

34155 (UCRL-14297) THREE-POLE FIT TO p-p SCATTERING BELOW 350 Mev. Bryan, R. A.; Arndt, R. A. (Lawrence Radiation Lab., Univ. of California, Livermore). June 30, 1965. Contract W-7405-eng-48. 58p. Dep. mn. CFSTI \$3.00 cy, \$0.50 mn.

Despite the complexity of the p-p scattering data, it is shown that it is possible to fit the gross structure of the 0-to 350-Mev scattering amplitude, excluding the S-wave, with a sum of three poles: a vector pole (V), a scalar pole (σ), and the pion pole (π). The vector pole represents a sum of ω , ρ , and ϕ effects. The scalar pole was not established experimentally, but is consistent with the scalar pole at 490 Mev that Thurnauer introduces to fit the low energy $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ data. The real part of the amplitude is fitted with the following parameters: $g_\rho^2 = 12.3$; $g_V^2 = 2.3$, $f_V/g_V = 2.3$, $g_\pi^2 = 1.6$, and $m_\sigma = 386$ Mev. These values are arrived at by means of an IBM 7094 search

against the experimental P, D, F, and G phase shifts of MacGregor, Arndt, Noyes, and Bailey. Studies are also made of four-pole fits to the data, wherein the V pole is resolved into $\rho + \omega$ (or ϕ). One effect is to raise the σ mass to 434 Mev. (auth)

34178 1S_0 p-p SCATTERING PARAMETERS OBTAINED FROM A RE-ANALYSIS OF EXPERIMENTAL DATA. Slobodrian, R. J. (Univ. of California, Berkeley). Nucl. Phys., 85: 33-9 (1966). (UCRL-16690).

Existing uncertainties in the scattering parameters that describe the low-energy p-p scattering were significantly reduced extending the analysis up to 4.203 Mev lab energy. A comparison with theoretical predictions is made. (auth)

34179 BASIC NEUTRON-NUCLEON INTERACTION. Perring, J. K. (Atomic Energy Research Establishment, Harwell, Eng.). pp 13-20 of Nuclear Structure Study With Neutrons. Neve de Mevergnies, M.; Van Assche, P.; Vervier, J. (eds.). Amsterdam, North-Holland Publishing Co., 1966.

A status report is presented on scattering experiments at high and low energies and the theoretical interpretation of such interactions. (B.G.D.)

34180 PROTON FORM FACTOR AT HIGH ENERGY. Barnes, K. J. (Imperial Coll. of Science and Tech., London); Guindon, W. G. Nuovo Cimento (10), 44A: 374-8 (July 21, 1966).

It is suggested that high-energy proton-proton scattering could be used to set limits on the high-energy behavior of the proton electromagnetic form factors. Although it is verified that a modified high-energy limit of the Møller formula is all that is required the complete expression for the elastic electromagnetic interaction of two identical spin- $1/2$ particles with structure was derived in terms of covariant variables and is given for reference. (auth)

34183 MULTIPLE MESON PRODUCTION. Takagi, S. (Kyoto Univ.); Dake, S.; Yokoi, K. Nuovo Cimento (10), 44A: 459-68 (July 21, 1966).

A statistical model of multiple meson production is proposed, in which the constancy of $\bar{p}_T$, the transverse momenta of generated mesons, is taken into account and which is more consistent and comprehensive than the similar model proposed by the Polish group. In the high-energy limit the following asymptotic behaviors are predicted: i) secondary pions have a uniform $\log_{10} \theta$ distribution, ii) multiplicity of secondary pions has a logarithmic dependence on the total available energy of the system. The angular distribution and the multiplicity of secondary pions for finite available energy are also predicted and, on the assumption of $\bar{p}_T = 400$ Mev/c and $K = 0.5$, the prediction reproduces the experimental results very well in a wide incident-nucleon momentum region: $2 \cdot 10^{10}$ ev/c $\leq$

v.20 (1966)

$P_0 \approx 2 \cdot 10^{12}$ ev/c. On the above-mentioned basis it is discussed that the essential average feature of ultra-high-energy nucleon-nucleon interaction is condensed in the constancy of $\bar{p}_T$. (auth)

34192 THE $p + R$ MODEL AND pn CHARGE-EXCHANGE SCATTERING. Hoegaasen, H.; Frisk, A. (CERN; Geneva). Phys. Lett., 22: 90-1 (July 15, 1966).

From medium energy nucleon-nucleon data it is concluded that a consistent description in terms of Regge poles is possible only if the polarization is nonzero in $n + p \rightarrow n + p$ or $n + p \rightarrow pn$ at medium energies. (auth)

34222 INFRARED APPROACH TO LARGE-ANGLE SCATTERING AT VERY HIGH ENERGIES. Kastrup, H. A. (Princeton Univ., N. J.). Phys. Rev., 147: 1130-5 (July 29, 1966).

The hypothesis is investigated that the observed exponential decrease of the elastic large-angle high-energy proton-proton cross section is a consequence of soft-meson emission in strong interactions at very high energies. This interpretation is suggested by the observation of leading particles and low cms energies of the secondary mesons in cosmic-ray collisions. Neglecting the recoil of the soft mesons implies the factorization of the cross section into a potential part and an infrared part which is given by Poisson's distribution law. These properties alone provide a number of interesting experimental predictions. Adding the assumption of asymptotic dilatation invariance determines the energy dependence of the potential cross section and yields new results: The magnetic form factor of the nucleon becomes a simple function of the multiplicity of soft mesons produced in quasi-elastic electron-nucleon scattering. If this relation can be confirmed experimentally, it will provide a new method of measuring electromagnetic form factors at very high energies. Furthermore, the factor $\exp(-\bar{n})$ of the Poisson distribution can account for the exponential decrease of the elastic proton-proton cross section, and this interpretation gives several new experimental predictions. (auth)

34223 MESON MASS SPLITTING, COPLANAR $U(3) \times U(3)$ SYMMETRY, AND NUCLEON-NUCLEON SCATTERING. Lai, C. S. (Univ. of Chicago). Phys. Rev., 147: 1136-8 (July 29, 1966).

For the case of nucleon-nucleon scattering, it is shown that there are large corrections to the prediction of coplanar $U(3) \times U(3)$ symmetry as a consequence of the mass-splitting effects in the intermediate meson states of the crossed channels. These corrections are calculated for certain coefficients of the pp scattering amplitude by using a meson pole model. A comparison is given with the result of experimental phase-shift analyses. (auth)

34233 PROPOSAL TO TEST TIME-REVERSAL INVARIANCE IN THE REACTIONS $\gamma + d \rightarrow n + p$. Barshay, S. (Rutgers State Univ., New Brunswick, N. J.). Phys. Rev. Lett., 17: 49-53 (July 4, 1966).

It is suggested that a significant test of time-reversal invariance can be carried out by comparing the differential cross sections for the reactions $\gamma + d \rightarrow n + p$ and $n + p \rightarrow \gamma + d$ at, or above, about 290-Mev/c photon laboratory momentum, or about 590-Mev neutron laboratory kinetic energy, respectively, with unpolarized initial and final particles. (B.G.D.)

34584 NEUTRON TOTAL CROSS SECTIONS FOR NEUTRONS, PROTONS, AND DEUTERONS IN THE ENERGY RANGE OF 90 TO 150 Mev. Measday, D. F. (Harvard Univ., Cambridge, Mass.); Palmieri, J. N. Nucl. Phys., 85: 142-52 (1966).

The neutron total cross section for scattering by protons and deuterons was measured to an accuracy of 2% in the energy range of 90 to 150 Mev. Monokinetic neutron beams were used and the results are therefore free of the systematic errors associated with many earlier measurements. The $n-p$ cross sections agree with an earlier measurement of Taylor, but below 100 Mev they are several per cent larger than the results of Bowen et al. The difference between the neutron cross sections for deuterium and hydrogen are consistent with the results of Riddle et al. below 120 Mev. The neutron-neutron cross sections were inferred, and they agree with the results of Riddle et al. (auth)

36033 (JINR-E-2743) PHASE-SHIFT ANALYSIS OF NUCLEON-NUCLEON SCATTERING AT 400 Mev. Kazarinov, Yu. M.; Legar, F.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 16p. Dep. mn.

New experimental data were used to specify the phase-shift analysis of the nucleon-nucleon scattering at 400 Mev. As a result of this specification two phase-shift sets remain from the previously obtained three ones. (auth)

37739 (JINR-E-2726) THE MEASUREMENT OF THE TRIPLE SCATTERING PARAMETER R_{pn} AT 70° AND THE PHASE-SHIFT ANALYSIS AT 630 Mev. Kazarinov, Yu. M.; Legar, F.; Pisarev, A. F.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 30p. Dep. mn.

The triple scattering parameter R_{pn} and the polarization in the elastic $p-n$ scattering were measured at 70° for 605 Mev protons. The values were found to be: $R_{pn} = 0.09 \pm 0.19$, $P_{pn} = -0.05 \pm 0.18$. The phase-shift analysis was performed at 630 Mev taking these data into account. Experimental quantities were calculated and further experiments determining the parameters D_{pn} , R_{pn} , A_{pn} , C_{pn} , and $A_{pn}^{(p)}$ were planned. It follows from the planning that for the given experimental possibilities the measurement of the D_{pn} and A_{pn} parameters is the most effective way to discriminate between the two remaining sets of phase shifts. (auth)

37743 (UCRL-16866) POLARIZATION IN PROTON-PROTON SCATTERING USING A POLARIZED PROTON TARGET. PART I, 0.330 TO 0.740 GeV. PART II, 1.70 TO 6.15 GeV. Betz, F.; Grannis, P.; Chamberlain, O. (and others) (Lawrence Radiation Lab., Univ. of California, Berkeley). Apr. 1966. Contract W-7405-eng-48, 14p. (CONF-660420-2). Dep. mn. CFSTI \$1.00 cy, \$0.50 mn.

From International Conference on Two-Body Problems at High Energy, Stony Brook, N. Y.

The results of two experiments to measure the polarization parameter in p-p scattering are reported. Both experiments utilize an unpolarized proton beam incident on a polarized proton target. One experiment was performed at the Berkeley 184-inch cyclotron using incident protons of 328, 614, 679, and 736 MeV kinetic energy. The other experiment was performed at the Bevatron and measurements were taken at 1.7, 2.85, 3.5, 4.0, 5.05, and 6.15 GeV kinetic energy. The angular regions measured were from 20 to 100° center of mass; the square of the four-momentum transfer ranged from 0.1 to 0.8 (BeV/c)². (auth)

37769 KINEMATIC ENHANCEMENT OF RESONANCE PRODUCTION IN CERTAIN TWO-BODY REACTIONS. Morrison, D. H. O. (CERN, Geneva). Phys. Lett., 22: 236-8 (Aug. 1, 1966). (UR-875-150).

An explanation is given of the fact that certain quasi two body reactions have a constant cross section with respect to incident momentum. It is supposed that there is a diffraction scatter at one vertex followed by a final state interaction. This mechanism is applied to reactions produced by incident protons, pions, kaons, and gammas. (auth)

37772 EVIDENCE OF A HIGHER SYMMETRY IN NUCLEON-NUCLEON SCATTERING. Brown, C. N.; Thorndike, E. H. (Univ. of Rochester, N. Y.). Phys. Lett., 22: 236-8 (Aug. 1, 1966). (UR-875-150).

SU(12)_v predicts six relations among the nucleon-nucleon scattering amplitudes. Experimentally the relation $\text{Re}B_1 = \frac{1}{2} \text{Re}G_0$ is satisfied to 5-10% between 95 and 210 MeV, while the other relations yield fair agreement for forward scattering and poor agreement for non-forward scattering. (auth)

37796 HIGH-ENERGY ELASTIC SCATTERING AT SMALL MOMENTUM TRANSFERS. Ida, Masakuni (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 35: 1074-87 (June 1966).

Experimental data on high-energy $\bar{p}$ -p, $\bar{p}$ -p, π^+ -p and K^+ -p elastic scatterings for small momentum transfers are analyzed under the assumptions that the spin effect is negligible at high energies and that the imaginary part of the scattering amplitude predominates over the real one for low momentum transfers. Four parameters, all of which have definite physical meanings, are introduced and determined numerically from experimentally available quantities. It is found that protons are more transparent for a pion or a kaon than for a proton. The transparency

increases with increasing energy independently of the shrinkage or nonshrinkage of the diffraction peak. It appears that there exists a non-negligible amount of contribution from the real part of the scattering amplitude to the elastic cross section except for $\bar{p}$ -p scattering, which is explainable by a simple model with no real amplitude. (auth)

37802 π -MESON PRODUCTION IN 655-MeV pp COLLISIONS AND THE DETERMINATION OF ABSORPTION COEFFICIENTS. Vovchenko, V. G. (Ioffe Inst. of Physics and Tech., Leningrad). Yadern. Fiz., 3: 1101-6 (June 1966). (In Russian).

The parameters of the π -meson creation resonance model are re-estimated, taking all possible transitions from the initial pp-system, allowed by S- and P-state emission into account. Three independent parameters give a statistically satisfactory description of the results of measuring cross sections, angular distributions and π^+ - and π^0 -meson spectra in the reactions $pp \rightarrow \pi^+pn$ and $pp \rightarrow \pi^0pp$. An analysis of inelastic pp-scattering by the partial-wave method is performed on the basis of the resonance model assumptions. (auth)

37862 ABSORPTIVE MODIFICATION OF SINGLE PARTICLE EXCHANGE MODELS AT HIGH ENERGIES. Chiu, Yam-Tsi. New Haven, Yale Univ., 1965. 140p. Thesis.

The effect of competition from open channels in high-energy scattering has been shown to significantly modify the predictions of the single-particle exchange model for high-energy peripheral reactions. In this work, the proper multichannel potential scattering problem is discussed in detail in the WKB approximation and is considered in the light of the absorptive effects generated by other open competing channels on the Born amplitude of the reaction in question. The modified amplitudes for the single-particle exchange model so obtained are then shown to satisfy the requirement of unitarity to first order in the Born term of the reaction. A self-consistent scheme for unitarization of amplitudes for the single-particle exchange model is considered using the multichannel K-matrix formalism. The parameterization of the amplitudes including spin and the construction of modified single-particle exchange reaction matrices are considered in detail. In particular, reaction matrices for scalar meson, pseudoscalar meson, vector meson, hyperon, and isobar productions in meson-baryon and baryon-baryon scattering were constructed for the modified single-particle exchange model. Construction of Regge amplitudes in the presence of spin and the partial wave analysis of Regge amplitudes in the direct channel were studied. Arguments for the inclusion of absorptive effects in the Regge pole exchange model are presented; and the amplitudes for the n-p charge exchange reaction proceeding via a Regge pole ρ -meson exchange are obtained. Comparisons with experiment for several representative reactions are considered in order to delineate the areas of success and failure of the modified single-particle exchange model. (Dissertation Abstr.)

38081 PROTON-PROTON SCATTERING: REVISION AND ANALYSIS OF EXPERIMENTAL MEASUREMENTS FROM 1.4 TO 3.0 Mev. Knecht, David J. (Air Force Cambridge Research Labs., Bedford, Mass.); Dahl, Per F.; Messelt, S. Phys. Rev., 148: 1031-44 (Aug. 19, 1966).

Revised experimental values are given for the differential cross section for proton-proton scattering at energies of 1.397, 1.855, 2.425, and 3.037 Mev. These result from the consolidation and re-evaluation of all published and unpublished data obtained in an experiment reported earlier by Knecht et al. Phase-shift analyses have been made. The preferred solutions determine the S-wave phase shift K_0 and the central-force ("effective") part γ of the P-wave phase shifts, under the assumption that the noncentral-force parts and all higher angular-momentum phase shifts are known with sufficient accuracy from one-pion-exchange theory; the values of γ derived in this way are small, with zero not excluded. Other solutions in which noncentral forces range from zero to very large values are given for comparison. The uncertainty in each of the derived phase shifts is calculated and discussed in detail; uncertainties obtained by the usual statistical method are shown to be too small. The polarization implied by each phase-shift solution has been calculated, and it is shown that reported measurements are in disagreement not only with the present data and theoretical predictions but with any combination of central, tensor, and spin-orbit forces. (auth)

38186 PRODUCTION OF CHARGED PIONS BY 600 Mev PROTONS ON VARIOUS NUCLEI. Heer, E.; Hirt, W.; Martin, M.; Michaelis, E. G.; Serre, C.; Skarek, P.; Wright, B. T. (European Organization for Nuclear Research, Geneva). 20p. (CONF-660209-15). ORAU. Gmelin, AED-CONF-66-023-18.

From Conference on Intermediate Energy Physics, Williamsburg, Va.

The method and analysis of measurements of charged pion production on various nuclei by 600-Mev protons from the CERN synchrocyclotron are discussed in detail. Production cross sections were measured for CH_2 , CD_2 , Be, C, Al, Cu, Ag, and Pb at pion energies between 100 and 350 Mev and for production angles of 0.8 and 21.5°; the results are presented. Hydrogen cross sections obtained by CH_2 -C subtraction, and neutron cross sections evaluated by CD_2 - CH_2 subtraction are also presented. The results are in agreement with other data. (L.B.S.)

39752 (JINR-E-2765) PLANNING OF n-p SCATTERING EXPERIMENTS ABOVE THE PION-PRODUCTION THRESHOLD. Janout, Z.; Fedorov, V. V.; Lehar, F. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 26p. Dep. mn.

The planning of the optimal experiment was performed for the measurements of D, R, A, C_{nn} , A_{55} in n-p-scattering at 400 and 630 Mev. From the obtained results follows that the measurement of the parameter D is most effective for discrimination of two phase-shifts sets at both energies. The measurements must be made on the angles 60 and 115° cms at 400 and 630 Mev, respectively. (auth)

39756 (JINR-P-2742) FAZOVYI ANALIZ NUKLON-NUKLONNOGO RASSEYANIYA PRI ENERGII 14.5 Mev. (Phase-Shift Analysis of the Nucleon-Nucleon Scattering at 14.5 Mev.). Kazarinov, Yu. M.; Legar, F.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 12p. Dep. mn.

The phase-shift analysis of the experimental data obtained at an energy near 14.5 Mev is performed. Three phase-shift sets with a positive phase-shift S_0 wave are obtained which give a satisfactory description of available experimental data. The results of the analysis show that the polarized beam and polarized target experiments are the most effective way to determine precisely the deviation from the pure S-state scattering. (auth)

39759 (JINR-P-2776) SPINOVAYA KORRELYATSIYA PRI UPRUGOM RASSEYANII POLYARIZOVANNYKH PROTONOV S ENERGIEI 605 Mev NA PROTONAKH. (Spin Correlation in Elastic Scattering of 605-Mev Polarized Protons on Protons). Golovin, B. M.; Zul'karneev, R. Ya.; Kiselev, V. S.; Medved, S. V.; Nikanorov, V. I.; Pisarev, A. F.; Semashko, G. L. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 8p. Dep. mn.

Spin correlation coefficients for elastic p-p scattering were measured at the angle of 90° cms. A polarized 605 Mev proton beam was used in the experiment. The measurements were made with spark chambers controlled by scintillation counters. The following coefficient values were found to be $C_{nn} = 0.56 \pm 0.18$; $C_{kp} = 0.27 \pm 0.18$; $C_{qkn} = 0.92 \pm 0.38$. (auth)

39777 HIGH-ENERGY LARGE-ANGLE SCATTERING BY A STRONGLY SINGULAR COMPLEX POTENTIAL. Kouris, C. B. (Nuclear Research Center Democritus, Athens). Nuovo Cimento (10), 44A: 598-612 (Aug. 1, 1966).

The experimental data for high-energy proton-proton and pion-proton scattering at large angles are analyzed in terms of a complex, energy-dependent potential of the form $V(r) = e^{-i\alpha} gr^{-4}$ with $g = \eta^4 k^2$. In general, for center-of-mass angles above 30° a good fit to the data is found. The ratio of the elastic to the total cross section for the above potential is also calculated and is compared with the experimental values at different energies. (auth)

39789 POLARIZATION IN PROTON-PROTON SCATTERINGS AT 735 Mev. McManigal, Paul G.; Eandi, Richard D.; Kaplan, Selig N.; Moyer, Burton J. (Univ. of California, Berkeley). Contract W-7405-eng-48. Phys. Rev., 148: 1280-1 (Aug. 26, 1966). (UCRL-16720).

New measurements by Cheng of p-C polarization as a function of angle and incident proton energy allow an uncertainty in a previously reported measurement of p-p polarization to be reduced. On the basis of this new information, it is concluded that the p-p polarization at 735 Mev reaches a maximum of $(60 \pm 2)\%$. (auth)

39791 POLARIZATION PARAMETER IN p-p SCATTERING FROM 328 TO 736 Mev. Betz, F.; Arens, J.; Chamberlain, O.; Dost, H.; Grannis, P.; Hansroul, M.; Holloway, L.; Schultz, C.; Shapiro, G. (Univ. of California, Berkeley). Contract W-7405-eng-48. Phys. Rev., 148: 1289-96(Aug. 26, 1966). (UCRL-16749).

The polarization parameter in elastic proton-proton scattering was measured using an unpolarized proton beam and a polarized proton target. Measurements were taken at a laboratory kinetic energies of 328, 614, 679, and 736 Mev in the angular regions from 33 to 110 degrees center-of-mass. The results indicate that the maximum polarization at a given energy increases in the region from 328 to 679 Mev. At 328 Mev the results are in good agreement with those of a previous experiment at 315 Mev performed by the double-scattering technique. (auth)

39797 THEORY OF W PRODUCTION IN NUCLEON-NUCLEON COLLISIONS. Chilton, Frank (Argonne National Lab., Ill.); Saperstein, A. M.; Shrauner, E. Phys. Rev., 148: 1380-4(Aug. 26, 1966).

The cross section for $N + N \rightarrow W + N + N$ is calculated in a double peripheral model. The effects of the principal corrections such as absorption, resonant final-state interactions, and the $\pi\pi W$ form factor are considered. μ pair production, which is intrinsically related to W production through the conserved vector current, is examined as a means of testing this model and also as a source of background. (auth)

39799 APPLICATION OF PARTIAL-WAVE ANALYTICITY TO NUCLEON-NUCLEON SCATTERING. Kantor, Paul B. (State Univ. of New York, Stony Brook). Phys. Rev., 148: 1411-18(Aug. 26, 1966).

In order to give a quantitative discussion of models for nucleon-nucleon scattering which are founded on analyticity and unitarity of the S matrix, the fact that each partial-wave amplitude has a nonvanishing imaginary part in the physical region must be dealt with unambiguously. The goal is achieved by evaluating certain integrals over the physical region, using rigorous bounds when experimental data are unavailable. The resulting modified amplitudes have known experimental uncertainty, and can validly be compared directly with dynamical models which do not themselves satisfy the requirements of unitarity, such as the popular single-boson-exchange models. The modified amplitudes are tabulated and various tests for models are discussed. (auth)

39806 GENERAL ANALYSIS OF NUCLEON-NUCLEON SCATTERING: CRITICAL TESTS FOR REGGE-POLE THEORY. Leader, Elliot (Cambridge Univ., Eng.); Slansky, Richard C. Contract W-7405-Eng-48. Phys. Rev., 148: 1491-1501(Aug. 26, 1966). (UCRL-16597).

Using analyticity and crossing, the experimental quantities for the physical channel can be expressed in terms of the crossed-channel amplitudes. For N-N scattering, a new set of t-channel amplitudes $\{g_i\}$ are introduced for which

the s-channel experimental quantities $I_0, D, D_0, C_{NN}, C_{KP}, P, R, A, R',$ and A' are very simple in form. By use of these it is shown that the measurement of certain spin-dependent parameters in N-N scattering can provide critical tests of the validity of the Regge-pole model of high-energy scattering. In particular it is possible to test the factorization theorem, which is an immediate consequence of the simple-pole Regge theory. The relationship of the new amplitudes g_i to the Wolfenstein parameters is given. (auth)

39826 PION PRODUCTION IN np COLLISIONS AT 600 Mev. Kazarinov, Yu. M.; Simonov, Yu. N. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 139-47(July 1966). (In Russian).

Angular distributions of charged pions have been measured as well as the total production cross section of neutral pions generated in np collisions at 600 ± 10 Mev. It was found that $\sigma_{\pi^0}(\theta) = [(0.115 \pm 0.005) + (0.004 \pm 0.013) \cos \theta + (0.01 \pm 0.02) \cos^2 \theta] \times (1.073 \pm 0.104) \cdot 10^{-27} \text{ cm}^2/\text{steradian}$ in the c.m.s. of the colliding nucleons. The total cross sections of the reactions are $\sigma(np \rightarrow \pi^0) = (4.6 \pm 0.6) \cdot 10^{-27} \text{ cm}^2$, $\sigma(np \rightarrow \pi^+) = \sigma(np \rightarrow \pi^-) = (1.68 \pm 0.17) \cdot 10^{-27} \text{ cm}^2$. The obtained data do not contradict the hypothesis of charge independence of nuclear forces. The cross sections for pion production in collisions of two nucleons in states with the total isotopic spin $T = 0$ and $T = 1$ were found to be $(4.4 \pm 1.0) \cdot 10^{-27} \text{ cm}^2$ and $(10.85 \pm 0.42) \cdot 10^{-27} \text{ cm}^2$, respectively. (auth)

39834 FORMATION OF CHARGED π MESONS IN COLLISIONS BETWEEN 600-Mev NEUTRONS AND PROTONS. Dzhelepov, V. P.; Kiselev, V. S.; Oganesyan, K. O.; Flyagin, V. B. (Joint Inst. of Nuclear Research, Dubna, USSR). Zh. Eksp. Teor. Fiz., 50: 1491-1504(June 1966). (In Russian).

The energy spectra of charged mesons produced in n-p encounters involving 600-Mev neutrons are measured in a broad angular range by means of a multichannel magnetic spectrometer. The spectra are characterized by the presence of a large number of low-energy mesons. The peak of the spectra is at an energy of ~ 0.6 from the largest possible value. The angular distributions of π^+ mesons in the c.m.s. is described by a formula. The total meson production cross section $\sigma_{np}(\pi^+) = \sigma(\pi_{np}^-) = (1.3 \pm 0.2) \cdot 10^{-27} \text{ cm}^2$. An analysis of the results shows that despite the dominating role of resonance pion production, in phenomenological studies the contribution of nonresonance transitions should be taken into account. (auth)

39844 NUCLEON-NUCLEON POLARIZATION AT 700, 600, 500, AND 400 Mev. Cheng, David. Berkeley, Calif., Univ. of California, 1965. 105p. Thesis.

The polarization parameters for the two-nucleon systems were measured at the 184-in. cyclotron at beam energies of 700, 600, 500, 400, and 310 Mev. They are measured for both the pp and pn systems by means of a polarized proton

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beam initially produced by scattering the external proton beam on a carbon target at ± 6 deg, and then scattered in a liquid hydrogen target or a liquid deuterium target. The outgoing particles are detected by 19 proton counters and 8 neutron counters fixed in space. All possible coincidence pairs are recorded through an on-line computer. The asymmetry is measured by reversing the sign of the beam polarization by reversing the pC scattering angle. The angular range treated is between 30 and 150 deg in the center-of-mass system, and involves measurements at eight angular positions at each energy. In order to calibrate the beam polarization, the polarization parameter for pC is also measured at the above energies in the forward direction between 6 and 14 deg in the laboratory frame. The NN polarization parameters, $P(\theta)$, are almost independent of energy. In the pp system, $P(\theta)$ can be approximated by $A \sin \theta^* \cos \theta^*$ where A varies between 0.85 at 310 Mev and 1.1 at 700 Mev. In the pn system $P_{\max}$ in the forward direction varies between 0.42 at 310 Mev and 0.34 at 700 Mev, and $P_{\min}$ in the backward direction varies between -0.25 at 310 Mev and -0.4 at 700 Mev. When fitting both the differential cross section, I_0 , and polarization, P , with all the data available in this energy region, in terms of power series, the differential cross sections in both the pp and pn systems were found to vary with energy to a greater extent than the polarization parameters. From these fits, I_0 and P , for the isotopic spin singlet ($I = 0$) state of the 2-nucleon system, are also calculated. The energy variation is considerable in this state. The polarization is small, but it tends to increase and be negative at the high end of this energy range. (Dissertation Abstr.)

39848 INFLUENCE OF THE NN* CHANNEL ON ELASTIC NN SCATTERING. Shepard, Harvey Kenneth. Pasadena, Calif., California Inst. of Tech., 1966. 151p.

Thesis.

The problem of two channels, NN and NN*, coupled through unitarity, is studied to see whether sizable peaks can be produced in elastic nucleon-nucleon scattering due to the opening of a strongly coupled inelastic channel. One-pion-exchange (OPE) interactions are calculated to estimate the $NN^* \rightarrow NN^*$ and $NN \rightarrow NN^*$ amplitudes. The OPE production amplitudes are used as the sole dynamical input to drive the multichannel ND^{-1} equations in the determinantal approximation, and the effect on the $J = 2+$ (1D_2) elastic NN scattering amplitude is studied as the width of the unstable N^* and strength of coupling to the inelastic channel are varied. A cusp-type enhancement appears in the NN channel near the NN^* threshold but for the known value of the N^* width the cusp is so "wooly" that any resulting elastic peak is likely to be too broad and diminished in height to be experimentally prominent. A brief survey of current experimental knowledge of the real part of the 1D_2 NN phase shift near the NN^* threshold is given, and the values are found to be much smaller than the nearly resonant phase shifts predicted by the coupled channel model. (Dissertation Abstr.)

39909 POLARIZATION TENSOR IN THE SCATTERING OF POLARIZED NUCLEONS ON A POLARIZED PROTON TARGET. Bilenkaya, S. I.; Winternitz, P.; Legar, F.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 132-8 (July 1966). (In Russian).

The components of the polarization tensor in the scattering of polarized nucleons on polarized nucleons are discussed and calculated using phase-shift analysis data for various energies in the region 23.1 to 630 Mev. (auth)

41793 (JINR-E-2822) DISPERSION SUM RULES FOR STRONG AND ELECTROMAGNETIC INTERACTIONS. Matveev, V. A.; Plesarenko, V. G.; Struminskii, B. V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 8p. Dep. mn.

Dispersion sum rules for strong and electromagnetic interactions of nucleons are considered. In the resonance approximation the relations between coupling constants and magnetic moments of nucleons are obtained. The results are in good agreement with the experiment. (auth)

41800 (UCRL-14716) ELASTIC AND INELASTIC PROTON-PROTON SCATTERING: A BIBLIOGRAPHY. Schauer, Carlotta V. (Lawrence Radiation Lab., Univ. of California, Livermore). Mar. 28, 1966. Contract W-7405-eng-48. 24p. Dep. mn. CFSTI \$1.00 cy, \$0.50 mn.

A selective bibliography is presented on elastic and inelastic proton-proton scattering covering the period 1960 to January 1966. References were compiled from Chemical Abstracts, Nuclear Science Abstracts, and Physics Abstracts. (B.G.D.)

41820 DISTORTED-WAVE ONE-PION-EXCHANGE MODEL FOR INELASTIC PROTON-PROTON SCATTERING. Yock, P. C. M. (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Nuovo Cimento (10), 44A: 777-83 (Aug. 1, 1966). (MIT-2098-246).

The one-pion-exchange model, modified to allow for initial- and final-state interactions, is applied to those inelastic two-body proton-proton scattering processes involving the excitation of the two lightest nucleon isobars. The model apparently overestimates the N^{*+} (1238) production cross-section, but gives a satisfactory account of N^{*+} (1430) production. (auth)

41873 TWO-PION-EXCHANGE EFFECTS IN NN SCATTERING AND CONSISTENCY WITH πN SCATTERING. Durso, John W. (Michigan State Univ., East Lansing). Contract AT-(11-1)-1051. Phys. Rev., 149: 1234-42 (Sept. 30, 1966). (TID-22834).

The two-pion-exchange contribution to nucleon-nucleon scattering was recalculated using the method of Amati, Leader, and Vitale; previous errors were eliminated. The new results show that low-energy pion-nucleon scattering phenomena and two-pion exchange effects in nucleon-nucleon scattering can be explained in a consistent way. The results also show that the two-pion parts of the NN phase shifts are dominated by the cross-channel s-wave contribution, in contrast to the results of Amati et al. The cutoff sensitivity of both the total and high-wave cross-

channel contributions is examined, and arguments are presented to explain the strong sensitivity of the high-wave part. (auth)

41877 LARGE-ANGLE NEUTRON-PROTON C_{NN} PARAMETER AT 23.1 Mev. Malanify, J. J.; Bendt, P. J.; Roberts, T. R.; Simmons, J. E. (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. Lett., 17: 481-4 (Aug. 29, 1966). (LA-DC-7537)

The neutron-proton spin-correlation parameter, C_{NN} , was measured at $\theta_n = 140$ and 174° c.m., by scattering polarized neutrons from a polarized proton target. Comparison to recent phase-shift analyses is made, and a sensitivity of the S-D coupling parameter to the data is noted. (auth)

41882 ENERGY DEPENDENCE OF PROTON-PROTON BREMSSTRAHLUNG. Slaus, Ivo; Verba, J. W.; Richardson, J. Reginald; Carlson, R. F.; van Oers, W. T. H.; August, L. S. (Univ. of California, Los Angeles). Phys. Rev. Lett., 17: 536-8 (Sept. 5, 1966).

An accurate measurement of the proton-proton bremsstrahlung cross section which can be compared with the independent measurement at 48 Mev by Warner (Phys. Letters 18: 289 (1965)) is presented, in order to investigate the energy dependence of the cross section, and to investigate the angular distribution of gamma rays for a fixed pair of proton angles. (B.G.D.)

41895 LARGE ANGLE PROTON-PROTON SCATTERING AND REAL PART OF THE SCATTERING AMPLITUDE. Yamamoto, Yoshitaka (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 35: 809-20 (May 1966).

The large angle P-P scattering in the accelerator energy region is discussed. This large angle scattering is assumed to be due to the real part of the scattering amplitude. The real amplitude for an arbitrary angle is derived, by using only the experimental information on the imaginary amplitude for small momentum transfer, and the ratio of the real to the imaginary forward amplitude. A model for the central collision is introduced. The differential cross section for large momentum transfer and the total elastic cross section can be obtained from this real amplitude. They fit the experimental curves well, and support the assumption. It is also inferred from the real amplitude that the region of the central collision is of the order of a nucleon Compton wave length. (auth)

41896 LARGE-ANGLE ELASTIC PROTON-PROTON SCATTERING AT HIGH ENERGY. Bando, Masako; Takada, Yoshio (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 35: 834-9 (May 1966).

A possible explanation of the characteristic features of large angle elastic proton-proton scattering at high energies is suggested. The effect of the diffraction scattering

of a cloud pion of the target proton from the incident proton is calculated; this gives the main contribution in the region II where the scattering angle ranges from 20 to 70° . (auth)

41899 ONE-BOSON EXCHANGE POTENTIALS IN NUCLEON-NUCLEON SCATTERING. Cronstroem, C.; Laurikainen, K. V. (Univ. of Helsinki). Soc. Sci. Fenn., Comment. Phys. Math., 31: No. 4, 1-16 (1965).

The N-N scattering was investigated assuming one-boson exchange process only. In addition to the OPEP, potentials corresponding to η -, ρ - and ω -meson exchange and a hard core are included in the N-N interaction. The results are not sufficiently compatible with all experimental phase shifts, and it is observed that the agreement could be improved by introducing a potential term corresponding to a hypothetical isotriplet scalar boson. (auth)

41915 MEASUREMENTS OF THE DIFFERENTIAL CROSS-SECTION AND POLARIZATION IN PROTON-PROTON SCATTERING AT ABOUT 143 Mev. Jarvis, O. N.; Cox, G. F.; Eaton, G. H.; Rose, B.; Van Zyl, C. P. (Atomic Energy Research Establishment, Harwell, Eng.). pp 595-601 of Proceedings of the Williamsburg Conference on Intermediate Energy Physics. Vol. II. Williamsburg, Va., College of William and Mary, 1966.

Measurements of the differential cross section and polarization in proton-proton interactions at 143 Mev were repeated with improved accuracy. The cross section data were obtained to a relative precision of better than $\pm 0.5\%$ and the absolute scale was determined to $\pm 0.8\%$. The polarization data were determined to a relative precision of about 1% of the maximum value and the absolute scale to 0.85% . These data are shown. (J.F.P.)

41916 EXPERIMENTAL ASPECTS OF NUCLEON-NUCLEON SCATTERING AND POLARIZATION BELOW 1 Bev. Rose, B. (Atomic Energy Research Establishment, Harwell, Eng.). pp 603-47 of Proceedings of the Williamsburg Conference on Intermediate Energy Physics. Vol. II. Williamsburg, Va., College of William and Mary, 1966.

The present state of nucleon-nucleon data is reviewed. There has been a resurgence of interest in the problem at 300-700 Mev, partly stimulated by the availability of polarized targets. Some of the new data is clearing away old discrepancies and some revealing new ones. The precision of existing data is rarely as high as claimed, and much greater precision will be needed if unique energy independent analyses are to be carried out at the higher energies. Twice as many experimental papers are published on the p-p as on the n-p system. It is proposed that more attention be devoted to the neutron proton system with neutron beams, in preference to quasi-free experiments using the deuteron as a neutron target. The problems of doing so are discussed. Recent results on nuclear bremsstrahlung are briefly mentioned. (auth)

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41921 P-P BREMSSTRAHLUNG CALCULATIONS. Signell, P. (Michigan State Univ., East Lansing); Marker, D. 12p. (CONF-660209-14; TID-22859). ORAU. Gmelin, AED-CONF-66-023-14.

From Williamsburg Conference on Intermediate Energy Physics, Va.

The predictions for p,p γ interactions are calculated from potentials of four types using the two-potential formalism of Gell-Mann and Goldberger: hard-core, long-range finite core, weak momentum dependent, and nonlocal separable potential. The results for the 50 Mev calculations are discussed, and discrepancies between theory and data are analyzed. (L.B.S.)

44074 SOME EFFECTS OF THE STRONG INTERACTIONS ON THE PROPERTIES OF NEUTRON-STAR MATTER. Wolf, Richard A. (California Inst. of Tech., Pasadena). *Astrophys. J.*, 45: 834-41 (Sept. 1966).

A modified phase-shift method is used to estimate the chemical potentials of neutrons and protons in neutron-star matter. The computed chemical potentials are used to calculate the densities of protons, electrons, and muons in neutron-star matter containing no strange particles. The strong interactions increase the number densities of protons and electrons by as much as a factor of 5 over the values calculated by the free-particle approximation. The clustering of protons into "nuclei" is considered, and it is shown that "nuclei" are likely to form at densities less than about $\frac{3}{4}$ nuclear density. The question of superfluidity in neutron-star matter is discussed. The effects of strong interactions on neutrino emission are also considered, and an expression is given for the rate of the reaction $n + n \rightarrow n + p + e^- + \bar{\nu}$ and its inverse. (auth)

44191 PHASE-SHIFT ANALYSIS OF NUCLEON-NUCLEON SCATTERING AT 400 Mev. Kazarinov, Yu. M.; Lehar, F.; Janout, Z. (Joint Inst. of Nuclear Research, Dubna, USSR). *JETP Lett. (USSR) (Engl. Transl.)*, 4: 75-8 (Aug. 1, 1966).

Translated from *Zh. Eksperim. Teor. Fiz., Pis'ma Redakt.*, 4: 110-14 (Aug. 1, 1966).

The results of a phase shift analysis in nucleon-nucleon scattering around 400 Mev are presented using data on triple-scattering polarization and parameters. (L.B.S.)

44196 THEORY OF DEUTERON PRODUCTION IN PROTON-PROTON COLLISIONS. Chahoud, J. N.; Russo, G.; Selleri, F. (Univ., Bologna. Istituto Nazionale di Fisica Nucleare, Bologna). *Nuovo Cimento* (10), 45A: 38-57 (Sept. 1, 1966).

A dynamical model is presented for the reaction $p + p \rightarrow d + \pi^+$ based on the assumption that its amplitudes are dominated by graphs with anomalous thresholds. The predictions of the model are calculated and found to be in good agreement with experiments. (auth)

44222 THE ρ' TRAJECTORY AND ITS CONTRIBUTION TO NN AND π N CHARGE EXCHANGE SCATTERING. Hoegaasen, H.; Fischer, W. (CERN, Geneva). *Phys. Lett.*, 22: 516-19 (Sept. 1, 1966).

The zero intercept of a ρ' Regge trajectory is determined from experimental data on nucleon-nucleon collisions. A neat explanation of the positive polarization in $\pi p \rightarrow \pi^0 n$ is presented. (auth)

44632 (CONF-660303, pp 1084-91) PROPOSED RECOIL TECHNIQUE FOR NEUTRON-PROTON DIFFERENTIAL CROSS SECTION MEASUREMENTS IN THE 15-30 Mev RANGE. Benenson, R. E. (City Coll., New York. Columbia Univ., New York); Patton, W. (Columbia Univ., New York).

A method is described for employing a single well-shielded counter for the simultaneous recording of a continuous distribution of recoil angles from a thin radiator. Angles are inferred from the $\cos^2 \theta_0$ angle-energy relation through pulse heights in a high-resolution solid-state detector. Recoil trajectories are caused to converge onto the detector by means of a nearly uniform magnetic field in which the radiator is placed. The possible advantages of such a system are discussed, analytical and graphical methods for specifying the specially shaped pole edges are described, and some practical details of magnet fabrication are mentioned. (auth)

46378 CROSSING RELATIONS AND SPIN STATES.

Jacob, M. (MATSCIENCE, Madras). pp 55-62 of *Symposia on Theoretical Physics. Vol. 2. Ramakrishnan, Alladi (ed.). New York, Plenum Press, 1966.*

Conservation of parity and time reversal invariance are used to reduce the number of independent p-p amplitudes to five. In the crossed p-p channel parity conservation and charge conjugation invariance are used. Meson (π)-nucleon scattering is also considered. (J.F.P.)

46379 EFFECTIVE-RANGE APPROXIMATION BASED ON REGGE POLES. Udagonkar, B. M. (Tata Inst. of Fundamental Research, Bombay). pp 87-93 of *Symposia on Theoretical Physics. Vol. 2. Ramakrishnan, Alladi (ed.). New York, Plenum Press, 1966.*

It is shown how singularities in the complex momentum plane can be used to provide a good description of low-energy n-p scattering. The expression obtained has no arbitrary constants and gives reasonably good agreement with experimental data. The effect of reggeizing the nucleon was to cut down its contribution even at threshold compared to what it is when treated as an ordinary particle. (J.F.P.)

46381 MEASUREMENT OF THE PARAMETER R IN THE ELASTIC pn-SCATTERING AT 605 Mev AND THE NUCLEON-NUCLEON PHASE SHIFT ANALYSIS. Kazari-

nov, Yu. M.; Legar, F.; Pisarev, A. F.; Simonov, Yu. N.; Yanout, Z. (Joint Inst. for Nuclear Research, Dubna, USSR). *Yadern. Fiz.*, 4: 567-77 (Sept. 1966). (In Russian).

The triple scattering parameter R_{pn} and the polarization P_{pn} in pn-scattering at 90 and 125° (cms) were measured at 605 Mev. The measurements were performed using spark chambers. The polarization power of the analyzers and "instrumental parameters" were determined experimentally. Corrections for geometric distortions due to the track photographing system are taken into account. The values were found to be: $R_{pn}(90^\circ) = 0.50 \pm 0.11$, $P_{pn}(90^\circ) = -0.07 \pm 0.06$, $R_{pn}(125^\circ) = -0.06 \pm 0.28$, $P_{pn}(125^\circ) = -0.44 \pm 0.16$. Three previously known phase-shift sets at 630 Mev were specified. It is shown that one of the sets can be excluded on the basis of the new data. (auth)

46723 n-p TRIPLE SCATTERING PARAMETER R_t AT 203 Mev. Reay, N. W.; Thorndike, E. H.; Spalding, D.; Thomas, A. R. (Univ. of Rochester, N. Y.). *Phys. Rev.*, 150: 801-6 (Oct. 21, 1966). (UR-875-132).

The neutron-proton interaction was studied by bombarding deuterons with 203-Mev polarized protons and observing high-energy neutrons recoiling into forward angles. The triple-scattering parameter R_t was measured at neutron laboratory angles between 0 and 20°, using a spin-analyzing scatterer of liquid hydrogen, and detecting charge-exchange scattered protons therefrom. The measurements are related to the free n-p scattering amplitudes by means of an impulse-approximation calculation which includes the s-wave final-state interaction between the incident proton and the proton in the deuteron. The measured values of R_t are compared with the phase-shift solutions YLAN of Breit and collaborators and with the energy-independent solution of Arndt and MacGregor. Solutions YLAN 0, 1, 2, 2M, and 3 do not agree with the data. Solutions YLAN 3M and 4M and the Arndt-MacGregor solution fit the data quite well. (auth)