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Alpha-Alpha Elastic Scattering:
A Bibliography

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Alpha-Alpha Elastic Scattering:
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Compiled by

Jean Furnish

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ALPHA-ALPHA ELASTIC SCATTERING:

A BIBLIOGRAPHY

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Jean Furnish

Nuclear Science Abstracts was searched from Volume 7 (1953) through Volume 22 Number 15 (August 15, 1968) for material on the elastic scattering of alpha particles on alpha particles. The references are arranged numerically within each volume with the abstracts from the most recent volume presented first.

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Volume 22 (1968)

1893 EFFECTIVE RANGE ANALYSIS OF LOW-ENERGY α - α SCATTERING. Kermode, M. W. (Univ. of Liverpool). Nucl. Phys., A104: 49-66(1967).

The experimental S-, D- and G-wave phase shifts for the scattering of alpha particles from the ${}^4\text{He}$ nucleus are analyzed by means of the hard-core effective range formula. It is found that an effective hard-core radius can be defined which takes approximately the same value (1.7 fm) for all three partial waves. The width of the ground state of ${}^8\text{Be}$ is found to be 6.14 ± 0.04 eV. This compares favorably with the experimental value of 6.8 ± 1.7 eV. The justification for the use of a hard core in the α - α interaction is given by a suggested modification to the resonating group method. Effective range formulae for scattering by Coulomb and short-range potentials without a hard core are also derived. (auth)

5769 LIFETIME AND ENERGY OF THE GROUND STATE OF ${}^8\text{Be}$. Benn, J.; Dally, E. B.; Mueller, H. H.; Pixley, R. E.; Staub, H. H.; Winkler, H. (Univ., Zurich). Nucl. Phys., A196: 296-312(1967).

A detailed account of measurements of the ground-state energy and the lifetime of ${}^8\text{Be}$ by α - α elastic scattering is presented. The nuclear ground-state energy is $E_0 = 92.12 \pm 0.05$ keV; the width of the ground state $\Gamma = 6.8 \pm 1.7$ eV corresponds to a lifetime $\tau = 0.97 \times 10^{-16}$ sec. (auth)

20434 (JINR-P4-3717) α - α RASSEYANIE V SLUCHAE NELOKAL'NOGO FAKTORIZUYUSHCHEGOSYA VZALMODEI-STVIYA. (α - α Scattering for the Case of Non-Local Factorizing Interaction). Tkébuchava, F.; Chilaashvili, G. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1968. 7p. (In Russian). Dep.

Alpha-alpha scattering is investigated taking into account the Coulomb interaction for the case of a nonlocal factorizing potential. The parameters of the interaction potential are found from the phase-shift analysis using the experimental values of the S phase in the interval $E = 0.2$ to 10 MeV. (auth)

22545 VACUUM POLARIZATION AND LOW-ENERGY SCATTERING. Kermode, M. W. (Univ. of Liverpool). J. Phys., A, 1: 236-50(Mar. 1968).

The effects of vacuum polarization on the S-wave scattering of protons by protons and alpha particles by alpha particles are investigated. The calculations are exact. The inclusion of vacuum

polarization gives a slightly improved effective range fit to the p-p scattering data. The width of the ground state of beryllium is calculated from the α - α scattering data. The value of 6.14 ± 0.04 eV compares favorably with the experimental value of 6.8 ± 1.7 eV. (auth) (UK)

26795 ALPHA-ALPHA SCATTERING BY ONE-BOSON-EXCHANGE POTENTIALS. Payne, G. (Univ. of Iowa, Iowa City). Phys. Rev., 168: 1181-3(Apr. 20, 1968).

Theoretical phase shifts are obtained for α - α elastic scattering, using one-boson-exchange potentials, at higher energies (40- to 100-MeV lab energy), where, it is argued, both exchange and polarization can be neglected. It is pointed out that the study of α - α scattering can be useful in determining meson-nucleon coupling constants, since selection rules prevent the direct exchange of some of the mesons that contribute to nucleon-nucleon scattering. In particular, one set of meson-nucleon coupling constants is shown to be inadequate, and strong support is given to a second set. Comparison with the methods used in previous calculations at lower energies is made, and an ambiguity in the definition of the one-boson-exchange potential is pointed out. (auth)

26826 INTERACTION BETWEEN α -PARTICLES. Abe, Y.; Endo, O.; Tamagaki, R.; Tanaka, H. (Hokkaido Univ., Sapporo). pp 45 of Contributions, International Conference on Nuclear Structure, September 7-13, 1967, Tokyo, Japan. Tokyo, Tokyo Univ., 1967.

See CONF-670910.

26846 0^+ STATES OF ${}^8\text{Be}$. Barker, F. C.; Hay, H. J.; Treacy, P. B. (Australian National Univ., Canberra). pp 107 of Contributions, International Conference on Nuclear Structure, September 7-13, 1967, Tokyo, Japan. Tokyo, Tokyo Univ., 1967.

See CONF-670910.

32487 ALPHA-ALPHA INTERACTION POTENTIAL. Shanta, Rajagopal (Saha Inst. of Nuclear Physics, Calcutta). pp 106-10 of Proceedings of the Nuclear Physics and Solid State Physics Symposium, Kanpur, February 27-March 3, 1967. Nuclear Physics. Trombay, India, Bhabha Atomic Research Centre, 1967.

v. 22 (1968)

See CONF-670220-(Vol.2).

An attempt is made to fit the phase-shift data for alpha-alpha scattering up to cms energies ≤ 12 MeV by a phenomenological α - α interaction potential. Following the discussions of the results obtained by Van Der Spuy and Pienaar, a potential with a strongly l-dependent repulsive core and an outside l-independent attractive region is considered in fitting the phase shifts. The repulsive core radius is smaller for higher l. With a suitable choice of the necessary parameters, this potential is seen to give reasonable results in the energy region considered. (auth)

32708 ALPHA PARTICLE SCATTERING: Mehta, M. K. (Bhabha Atomic Research Centre, Trombay, India). pp 131-57 of Proceedings of the Nuclear Physics and Solid State Physics Symposium, Kanpur, February 27-March 3, 1967. Nuclear Physics. Trombay, India, Bhabha Atomic Research Centre, 1967. See CONF-670220-(Vol.2).

The use of alpha scattering in the investigation of nuclear phenomena is discussed, including methods for analyzing alpha scattering data. (D.C.W.)

32723 NUCLEAR GLORY SCATTERING. Bryant, Howard C. (Univ. of New Mexico, Albuquerque); Jarmie, Nelson. Contract AT(29-1)-789. Ann. Phys. (N.Y.), 47: 127-40(1968). (SC-CR-67-2578).

A simple model in terms of surface waves for nuclear backscattering analogous to the optical explanation of the meteorological glory is derived for spin-0 and spin $-\frac{1}{2}$ particles from spin-0 targets. Numerous examples of α scattering from spinless nuclei in the energy range from 18 to 50 MeV and π^+ scattering from protons in the range 2 to 8 GeV are fit successfully with the model. The model yields estimates of the radius of interaction whose values are in agreement with radii determined by other means. Other theories and models relating to backscattering are discussed and attention is called to the similarity between the model and the Regge-pole treatment of this problem by Ceuleneer, Demeur, and Reignier. (auth)

Volume 21 (1967)

11965 EFFECTIVE RANGE ANALYSIS OF s- AND d-WAVE α - α SCATTERING. Rasche, G. (Univ., Zurich). Nucl. Phys., A94: 301-12(1967)

The new Q-value E_r and width Γ of the ^8Be ground state as determined by the Zurich group were analyzed with the low-energy α - α s-wave phase shifts δ_0 to determine the effective range expansion parameters of the phase shift δ_0 . Use of these parameters gives better limits on Γ than the direct experimental limits quoted previously. The maximum of δ_0 as a function of the center-of-momentum energy is calculated to be very close to 180° , but does not exceed this value. The order of magnitude of δ_0 in this energy region is estimated on the basis of an effective-range analysis for $l = 2$; it is seen that δ_0 is negligible. (auth)

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.)

20735 INTERACTION POTENTIAL OF α -PARTICLES OBTAINED FROM SCATTERING DATA AT LOW ENERGIES. Kamuntavicius, G.; Sugurov, V.; Janavicius, A. (Kapsukas State Univ., Vilnius, USSR). Lietuvos Fiz. Rinkiny, Lietuvos TSR Mokslu Akad., Lietuvos TSR Aukstosios Mokyklos, 6: 23-31 (1966). (In Russian).

A theoretical discussion is given for α -particle interaction potentials. Experimental data obtained at low energies are compared with the theory. (M.O.W.)

21447 EFFECTIVE-RANGE THEORY AND THE GROUND STATE OF ^8Be . Kermode, M. W. (Univ. of Liverpool). Phys. Lett., Part B, 24: 357-8(Apr. 17, 1967).

A width of 6.14 ± 0.04 eV for the ^8Be ground state is obtained from an effective-range analysis of the s-wave phase shift for α - α scattering. (auth)

23585 COMPLEX ANGULAR MOMENTUM IN NUCLEAR REACTIONS. Treacy, P. B. (Australian National Univ., Canberra). Nucl. Phys., A96: 145-58(1967).

The scattering amplitude and reaction line shapes in a spinless charged-particle channel are analyzed in terms of poles in angular momentum. The case of ^4He plus ^4He is considered as an example of the one-pole approximation. Practical difficulties are considered in regard to lack of unitarity, wrong threshold behavior, and ambiguity of background, in the representation. A modified representation is proposed, from which these difficulties have been eliminated. (auth)

35511 EXCHANGE CONTRIBUTION IN THE ELASTIC SCATTERING OF α -PARTICLES BY LIGHT NUCLEI. Quesne, C.; Willain, C. (Univ. Libre, Brussels). Bull. Cl. Sci., Acad. Roy Belg. (5), 49: 1156-64(Nov. 9, 1963). (In French).

The elastic scattering differential cross section of α particles by α nuclei described in the α model was calculated in the plane-wave Born approximation. It is shown that, when the target nucleus is ^8Be and the range of the interaction between α particles is zero, the contribution of the heavy-particle stripping mode is very small in comparison with those of the direct and knock-out processes, so that the total differential cross section is forward peaked. (auth)

37835 PHASE-SHIFT CALCULATIONS FOR REAL AND REALISTIC POTENTIALS. Ali, Shamsheer; 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)

38241 PHENOMENOLOGICAL α - α POTENTIAL AND THE GROUND STATE OF ^8Be . Ali, S.; Afzal, S. A. (International Atomic Energy Agency, Trieste, Italy). Nuovo Cim. (10), 50B: 355-8(Aug. 11, 1967).

v. 21 (1967)

It was shown that a phenomenological s -state α - α potential, the attractive part of which is constructed from G -wave scattering data and which is in keeping with the qualitative features demanded by a fundamental model of the α - α interaction, can provide a fairly adequate representation of the ground state of ${}^8\text{Be}$. (D.C.W.)

40368 α - α INTERACTION AT HIGH ENERGIES. Abe, Yasuhisa; Endo, Osamu; Tamagaki, Ryozi (Hokkaido Univ., Sapporo). Progr. Theor. Phys. (Kyoto), 37: 1116-30 (June 1967).

It is shown that the inside repulsive core of the α - α interaction appearing in the effective potential description at low energies, turns strongly absorptive at very high energies. The impulse approximation is used to construct an α - α optical potential at high energies from two-nucleon scattering amplitudes. By comparison with the elastic scattering data at 915 MeV, the qualitative properties of the α - α optical potential thus derived are confirmed as reliable. Also, it is shown that the effects of target exchange terms give no essential modification to this potential. (auth)

Volume 20 (1966)

13879 A POSSIBLE ORIGIN OF REPULSIVE CORE IN NUCLEAR FORCES. Otsuki, Shoichiro; Tamagaki, Ryo-
Yasuno, Masaru (Nagoya Univ., Japan). [Progr. Theoret.
Phys. (Kyoto), 34: Suppl., 578-601(1965)].

A dynamical treatment is made of an originating mechanism of repulsive core provided that the nucleon is a few fermion system with hard internal structure, by investigating N-N interaction in parallel with α - α one. It is clarified that the originating mechanism of such a structural core is closely related, above all, with the internal structure of the composed state of two nucleons (corresponding to ${}^8\text{Be}$ in the α - α case). A typical exchange kernel expected by the few fermion structure is proposed, whose effect is almost equivalent to the observed hard core. Some phenomenological aspects of such structural core are discussed. (auth)

15489 (CEA-R-2786) CONTRIBUTION A L'ETUDE DE L'INTERACTION ALPHA-ALPHA [THESES]. (Contribution to the Study of the Alpha-Alpha Interaction [Thesis]). Darriulat, Pierre (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1965. 96p. Dep. mn.

Submitted to Paris Univ.

Two sets of measurements of the α - α elastic scattering differential cross section are presented. The first set—angular distributions from 50 to 120 Mev—shows resonances, 6^+ and 8^+ , at 25 and 57 Mev. Complex phase shifts are extracted from the data and a phenomenological potential is given. A description of the 3 α -particle 0^+ states in ${}^{12}\text{C}$ is made with this interaction potential. The second set—excitation curves between 20 and 50 Mev—allows investigation of the ${}^8\text{Be}$ level structure within this energy range. The 16.6 and 16.9 Mev states are identified as 2^+ , but the rise of inelastic processes at higher energies makes further identification of spins and parities difficult. (auth)

22061 PHENOMENOLOGICAL α - α POTENTIALS. Ali, S. (The Univ., Manchester, Eng.); Bodmer, A. R. Nucl. Phys., 80: 99-112(1966).

Phenomenological l-dependent α - α potentials are obtained for $l = 0, 2$ and 4 from fitting the relevant phase shifts for c.m. energies ≤ 12 Mev. For the nuclear part of the potentials, a superposition of repulsive and at-

tractive Gaussian shapes was used. Following theoretical indications, an attempt was made to obtain fits with an l-independent attractive part having a longer range than the repulsive parts, and to obtain, at first, the attractive part from just the $l = 4$ phase shift in view of the effect of the large $l = 4$ centrifugal barrier in masking the inner repulsive part. It is, in fact, found possible to obtain acceptable potentials with a common attractive part. These potentials are, however, strongly l-dependent through the repulsive part which becomes weaker as l increases. For $l = 4$, only a quite weak repulsive part is found to be permissible. The potentials are in good agreement with those recently obtained by Darriulat et al. The possible importance of the attractive tail of the α - α potential as a selective probe into just the central, spin-independent, isospin-independent part of the nuclear force is pointed out and discussed. (auth)

23433 CLUSTER-MODEL CALCULATION FOR PHASE SHIFTS OF α - α SCATTERING. Okai, Sueji (Florida State Univ., Tallahassee); Park, Shim C. Phys. Rev., 145: 787-93(May 20, 1966).

In the framework of the binary alpha cluster model, phase shifts for s, d, g, i, and k partial waves for α - α scattering are calculated through the excitation energy of 40 Mev. These are compared with recent experiments that appear to suggest the existence of the rotational states with $J^\pi = 6^+$, 8^+ of the nucleus ${}^8\text{Be}$, beyond the lowest three states with $J^\pi = 0^+$, 2^+ , and 4^+ . A reasonable agreement is obtained between the calculated phase shifts and the real part of the experimental ones. The present result is also compared with the phase shifts obtained by the phenomenological α - α two-body potential models. A detailed analysis shows that the angular-momentum-dependent but energy-independent core radii of the two-body potential models coincide with the outermost nodes of the scattering functions within the contact distance of two α nuclei. The wave functions within the contact distance do not vanish, however, and hence the repulsive core in a literal sense does not exist. This result is examined in reference to the cluster structure of the ${}^8\text{Be}$ compound nucleus. (auth)

32531 OPTICAL POTENTIAL FOR HIGH-ENERGY α - α SCATTERING. Abe, Yasuhisa; Tamagaki, Ryo-
(Hokkaido Univ., Sapporo). Progr. Theoret. Phys. (Kyoto),

v. 20 (1966)

35: 569-71(Mar. 1966).

An investigation is presented on how the α - α repulsive core at low energies turns to the absorptive core at high energies, where a number of channels are open. An α - α optical potential at $E_{\text{lab}} = 915$ Mev is derived. (B.G.D.)

32532 HIGH-ENERGY α - α SCATTERING. Endo, Osamu (Hokkaido Univ., Sapporo). Progr. Theoret. Phys. (Kyoto), 35: 571-2(Mar. 1966).

An investigation is presented on how the α - α repulsive core at low energies turns to the absorptive core at high energies. The differential cross section at $E_{\text{lab}} = 915$ Mev is analyzed in the diffraction model. (B.G.D.)

46696 EFFECTIVE-RANGE THEORY AND THE GROUND STATE OF ^8Be . Tombrello, T. A. (California Inst. of Tech., Pasadena). Phys. Lett., 23: 106-8(Oct. 10, 1966).

It is shown that on the basis of the available data the width of the ^8Be ground state can not be accurately determined from an effective-range analysis of the S-wave shift for α - α scattering. (auth)

Volume 19 (1965)

25295 THE CONTRIBUTION OF MESON EXCHANGE TO THE α - α POTENTIAL. T. W. Preist (Brown Univ., Providence). Nuovo Cimento (10), 37: 186-71 (May 1, 1965).

The graphs for the exchange of the ω meson and a neutral scalar meson σ are used to calculate the α - α potential. The phase shifts for this potential are compared with experiment and reasonable agreement is obtained using coupling constants similar to those used in nucleon-nucleon calculations. (auth)

25300 THE ANALYTIC PROPERTIES OF REGGE TRAJECTORIES. PART II. A. E. A. Warburton (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Nuovo Cimento (10), 37: 268-77 (May 1, 1965).

The branch points of the Regge trajectories $\alpha(k)$ are studied for varying strength A of a Yukawa potential, both attractive and repulsive. They go to $k = 0$ for $A \rightarrow 0$, while for large A they go to infinity as $A^{\frac{1}{2}}$, or leave the physical sheet. For attractive potentials, the branch points leave the physical k^2 sheet for A of order unity. Those trajectories which tend to complex l_0 as $k \rightarrow 0$ are also discussed. As an example of a more complicated potential with relativistic-looking trajectories, α - α scattering is considered. (auth)

43174 REPULSIVE CORE OF EFFECTIVE α - α POTENTIAL. Tamagaki, Ryozi; Tanaka, Hajime (Hokkaido Univ., Sapporo). Progr. Theoret. Phys. (Kyoto), 34: 191-2 (July 1965).

An investigation was made of the origin of the repulsive core, the angular momentum dependence, and the energy independence of the effective α - α potential, based on solutions of the integro-differential equations for the α - α relative wave function. (L.B.S.)

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Volume 18 (1964)

14927 α - α SCATTERING AND PAULI PRINCIPLE.
Hans W. Wittern (Florida State Univ., Tallahassee).
Z. Naturforsch., 18a: 1254-65 (Dec. 1963). (In German)

With regard to the Pauli principle and some general characteristics of 8-particle problems, an approximately valid reduction to a two-particle problem was undertaken and a potential derived, that correctly describes α - α scattering at least for low energies. (tr-auth)

17019 EXCHANGE CONTRIBUTION TO THE SCATTERING OF ALPHA PARTICLES BY LIGHT NUCLEI.
C. Quesne and C. Willain (Institut Interuniversitaire des Sciences Nucléaires, Brussels). J. Phys. (Paris), 24: 940-1 (Nov. 1963). (In French)

The contribution of the exchange term to the elastic scattering differential cross section of α particles has been calculated in the Born approximation, the target being described by the alpha-model. (auth)

30532 (UCRL-11382) ELASTIC ALPHA-ALPHA SCATTERING NEAR 40 Mev. H. E. Conzett, R. J. Slobodrian, S. Yamabe, and E. Shield (California Univ., Berkeley, Lawrence Radiation Lab.). Apr. 21, 1964. Contract W-7405-eng-48. 7p. (CONF-502-13)

From the International Congress of Nuclear Physics, Paris, July 1964.

In order to investigate suggested rapid energy variation of the s, d, and g-wave phase shifts near 40 Mev, differential cross sections were measured for alpha-alpha scattering over center-of-mass angles from 16 to 100 degrees at nine energies between 37 and 43 Mev. Analysis of these data is underway and is directed toward determining whether resonances corresponding to states in ${}^8\text{Be}$ or threshold effects of opening reaction channels are responsible for the indicated behavior of the phase shifts. (auth)

34001 EXCHANGE CONTRIBUTION TO ELASTIC SCATTERING OF α PARTICLES BY LIGHT NUCLEI.

C. Quesne and C. Willain (Université Libre, Brussels). Bull. Classe Sci., Acad. Roy. Belg. (5), 49: 1156-64 (1963). (In French)

The differential cross section for elastic scattering of alpha particles by light nuclei described by the alpha model was calculated in the plane-wave Born approximation. Be^8 was treated as an example. When the range of interaction between alpha particles was zero, the contribution of the heavy-particle stripping mode was very small in relation to those of the direct and knock-out processes, producing forward peaking of the total differential cross section. (D.C.W.)

44581 PHENOMENOLOGICAL α - α POTENTIAL.
Osamu Endō, Ichirō Shimodaya, and Jun Hiura (Hokkaido Univ., Sapporo). Progr. Theoret. Phys. (Kyoto), 31: 1157-8 (June 1964).

The features of the alpha-alpha interaction were investigated, together with the extent to which alpha-alpha scattering can be explained in terms of an energy-independent potential. (D.C.W.)

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Volume 16 (1962)

8176 THE PHASE SHIFT ANALYSIS ON ALPHA-ALPHA SCATTERING IN THE ENERGY RANGE FROM 22.9 TO 28.9 Mev. Kozo Miyake (Kimura Lab., Japan). Bull. Inst. Chem. Research, Kyoto Univ., 39: 313-21 (Nov. 1961). (In English)

Alpha scattering by helium was studied experimentally with increased accuracy at five energies between 22.9 and 28.9 Mev. The phase shift analysis up to $L = 6$ was performed for each energy. The result shows that the S-, D- and G-wave phase shifts are necessary to fit the data and the I-wave phase shift is small in this energy range. Low parameters for the G-state were extracted using the dispersion theory, and are compatible with the alpha-alpha model of Be⁸. (auth)

26171 INTERACTION BETWEEN ALPHA PARTICLES: Ichirō Shimodaya, Ryōzō Tamagaki, and Hajime Tanaka (Hokkaido Univ., Sapporo). Progr. Theoret. Phys. (Kyoto), 27: 793-810 (Apr. 1962). (In English)

Effective α - α potential is investigated from the standpoint of the cluster model using reliable properties of the pion-theoretical nucleon-nucleon potentials. The main features of α - α potential (outside attraction, inside repulsion, and angular momentum dependence) demanded from the analyses of low energy α - α scattering phenomena can be qualitatively reproduced. In constructing the α - α potential, the importance of the Pauli principle, which damps the relative wave function of two α -particles at small α - α distances, should be emphasized. Its connection with nucleon-nucleon potentials is discussed. (auth)

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Volume 15 (1961)

28560 INTERACTION BETWEEN ALPHA PARTICLES.

Ichirô Shimodaya, Ryozi Tamagaki, and Hajime Tanaka
(Hokkaido Univ., Sapporo). Progr. Theoret. Phys. (Kyoto),
25: 853-5 (May 1961). (In English)

By applying the pion-theoretical potentials recently verified in two-nucleon problems, alpha particle interactions were investigated from the viewpoint of the cluster model, without taking account of the polarization effects of the alpha particles. All the features essential to the alpha interactions can be reproduced by pion-theoretical potentials without polarizing alpha clusters. Thus there is strong support for the cluster model. (L.N.N.)

29899 PHASE SHIFT CALCULATIONS ON α - α SCATTERING. E. W. Schmid and K. Wildermuth (Florida State Univ., Tallahassee and Oak Ridge National Lab., Tenn.). Nuclear Phys., 26: 463-8 (1961). (In English)

The α - α scattering phase shifts are calculated, with two-nucleon forces that describe the low-energy two-nucleon scattering data. (auth)

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Volume 14 (1960)

5812

THE SCATTERING OF ALPHA PARTICLES BY HELIUM. A. C. Butcher (Univ. of Glasgow) and J. M. McNamee (University College, London). Proc. Phys. Soc. (London) **74**, 529-39(1959) Nov. 1.

Nuclear phase shifts are calculated for the scattering of two alpha particles, using the method of the resonating group structure, and assuming central Gaussian internucleonic potentials and Gaussian wave functions. It is found that a mixture of two-thirds Serber and one-third MHWB exchange force gives good agreement with the experimentally observed phase shifts. (auth)

11030

ALPHA-ALPHA SCATTERING IN THE ENERGY RANGE 5 TO 9 MEV. C. M. Jones, G. C. Phillips, and Philip D. Miller (Rice Inst., Houston, Tex.). Phys. Rev. **117**, 525-30 (1960) Jan. 15.

The scattering of alpha particles from helium was experimentally studied in the energy range 5 to 9 Mev by the measurement of three excitation functions at the center-of-mass angles 30° , 33° , 54° , 44° , and 70° . A phase-shift analysis was performed which indicates that only the S- and D-wave phase shifts are necessary to fit the data in this energy region. Only the well-known D state at approximately 2.9 Mev in Be^8 was observed. The D state was compared to the single-level dispersion theory and level parameters were extracted which are compatible with the alpha-particle model of Be^8 . (auth)

11110

ALPHA-ALPHA SCATTERING AT 7.56 MEV. N. Berk, F. E. Steigert, and G. L. Salinger (Yale Univ., New Haven) Phys. Rev. **117**, 531(1960) Jan. 15.

Alpha particles scattered from a helium gas target at an incident energy of 7.56 Mev were observed in nuclear emulsions. The differential cross sections measured can be fitted with phase shifts of $\delta_0 = 70^\circ$ and $\delta_2 = 100^\circ$. (auth)

13175

ALPHA-ALPHA SCATTERING IN THE RANGE 36.8 TO 47.3 MEV. Homer E. Conzett, George Igo, Harlan C. Shaw, and Rodolfo J. Slobodrian (Univ. of California, Berkeley). Phys. Rev. **117**, 1075-9(1960) Feb. 15.

Absolute differential cross sections for the elastic scattering of alpha particles from helium were obtained at 36.8, 38.8, 40.8, 41.9, 44.4, 46.1, 47.1, and 47.3 Mev. Measurements were made at intervals of 2 degrees over an angular range from about 15° to beyond 90° in the center of mass system. The angular distribution shows a single minimum at 65° at the two lowest energies, and two minima, at about 35° and 70° , at the other energies. (auth)

13176

OPTICAL MODEL ANALYSIS OF THE SCATTERING OF ALPHA PARTICLES FROM HELIUM. George Igo (Los Alamos Scientific Lab., N. Mex.; Inst. for Theoretical Physics, Heidelberg, Ger. and Max Planck Inst. for Nuclear Phys., Heidelberg, Ger.). Phys. Rev. **117**, 1079-85 (1960) Feb. 15.

An optical model analysis using a complex potential was made of the elastic scattering of alpha particles from helium. In the data analyzed, the bombarding energy ranges from 23.1 Mev to 47.1 Mev. The best agreement with the angular distributions taken at eight different bombarding energies was obtained when the parameters V , W , r_0 , and d were -112 Mev, -1 Mev (for bombarding energies near 40 Mev), 1.8×10^{-13} cm, and $0.6 \pm 0.1 \times 10^{-13}$ cm, respectively. The value -112 Mev for V is an average value; V decreases by 15% when the bombarding energy is increased from 23 to 47.1 Mev. Since W is small, the central depth of the real part of the potential V has significance. This is in contrast to the scattering of alpha particles from heavier elements where the absorption is so large that the central part of the potential is not easily determined. No lower limit was placed on r_0 ; however, r_0 must be less than 2.7×10^{-13} cm. The phase shifts obtained from this analysis are in good agreement with the preliminary results of Snyder below 42 Mev. Above 42 Mev they continue to vary slowly with no new states of Be^8 appearing up to 47.1 Mev. (auth)

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Volume 13 (1959)

17178

THE α , α INTERACTION. E. Van Der Spuy (Stellenbosch Univ., Union of South Africa). Nuclear Phys. 11, 615-24(1959) June (1).

The 8-body problem of the (α, α) scattering interaction is formulated by using the group resonance formalism, with two unpolarized α groups, and with the central nucleon-nucleon exchange force and α wavefunction both having a gaussian radial dependence. Choosing parameters as far as possible the same as required by the low energy nucleon-nucleon data, the α binding energy, and the (α, n) scattering interaction, it was attempted to explain the S and D phases for low energy (α, α) scattering which was previously found to require a velocity-dependent interaction. The (α, α) scattering requires slightly different values of $y = 4w + 2b - 2h - m$, both of which are lower than required by the (α, n) problem. It is shown that the S wave interaction essentially behaves as a potential at low energies. For low energies this potential effectively has a repulsive core with an attractive outside well—features which also emerged from a previous purely phenomenological analysis. (auth)

22804

THE INTERPRETATION OF α - α SCATTERING. Hans Wittern (Universität, Munich). Naturwissenschaften 46, 443-4(1959). (In German)

A semiphenomenological potential is derived from a consideration of the repulsion of single nucleons given by the Pauli principle and from the character of the shell model wave functions for the actual levels of the Be^8 compound nucleus and their excitation functions. The scattering phases are calculated from the potential. (J.S.R.)

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INVESTIGATION OF EXCITED STATES IN Be^8 BY
ALPHA-PARTICLE SCATTERING FROM He . R. Nilson,
W. K. Jentschke, G. R. Briggs, R. O. Kerman, and J. N.
Snyder (Univ. of Illinois, Urbana). Phys. Rev. **109**, 880-
60(1958) Feb. 1.

Partial phase shifts have been deduced from the data on the scattering of α particles (12.3 to 22.9 Mev) from He , reported in an earlier publication. The interpretation of the phase shifts is as follows: The monotonic decrease of the S-wave phase shift throughout the energy range investigated indicates no broad S states in Be^8 for excitations between 0.5 and 11.45 Mev. The D-wave phase-shift energy dependence clearly indicates the 2.9-Mev 2^+ state in Be^8 . The G-wave phase shift shows a broad 4^+ state in the neighborhood of 11 Mev with a reduced width of about 2 Mev. The I-wave phase shift is first observed at 20 Mev and is positive. Moderate success has been achieved in explaining the scattering results in terms of Haefner's alpha-particle model of Be^8 . (auth)

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752

SCATTERING OF ALPHA PARTICLES FROM HELIUM.

J. L. Russell, Jr., G. C. Phillips, and C. W. Reich (Rice Inst., Houston, Tex.). *Phys. Rev.* 104, 135-42(1956) Oct. 1.

Excitation curves and angular distributions for the scattering of α particles from helium have been obtained for bombarding energies of 3 to 6 Mev, using a differentially pumped gas scattering chamber and a singly charged α -particle beam from the Rice Institute Van de Graaff accelerator. A phase shift analysis of the data, yielding phase shifts accurate to about 2° , reveals that only S- and D-wave scattering occurs and shows that the well-known excited state at 2.9 Mev in Be^8 is a D state. The scattering data taken at the Department of Terrestrial Magnetism and the Universities of Illinois and Indiana are compared to the Rice Institute data by using the dispersion theory and the Landau K-function formalism developed for proton-proton scattering. The dispersion theory, applied to the Rice data, allows a rough estimate of the D-state level parameters, while the K function, applied to the Rice and D.T.M. data, is used to deduce a ground state width for Be^8 of 4.5 ± 3 ev (c.m.). For excitation energies below 12 Mev, the scattering data are consistent with a description of the Be^8 nucleus as an interaction of two α -particles. Certain qualitative features of the potential of interaction of such a two-body configuration are discussed. (auth)

3595

ELASTIC SCATTERING OF α -PARTICLES. S. W. MacDowell and J. J. Giambiagi. *Nuovo cimento* (10) 4, 1594-6 (1956) Dec.

Some remarks are made concerning an explanation of the elastic scattering of α particles based on a nuclear model in which the protons are more concentrated close to the center than the neutrons. (B.J.H.)

Refer also to abstract 3828.

5511

STUDIES IN THE α -PARTICLE MODEL OF NUCLEI. III. CALCULATION OF THE INTERACTION BETWEEN α -PARTICLES. A. Herzenberg (Univ. of Manchester). *Nuclear Phys.* 3, 1-34(1957) March.

The interaction between α particles is investigated and compared with the requirements of the α -particle model. These are that there should be a short-ranged repulsion to prevent the α particles from overlapping, and an additive attractive force reaching beyond the repulsion. The interaction energy is divided into four components of different origin and properties. These components are a direct interaction (V_N), which is analogous to the Coulomb interaction between ions and which exists only if the nuclear potential has a direct (i.e. non-exchange) tail, a nucleon-exchange interaction (V_X), a polarization interaction (V_{POL}), and the Coulomb interaction E_C . It is shown that where the direct attraction predominates, the α - α interaction energy can be represented by a static potential; at shorter separations of the α particles, V_X predominates and the α - α interaction can be represented by a potential only if one assumes that because of the strongly repulsive nature of V_X one may replace the latter by an effective repulsive potential. The complete interaction potential between α particles which one obtains in this way agrees in order of magnitude but disagrees in shape with the parabolic potentials which have been used in published treatments of the energy spectra of some α nuclei. It is concluded that the attraction between α particles required by the α -particle model can be accounted for if the force between nucleons has a direct component like that in the Serber potential. The mechanism of the attraction entails no more than a small probability of the α particles' being dissolved in nuclei with $A \approx 40$. (auth)