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EXPERIMENTAL PHYSICS

Elastic and inelastic scattering measurements with protons on protons and deuterons using a supersonic gas jet target at the NAL accelerator have given important new results. The elastic scattering measurements, begun last year, have been extended to 400 GeV. These data show that the ratio of the real to imaginary scattering amplitude rises monotonically from a negative value of 0.17 at 40 GeV, crosses zero at 260 ± 60 GeV, and thereafter rises to a positive value of 0.04 ± 0.01 at 400 GeV. The fact that this ratio becomes positive, rather than approaching zero asymptotically, has strong theoretical implications concerning the energy dependence of the proton-proton total cross section. If the proton-proton and antiproton-proton total cross sections become equal at high energies as suggested by the Pomeranchuk theorem, our results imply that the proton-proton total cross section must rise with increasing energy. Thus these observations are consistent with and confirm the increase of $\sigma_T(pp)$ reported from the CERN ISR.

The technique of the NAL experiment has proved to be a powerful method for studying the inelastic diffraction dissociation of the proton. A comparison of inelastic data from hydrogen and deuterium allows us to isolate this phenomenon and to measure its dependence on the three relevant variables: energy, momentum transfer and the mass of the diffractively produced state. We have been able to show that $d\sigma/dM^2 = A/M^2$, where A is a measured constant, and that the single diffraction dissociation cross section $\sigma_{SD} \propto \ln s$. Quantitatively, the increase in the cross section for diffraction dissociation is equal to the observed increase in σ_T between 50 and 1500 GeV. Thus the origin

of the increasing total cross section may well be the diffraction dissociation phenomenon. The $1/M^2$ dependence is beautifully consistent with Regge pole models with triple pomeron exchange.

This work continues to be a collaboration between scientists from the Dubna Laboratory of the U.S.S.R. and U.S. scientists from NAL, Rochester University and Rockefeller University.

Precision measurements of $\pi^\pm$, $k^\pm$, and $p^\pm$ on hydrogen and deuterium at NAL energies have begun. Initial measurements have been completed and reported for energies of 50, 100, 150 and 200 GeV. These data show that all of the total cross sections except antiprotons increase with increasing energy. Thus the phenomenon that total cross sections at high energies increase with increasing energy appears to be common to all strongly interacting hadrons and thus a characteristic of strong interactions. Even in the case of antiprotons for which σ_T is falling rapidly below 50 GeV, the rate of decrease slows between 50 and 150 GeV and the cross section becomes constant between 150 and 200 GeV. It seems likely that our future measurements will show an increase in the 200-350 GeV region.

With the universality of the phenomenon of increasing cross sections for strong interactions established, it becomes important to establish the rate of rise as precisely as possible for comparison to theory. Our measurements to date show that our apparatus is in statistical control to a level of less than 0.1%. Thus we will be able to reach a precision of 0.1% on relative cross sections with an absolute scale error of $\lesssim$ 0.3%. During the next year we expect to complete measurements from 20 to 400 GeV at intervals of about 20 GeV.

One of the most interesting results is that the difference of the cross sections for particles in the same isotopic multiplet (e.g., π^+ and π^- , K^+ and K^- , p and $\bar{p}$) approach each other as E^{-1} from 20 to 400 GeV. This fact strongly supports the Pomeranchuk theorem which predicted this behavior at asymptotic energies.

The total cross section measurements at NAL are being carried out in a collaboration between physicists from BNL, NAL and Rockefeller University.

The first phase of our program at the CERN ISR has ended and the analysis of the data completed. Partial results, reported last year, of a study of the inclusive cross section for the production of pions showed unexpectedly large values at large transverse momentum. This year we have completed analysis of the data searching for the production of electrons or electron-positron pairs. A positive result could reveal the existence of the often postulated intermediate vector bosons, the quantum of the weak interaction, or of vector mesons. Our results, although they reached the predicted sensitivity level of $\sigma \sim 10^{-34} \text{ cm}^2$, were entirely negative. The upper limits which are established on the production cross section serve to eliminate several models which predicted larger values.

Although our Phase I apparatus was not specifically designed for the purpose, we have been able to obtain some results from a study of $\pi^0 - \pi^0$ and π^0 -charged particle correlations in which one of the π^0 -mesons has large transverse momentum. Our discovery of the large transverse momentum phenomenon has generated great interest in correlations since theoretical models which seek to explain the observations differ widely in their prediction of correlations. Despite our limitations in solid angle coverage, we have been

able to show the existence of strong correlations which cannot be explained on a purely kinematic basis, but which must have their origin in the dynamics of the interaction process. It is clear that further experiments could be very useful in establishing the dynamic properties of the strong interaction.

A Phase II experiment is now underway which should allow progress on the study of correlations and an increase in sensitivity on the electron search. It is however clear that progress will be limited until a new and more powerful apparatus can be prepared. Last year we proposed the construction of a large superconducting solenoidal magnet to be used in conjunction with our Pb-glass spectrometer. This proposal has now been accepted and the magnet will be built by CERN. The new apparatus will have a large solid angle aperture and the capability of measuring charged particle momenta as well as γ -ray and electron energies. It will be able to operate at about 100 times the interaction rate of the old equipment. Thus, we can achieve 100 times greater sensitivity. The equipment is scheduled for completion at the end of 1975 when our Phase III experiment will begin.

The ISR work is done in collaboration with scientists from CERN and Columbia University. We have been joined by physicists from SACLAY for Phase II and from Oxford in Phase III.

The apparatus for the neutrino experiment at BNL has been completed and a substantial amount of data has been taken. Analysis of this data to search for evidence for neutral currents in the weak interaction is now in progress. The experiment is being carried out in a collaboration with Columbia University and the University of Illinois.

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