Angular dependence of the polarization correlation parameter A_{00nn} and the asymmetry parameter A_{000n} in elastic proton-proton scattering at 690–950 MeV

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The polarization correlation parameter A_{00nn} and the asymmetry parameter A_{000n} have been measured in elastic pp scattering at energies of 690, 850, and 890 MeV. The results are compared with the results of phase-shift analysis. The ratio of the contributions of the triplet and singlet interactions to the pp scattering cross section at the maximum of the dependence $A_{00nn}(90°, E)$ at $E = 690$ MeV has been found.

Nucleon-nucleon scattering has recently been the subject of intense experimental and theoretical research because of the fundamental importance of this process and also because of the hope of extracting from the experimental results information on possible dibaryon resonances and manifestations of the quark degrees of freedom of

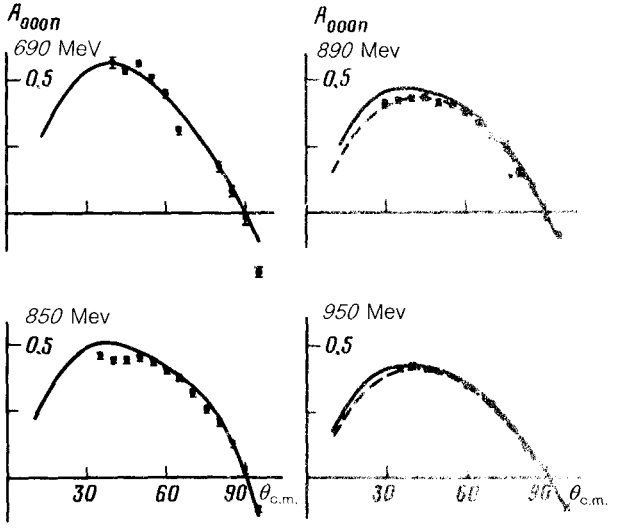

FIG. 1. The asymmetry parameter A_{000n} in elastic proton-proton scattering. Solid line—Prediction of Hoshizaki's phase-shift analysis;[4] dashed line—phase-shift analysis carried out at the Leningrad Institute of Nuclear Physics.

nucleons. This effort has been rewarded with the acquisition of enough information on the NN interaction in the channel with an isospin $I = 1$ for a direct reconstruction of the scattering amplitude at an energy of 578 MeV and for an unambiguous phase-shift analysis at energies up to 800 MeV. On the other hand, we do not have all the information that we need on the scattering at energies above 800 MeV or on the NN interaction in the $I = 0$ channel. In particular, until very recently, the only information available on proton-proton scattering in the energy interval 800–1000 MeV has consisted of fragmentary measurements of differential cross sections and the polarization. An exceptional case is the region near 950 MeV, which has been studied thoroughly at the accelerator of the Leningrad Institute of Nuclear Physics.[1] The results of measurement carried out at Saclay, reported in 1985–86, also fall short of completely solving the problem of studying pp scattering at energies up to 1000 MeV because of the limited angular interval in which some of these measurements were carried out[2] ($42° < 0 < 80°$). In an effort to obtain more information on pp scattering in the region 800–1000 MeV, the parameters A_{00nn} and A_{000n} have been measured in the angular interval 35°–95°, at energies of 690, 850, and 890 MeV, at the synchrocyclotron of the Leningrad Institute of Nuclear Physics. These results supplement the results of our earlier measurements, carried out in the same angular interval at 950 MeV and at angles $\theta = 50°$ and 90° over the energy interval from 690 to 950 MeV (Ref. 3).

The experiment to measure the angular dependence of the parameters A_{00nn} and A_{000n} was carried out in a polarized proton beam with a polarized proton target. The products of the scattering of the beam by the propanediol target (the degree of polarization of the target was 85%) were measured with a hodoscopic apparatus consisting of proportional chambers and scintillation counters. The information acquired was

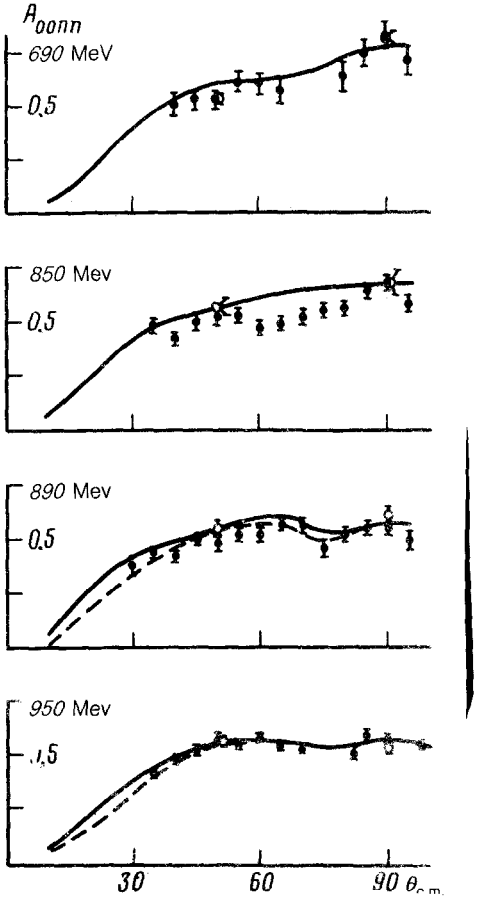

FIG. 2. The polarization-correlation parameter A_{00nn} in elastic proton scattering. Filled points—Results of the present experiment; open points—results of previous measurements[3] at angles of 50° and 90°; solid line—predictions of the phase-shift analysis of Ref. 4; dashed line—predictions of the phase-shift analysis carried out at the Leningrad Institute of Nuclear Physics.

used to reconstruct the paths of the particles and the interaction vertex. When this information is combined with the kinematics of the elastic scattering, it becomes possible to distinguish events of elastic *pp* scattering against the background of the quasi-elastic scattering of protons by target nuclei. The relative intensity of the proton beam and also its degree of polarization were monitored constantly.

In the measurements with the polarized beam and the polarized target, the values of the parameters A_{00nn} and A_{000n} can be found from equations relating the intensity of elastic *pp* scattering through the given angle for various relative orientations of the polarization vectors of the beam and the target and the normal to the reaction plane:

$$A_{00nn} = \frac{1}{\mathbf{P}_B \cdot \mathbf{P}_T} \frac{(I_{++} + I_{--}) - (I_{+-} + I_{-+})}{(I_{++} + I_{--} + I_{+-} + I_{-+})};$$

$$A_{000n} = \frac{1}{\mathbf{P}_T} \frac{(I_{++} + I_{+-}) - (I_{--} + I_{-+})}{(I_{++} + I_{--} + I_{+-} + I_{-+})}.$$

where I_{+-} is the scattering intensity, and the $+$ and $-$ correspond to the cases in which the polarization vectors of the beam ($\mathbf{P}_B$) and of the target ($\mathbf{P}_T$) are parallel and antiparallel to the normal to the scattering plane.

The results of these measurements are shown in the accompanying figures, along with data obtained previously for the angles $\theta = 50°$ and 90° and also results of measurements at the energy of 950 MeV. In addition, for the energies of 690, 850, and 890 MeV we show the predictions of a phase-shift analysis[4] carried out for approximately the same energies. For 890 and 950 MeV, we also show the results of a phase-shift analysis carried out at the Leningrad Institute of Nuclear Physics. The statistical errors of the measurements are indicated in the figures; the possible systematic error due to errors in the measurements of the beam and target polarizations is no greater than 5% (for A_{00nn}).

The data obtained at all energies furnish qualitative support for the predictions of the phase-shift analysis of Ref. 4. The greatest discrepancies, which still do not exceed three standard deviations, are observed in the angular interval 60°–80° at the energy of 850 MeV.

Analysis of the results for the energy of 690 MeV shows that it is necessary to renormalize the data obtained by us previously at this energy.[3] This renormalization has become necessary because of the refinements in the values of the polarization parameter in elastic *pp* scattering through an angle of 45° which have been made in recent years. This quantity figures directly in the expressions which are used to determine the beam polarization (P_B) from measurements of the scattering asymmetry, so it also affects the value of A_{00nn}. The value $P(45°) = 0.516$, which was used in Ref. 3, has not been supported by subsequent experiments. Analysis of all of the data on the polarization in *pp* scattering over the energy range 593–970 MeV (643 points) reveals the most probable value for the energy of 690 MeV to be $\langle P(45°)\rangle = 0.554$, consistent with the result of the present experiment: $P(45°, 690\ \text{MeV}) = 0.537 \pm 0.011$. A renormalization of the result of Ref. 3 on this basis leads to the value $A_{00nn}(90°, 690\ \text{MeV}) = 0.799 \pm 0.030$, consistent with the value of 0.815 ± 0.068 found in the present study. The average value of the results of the two measurements of $A_{00nn}(90°, 690\ \text{MeV})$ is 0.804 ± 0.040. This value can be used to determine the ratio of the contributions of the triplet and singlet interactions in the vicinity of the maximum of the energy dependence of $A_{00nn}(90°)$ (Ref. 3):

$$\alpha = \frac{\sigma_t}{\sigma_s} = \frac{1 + A_{00nn}}{1 - A_{00nn}} = 9^{+2.5}_{-1.7}.$$

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