Asymmetry in elastic scattering of protons by deuterons at 630 MeV

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Using a beam of polarized 630-MeV protons, we measured the asymmetry in the elastic scattering of the protons by deuterons in the c.m.s. angle interval $80° \leq \rho_p \leq 158°$. Results obtained at large angles are compared with the predictions of the resonant one-pion exchange model.

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The investigation of the scattering of protons by deuterons is of interest primarily from the point of view of the study of the mechanism of this reaction at large angles.

It was established experimentally that at average energies the process of elastic *pd* scattering at large c.m.s. angles has the following features: 1) its cross section increases with increasing scattering angle ($\theta_p \geqslant 130°$); 2) at a fixed angle, the cross section decreases with increasing energy, and at angles close to 180° there is an irregularity (step) in the energy dependence of the cross section at incident-proton energies 300–670 MeV.[1]

There are several known models [2–7] which are used in the attempt to explain the behavior of the cross section of elastic *pd* scattering as a function of angle and energy. The singularities indicated above can be explained with the aid of the resonant one-pion exchange model,[2–4] which includes a triangular diagram in one of the vertices of which the virtual reaction $pp \rightarrow \pi^+ d$ takes place. On the basis of this model it is predicted in [3,4] that the polarization of the deuterons or the asymmetry of the emission of the final particles (if the reaction takes place with polarized incident protons) in the reaction $pd \rightarrow pd$ should coincide with the corresponding values of the reaction $pp \rightarrow \pi^+ d$.

To verify this statement, we measured the asymmetry in the elastic scattering of protons by deuterons, using the beam of polarized protons of the synchrocyclotron of our Institute, which have a polarization $P_0 = 0.425 \pm 0.013$ and an energy $E = 630$ MeV. The results of these measurements were compared with the measurements of the asymmetry of the $pp \rightarrow \pi^+ d$ reaction.

In a measurement of the asymmetry of the elastic scattering of the protons by deuterons we used the known method of conjugated telescopes. Telescopes containing scintillation counters were installed at proton and deuteron emission angles corresponding to elastic-scattering geometry. Filters and an anticoincidence counter in one of the telescopes were used to separate the interval of the ranges of one of the registered particles, while the registration at threshold in the second telescope was set with the aid of a filter. The targets in the principal measurements were solid deuterated (CD_2) and ordinary (CH_2) polyethylene.

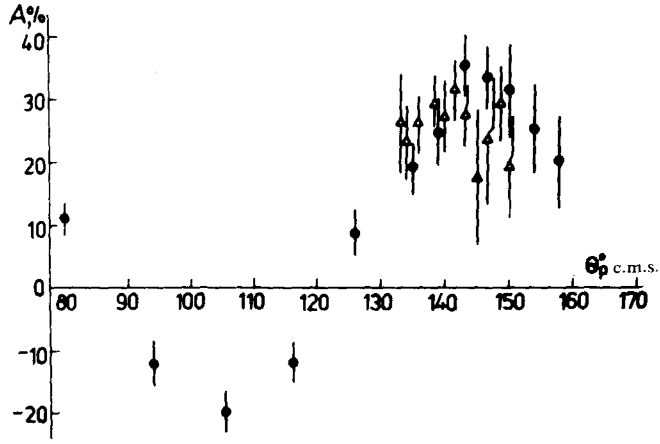

FIG. 1. Angular dependence of the asymmetry of elastic *pd* scattering: circles–$pd \to pd$ at $E = 630$ MeV (present work); triangles–$pp \to \pi d$, $E = 591$ MeV[9].

The background source in the registration of the elastic *pd* scattering, which was not subtracted in the differential experiment, could be the inelastic reaction on the deuteron neutrons ($pn \to \pi \bar{p} p$) and quasielastic *pp* scattering by the deuteron protons. To determine the possible contribution of these reactions, additional measurements were made in a geometry different from that of elastic *pd* scattering.

The angle of resolution of the telescopes in the c.m.s. was $\pm 1.4°$ at larger angles.

The asymmetry in the $pp \to \pi^+ d$ reaction with the beam of polarized protons was measured in our laboratory earlier [8] at 616 MeV, and also in [9] with a butanol target at 590 MeV. A comparison shows that the results are in agreement.

Figure 1 shows the values of the parameter $A = e/P_0$ (where e is the experimental asymmetry) obtained in the present study for elastic scattering of protons by deuterons. In the region of large angles, the same figure shows also the values of the asymmetry parameter of the reaction $pp \to \pi^+ d$, taken from [9] are given for the case of a polarized incident beam. The parameters of the two reactions are comparable at equal four-momentum transfers. It is seen that there is an angle interval in which the asymmetries of the two reactions are approximately equal. Thus, the results of the present study do not contradict the earlier conclusion [1,3] that the mechanism described by the triangular diagram plays an essential role in the scattering of protons by deuterons at large angles and at an energy–630 MeV.

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