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4.16 Elastic Scattering of Polarized Deuterons from ^{16}O at 200, 400 and 700 MeV

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Angular distributions of cross section, vector A_y and tensor A_{yy} analyzing powers were measured for the elastic scattering of polarized deuterons from ^{16}O at 200, 400 and 700 MeV for momentum transfer $q< 4$ fm^{-1}. Similar measurements were recently made[1] for a ^{58}Ni target at the same energies and ^{40}Ca at 700 MeV. Until now, no other polarization data for deuteron-nucleus scattering obtained with a polarized beam are available above 80 MeV. Some fragmentary data[2] have been previously measured, with a limited accuracy, through double-scattering techniques.

In the present experiments, the polarized deuteron beams with intensity up to 8.10^9 particles/s were provided by the Saturne-2 synchrotron using an atomic beam source. The nuclear polarization is induced by radio-frequency transitions. The source produces a 400 keV polarized beam, which is accelerated to 10 MeV in a Linac and then injected into the synchrotron ring. The beam polarization is measured with an uncertainty of about 6% by means of a polarimeter based on the $^2H(d,p)^3H$ reaction at 400 keV. The depolarization effects during the subsequent acceleration are negligible. A detailed description of the production and calibration of the polarized deuterons was made elsewhere[3].

Deuterons scattered from a water target were detected in a high resolution spectrometer (SPES 1). The relative normalization of the coutings was made by means of a secondary-emission detector placed upstream of the scattering chamber and or a three-scintillator telescope mounted in that chamber at 50° in the vertical plane. The absolute normalization of the cross section was performed with an accuracy of about 10% by using a mylar target and counting the incident deuterons through an activation method.

Optical model analyses of the proton scattering[4] at intermediate energies (100 - 800 MeV) lead to potentials having non-Woods-Saxon form-factors, in agreement with microscopic[5] and relativistic[6] approaches. The real central potential changes from attraction to repulsion with increasing energy, and its shape changes from a standard Woods-Saxon (WS) form to a six-parameter form containing an attractive pocket at the nuclear surface.

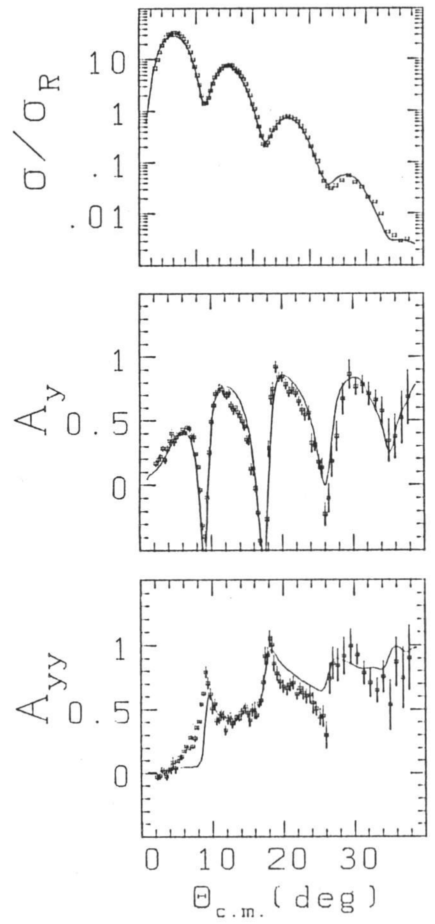

Fig. 1. $\vec{d}$ + ^{16}O elastic scattering data at 700 MeV compared to optical model calculations using a wine-bottle shape for the real central potential.

The present data were also analyzed in terms of the optical model (OM). The real part of potential is written as

$$\text{Re } U(r) = V_1 \, f_1 \,(r) + 4a_2 \, V_2 \, df_2(r)/dr,$$

where $f_1(r)$ is a WS form factor. The second term allows one to add an attractive pocket to the WS shape. The imaginary part has a WS form and the spin-orbit a Thomas form.

At 200 MeV, large values (0.75-1) of A_y and A_{yy} and the characteristic behavior of the cross section for momentum transfer q> 2 fm-1 clearly indicate a nuclear rainbow phenomenon. The data can be described by OM calculations without the pocket term ($V_1 < 0$, $V_2 = 0$), and with an imaginary central strength of about half the real one. At 400 MeV the irregular oscillations observed for the cross section and the analyzing powers are reminiscent of the proton scattering data around 200 MeV. Adding a pocket term to the WS shape allows one to improve the description of A_y. The data at 700 MeV have a diffractive pattern similarly to that observed for proton scattering above 400 MeV. The best-fit OM calculations shown in Fig. 1 were obtained with a potential consisting of a strongly absorptive imaginary part and a real part composed of a repulsive core and an attractive pocket.

The total reaction cross sections deduced from the OM calculations are appreciably smaller than the geometrical limit, characterizing the nuclear transparency at intermediate energies as observed earlier[1]. Such a transparency is understandable in terms of the energy-dependence of the nucleon-nucleon total cross section within the framework of the Glauber theory optical limit. This theory is also able to fairly describe the main features of the data at 700 MeV (ref. 7).

References

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