Zeitschrift: Helvetica Physica Acta

Band: 62 (1989)

Heft: 6-7

Artikel: Polarization transfer in the reaction ^2H(p,p)^2H at E_p=22.7 MeV

Autor: Clajus, M. / Egun, P.M. / Grüebler, W.

DOI: https://doi.org/10.5169/seals-116166

Polarization Transfer in the Reaction $^2H(\vec{p},\vec{p})^2H$ at $E_p = 22.7$ MeV

M.Clajus, P.M.Egun, W.Grüebler, P.Hautle, A.Weber, IMP, ETH Zürich
P.A.Schmelzbach, PSI Villigen; I.Slaus, Inst. Ruder Boskovic, Zagreb
B.Vuaridel, Univ. of Michigan; F.Sperisen, IUCF
W.Kretschmer, A.Rauscher, R.Weidmann, M.Haller, R.O.Karschnick, Univ. Erlangen
M.Bruno, F.Cannata, M.D'Agostino, INFN, Bologna

Abstract: We report measurements of proton to proton polarization transfer in elastic p-d scattering at a proton energy $E_p = 22.7$ MeV. The measurements have been performed at the Philips injector cyclotron at PSI. The statistical accuracy is typically 0.02, the estimated systematic errors amount to a comparable value. The results are compared to Faddeev calculations using realistic two nucleon potentials

One of the most interesting and fundamental problems in few body nuclear physics is the description of the nucleon-nucleon (N-N) interaction by a general potential, which not only includes the central forces but also the non-central spin interactions. For the determination of the spin-dependent contribution to such a potential accurate measurements of polarization observables are required. The most direct access to information seems to be offered by N-N experiments, since a large amount of p-p data are available. However, at energies below 30 MeV the ^3P_J phase-shifts are quite small and consequently the analyzing powers in N-N elastic scattering are tiny, requiring extremely high precision measurements. Unfortunately, the mixing parameter ϵ_1 is only accessible through the n-p scattering, where the experimental results bear large uncertainties and are still incomplete. On the other hand, the binding energies of ^{3}H and ^{3}He critically depend on the mixing parameter ϵ_1 of the N-N force. Thus N-d scattering can deliver quantitative information on ϵ_1 at low energy provided one performs high precision measurements of polarization observables, which are sensitive to ϵ_1. Rigorous three body Faddeev calculations based on realistic potentials can provide information about the sensitivity of the relevant observables and give guidelines to the experiments to be carried out. It has been shown that the polarization-transfer coefficient $K_y^{y'}$ (Wolfenstein's notation D) is particularly sensitive to the strength of the $^3S_1$-$^3D_1$ tensor force [1].

Here we report the results of $^2H(\vec{p},\vec{p})^2H$ measurements with incident polarized protons of an energy of 22.7 MeV. This experiment requires double scattering of the polarized beam and is therefore more difficult and time consuming than analyzing power measurements. The polarization transfer coefficient $K_y^{y'}$ has been determined, where the subscript y denotes the polarization component of the incident beam in the Madison convention [2]. The primed superscript refers to the measured polarization in the outgoing particle coordinate system, where the y'-axis is in the same direction as the y-axis. The polarization transfer formalism and the measurement techniques are described in detail in ref. [3]. For the determination of $K_y^{y'}$ one needs to know in addition the analyzing power A_y.

The 22.7 MeV polarized proton beam from the PSI cyclotron was scattered from a deuterium gas target, pressurized to 12 bars and cooled to 77 K. The scattered protons were focused by a magnetic quadrupole triplet lens into the polarimeter about 2 m from the first scattering chamber. The beam polarization was continuously monitored by a

^{12}C polarimeter located upstream of the primary scattering target. One of the main experimental problems is the measurement of the polarization of the scattered protons over a large angular range, since their energy decreases strongly with scattering angle. Two different polarimeters based on $p - \alpha$ and $p{-}^{12}$C scattering were used to cover the energies of an angular range between 45° and 125° in the c.m. system. Details of these polarimeters and their calibration procedure are given in ref. [4]. The sign of the beam polarization was inverted every few seconds. This method allows to determine $K_y^{y'}$ from the ratios of the detector counting rates independently of solid angles. The formalism used is described in ref. [5]. For A_y interpolated values and uncertainties from ref. [6] were used.

The measured spin transfer coefficients $K_y^{y'}$ are plotted in Fig. 1. The quoted errors are due to the counting rate statistics. The curves in Fig. 1 are the results of rigorous three nucleon calculations [1] (no Coulomb force included) using the Paris potential with $j \leq 3$ (dotted curve) and with $j \leq 2$ (dashed curve). The solid curve is the result using the Bonn potential (OBEPQ(A)) with $j \leq 2$, which has a smaller ϵ_1 parameter than the Paris potential. A clear sensitivity to ϵ_1 of the results of the two calculations can be observed near the minimum of the cross section. The excellent agreement of the calculations with first order observables in the angular region $\theta > 45°$ suggests that the influence of the Coulomb force on spin observables at this energy is not appreciable. The experimental results are in better agreement with the Bonn potential calculation, which suggests that the $^3S_1$-$^3D_1$ tensor force of the Paris potential is too strong.

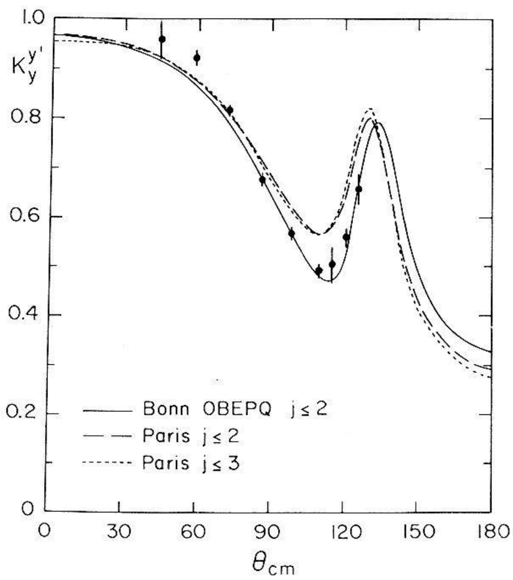

Fig. 1 $K_y^{y'}$ as a function of angle.

[1] H. Witała et al., Nucl. Phys. A (1989) in press, and to be published.
[2] Proc. 3rd. Int. Symp. Polarization Phenomena, Madison (1971).
[3] F. Sperisen et al., Nucl. Phys. A **422** (1984) 81.
[4] F. Sperisen et al., Nucl. Instr. Meth. **190** (1981) 301.
[5] F. Sperisen et al., Nucl. Instr. Meth. **204** (1983) 491.
[6] W. Grüebler et al., Nucl. Phys. A **398** (1983) 445.