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SIMULTANEOUS EFFECT OF P-WAVE INTERACTIONS AND TENSOR FORCE ON THE POLARIZATION IN N-d SCATTERING

Hungarian Academy of Sciences

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BUDAPEST

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SIMULTANEOUS EFFECT OF P-WAVE INTERACTIONS AND TENSOR FORCE ON THE POLARIZATION IN N-d SCATTERING

P. Doleschall

Central Research Institute for Physics, Budapest, Hungary

Nuclear Physics Department

ABSTRACT

A three-body calculation is performed at E_n = 14.1 MeV for the n-d elastic scattering which takes into account the ^1S_o, $^3S_1$ - $^3D_1$, and $^3P_2$ components of the nucleon-nucleon interaction. Good agreement with experimental data is obtained for the differential cross section and neutron polarization. The deuteron polarizations are also qualitatively reproduced.

РЕЗЮМЕ

Для упругого рассеяния n-d при энергии падающего нейтрона 14.1 Мэв выполнено трехчастичное вычисление с совместным использованием s-, p-волновых компонентов и тензорной части двухнуклонного взаимодействия. Для дифференциального сечения и для векторной поляризации нейтрона получено хорошее согласие с экспериментами. Результаты для поляризации дейтрона находятся в качественном согласии с экспериментами.

KIVONAT

A 14.1 MeV-es neutron bombázó energiánál végbemenő n-d rugalmas szórási folyamat leirására olyan háromrészecskeszámitást végeztünk el, amely figyelembe vette a kétnukleon kölcsönhatás s- és p- hullámu komponenseinek, valamint a tenzor-erőnek az együttes hatását. A rugalmas szórás szögeloszlására, valamint a neutron végállapoti polarizációjára kapott elméleti eredmények jó egyezésben vannak a kisérleti adatokkal. A deuteron polarizációjára vonatkozó eredmények minőségileg szintén megfelelőek.

In the last year there have been several theoretical investigations of the polarization effects in the n-d elastic scattering [1-4]. These calculations were performed on the basis of the Faddeev equations with separable two-body t-matrices.

In refs. [1-3] only the ^1S_o and $^3S_1 - {}^3D_1$ parts of the nucleon--nucleon interaction were taken into account, while in ref. [4] all s-, p- and d- wave central interactions were included in the framework of the two-potential perturbation technique [5] . The results of refs. [1] and [2] are in good agreement with each other and disagree with those of ref. [3]. A detailed comparison of the results [6] indicates that the calculations of Avishai and Rinat [3] contain some error.

The results of ref. [1,2] show that the Yamaguchi type tensor force [7] is not able to produce sufficient neutron and deuteron vector polarization. Pieper's calculations [4] reproduce the vector polarizations up to 10- 15 MeV laboratory energy of neutrons, however, the tensor polarizations and the vector polarizations at energies higher than 15 MeV disagree with the experimental data. At the same time Aarons and Sloan [1] got quite good results for the tensor polarization.

These results suggest that both p-wave interactions and tensor force must be taken into account simultaneously in order to obtain the correct vector and tensor polarizations. Therefore in the present calculation the ^1S_o, $^3S_1 - {}^3D_1$, $^1P_1$, ^3P_o, $^3P_1$ and $^3P_2$ one term separable interactions were taken into account. The ^1S_o and $^3S_1 - {}^3D_1$ interactions were taken from ref. [8] with $P_D = 7$ %. The p-wave interactions are taken to be of the form

$$v(p,q) = \lambda \frac{p}{(\beta^2 + p^2)^2} \frac{q}{(\beta^2 + q^2)^2}$$

the parameters are listed in Table 1. This choice of p-wave interactions fits quite well the two-nucleon phase shifts [9] up to 100-150 MeV.

The calculation was performed at 14.1 MeV neutron bombarding energy using the same formalism and numerical methods as in ref. [2]. The contributions of three-body states with total angular momentum and parity J^π up to $7/2^+$ were obtained by solving the three-body integral equations, while for the states $J^\pi = 7/2^-, \ldots, 19/2^+$ Sloan's approximation [10] was applied.

Table 1

The Lovelace [17] type variables are used and therefore the dimensions are expressed in MeV units

Type of interaction	$\lambda(MeV^{5/2})$	$\beta(MeV^{1/2})$
$^1P_1$	86620	8.4460
^3P_o	-34788	7.2741
$^3P_1$	110950	8.6737
$^3P_2$	-1416000	14.827

The numerical accuracy is the same as in refs. [2] and [6]. The results are plotted in Figs. 1 - 4.

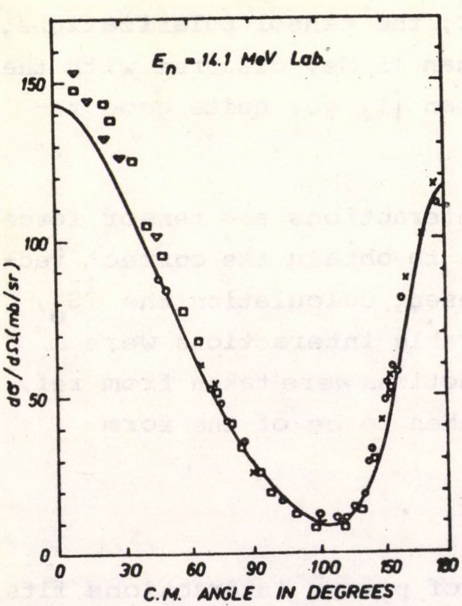

Fig. 1
Elastic n-d differential cross section. Experimental data; circles are from ref. [11] crosses from ref. [12], squares from ref. [13] and triangles from ref. [14].

The calculated differential cross section of the elastic scattering /Fig. 1/ is in excellent agreement with the experimental data [11-14] from 60° to 180°. It is remarkable that the minimum which was not reproduced by Pieper's calculation [4] also has the correct value. Though the cross section at forward angles is less than the experimental data the agreement is better than in the pure s-wave or s-wave plus tensor force case [2].

The neutron vector polarization is plotted in Fig. 2. The theoretical curve seems to be closer to the data than in ref. [4], however, the minimum near to 90° in not reproduced.

The deuteron polarization results /analyzing power corresponding to the Madison convention [16]/ are plotted in Figs. 3 and 4. Unfortunately at E_n = 14.1 MeV there are no experimental data available. Therefore for the sake of a qualitative comparison experimental data at E_n = 10.85 MeV are plotted. The results are acceptable, though the positive peak in the deuteron vector polarization at 130° seems to be too high.

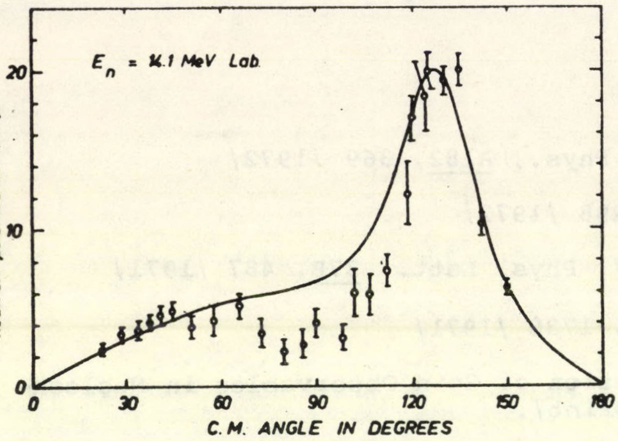

Fig. 2

Neutron polarization. The experimental data are from ref. [15]

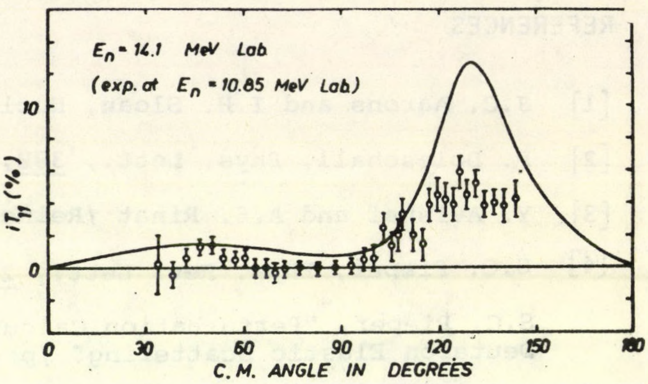

Fig. 3

Deuteron vector polarization. The experimental data at E_n=10.85 MeV Lab. [18]

On the basis of earlier [1,2,4] and present results we can conclude that in the 0-15 MeV neutron bombarding energy region the polarization effects in the n-d elastic scattering are determined by both of the tensor force and p-wave components of the nucleon-nucleon interaction. However the failure of reproducing the minimum of the neutron polarization at 90^o seems to be a crucial point of the n-d scattering problem. This minimum becomes deeper increasing the nucleon energy and at 22.7 MeV it reaches the value of -10 %. Pieper's calculation [4] does not reproduce this minimum at 22.7 MeV and it is an open question whether the present calculation repeated at this energy will be able to give the correct form of the neutron polarization or not. Though the similarity of the calculation and those of ref. [4] for the neutron polarization seems to be discouraging, the increased importance of the tensor force at 22.7 MeV, reported in ref. [1], makes it feasible that the tensor force and p-wave interaction simultaneously are able to reproduce the correct neutron vector polarization at this energy.

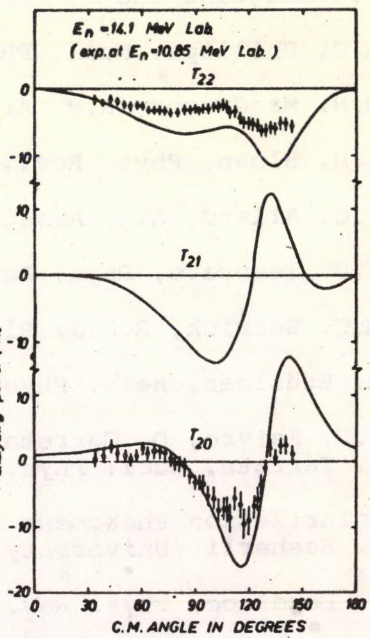

Fig. 4

Deuteron analysing power. The experimental data at E_n=10.85 MeV Lab. [18]

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