(n,d) elastic differential cross section at 2,48 and 3.28 MeV

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(n, d) Elastic differential cross section at 2.48 and 3.28 MeV[1][2]

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Abstract. (n, d) elastic differential cross section data at 2.48 and 3.28 MeV are presented in the center of mass angular ranges of 60°–180° and 47°–180° respectively. These results confirm that, in this energy range, the scattering amplitude should include partial waves up to at least $l_{max} = 4$.

1. Introduction

A good analysis of the differential cross section is very valuable to give a starting point for a more complex analysis including spin effects. It has been shown that in the nucleon–deuteron scattering the partial waves higher than $l_{max} = 2$ are necessary for the parametrization of the scattering amplitudes even at energies as low as 2 MeV (see for example Reference [1] for the (p, d) case). In the case of (n, d) scattering, at energies of a few MeV, the elastic differential scattering cross sections are not well determined, especially beyond $\cos\theta_{CM} = -0.8$ and the number of data points is rather scarce [2]. This lack of experimental data causes great difficulty to perform a phase shift analysis even in the simple case when partial waves up to $l_{max} = 2$ are included as free parameters in the parametrization of the scattering amplitude. We have therefore, in the framework of our study of the (n, d) scattering [3, 4], measured this cross section at 2.48 and 3.28 MeV with special emphasis on large scattering angles.

2. Data acquisition and analysis

We have used the recoil energy spectrum method [5]. The neutrons were produced by the $D(d, n)^3He$ reaction. The incident deuteron beam was produced by our 3 MeV Van de Graaff accelerator. In order to reduce the background as much as possible, we have discriminated between neutrons and gammas and used the method of the associated particle by detecting the ^3He recoil nuclei. The experimental set-up as well as the method which we have used to measure the resolution of our detector and its light output function is fully described elsewhere [6].

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[1]) Work supported in part by the Swiss National Science Foundation.
[2]) Cet article est dédié au professeur Jean Rossel, à l'occasion de son 60ème anniversaire.

The data reduction and analysis methods follow the scheme described in References [5, 6]. We have of course taken into account and corrected for the multiple scattering contribution to the spectrum from the scatterer. A complete and detailed description of the method we have used to analyse the raw data will be published in a later paper.

3. Results

Figures 1 and 2 show our results. The solid line is the cross section as given in Reference [2] and the points are a selection of our results. Each point represents the cross section obtained from the procedure used to analyse the raw spectrum. The

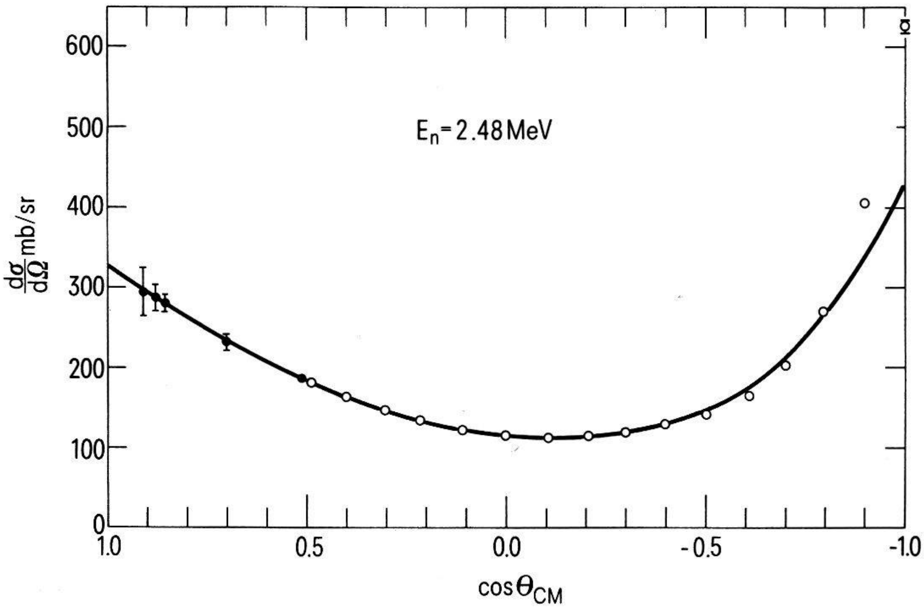

Figure 1
(*n*, *d*) elastic differential cross section. E_n = 2.48 MeV (Lab). —— BNL-400 [2]; ● from J. D. Seagrave and L. Cranberg, Phys. Rev. *105* (1957) 1816, ○ present data; the error bars are discussed in the text; if not shown, they are smaller than the dots.

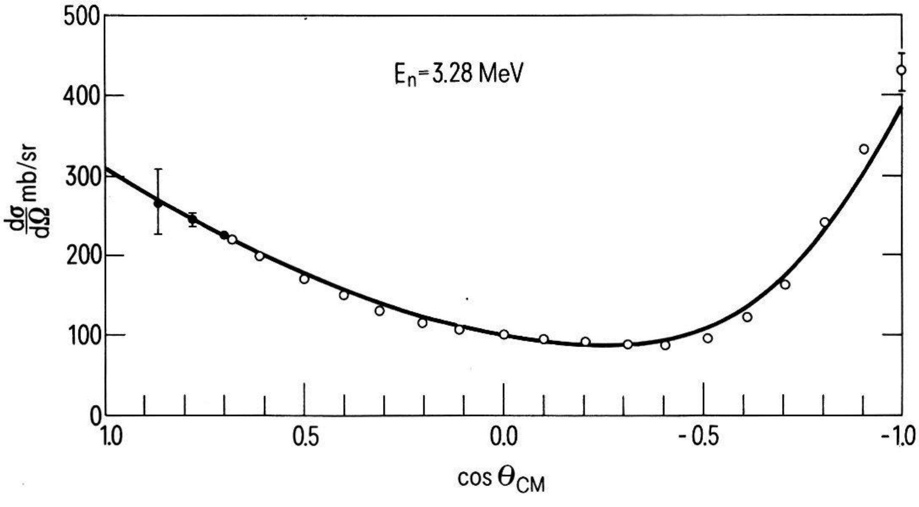

Figure 2
(*n*, *d*) elastic differential cross section. E_n = 3.28 MeV (Lab). —— BNL-400 [2]; ● from J. D. Seagrave and L. Cranberg, Phys. Rev. *105* (1957) 1816, ○ present data; the error bars are discussed in the text; if not shown, they are smaller than the dots.

final step was a Legendre polynomial fit to our data and to a few BNL-400 data points. These latter points which were included in this step are also shown in Figures 2 and 3. Our data have been normalized to the BNL-400 values at $\cos\theta_{CM} = 0$.

The errors are calculated by the data analysis procedure and error bars include uncertainties due to the statistics, energy width of the incident neutron beam and data analysing procedure.

Our results agree very well with BNL-400 data in a large range of $\cos\theta_{CM}$, but show a more pronounced peaking at large angles. These results are also presented in a tabulated form in Tables I and II. Each set of results contains in fact more than a hundred values. Complete lists of the results can be sent on request.

The sets of Legendre polynomial coefficients and their associated variance matrices will be presented and discussed in a later paper. However, it can be said that the coefficients a_0's of the Legendre polynomials parametrizations give a total cross section of 2499 ± 8 mb at 2.48 MeV and 2103 ± 18 mb at 3.28 MeV. These values should be compared with the values given for example in Reference [7] for further normalization.

4. Conclusion

The Legendre polynomial fits to the 2.48 and 3.28 MeV data show[3]) that partial waves up to $l = 4$ are statistically significant and should therefore be included in the

Table I
(n, d) elastic differential cross section at 2.48 MeV (Lab).

$\cos\theta_{CM}$	$d\sigma/d\Omega$[b]) mb/sr	Standard deviation
0.908[a])	294.0	28.1
0.880[a])	286.1	15.9
0.855[a])	279.1	12.4
0.702[a])	237.7	10.4
0.507[a])	189.1	1.2
0.493	185.9	1.0
0.399	165.5	0.3
0.305	147.8	0.2
0.214	133.8	0.1
0.111	122.2	0.1
−0.001	115.1	0.1
−0.106	113.2	0.1
−0.206	115.2	0.1
−0.301	119.9	0.1
−0.405	128.3	0.1
−0.503	140.9	0.1
−0.609	164.6	0.1
−0.699	200.6	0.1
−0.797	270.4	0.2
−0.902	406.5	0.4
−1.000	627.9	7.4

a) From J. D. Seagrave and L. Cranberg, Phys. Rev. *105*, 1816 (1957).
b) Normalized at the BNL-400 [2] value at $\cos\theta_{CM} = 0$.

3) The statistical (level 5%) test F was used to determine the statistically significant l_{max} in these fits.

Table II
(*n*, *d*) elastic differential cross section at 3.28 MeV (Lab).

$\cos\theta_{CM}$	$d\sigma/d\Omega$[b]) mb/sr	Standard deviation
+0.855[a])	264.6	39.7
+0.781[a])	246.3	6.9
+0.702[a])	224.9	1.9
+0.681	219.1	1.4
+0.610	199.7	0.5
+0.501	171.5	0.2
+0.401	148.8	0.1
+0.308	131.3	0.1
+0.205	116.6	0.1
+0.108	106.9	0.1
+0.0	100.0	0.1
−0.098	95.2	0.1
−0.206	90.8	0.1
−0.308	87.5	0.1
−0.405	87.4	0.1
−0.509	96.1	0.1
−0.609	120.4	0.1
−0.704	165.5	0.2
−0.806	242.2	0.5
−0.903	337.5	0.9
−0.997	428.4	22.0

[a]) From J. D. Seagrave and L. Cranberg, Phys. Rev. *105*, 1816 (1957).
[b]) Normalized at the BNL-400 [2] value at $\cos\theta_{CM} = 0$.

phase shift analysis of the *n-d* scattering. In this energy range, the number of data points is now sufficient to allow the inclusion of these higher partial waves for the parametrization of the scattering amplitudes so that it should not be necessary to take them into account by some model dependent calculation.

Our effective range approximation code for the analysis of the cross section and spin observable of this reaction [3, 4] is currently being modified to include these higher partial waves.

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