A STUDY OF THE ABSOLUTE ELASTIC SCATTERING CROSS SECTIONS FROM THE ^{100}Mo (t, t) ^{100}Mo EXPERIMENT AT 12 MeV

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The absolute differential scattering cross sections have been measured from the (t, t) experiments on the ^{100}Mo at $E_t = 12$ MeV using a tandem accelerator and a multichannel magnetic spectrograph. Optical model parameters have been obtained from an analysis of the data with an optical-model search programme.

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1 Introduction

Molybdenum nuclei lying in the $A \sim 100$ region exhibit sphericity with neutron number $N \sim 50$ but undergoes rapid changes in structure as a function of neutron number [1–4]. A broad programme has been drawn to study the level structures of Mo nuclei with the (t, p) reaction. Accurate measurements of absolute elastic scattering cross sections are necessary to obtain the optical model parameters which are essential to carry out the distorted-wave Born approximation (DWBA) calculations to analyze the double stripping (t, p) experimental data from these nuclei. Triton elastic scattering data from ^{100}Mo are not so far available in the literature. The present work describes the results of the (t, t) elastic experiments on the ^{100}Mo at $E_t = 12$ MeV and the angular distributions are measured for a wide range of angles up to $175°$.

2 Experimental details

The 12 MeV triton elastic scattering experiments were carried out using the tandem Van de Graaff accelerator at the Atomic Weapon Research Establishment (AWRE), Aldermaston with emulsion plates in the 24 angles of the multiple gap magnetic spectrograph [5]. The spectrograph consists of 24 broad range magnetic spectrographs of Browne-Buechner [6] type and is arranged to have a common magnetic circuit. The 24 channels provide scattering angles at $7.5°$ intervals in the angular range $5°$ to $87.5°$ and $92.5°$ to $175°$. In the present experiments, the triton beams were focussed as a rectangular spot 1.55 mm wide and 1.0 mm high on the target. The scattering products were detected by Ilford $K2$ emulsion plates 50 μm thick mounted in the focal plane of each channel. The target was approximately 100 μgcm^{-2} thick. The measurements were made

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at 24 angles between 5° and 175°. The target was self-supporting, isotopically enriched and was obtained from the Oak Ridge National Laboratory. The isotopic composition of the target is summarized in Table 1.

Tab. 1. The isotopic composition of the target.

Target	^{92}Mo	^{94}Mo	^{95}Mo	^{96}Mo	^{98}Mo	^{99}Mo	^{100}Mo
^{100}Mo	1.30	0.32	0.20	0.09	0.20	0.24	97.65

The exposed zones of the (t, t) plates were scanned in strips 0.24 mm wide at intervals of 0.25 mm.

3 Optical model analysis

The calculations for the optical parameters were carried out using the optical model search programme. The potential was of the form

$$\begin{aligned} U(r) &= V_c(r) - V\left(1+e^{x}\right)^{-1} + 4iW\,\frac{d}{dx'}\,\left(1+e^{x'}\right)^{-1} \\ &+ \left(\frac{\hbar}{m_\pi c}\right)^2 r^{-1}\left(V_{so}+iW_{so}\right)\,\frac{d}{dr}\left(1+e^{x_s}\right)^{-1}\,\sigma.L\,, \end{aligned}$$

where $x = (r - r_0A^{1/3})/a_0$, $x' = (r - r_1A^{1/3})/a_1$ $x_s = (r - r_sA^{1/3})/a_s$ and σ is the Pauli spin operator for nucleons. The Coulomb potential $V_c(r)$ is due to a uniformly charged spherical nucleus of radius $R_c = r_cA^{1/3}$ and charge Z. The Coulomb radius was $1.3A^{1/3}$ fm. V and W are the depths of the real and imaginary potential wells, V_S and W_S are the real and imaginary depths of the spin-orbit potential. The $r_0A^{1/3}$ and $r_1A^{1/3}$ are the mean radius of the real and imaginary wells, and $r_sA^{1/3}$ is the mean radius of the spin-orbit potential well and a is a measure of surface diffuseness. Some molybdenum optical starting parameters were inserted to initiate the search and the starting values for the search were those from Ref. [1]. The search programme was then allowed to adjust these parameters iteratively so as to minimize the quantity

$$\chi^2 = 1/N \sum^{N} \left[\left\{\sigma_{th}(\theta i) - \sigma_{exp}(\theta i)\right\}/\Delta\sigma_{exp}(\theta i)\right]^2$$

in which σ_{th} and σ_{exp} are, respectively, the calculated and experimental values of the differential cross sections at centre of mass angle θi, $\Delta\sigma_{exp}$ is taken as the experimental error and N is the number of experimental angles.

4 Results and discussions

The ^{100}Mo (t, t) ^{100}Mo experiments were carried out at $E_t = 12$ MeV and the multi-gap spectrograph enabled to measure the full angular distribution simultaneously over 24 angles ranging from 5° to 180°. In the (t, t) experiments on ^{100}Mo, each emulsion plate was exposed to two

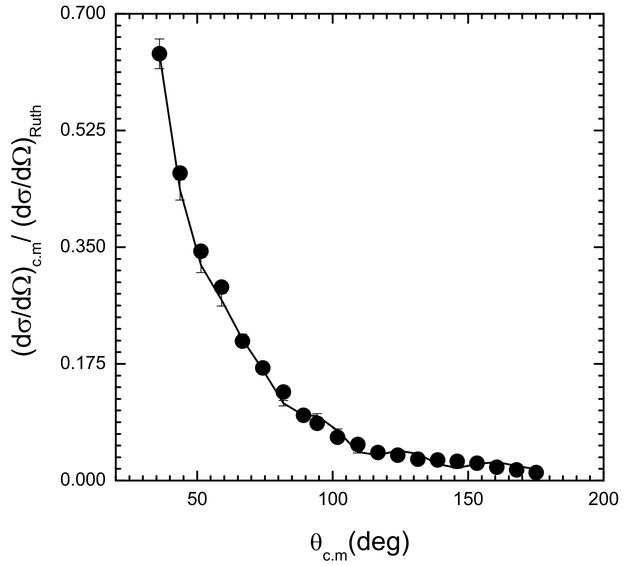

Fig. 1. Elasic scattering of triton from ^{100}Mo.

triton bursts. One was of 100 μC and the other was 1000 μC. The longest exposure is required to give reasonable scanning statistics at backword angles, while the shorter exposure enables groups to be countable on channels 5 to 7 $(35^\circ$ to $50^\circ)$. On scanning the emulsion plates, groups of tracks of tritons corresponding to two bursts were distinctly observed for the forward channels $(35^\circ$ to $50^\circ)$ and the number of tracks in two different groups on the same channel agreed well in proportion to their exposure strengths. Groups of tracks on the plates in the first four forward channels $(5^\circ$ to $27.5^\circ)$ were too dense to scan even for the shorter burst.

The theoretical differential scattering cross section was calculated using the formula

$$\left(\frac{d\sigma_{th}}{d\Omega}\right)_{E,L} = \frac{1.2958Z^2}{E_L^2 \sin^4 \frac{\theta}{2}} \quad mb/sr, \tag{1}$$

where Z is the target atomic number, E is the triton energy in MeV and θ is the scattering angle. The experimental cross sections at different angles were equated with the theoretical cross sections at the corresponding angles and a factor K was obtained by using the equation [7]

$$\frac{(d\sigma/d\Omega)_{E,L}}{(d\sigma_{th}/d\Omega)_{E,L}} = K, \tag{2}$$

which converts the observed cts/μC into mb/sr. The mean value of K is 0.052 mbμC/sr.cts. The absolute differential scattering cross sections at 12 MeV were obtained using the relation

$$(d\sigma/d\Omega)_{12,L} = K \times (cts/\mu C)_{12}. \tag{3}$$

Tab. 2. Absolute differential cross sections from the ^{100}Mo(t,t) ^{100}Mo experiment.

No. of obs.	Angle [$\theta_{c.m}$]	$(d\sigma/d\Omega)_{c.m}/(d\sigma/d\Omega)_{Ruth}$
1	36.10	0.640
2	43.70	0.461
3	51.40	0.344
4	59.00	0.290
5	66.70	0.209
6	74.20	0.169
7	81.80	0.133
8	89.30	0.098
9	94.30	0.086
10	101.80	0.065
11	109.30	0.054
12	116.70	0.042
13	124.00	0.038
14	131.40	0.032
15	138.70	0.031
16	146.00	0.029
17	153.30	0.026
18	160.60	0.020
19	167.90	0.016
20	175.10	0.012

Tab. 3. Triton optical model parameters.

V	r_0	a	W	r_0'	a'	V_{so}	W_{so}	r_s	a_s
(MeV)	(fm)	(fm)	(MeV)	(fm)	(fm)	(MeV)	(MeV)	(fm)	(fm)
156.50	1.240	0.700	12.50	1.530	0.799	7.340	0.066	1.305	0.020

The ratio $\sigma(\theta)_{cm}/\sigma_{Ruth}$ is actually of greater significance than the differential scattering cross sections itself and so this ratio is found at different angles. By comparing the experimental results to the optical-model predictions at small angles, an absolute normalization is obtained. Adjustment of optical-model parameters was done automatically by the programme in order to minimize the value of χ^2. The absolute values of the differential cross sections obtained by minimizing χ^2 are shown in Table 2. The results are plotted in Fig. 1. Figure 1 shows the variation of the absolute values of differential cross section with the center mass angles. The circles with error bars represent differential cross section and the smooth curve gives the best fit to the data points obtained from optical model calculation. The triton optical-model parameters obtained from an analysis of the absolute differential cross sections are shown in Table 3. The values of the parameters obtained in the present work are compared with the previous data of Flynn et al. [8] obtained from triton elastic scattering on Zr nuclei and the results are in reasonable agreement.

5 Conclusion

The absolute differential cross sections are measured from the (t, t) experiment on ^{100}Mo at $E_t = 12$ MeV and the optical model parameters were obtained from an analysis of the data using an optical-model search programme. The triton parameters would be useful in carrying out distorted-wave Born approximation calculations in a (t, p) reaction on Mo nuclei.

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