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Generalized Diffraction Model Analysis of Elastic Scattering of Spin-$\frac{3}{2}$ Projectiles

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The study of polarization phenomenon has recieved recently great interest specially in heavy-ion elastic scattering[1,2] . This is due to the fact that polarization measurements do not only provide information about the spin and tensor interactions, but are also a sensitive test to the scattering mechanisms involved and the structure of the incident ion[3,4].

The analysis of the Heidelberg data[1,2] on scattering of polarized ^{7}Li by ^{58}Ni has recently attracted much attention. Various approaches to the problem such as the optical model analysis and/or coupled channel approach have been developed. Although these approaches may account for some of the data yet they are much involved, and need too much big memory and are computer time consuming.

On the other hand, for most of the heavy ion projectiles (with energies near and above the coulomb barrier) the reaction features may seem to be consistent with a simple diffraction picture.

In the present work, the scattering of 21.1 MeV polarized ^{7}Li projectiles on ^{12}C targets and on ^{58}Ni at 20.3 MeV are studied adopting a generalized diffraction model for the scattering of spin-$\frac{3}{2}$ projectiles. The differential cross section ratio $\sigma(\theta)\ /\ \sigma_R(\theta)$, the vector iT_{11} and the tensor analysing powers T_{kq} (k=2,q=0,1,2) and T_{T20} are calculated in that way.

Using the standard convension of Simonius[5] and the extended formalism of Cook et. al.[6] , the cross section $\sigma(\theta)$ and the analysing powers for polarized beam of spin- $\frac{3}{2}$ projectiles are defined in terms of the scattering matrix M of the eight amplitudes (A —— H) as

$$\sigma(\theta)\, T_{kq} = \frac{1}{(2s+1)} \mathrm{Tr}(M\ \tau_{kq}\ M^{+}) \qquad .....(1)$$

and

$$\sigma(\theta) = \frac{d\sigma}{d\Omega} = \frac{1}{(2s+1)} \mathrm{Tr}(M\, M^{+}) \qquad .....(2)$$

where τ_{kq} is the spherical tensor operator. In this analysis the eight amplitudes (A —— H) contain diagonal as well as non diagonal terms to account for tensor interactions[4].

In the present work a generalized nuclear S-matrix S_l^j is introduced which accounts for the central, spin-orbit and tensor interactions. In the "eikonal" approximation[7] the S_l^j matrix/element may be factorized as

$$S_l^j = S_l^c \cdot S_{jl}^{s-0} \cdot S_{jl}^{T} \qquad .....(3)$$

But projectile excitation has a dominant effect[3,4] on the vector analysing power iT_{11}. Therefore dynamic polarization effects due to coulomb excitation should be also considered. This results in a multipication of the S_l^j matrix element by a damping function $\eta_p(l)$ as described in ref.[8].

The cross section ratio $\sigma(\theta)/\ \sigma_R$, the vector and tensor analysing powers iT_{11} and T_{T20} are shown in Figs. (1), (2), (3), (4) and are compared with the experimental data. The agreement between the calculations and the experimental values is satisfactory. The values of the fitting parameters are listed in Table I.

Reaction	$E_{lab.}$ (MeV)	ℓ_0	Δ_0	ℓ_{os}	Δ_s	ℓ_{0T}	Δ_T	r_0	d	β	μ
$^7Li + ^{12}C$	21.1	9.15	0.73	8.15	0.7	8.20	0.71	1.55	0.23	- 0.18	0.0
$^7Li + ^{58}Ni$	20.3	12.35	0.8	11.5	0.9	11.2	0.92	1.67	0.35	- 0.16	0.0

From the present analysis of the data, it is possible to conclude that, the diffraction model is capable of accounting for the polarization data of spin-$\frac{3}{2}$ projectiles and of describing the spin and tensor effects in nuclear scattering.

From the table the values of the S_1^j parameters are seen to be consistent with these values obtained previously[2]. Reasonable results may be obtained, if the break-up channels of ^7Li are also considered, and the exchange effects of $^7Li + ^{12}C$ scattering are taken into account.

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Fig. 1

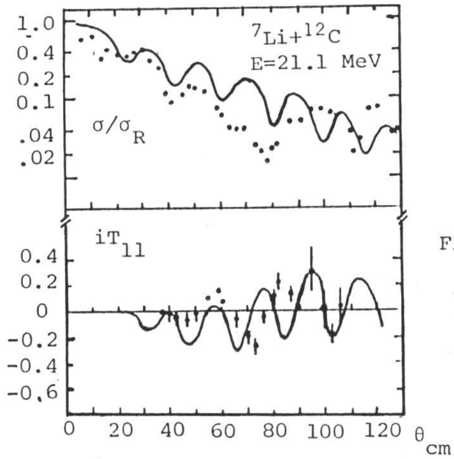


Fig. 2

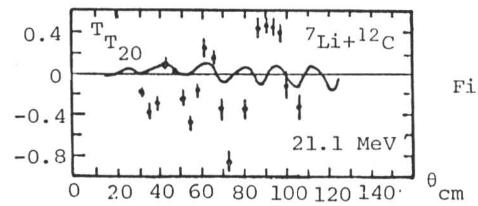


Fig. 3

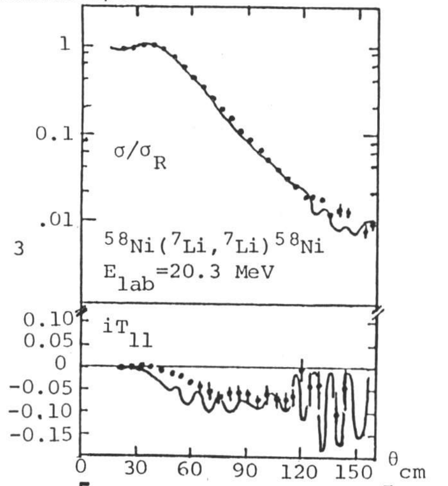
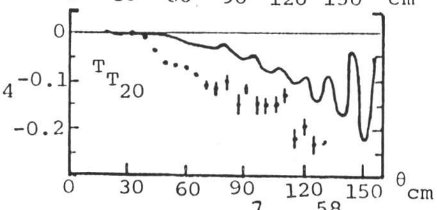


Fig.4



Figs.1-4. Angular distributions of σ / σ_R, iT_{11} and T_{20} for $^7Li - ^{58}Ni$ at 20.3 MeV and $^7Li - ^{12}C$ at 21.1 MeV. The solid lines are calculated with diffraction model.

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