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2.7 A simple model of tensor analysing powers in ^{7}Li scattering

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The data on elastic scattering of polarised ^{6}Li and ^{7}Li nuclei attracted recently a considerable theoretical interest[1-3] and their unusual features have been successfully reproduced in terms of folding models and projectile structure effects. In an earlier work Moroz et al.[4] suggested a classical model of the scattering mechanism, the 'shape-effect model' which relates the observed tensor analysing powers T_{2q} to a deformed shape of the ^{7}Li projectile assuming that the spin symmetry axis $\underline{s}$ coincides with the intrinsic ^{7}Li symmetry axis. It is shown here that the model assumptions are sufficient to express the angular dependence of T_{2q} analyticaly using the behaviour of the experimental differential cross section.

Writing the cross section with the aligned beam as $\sigma(\theta,r+\Delta r)$ where r is the distance of closest approach and expanding to the first order, the change in the cross section is

$$\Delta\sigma = \sigma(\theta,r+\Delta r) - \sigma(\theta,r) = \frac{d\sigma}{dr}(\theta,r)dr \qquad ...(1)$$

For a purely aligned beam with $\underline{s}$ perpendicular to the scattering plane, $\Delta\sigma=\sigma(\theta,r)^T T_{20}$ where $^T T_{20}= -1/2\ T_{20} - (3/2)^{1/2} T_{22}$. In the case of a ^{7}Li nucleus with quadrupole deformation, $R=R_{Li}[1+\beta_s Y_{20}(\lambda)] = R_{Li} + \Delta R_{Li}$ where λ is the angle between the symmetry axis $\underline{s}$ and a vector r_o along the distance of closest approach, which in this case is $\lambda=\pi/2$. Therefore, $\Delta R_{Li} = -R_{Li}\beta_s\sqrt{5/16\pi}$. Equating Δr with $-\Delta R_{Li}$ the analysing power can be expressed as

$$^T T_{20}(\theta) = \frac{1}{\sigma(\theta)} \frac{d\sigma}{dr}(\theta)\, R_{Li}\beta_s \sqrt{\frac{5}{16\pi}} \qquad ...(2)$$

Replacing dr by $d\theta(dr/d\theta)$ and using the classical expression

$$r = \frac{Z_1 Z_2 e^2}{E}\left(1 + \frac{1}{\sin\theta/2}\right),$$

$$\frac{1}{\sigma}\frac{d\sigma}{dr} = \frac{d\theta}{dr}\frac{d\ln\sigma}{d\theta} = -\frac{2E}{Z_1 Z_2 e^2}\sin\frac{\theta}{2}\, tg\frac{\theta}{2}\frac{d\ln\sigma}{d\theta} \qquad ...(3)$$

The equation (3) can be further simplified in the angular region where $\ln(\sigma/\sigma_R)$ can be approximated by a straight line of a slope k. Substituting (3) into (2) we get

$$^T T_{20}(\theta) = \frac{E}{Z_1 Z_2 e^2}\sqrt{\frac{5}{4\pi}}\sin\frac{\theta}{2}\, tg\frac{\theta}{2}\left(2\, cotg\frac{\theta}{2} - k\right) R_{Li}\beta_s \qquad ...(4)$$

As shown in ref.[4] the Madison-convention analysing powers T_{2q} are simply related to $^T T_{20}(\theta)$ namely

$$T_{20}(\theta) = (1-3\sin^2\theta/2)\ ^T T_{20},\quad T_{21}(\theta) = -(3/2)^{1/2}\sin\theta\ ^T T_{20}(\theta) \text{ and}$$
$$T_{22}(\theta) = -(3/2)^{1/2}\cos^2\theta/2\ ^T T_{20} \qquad ...(5)$$

Using the Heidelberg experimental data[4,5] and expression (4) and (5) the common scaling factor $R_{Li}\beta_s$ was deduced and the results are shown in Figs.1 and 2. Both sets of data are best fitted with the same value of the spectroscopic deformation length

$$R_{Li}\beta_s = -0.35 \pm 0.02 \text{ fm}$$

which is related to the known spectroscopic quadrupole moment[6] of ^{7}Li, $Q_s = -0.370 \pm 0.07$ efm^2. This simple model is of course not limited to ^{7}Li and it would be interesting to test its application in the case of other projectiles with quadrupole deformation, as ^{23}Na.

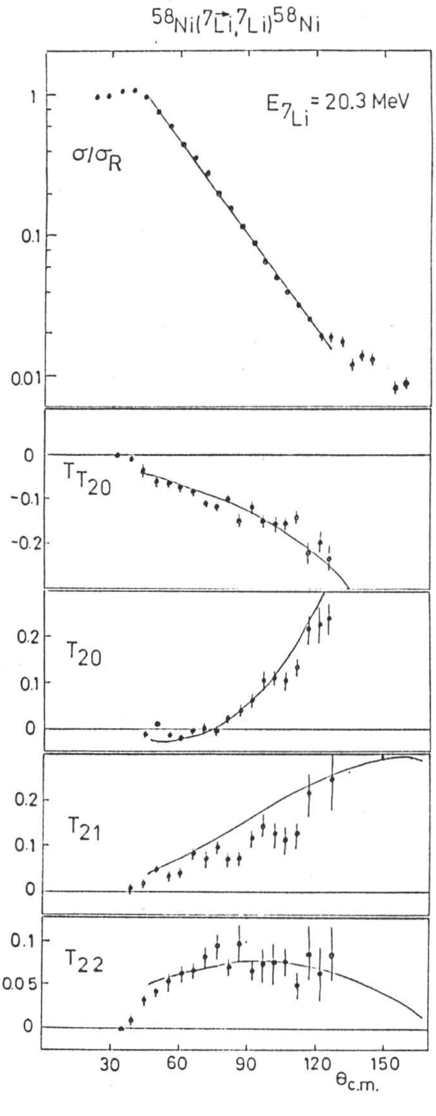

Fig.1 Experimental tensor analysing powers[4] of the ^{7}Li+^{58}Ni elastic scattering compared with predictions of the present model.

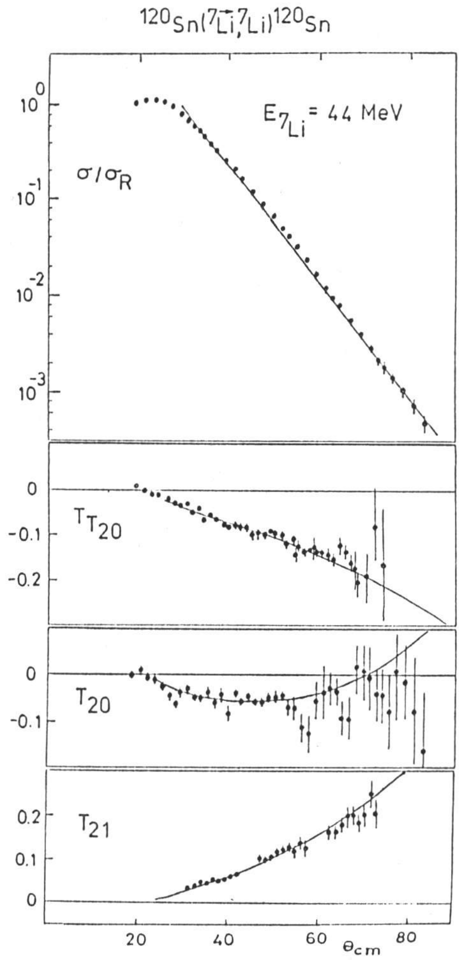

Fig.2 Experimental tensor analysing powers[5] of the ^{7}Li+^{120}Sn elastic scattering compared with predictions of the present model.

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