Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 778–779

2.9 Tensor Analysing Powers for Charged Particle Continuous Spectra Emerging from the ^7Li-^{51}V Interaction*)

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The analyses of continuous charged particle spectra emerging from light heavy ion reactions suffer from their structureless features[1)]. The polarized Li-beam at the Heidelberg EN-Tandem[2)] provided for the first time the opportunity to extend such investigations and to collect information independent of the measurement of σ.

Since it was widely investigated in the past[3)] the ^7Li-^{51}V system was chosen as the example. The experiment was performed as previously[2,3)]. In order to identify and stop as well high energetic as low energetic light charged particles triple telescopes were used. Careful dead time corrections were applied to the data. Assuming as usually binary reactions the charged particle energy spectra were converted into spectra depending on the reaction Q-value (not shown). This step is not justified but allows for a consistent integration over energy. Integration of these spectra for each laboratory angle leads to angular distribution of the differential cross section (normalized to the Rutherford cross section at ϑ_{lab}=30°) and of T_{20} as a function of the CM-angle (Fig.1). (The laboratory to center of mass conversion is only approximative, uncertainty less than 5°!)

The spectra and angular distributions display the typical behaviour observed previously in such reactions (mainly at higher energies[1,4)]). The broad distributions of the spectra peak at energies which correspond to the one for which the particle velocity is equal to the ^7Li beam velocity. At forward angles the angular distributions of σ indicate mainly a direct reaction mechanism. The magnitude of σ for each individual ejectile is as expected[1,4)], except for the protons for which the main part of the spectra was cut off experimentally.

At a first glance the angular distributions of T_{20} indicate a direct peripheral reaction process. For this in zeros order angular distributions proportional to $(3\sin^2\vartheta/2-1)$ are expected ('shape effect')[5,6)]. A more careful inspection however, shows remarkable differencies. In what follows, only the zero crossing of T_{20} will be discussed. It is predicted by the peripheral model to occur at ϑ_0=70.5°, which is indeed observed for (^7Li,^6Li) reactions of moderate small Q-values[5)]. Deviations from the above simple angular distribution occur for large Q-values[5,6)]. Independent of the specific model used ϑ_0 shifts to smaller angles for large negative Q-values as here. But the data show clearly a shift of ϑ_0^{exp} to larger angles (Fig.1). These shifts increase with the mass A_f of the 'fusing' particle ($A_x+A_f=A_{Li}=7$). It clearly rules out any type of peripheral reaction process to explain the data!

Recently such continuous light particle spectra were considered to emerge from break up (fusion) of the projectile in the hadronic field of the target (not peripheral!)[7)]. If so the mass dependence of the shift of the zero crossing relative to the peripheral model $\Delta\Theta=\vartheta_0^{exp}-\vartheta_0$ can be parameterized taking into account firstly that the remaining fragment (mass A_x) is moving with beam velocity and secondly that momenta are in a binary process conserved perpendicular to the local beam direction. If the effective energy deposit $E_\perp$ in that degree of freedom is considered as the only free parameter, the shift angle is given approximately by

$$\mathrm{tg}\,\Delta\Theta \cong \sqrt{E_\perp/E_{CM}}\left(\sqrt{A_f/A_x} - \sqrt{1/6}\right) \qquad (1)$$

($\sqrt{1/6}$ appears since for the peripheral (^7Li,^6Li) reaction ΔΘ has to be zero.)

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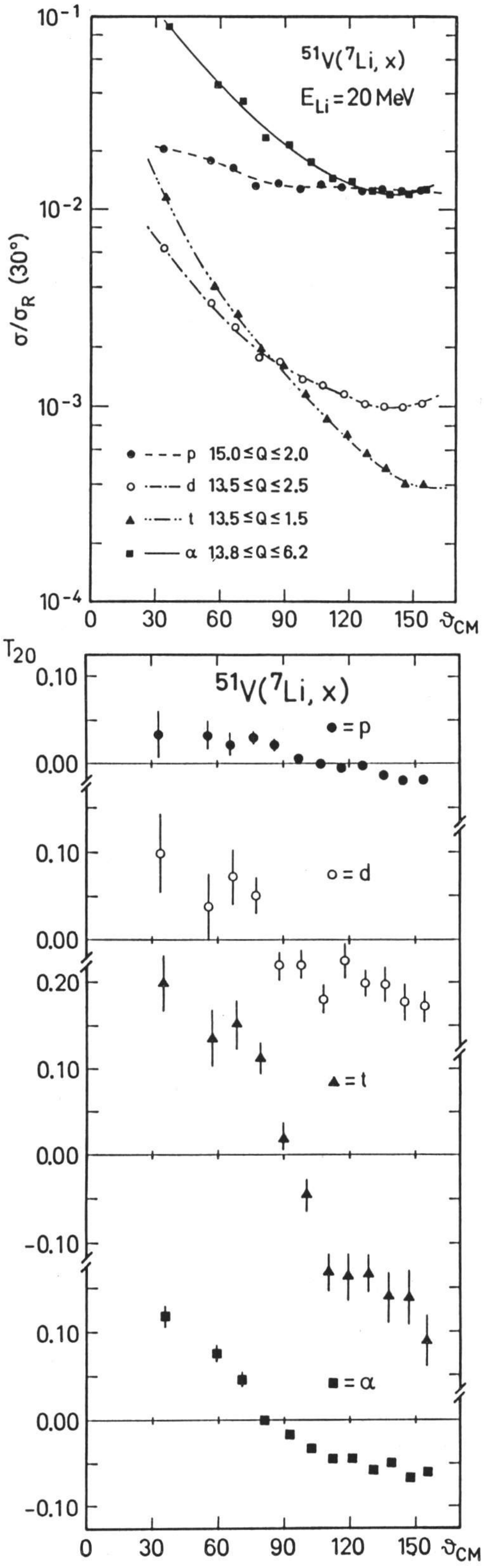

Fig. 1 Energy integrated cross section, normalized to the Rutherford cross section at 30° and T_{20} for light particles emerging from ^7Li-^{51}V interaction.

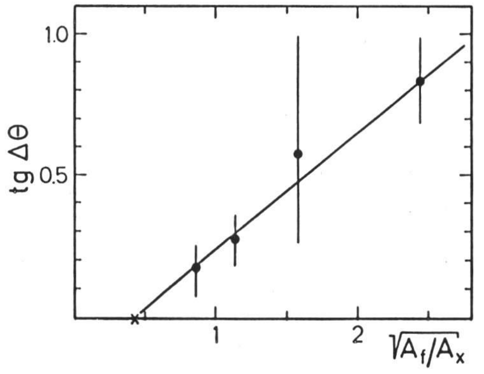

Fig. 2 Tangens of the shift of the zero crossing of T_{20} in respect to ϑ_0=70.5° as a function of $\sqrt{A_f/A_x}$.

Fig. 2 displays the experimental data for tgΔΘ (extracted from Fig. 1) together with the results of eq.1 using $E_\perp$=2.8MeV. The cross in Fig. 2 at tgΔΘ=0 indicates the expected experimental value for a (^{7}Li,^{6}Li) peripheral transfer reaction. The above formula describes quite well the data!

In summary the experiment and its crude analysis shows, that polarized light heavy ions are probably an excellent experimental tool to shed new light into the old field of continuous particle spectra emerging from nuclear reactions.

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