Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 780-781

2.10 Spin Polarization of Residual Nuclei in the Reaction $^{159}Tb(^{14}N$, light particles) at 208 MeV

T. Fukuda, M. Ishihara+, K. Ieki++, T. Shimoda+++, K. Ogura, S. Shimoura* and H. Ogata**

Department of Physics, Osaka University
Toyonaka, Osaka 560, Japan
+ Institute of Physical and Chemical Research
Wako-shi, Saitama 351, Japan
++ Department of Physics, Institute of Technology
Ohokayama, Meguro, Tokyo 152, Japan
+++ College of General Education, Osaka University
Toyonaka, Osaka 560, Japan
* Department of Physics, Kyoto University, Kyoto 606, Japan
** Research Center for Nuclear Physics, Osaka University
Ibaraki, Osaka 567, Japan

Many studies[1)] on nonequilibrium emission of light particles have been made in heavy-ion reactions with an energy above the Coulomb barrier. Inclusive energy spectra are analyzed in terms of a moving-source model[2)], an exciton model[3)], promptly emitted particles[4)] and a breakup fusion model[5)], etc. However energy spectra alone are not sufficient to differenciate various models.

Recent studies[6,7)] on spin polarization of residual nuclei by measuring γ-ray circular polarizations in ^{14}N- and ^{16}O-induced reactions at ~8 MeV/N have provided a unique information about reaction mechanisms; i.e. trajectories of emitted particles. There it is argued that there are two processes for α-particle emission, i.e. one is the α-particle emission to the negative angles and the other is to the positive angles, and that the relative strengths of two processes vary with emission angles and target species.

The aim of this work is to investigate the spin polarization of residues following emissions of various light particles (p, d, t as well as α) at a higher bombarding energy (15 MeV/N). Nonequilibrium particle emissions of p, d and t have been observed[1)] much more than the lower bombarding energies. A self-supporting ^{159}Tb target with 3.5 mg/cm^2 thickness was bombarded by a 208-MeV ^{14}N beam from the AVF cyclotron at RCNP, Osaka University. The γ-ray circular polarization was measured using the same sets as Ref. 6), where γ rays were Compton-scattered on a surface of an iron magnet to the forward direction and recorded in 6"ϕ × 6" NaI detectors. The polarimeters were placed at both sides of the normal direction to the reaction plane. Analyzing power A_p of the polarimeter[6)] was around 1.65% for E_γ = 400-4000 keV, and was about 0.8% at E_γ = 200 keV, at which the threshold was set. Light particles were measured by two sets of detector telescopes consisting of 300 μm Si ΔE + 15 mm high purity Ge E. They were placed at symmetric angles $\pm\theta$ (θ=28° and 45°) with respect to the beam axis. The solid angle was 33 msr and 50 msr for θ=28° and 45°, respectively. The circular polarization P_γ was obtained from coincidence rates N_{ij} in pairs of particle detector i (=1,2) and NaI detector j (=1,2). The spin polarization P_z was assumed to be $P_\gamma = 0.5\ P_z$ [6)], taking into account the diluting effect of nonstretched γ decay and neutrons which were also recorded in the NaI detectors.

Energy spectra of light particles showed a smooth structureless shape extending well beyond the energy corresponding to the beam velocity. The energy dependence of P_z for various light particles at θ=28° are shown in Fig. 1. The sign of P_z is defined to be positive when polarization vector is in the direction of $\vec{k}_i \times \vec{k}_f$, corresponding to the negative deflection angle. The polarization spectra generally show a tendency characterized by a dip (minimum) with negative values in the energy range corresponding to the beam velocity. This behaviour has been also observed in the α-particle emission for heavier targets at lower bombarding energies[5,6)]. On the other hand, this was not observed for θ=45°. Fig. 2 compares P_z integrated over the light particle energy for 28° and 45°. Integration was made for E_p, E_d, $E_t \geq 20$ MeV and $E_\alpha \geq 35$ MeV in order to reduce the contribution from equilibrium components. Spin polarizations at 28° tend to be negative (i.e. positive deflection angle), while those at 45° tend to be positive (negative deflection angle) except for d.

As measured in Ref. 6, a direct-like reaction shows negative P_z. Thus the light particles emitted at θ=28° may be produced mainly via a direct-like reaction such as breakup fusion, which is to be concentrated around the grazing angle (θ=16°). On the other hand, the light particles at θ=45° may be produced via more complicated multi-step reaction, where incoming ions interact with the target nucleus long enough to rotate towards the negative deflection angles. This component is expected to prevail at larger angles because there is no a priori limit on reaction time i.e. deflection angle. Theoretical efforts which describe the spin polarization explicitly by taking into account the angular momentum transfer during reaction would be anticipated.

References

1) T. Fukuda et al., Nucl. Phys. A425 (1984) 548 and references therein.
2) T.C. Awes et al., Phys. Rev. C25 (1982) 2361.
3) T. Otsuka et al., Phys. Lett. 121B (1983) 106.
4) J.P. Bondorf et al., Nucl. Phys. A333 (1980) 285.
5) T. Udagawa et al., Phys. Rev. Lett. 45 (1980) 1311.
6) K. Ieki et al., Phys. Lett. 150B (1985) 83.
7) W. Trautmann et al., Phys. Rev. Lett. 53 (1984) 1630.

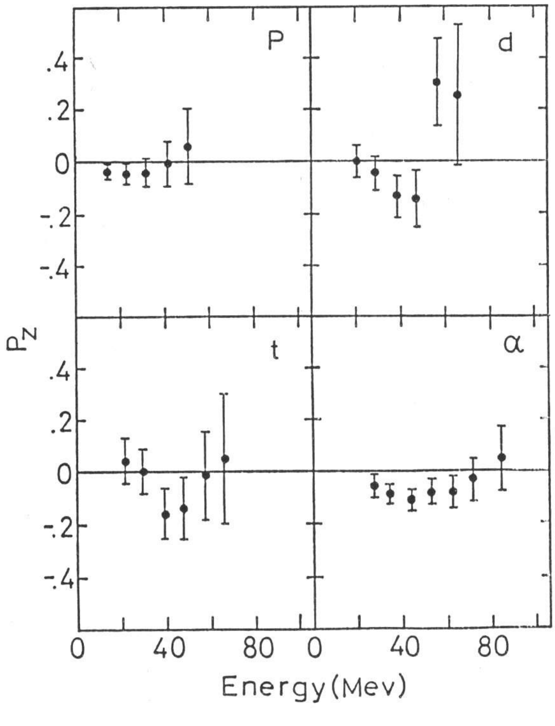

Fig. 1

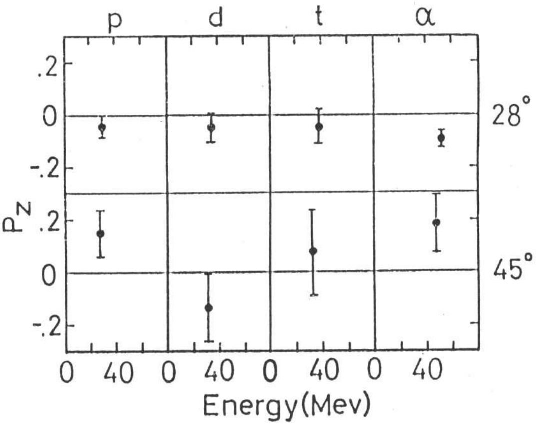

Fig. 2