Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 628-629

1.38

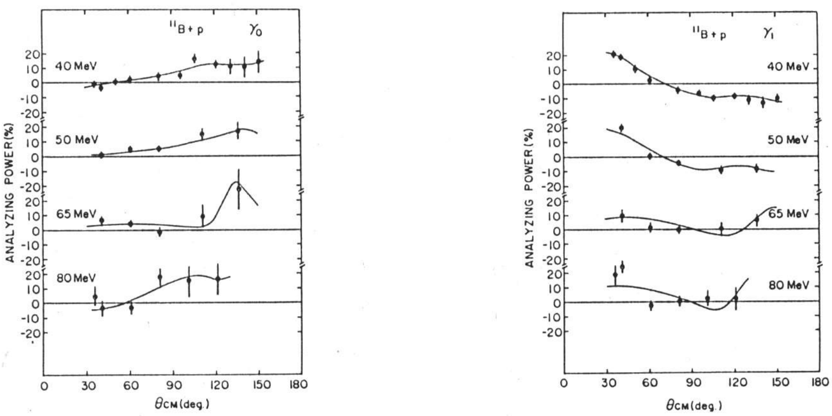
# Analyzing Power of the $(\vec{p},\gamma)$ Reaction on Light Nuclei with 40-80 MeV Polarized Protons

T.Shibata, T.Satoh, N.Kamikubota, Y.Nagai, and H.Ejiri

Department of Physics, Osaka University
Toyonaka, Osaka 560, Japan

Recent studies of the radiative capture reactions with polarized protons have shown that the value of the $b_2$ coefficient of the Legendre polynomial expansion of the angular distribution of the analyzing power shows a systematic difference for two types of transitions.[1,2] One is transitions feeding the final state with the spin of which direction is parallel to the orbital angular momentum of the state and the other is transitions deexciting the state whose spin is antiparallel to the orbital angular momentum. It is interesting to study the energy dependence of the angular distribution of the analyzing power using polarized protons.

Selfsupporting enriched $^{11}B$ targets with 31 mg/cm$^2$ and 62 mg/cm$^2$ and a natural carbon target with 34 mg/cm$^2$ were irradiated by polarized protons provided by the Osaka University RCNP cyclotron. The isotopic enrichment of the $^{11}B$ target was 98.6 % and proton energies used were 40 to 80 MeV. The beam polarization was 70 - 80 %. Gamma-rays were measured by a large NaI(Tl) crystal named HERMES.[3] The distances between the target and the HERMES were 60 cm ($E_p$ = 40MeV) and 116 cm ($E_p$ = 80 MeV). Neutron and $\gamma$-ray signals were discriminated by the TOF method. Angular distributions of analyzing power of the $\gamma$-rays following the $^{11}B(\vec{p},\gamma)$ reaction are shown in Fig.1 and those for the $^{12}C(\vec{p},\gamma)$ reaction are shown in Fig.2. The angular distributions of the analyzing power for the $^{11}B(\vec{p},\gamma_0)$ and $^{12}C(\vec{p},\gamma_1)$ reactions show increasing patterns as the measured angle increases. On the other hand those for the $^{11}B(\vec{p},\gamma_1)$ and the $^{12}C(\vec{p},\gamma_0)$ reactions decreases with angle. These features are contrast to the fact that the angular distributions of the yields of these $\gamma$-rays show similar patterns in spite of they feed the different final states.[4]




(a) (b)

Fig.1. Analyzing power of the $^{11}B(\vec{p},\gamma_0)$ (a) and $^{11}B(\vec{p},\gamma_1)$ (b) reactions. Solid lines are fits by Legendre polynomials.

The measured angular distributions of γ-ray yield is expressed by an expansion of Legendre polynomials

$$\frac{d\sigma}{d\Omega} = A_0(1 + \Sigma a_k P_k + \vec{P}\vec{n}\Sigma b_k P_k^1), \quad (1)$$

where $\vec{P}$ is the beam polarization and $\vec{n} = \vec{k}_i \times \vec{k}_f$. Obtained $b_1$ and $b_2$ values are shown in Fig.3.

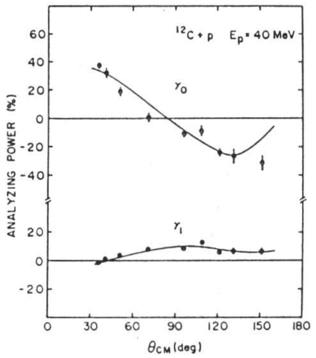



Fig.2. Analyzing power of the $^{12}C(\vec{p},\gamma_0)$ and $^{12}C(\vec{p},\gamma_1)$ reactions. Solid lines are fits by Legendre polynomials.

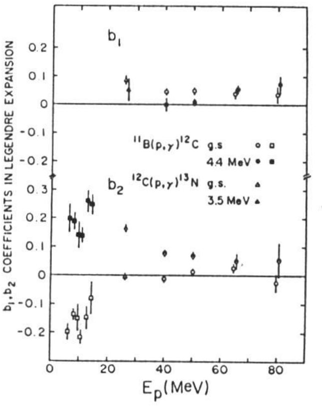



Fig.3. The $b_1$ and $b_2$ coefficients Squares are taken from ref. 5. The values for the $^{12}C(\vec{p},\gamma)$ reaction was plotted at proton energy lower than the energy used so as to adjust the Q-value difference.

The results show the systematic difference in $b_2$ coefficients. The $b_2$ values for the γ-ray feeding the states with spin of which direction is antiparallel to the orbital angular momentum of the state(p1/2) has positive values for low energy γ-rays and decreases gradually as the γ-ray energy increases. On the other hand the $b_2$ values for the state with spin parallel to the orbital angular momentum(p3/2,d5/2) show negative values for low energy γ-rays and increases with the γ-ray energy and get close to zero. The $b_2$ value arises mainly from the interference between E1 transitions originating from the different incident particle waves. The interference term contains the phase difference between two waves which emit the E1 transitions. As the energy of the incident particle increases, the incident wave is absorbed by nuclei at the position with smaller impact parameter. The phase difference between two waves with angular momentum $\ell$ and $\ell + 2$ is getting small when the waves hit the nuclei with smaller impact parameter. Thus the interference term decreases as the γ-ray energy increases, resulting in decreasing $|b_2|$ value as the proton energy increases.

## References

1) M.Nomachi, T.Shibata, K.Okada, T.Motobayashi, F.Ohtani, H.Ejiri, and T.Kishimoto: Phys. Rev. C31(1985)242.
2) R.G.Sayler and H.R.Weller: Phys. Rev. C30(1984)423.
3) T.Kishimoto, T.Shibata, M.Sasao, M.Noumachi, and H.Ejiri: Nucl. Instr. Meth. 198(1982)269.
4) T.Shibata, H.Ejiri, N.Kamikubota, T.Kishimoto, T.Motobayashi, Y.Nagai, M.Noumachi, H.Ohsumi, F.Ohtani, and T.Satoh: 'Nuclear Spectroscopy and Nuclear Interaction' Ed by H.Ejiri and T.Fukuda (World Scientific 1984)