Polarization Transfer Observables in the ^{12}C(p,p') Reaction at 0°

A. Tamii,[a] H. Akimune,[b] I. Daito,[c] Y. Fujita,[d] M. Fujiwara,[b,e] K. Hatanaka,[e] K. Hosono,[f] F. Ihara,[e] T. Inomata,[e] T. Ishikawa,[g] M. Itoh,[g] M. Kawabata,[h] T. Kawabata,[g] M. Nakamura,[g] T. Noro,[e] E. Obayashi,[e] H. Sakaguchi,[g] H. Takeda,[g] T. Taki,[g] H. Toyokawa,[i] H.P. Yoshida,[e] M. Yoshimura,[e] and M. Yosoi[g]

[a] *Department of Physics, University of Tokyo, Tokyo 113-0033, Japan*
[b] *Advanced Science Research Center, Japan Atomic Energy Research Institute, Tokai-mura, Ibaraki 319-1195, Japan*
[c] *Center for Integrated Research in Science and Engineering, Nagoya University, Nagoya 464-8601, Japan*
[d] *Department of Physics, Osaka University, Toyonaka, Osaka 560-0043, Japan*
[e] *Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567-0047, Japan*
[f] *Department of Engineering, Himeji Institute of Technology, Hyogo 678-1297, Japan*
[g] *Department of Physics, Kyoto University, Kyoto 606-8502, Japan*
[h] *Laboratory of Nuclear Science, Tohoku University, Sendai 982-0826, Japan*
[i] *Japan Synchrotron Radiation Research Institute, Hyogo 679-5198, Japan*

Polarization transfer (PT) observables at 0° are sensitive to bulk properties of excited states, *i.e.*, spin, parity, and isospin, while they are rather insensitive to distortion effects and to the detailed configurations of the relevant nuclear wave functions. Applying these unique and useful features, information on the effective nucleon-nucleon (NN) interactions and nuclear structures has been deduced [1] from the PT observables in the ^{12}C(p,p') reaction at 0° [2, 3].

In Fig. 1, the measured PT observables for the 1^+, T=0 state at 12.7 MeV and the 1^+, T=1 state are compared with microscopic DWIA calculations using the program code DWBA91. In the calculations, Cohen and Kurath target wave functions and three types of NN interactions were employed: the 425 MeV parameter set of the Franey and Love (FL) [4] effective interaction, the Paris free interaction (PF), and the Paris density-dependent (PD) interaction [5]. The averaging effect in the angular acceptance of the spectrometer has been corrected.

For the 1^+, T=1 state, the total spin transfer [6, 7], $\Sigma \equiv \{3-(D_{SS}+D_{NN}+D_{LL})\}/4$, is well reproduced by the DWIA calculations. The calculation with the FL interaction better describes the measured D_{SS} and D_{LL} than those with the PF and PD interactions. For the 1^+, T=0 state, the total spin transfer is reasonably reproduced by the calculation with the FL interaction. This result means that the strength of the isoscalar spin-orbit term (V_0^{LS}) relative to that of the V_τ^T term is reasonably described in the FL interaction. The calculations using the PF and PD interactions fail to reproduce D_{SS} and D_{LL}, while the FL interaction well reproduce them. The PT observables for 1^+, T=0 excitation are sensitive to the strength ratio of the V_σ term to the V_τ^T term. The V_σ term is considered to be very weak and has not been well determined from the NN scattering data. This result shows that the strength of the V_σ term is well described in the FL interaction, but not in the PF and PD interactions.

Fig. 2(b) plots double differential cross sections ($\frac{d^2\sigma}{d\Omega d\omega}$) and total spin transfer times double differential cross sections ($\Sigma \times \frac{d^2\sigma}{d\Omega d\omega}$). The $\Sigma \times \frac{d^2\sigma}{d\Omega d\omega}$ value represents spin-flip strengths. It is inferred from Fig. 2(b) that the broad resonances at 18.4 MeV and 19.5 MeV predominantly have spin-flip nature, while the broad resonance at 22.5 MeV has both the spin-flip and non-spin-flip strengths.

Fig. 2(c) plots $(S_{LL}\text{-}S_{SS})\frac{d\sigma}{d\Omega d\omega}$ as a function of the excitation energy. In the figure, it is expected that isoscalar spin-flip strengths appear in the negative side and isovector spin-flip strengths in the positive side. In fact, we observe negative values for the broad isoscalar resonance at 18.4 MeV, and for the isoscalar spin-flip resonance at 20.5 MeV which was observed in $(\vec{d},\vec{d}\,')$ experiments. The broad resonances at 19.5 MeV and at 22.5 MeV are the isobaric analogue states of the spin dipole resonances observed in charge exchange reactions. Since the resonances have an isovector nature, they take positive $S_{LL} - S_{SS}$ values.

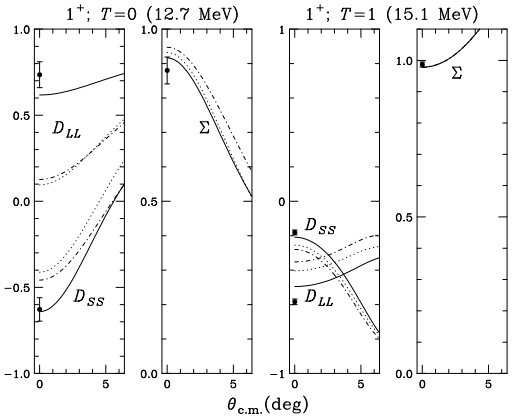

Fig. 1: Measured PT observables (D_{LL} and D_{SS}) and total spin transfer (Σ) versus c.m. scattering angles (solid circles) for excitation of the 1^+, T=0 state and the 1^+, T=1 state compared with DWIA calculations. See text for details.

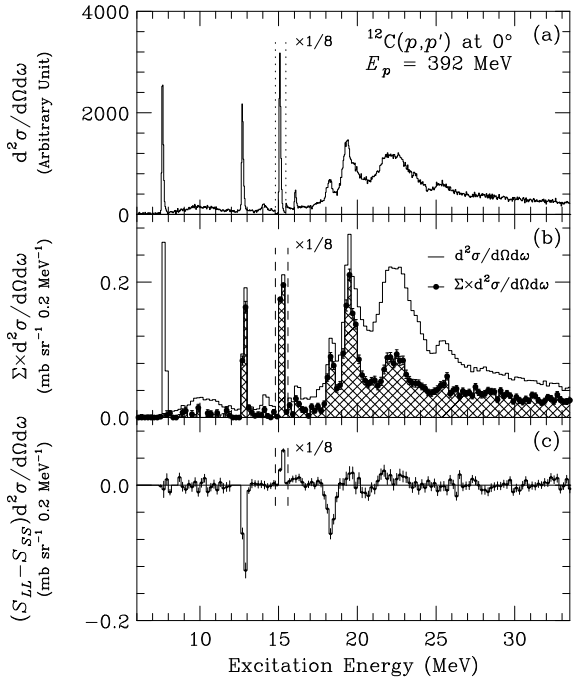

Fig. 2: Energy spectra for the $^{12}\mathrm{C}(p,p')$ reaction at θ=0°: (a) The excitation energy spectrum, (b) $\Sigma \times d^2\sigma/d\Omega d\omega$ compared with double differential cross sections ($d^2\sigma/d\Omega d\omega$), and (c) $(S_{LL} - S_{SS})d^2\sigma/d\Omega d\omega$.

References

[1] A. Tamii *et al.*, submitted to Phys. Lett. B.
[2] A. Tamii *et al.*, RCNP Annual Report 1996, p. 31.
[3] A. Tamii *et al.*, in *Proc. Int. Symp. on New Facet of Spin Giant Resonances in Nuclei*, eds. by H. Sakai, H. Okamura, T. Wakasa (World Scientific, Singapore, 1998) p. 424.
[4] M.A. Franey, W.G. Love, Phys. Rev. C **31** (1985) 488.
[5] H.V. von Geramb, in *The Interaction between Medium Energy Nucleons with Nuclei*, AIP Conf. Proc. No. 97, ed. H.O. Meyer (AIP, New York, 1982), p. 44.
[6] H. Sakai *et al.*, in *Proc. Int. Symp. on New Facet of Spin Giant Resonances in Nuclei*, eds. by H. Sakai, H. Okamura, T. Wakasa (World Scientific, Singapore, 1998) p. 29.
[7] T. Suzuki, Nucl. Phys. **A577** (1994) 167c and references therein.