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4.7 Polarization Transfer in Proton Inelastic Scattering from ^{12}C and ^{16}O

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Measurements of the in-plane polarization transfer coefficients $D_{LL'}$, $D_{LS'}$, $D_{SL'}$ and $D_{SS'}$ have recently been completed for the 200-MeV inelastic excitation of the 1^+, T=0 (12.71 MeV) state in ^{12}C, and the 4^-, T=0 (17.79 MeV and 19.80 MeV) and the 4^-, T=1 (18.98 MeV) states in ^{16}O. The data for ^{12}C span the range from 80 to 250 MeV/c (7° to 22.5° laboratory angle), while the data for ^{16}O span the range from 230 to 400 MeV/c (20.5° to 37° laboratory angle).

These measurements involve the precession of the normally-polarized proton beam into the horizontal plane prior to acceleration in the cyclotrons. Polarimeters in the high-energy beam lines and in the focal plane of the QDDM magnetic spectrometer determine the components of the proton polarization before and after the inelastic scattering.[1] The in-plane polarization transfer coefficients then relate the sideways and longitudinal components of the initial and scattered proton polarization.

The principle aim of this study is to exploit the enhanced sensitivity of these coefficients to spin-dependent terms of the effective nucleon-nucleon interaction in order to investigate in detail the spin-dependent isoscalar components of the interaction. For this purpose, we have concentrated on the inelastic excitation of unnatural parity transitions for which the nuclear structure is relatively well known, and where the contribution of the spin-independent parts of the interaction is small. The 1^+, T=0 transition in ^{12}C has been extensively studied and, moreover, is one of the few transitions for which measurements have been made of the spin-flip probability (related to $D_{NN'}$) and P-A (the difference of polarization and analyzing power). The 4^- states in ^{16}O are representative of stretched states, where the one-particle, one-hole component can arise from only a single particle-hole configuration. These transitions in ^{12}C and ^{16}O have also been studied with other probes, such as by electron and pion scattering.

Distorted-wave impulse approximation (DWIA) calculations[2] have been performed for these inelastic transitions. The distorted waves were generated from an optical potential of Woods-Saxon form, which contained an additional squared Woods-Saxon dependence in the real central term. The ^{12}C optical potential resulted from a simultaneous fit[3] to the measured elastic scattering cross-section σ, analyzing-power A and spin-rotation Q data. The ^{16}O calculations employed an optical potential[4] based on a simultaneous fit to the elastic σ and A data, and which qualitatively reproduces the measured Q data[1] at small scattering angles. Optical-model analyses incorporating the Q data have so far been unable to achieve a detailed reproduction of these data.

The DWIA calculations for the 1^+, T=0 state in ^{12}C employed the Cohen-Kurath wave function[5], which includes particle-hole amplitudes for the $p_{3/2}$ and $p_{1/2}$ shells. The 4^- transitions in ^{16}O are each described by a $(d_{5/2})(p_{3/2})^{-1}$ stretched particle-hole configuration. The results of inelastic π^+ and π^- scattering have been interpreted[6] in terms of a three-state mixing model, in which the 18.98 MeV state is shown to be almost pure T=1, whereas the 17.79 and 19.80 MeV states are predominantly T=0, with some T=1 mixing. Calculations[6] of electron inelastic scattering using these isospin-mixed wave functions correctly reproduce the measured strengths of these transitions.

Several different forms of the effective nucleon-nucleon interaction have been examined in the present work. These include the Love-Franey[7] and Paris[8] interactions, both based on the free nucleon-nucleon scattering information, and the density-dependent Paris interaction[8], in which nuclear medium modifications have been incorporated using the local density approximation. All of these interactions include both direct and knock-on exchange terms exactly; both direct and exchange contributions are important for these unnatural-parity transitions at an incident energy of 200 MeV.

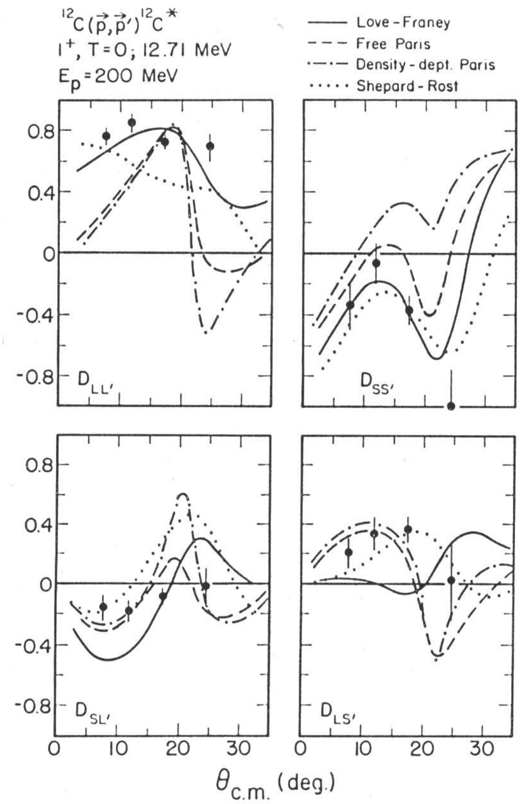

Fig. 1. Polarization transfer coefficients for the 200-MeV inelastic proton excitation of the 1^+, T=0 state in ^{12}C.

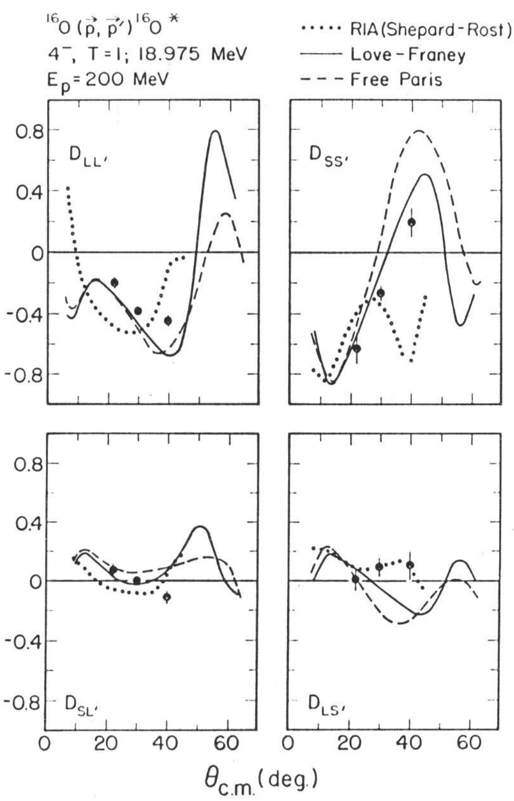

Fig. 2. Polarization transfer coefficients for the 200-MeV inelastic proton excitation of the 4^-, T=1 state in ^{16}O.

Preliminary values of the polarization transfer coefficients for the 1^+, T=0 state in ^{12}C and the 4^-, T=1 state in ^{16}O are shown in Figs. 1 and 2, together with the DWIA calculations. Many of the differences in the shapes and magnitudes of the predicted coefficients can be understood as resulting from different contributions of central, spin-orbit and tensor components in the various forms of the interaction.

Recently, Shepard and Rost have performed the first microscopic inelastic scattering calculations within the relativistic Dirac framework.[9] These calculations employ the same nonrelativistic wave functions as used in the present work, and specify the nucleon-nucleon interaction as only a direct process. Since this model involves a fit of the free scattering data out to only 60°, a comparison of the resulting inelastic calculations with the data should not extend beyond about 25°. The implementation of exchange in this framework is in progress. The resulting calculations are displayed in Figs. 1 and 2.

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