Study of Effective NN Interaction in Nuclei via the ^{28}Si$(\vec{p},\vec{n})^{28}$P(6^-) Reaction at 295 MeV

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The study of stretched states through measurements of polarization transfer coefficients is suitable for getting information on the effective nucleon-nucleon (NN) interaction in nuclei. It is because (1) a stretched state can be described as an excited state with a simple one-particle–one-hole configuration, and (2) polarization transfer coefficients are less sensitive to distortion effects than other spin observables such as analyzing powers. Actually, some measurements of polarization transfer coefficients in (p,p') reactions to the stretched states suggest modifications of the effective NN interaction in nuclear medium [1, 2]. In the (p,p') reaction, however, we could not discriminate between the effect of medium modifications and that of isospin mixing. In order to exclude this ambiguity, we performed measurements in the (p,n) reaction which excites exclusively the pure isovector modes.

In this article we report measurements of differential cross sections and polarization transfer coefficients for the stretched 6^- state at 4.94 MeV via the ^{28}Si$(p,n)^{28}$P reaction at 295 MeV.

The data were obtained with the Neutron Time-of-Flight facility [3, 4] at the Research Center for Nuclear Physics. We used natural silicon targets (92.2% ^{28}Si, 4.7% ^{29}Si, and 3.1% ^{30}Si) for the measurement. Figure 1 shows the double differential cross sections at $\theta_{\rm lab} = 27.8°$ as a function of excitation energy of ^{28}P. The overall energy resolution is about 1.6 MeV in full width at half maximum. Since this energy resolution is not sufficient to isolate the 6^- state at 4.94 MeV, we have fitted the spectra with three gaussians and a smooth background to extract the differential cross sections and spin observables of the stretched state (see Fig. 1).

In order to see if there are some changes in scattering amplitudes of the effective interaction, we separated the observables into polarized cross sections [5, 6]. In the plane wave impulse approximation framework, each polarized cross section σ_i is associated with one structure form factor, χ_L or χ_T, and one scattering amplitude defined by Kerman, McManus, and Thaler [7]. In the case of unnatural parity transition,

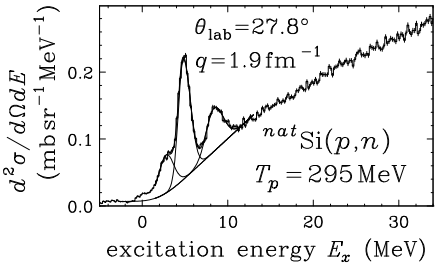

Figure 1: The double differential cross sections at 27.8°.

$$\begin{pmatrix} \sigma_{LS} \\ \sigma_n \\ \sigma_p \\ \sigma_q \end{pmatrix} = \begin{pmatrix} |C|^2\chi_T^2 \\ |B|^2\chi_T^2 \\ |F|^2\chi_T^2 \\ |E|^2\chi_L^2 \end{pmatrix} ,$$

where B, C, E, and F are the isovector KMT scattering amplitudes. Even if distortions are included, the polarized cross sections are predominantly sensitive to the same terms.

Figure 2 shows the obtained polarized cross sections by solid circles as a function of momentum transfer. The solid curves are the results of distorted wave impulse approximation (DWIA) calculations by using the computer code DW81 [8]. We used the effective NN t-matrix

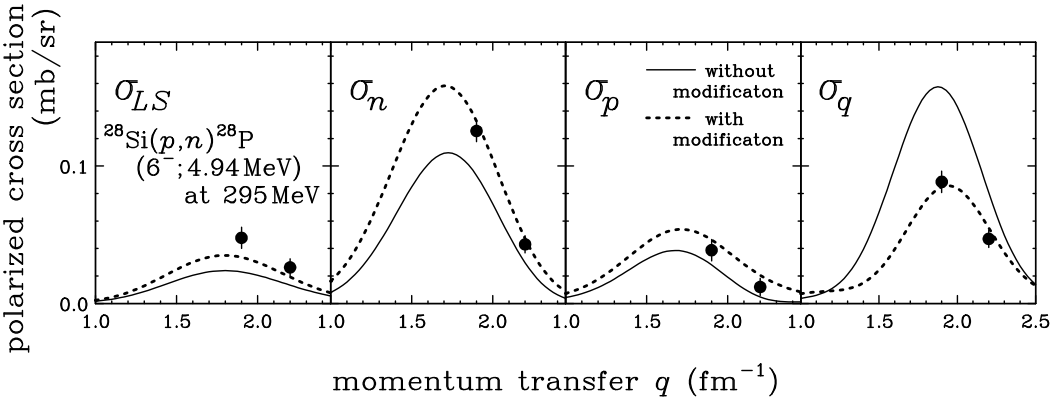

Figure 2: Polarized cross sections. The solid curves are the results of the DWIA calculation by using the FL t-matrix. The dotted curves are those by using the modified t-matrix (see text).

interactions parameterized by Franey and Love (FL) at 325 MeV [9]. The configuration of the 6^- transition was assumed to be $(\pi f_{7/2}, \nu d_{5/2}^{-1})$. The optical-model parameters were taken from Ref. [10]. The single particle radial wave functions were described by harmonic oscillator wave functions with an oscillator length parameter of 1.743 fm [10].

The calculations underpredict the normal and in-plane spin-transverse cross sections, σ_n and σ_p, by 20% and overpredict the spin-longitudinal cross section σ_q by 60%. The spin-orbit cross section σ_{LS} is underpredicted by a factor of 2. These discrepancies imply a medium modification of the effective NN interaction.

We made an attempt to reproduce the data by adjusting the t-matrix amplitudes phenomenologically. In order to reproduce the data, the following changes in the scattering amplitudes are needed: the spin-longitudinal amplitude E is decreased by a factor of 3/4, the spin-transverse amplitudes, B and F, are increased by a factor of 5/4, and the spin-orbit amplitude C is increased by 50%. The dotted curves in Fig. 2 are the results of the calculations with the modified effective NN interaction.

A possible interpretation of the medium modification in the $\pi + \rho + g'$ model [11] is an enhancement of the Landau-Migdal parameter g' in medium, which increases the spin-longitudinal amplitude and decreases the spin-transverse amplitudes simultaneously. However, more theoretical works are needed to understand the mechanism of the observed medium modification.

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