RCNP EXPERIMENT E203

PROPOSAL FOR EXPERIMENT AT RCNP

27/01/2003

TITLE:

Precise Measurement of Pionic Correlations in Nuclei via $^{16}O(\vec{p},\vec{p}')$

SPOKESPERSON:

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RUNNING TIME:

Test running time for experiment	2 days
Data runs	21 days

BEAM LINE: WS (WS beam line + Grand Raiden + FPP)

BEAM REQUIREMENTS:

Type of particle	Polarized Protons
Beam energy	295 MeV
Beam intensity	> 20 nA on target
Energy resolution	< 100 keV (FWHM)
Beam polarization	> 0.7
Injection mode	High Resolution Mode
WS transport mode	Dispersive/Achromatic Modes

BUDGET:

Summary of budget request	3,700,000
Experimental expenses	3,200,000
Travel plan	500,000

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SUMMARY OF THE PROPOSAL

Isovector $J^\pi = 0^-$, $0^\pm \to 0^\mp$ excitations are of particular interest since they carry the simplest pion-like quantum number. At low momentum transfers, they have been investigated in beta decay and muon capture experiments. Axial-vector and pseudoscalar currents are responsible for these first-forbidden transitions in nuclear weak processes. Gagliardi *et al.* reported an enhancement of the decay rate by more than a factor 3 for the first-forbidden beta decay of the 120 keV, 0^- state in ^{16}N. This enhancement can be explained by considering the meson-exchange effects.

The (p,n) and (p,p') reactions are suited to study these transitions for a wide momentum-transfer range. Orihara *et al.* reported the angular distribution for the $^{16}O(p,n)^{16}N(0^-$, 0.12 MeV) reaction at $T_p = 35$ MeV. The discrepancy between the distorted wave Born approximation (DWBA) calculation and their data in the large momentum transfer region of $q = 1.4$–2.0 fm^{-1} has been observed, which might be due to the effect of the enhancement of the pion probability in the nucleus. However, in the proton inelastic scattering to the 0^-, $T = 1$ state in ^{16}O at $T_p = 65$ MeV, such an enhancement was not observed. The differences between (p,n) and (p,p') results might indicate the contribution from complicated reaction mechanisms in these low incident energies.

In the previous experiment E155, we measured the cross sections and analyzing powers of the $^{16}O(p,p')^{16}O(0^-,T=1)$ scattering at a bombarding

energy of 295 MeV and an angular range of $14^\circ \leq \theta_{\rm lab} \leq 30^\circ$. At intermediate energies of $T_p > 100$ MeV, for the first time, the isovector 0^- state at E_x = 12.80 MeV is clearly separated from the neighboring states with an energy resolution of $\Delta E \simeq 30$ keV. The data have been compared with distorted wave impulse approximation (DWIA) calculations. The DWIA calculation with shell-model wave functions (free response functions) reproduces the cross sections around the 2nd maximum at 14° without a normalization factor, while it underestimates and slightly misses the 3rd maximum. On the contrary, the calculation with random phase approximation (RPA) response functions reproduces the 2nd and 3rd maxima simultaneously with a normalization factor of 0.5. This means that our experimental data supports the enhancement of the pionic 0^- mode in nuclei as is predicted in RPA calculations.

In this experiment, we propose to measure a complete set of polarization transfer (PT) observables for the inelastic excitation to the 0^-, T=1 (12.80 MeV) unnatural-parity state in ^{16}O in 295 MeV inelastic proton scattering from ^{16}O. PT observables are sensitive to the spin-parity transfer J^π. Especially PT observables for J^π=0^-, ΔT=1 are independent of details of reaction mechanisms and effective interactions. Thus the PT measurement will give a strict restriction to the cross sections for the 0^-, T=1 state because the PT observables for this state should be D_{qq}=+1 and D_{nn}=D_{pp}=−1 in the center-of-mass frame. Therefore PT observables are useful to improve the precision of cross sections for the pionic 0^- state as well as to reduce their systematic uncertainties, which are crucial in order to draw the definite conclusion for the pionic correlation effects (pionic enhancement) in nuclei.