E1 States Observed in Proton Inelastic Scattering on ^{58}Ni at 0-degree

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In 0° proton inelastic scattering at intermediate incident energies, transitions caused by the isovector spin-flip ($\sigma\tau$) interaction are prominent. This is because of the $L = 0$ nature of the transition, $\sigma\tau$ dominance and relatively weak isoscalar component of nuclear interaction [1]. From the similarity with charge exchange (CE) reaction like (p, n) and (^{3}He,t), good proportionality between cross sections of the spin-isospin excitations and reduced transition strengths is expected. These final states having $J^\pi = 1^+$ are called $M1$ states. By comparing high resolution CE reactions from the same target, isospin symmetry structure of spin-isospin excited states can be studied [2].

In (p, p') scatterings at intermediate energies, however, Coulomb interaction is also important at 0°, by which GDR is mainly excited. In general, GDR is observed as a bump-like structure at higher excitation energies than spin-isospin excited states. In addition to GDR, discrete $E1$ states can be excited at lower energy region. Therefore, it is important to distinguish $E1$ and $M1$ states in the 0° spectra. Nuclear resonance fluorescence (NRF) measurement was performed by F. Bauwens *et al.* on ^{58}Ni and they reported $M1$ and $E1$ states up to 10 MeV. From the comparison between our ^{58}Ni(p, p') spectrum with their data, the existence of possible *E1* states was studied.

A ^{58}Ni(p, p') experiment at 0° and at incident energy of 160 MeV was performed at Indiana University Cyclotron Facility (IUCF) as a part of experiment E409 using the QDD-type K600 spectrometer. Along the focal plane of the spectrometer, two sets of multi-wire drift chamber were installed. The horizontal wire plane is sensitive for horizontal position and angle, while, the vertical wire plane is used only for the vertical position measurement allowing *over-focus mode* [4] to be applied. Downstream of these chambers, two ΔE-type plastic scintillators were installed for particle identification and for generating fast timing signals. A 160 MeV proton beam from the cyclotron was used to bombard the 2.5 mg/cm^2 ^{58}Ni target. *Lateral dispersion matching* [5] was applied to achieve high energy resolution. In Fig. 1, energy spectrum of (p, p') reaction is shown (top) for the energy region overlapping with the NRF data, *i.e.* E_x of 8.0 to 9.6 MeV. Values of $B(M1)$ and $B(E1)$ from the NRF measurement [3] are also shown (bottom).

In the region, states at 8.461 MeV, 8.602 MeV, 8.677 MeV, 9.071 MeV and 9.156 MeV were identified to be te $M1$ states by the NRF measurement [3]. All of these states were found in our (p, p') spectra, suggesting a good selectivity of spin-isospin excitation in (p, p') measurement at 0°. These *M1* states are labeled "1", "2", "3", "4" and "5" in Fig. 1. The

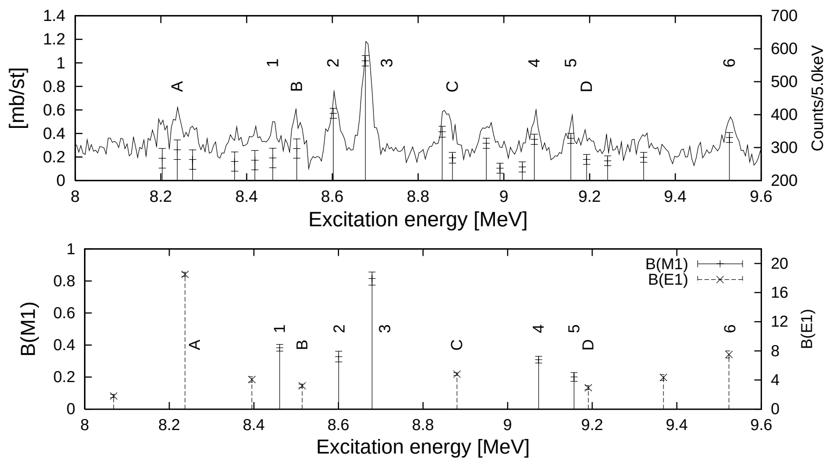

Figure 1: Measured cross sections of (p, p') experiment (top) and $B(M1)$ and $B(E1)$ values from Ref. [3] (bottom) as functions of excitation energies. The energy spectrum of (p, p') experiments are also shown for excitation energy from 8.0 to 9.6 MeV.

relative strengths of these states show good quasi-proportionality.

On the other hand, states at 8.238 MeV, 8.517 MeV, 8.880 MeV, and 9.193 MeV were identified as $E1$ states in the NRF measurement [3]. These states are labeled "A", "B", "C" and "D" in Fig. 1. Rough proportionality was found in cross sections of (p, p') spectrum and $B(E1)$ values, except for the strongest state "A". From comparison with good energy resolution (^{3}He,t) spectrum, in which all the states in this high level density region are well isolated, validity of these *E1* assignments can be tested since Coulomb excitation is not allowed in CE reactions. The 9.526 MeV state, which is labeled "6", is reported to be an *E1* in Ref. [3]. But this state still can be spin-isospin excited states, because the analog candidate was found in the (^{3}He,t) spectrum at corresponding energy, 9.645 MeV. Another possibility is that this is accidental correspondence of *E1* state in ^{58}Ni and 1^+ state having $T_f = 0$ in ^{58}Cu, which is forbidden in ^{58}Ni.

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