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STUDY OF HIGHER ISOSPIN COMPONENTS OF GAMOW-TELLER STRENGTH IN Ni(p,n) REACTIONS

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A recent high-energy inelastic proton scattering study on the even Ni isotopes reported the observation of peaks that are believed to be the T_o and T_o+1 components of the M1 resonance.[1] Here T_o is the isospin of the target ground state. Motivated by this, we undertook a study of the (p,n) reaction on the even Ni isotopes to excite the analogues of these states, as well as the dominant T_o−1 component. The T_o and T_o+1 components are expected to be populated more weakly in general, partly as a result of isospin coupling geometry.

The measurements were performed using a 134-MeV proton beam. The 0° (p,n) spectra for the four targets are shown in Fig. 1. The energy resolution is about 400 keV. The ^{58}Cu spectrum is similar to those measured by Rapaport et al.[2] at 120 and 160 MeV. The ground-state isobaric analogue state (IAS) occurs at excitations of 0.2, 2.5, 4.6, and 6.8 MeV, respectively, in ^{58,60,62,64}Cu. By adding to the IAS energies the T_o and T_o+1 excitation energies observed in (p,p'), the positions of these isospin components in the (p,n) spectra can be predicted. The comparison between the predicted and observed positions is shown in Table I. Based on this comparison, we tentatively make the isospin assignments indicated in Table I to some of the (p,n) peaks. The T_o+1 level is not observed in ^{64}Cu, probably because it is too weak.

The remaining broad structures in the spectra, at excitations above 5.5 MeV, are given the isospin

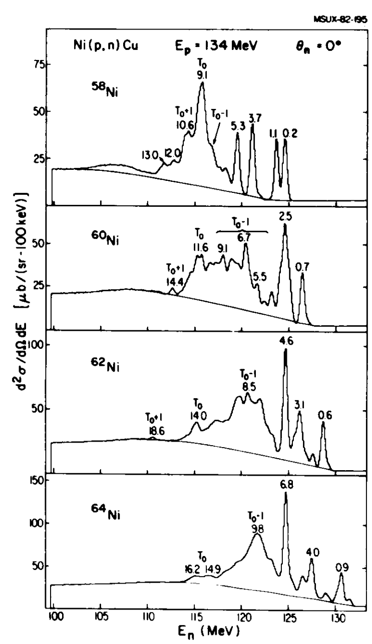

Figure 1. Spectra of neutrons from the (p,n) reaction on ^{58,60,62,64}Ni.

Table I. Expected and observed energies of T_o and (T_o+1) states in Cu isotopes.

Nucleus	Energy in Parent Nucleus* (MeV) T_o	T_o+1	IAS Energy (MeV)	Expected Energy (MeV) T_o	T_o+1	Observed Energy (MeV) T_o	T_o+1
^{58}Cu	8.5	10.7	0.2	8.7	10.9	9.1	10.7
^{60}Cu	8.9	11.9	2.5	11.4	14.4	11.6	14.4
^{62}Cu	8.8	14.0	4.6	13.4	18.6	14.0	18.6
^{64}Cu	8.9	15.6	6.8	15.7	22.4	14.9, 16.2	----

*From the (p,p') data of reference 1.

assignment T_o-1. We emphasize that such division of the observed peaks into different isospin components is open to question, and that it is possible that there is an overlapping of Gamow-Teller (GT) strength for the different isospin components. However, inspection of the spectra indicates that the T_o+1 strengths in $^{60,62}Cu$ and the T_o strengths in $^{62,64}Cu$ can be determined with reasonable precision. Moreover, shell-model calculations done by us for the T_o and T_o+1 strength distributions in the four nuclei show that these components are non-overlapping in energy (Fig. 2). The model space used is similar to that of Ref. 2, and the modified surface delta interaction is used for the residual two-body force.

Yields were extracted using the "experimentalist's" backgrounds shown by the solid lines in Fig. 1. Angular distributions for the high-lying (E_x>5.5 MeV) T_o-1, T_o and T_o+1 components of the GT strength in $^{58,60}Cu$ are shown in Fig. 3. The solid lines are the results of microscopic DWIA calculations using the nucleon-nucleon effective interaction of Love and Franey[3] and simple $f_{5/2}\,f^{-1}_{7/2}$ wave functions. The fits to the data are good.

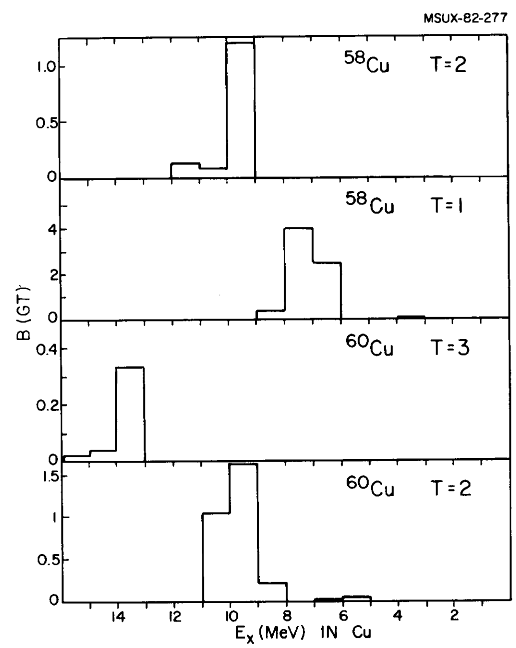

Figure 2. Shell-model results for the T_o and T_o+1 Gamow-Teller strength distributions in ^{58}Cu and ^{60}Cu.

B(GT) values were obtained in a model-independent way by the method of Taddeucci et al.[4] by considering the ratio of the 0° GT and IAS cross sections. They are compared with our shell-model predictions in Fig. 4. As shown there, a uniform reduction of the theoretical values to 0.35 of the prediction is

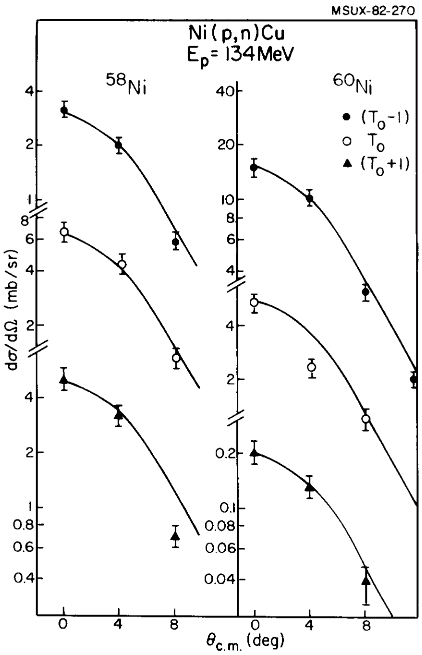

Figure 3. Angular distributions for the high-lying GT isospin components in ^{58}Cu and ^{60}Cu.

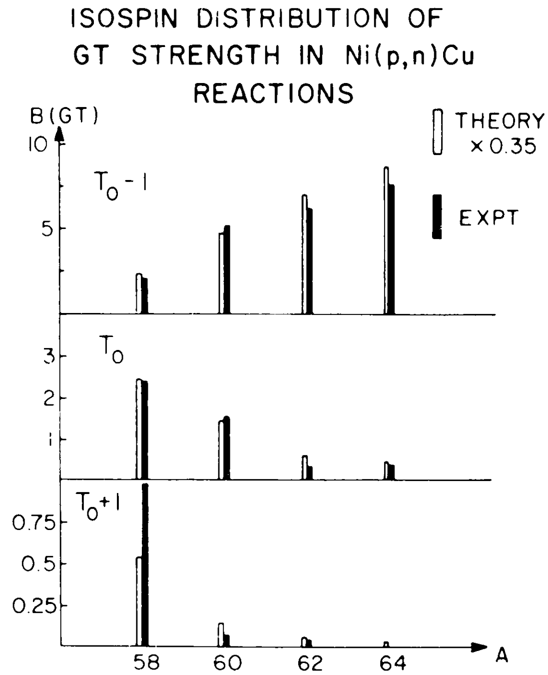

Figure 4. Comparison of experimental and theoretical isospin distributions of GT strength in Ni(p,n)Cu reactions.

required to bring agreement between experiment and theory for the T_0-1 and T_0 components for all for nuclei. For the weak T_0+1 component, there are large fluctuations between experiment and (reduced) theory, at least partly due to the uncertainties in the extraction of the experimental values.

The determination of the amount of the GT strength in the background shown in Fig. 1 is presently in progress. When all the L=0 strength in the background is included, the overall "reduction factor" rises from 0.35 to 0.54. This latter value is consistent with values found for the quenching of the GT strength in other medium-weight and heavy nuclei.[5]

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