THE $^{20}Ne(p,n)^{20}$ Na REACTION AT 120 MeV

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Differential cross sections have been measured for the reaction $^{20}Ne(p,n)^{20}Na$ at 120 MeV covering the angular range $0° < \theta_{cm} < 38°$. The target was a gas cell, developed for the IUCF beam swinger, containing isotopically enriched ^{20}Ne gas. Neutron time-of-flight (TOF) spectra were measured simultaneously along 0° and 24° flight paths of 102 m and 80 m respectively. At each angle yields were also measured for an empty cell. Peak areas were extracted using the program FITIT. Background peaks are determined from the empty cell runs while the slope of the background is determined from the ^{20}Ne spectra (cell background + wraparound). Cross sections are normalized using the $^{12}C(p,n)^{12}N$ (g.s.) transition (CO gas) as reported by Rapaport et al.[1] In addition a check was made using the solid target ^{7}Li and ^{12}C data. These targets are also used as a velocity calibration.

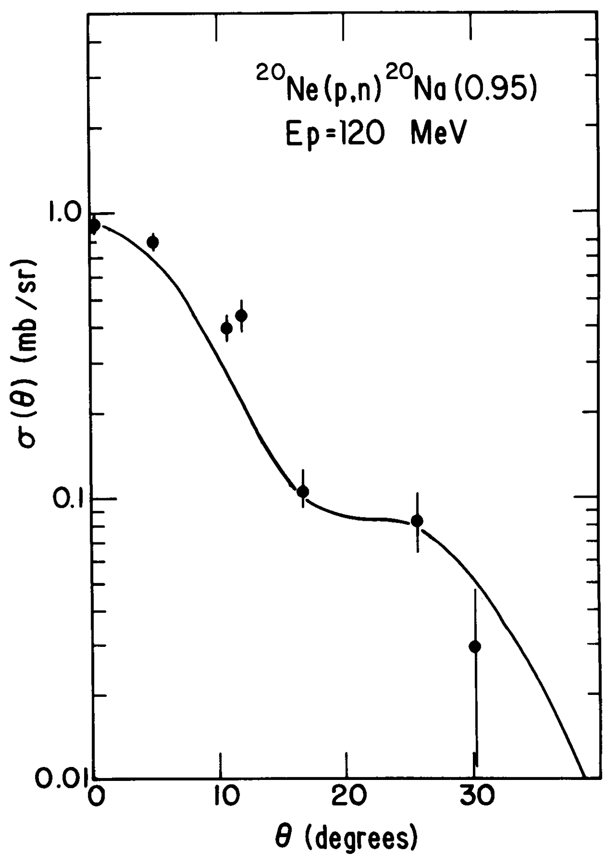

Figure 1. Angular distribution for the $^{20}Ne(p,n)^{20}Na$ (0.95 MeV, 1^+) reaction at 120 MeV. The curve is a DWBA calculation using the Chung-Wildenthal transition densities and the Love-Franey 140 MeV t-matrix interaction.

Figure 1 shows the angular distribution in the center-of-mass frame for the first 1^+ state in ^{20}Na. This state is the analog of the strong M1 state seen in $^{20}Ne(e,e')$. The curve is the result of a DWBA calculation using Chung-Wildenthal[2] wavefunctions and the full (complex) Love-Franey[3] 140-MeV force. The calculation reproduces the data very well with no adjustments.

The isovector M1 operator mediating (e,e') reactions has both orbital current and spin contributions while in the analog (p,n) reaction near 0° only the spin-flip interaction will contribute. Since the tensor interaction, the spin-orbit interaction and the L=2 transition densities are small near q=0, we have approximately[4]

$$B(M1,q) \approx g \left(\frac{eh}{2Mc}\right)^2 \left|\frac{1}{2} g_s^1 \rho_{10}^{s1}(q) + g_\ell^1 \rho_{10}^{\ell 1}(q)\right|^2$$

$$\frac{d\sigma}{d\Omega} \approx 8\pi \left(\frac{\mu}{2\pi h^2}\right)^2 \frac{k_f}{k_i} 3\left|v_1^c(q) \rho_{10}^{s1}(q)\right|^2$$

where $\rho_{10}^{s1}(q)$ and $\rho_{10}^{\ell 1}(q)$ are the momentum representations of the spin and orbital current transition densities, $v_1^c(q)$ is the Bessel transform of the effective interaction and g_s^1 and g_ℓ^1 are the spin and orbital g-factors. Comparison of B(M1) values and (p,n) cross sections will determine the current and spin contributions to the M1 isovector excitation.

In the case of ^{20}Ne(e,e') at 180° only one strong M1 transition ($J^\pi=1^+$, T=1) has been observed below 20 MeV excitation. Our measurement of σ_{pn} for the $T_z=+1$ analog leads to a determination of the spin transfer matrix element consistent with the Chung-Wildenthal[2] wavefunctions and consistent with that determined for the $T_z=-1$ analog from the ^{20}Ne(π^-,γ)^{20}F work of Martoff et al.[5]

In addition to the ground state ($J^\pi=2^+$) and the first M1 state, at least three more peaks are observed in the spectra. The transition strength and angular distributions for states at E_x=1.29 MeV and E_x=1.79 MeV (see Fig. 2) indicate that these states are spin-flip ΔL=1 transitions. DWBA calculations can rule out a 0^- assignment but can not distinguish between 2^- and 1^- in the angular region measured. Based on the assignment given to the apparent T_Z= -1 analogs,[5] a $J^\pi=2^-$ assignment is assumed. A broad peak with its centroid at 5.58 MeV excitation appears to be a combination of ΔL=0 and ΔL=1 strength. The apparent analog in ^{20}F was given a tentative 2^- assignment.[5] The Chung-Wildenthal calculations predict additional M1 transition strength in this energy region. Estimates

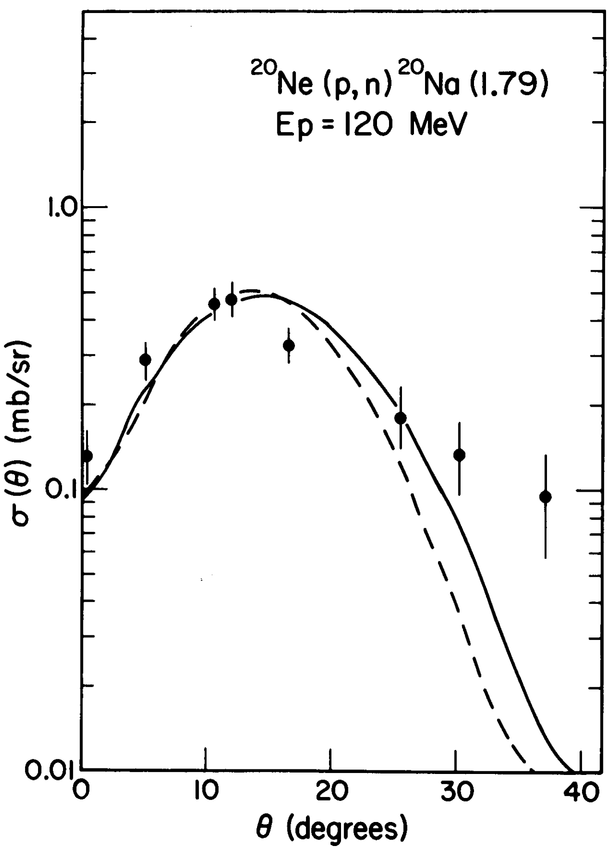

Figure 2. Angular distribution for the ^{20}Ne(p,n)^{20}Na (1.79 MeV) reaction at 120 MeV. The curves are DWBA calculations assuming $J^\pi=2^-$ (solid line) and $J^\pi=1^-$ (dashed line).

based on the observed 2^- and 1^+ angular distributions give values for the 1^+ cross sections consistent with the expected strength.

The simultaneous description of the B(M1) values and the (p,n) cross sections for ^{20}Ne provide evidence of 1^+ states with constructive interference and states with destructive interference of spin and orbital-recoupling transition densities. Further work is in progress.

1) J. Rapaport, et al., Phys. Rev. C 24, 335 (1981).

2) B.H. Wildenthal and W. Chung, in The (p,n) Reaction and Nucleon-Nucleon Force, eds. C.D. Goodman, et al. (Plenum, New York 1980); W. Chung and B.H. Wildenthal (unpublished).

3) W.G. Love and M.A. Franey, Phys. Rev. C 24. 1073 (1981).

4) F. Petrovich, W.G. Love, and R.J. McCarthy, Phys. Rev. C 21, 1718 (1980).

5) C.J. Martoff, et al., Phys. Rev. Lett. 46, 891 (1981).

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

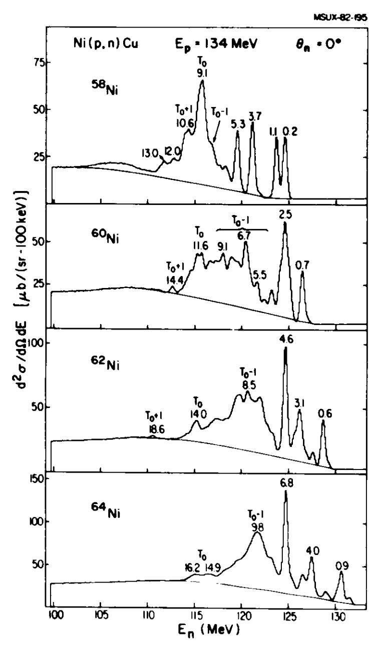

Figure 1. Spectra of neutrons from the (p,n) reaction on ^{58,60,62,64}Ni.