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GENERAL FEATURES OF THE GAMOW-TELLER RESONANCES

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A striking feature of the (p,n) reaction in the IUCF energy range is that the 0° neutron spectra are so strongly dominated by Gamow-Teller (GT) transitions that these spectra provide an instant snapshot of GT strength distributions. This feature of the (p,n) reaction is understood¹⁾ on the grounds that at 0°, where there is no transverse momentum transfer and the longitudinal momentum transfer is small, most terms in the projectile-nucleus interaction do not contribute, and the only important terms are $V_{\tau}(\tau_p \cdot \tau_i)$ and $V_{\sigma\tau}(\sigma_p \cdot \sigma_i)(\tau_p \cdot \tau_i)$, where σ and τ are spin and isospin operators, the subscript p refers to the projectile proton and the subscript i refers to the ith nucleon in the nucleus. A summation over nucleons is implied. The (p,n) results also show that V_{τ} is much smaller

than $V_{\sigma\tau}$ for $E_p \sim 200$ MeV.

In interpreting the data on GT strength distributions it is useful to think in terms of how a nucleus with a neutron excess responds to the transformation of a neutron to a proton. This is easily representable in an independent-particle model. Each nuclear state is represented as an occupancy pattern of a set of single-particle states appropriate to the specific model. The neutrons, of course, are indistinguishable from each other, so that the transformation of a neutron into a proton implies a summation over all neutrons. The relevant operator is $\tau_p^+ \tau_i^- (\sigma_p \cdot \sigma_i)$. The result of operating on the target ground state yields a fictitious state that we may call the collective Gamow-Teller (CGT) state. The Gamow-

Teller strength distribution may then be thought of as the expansion of the CGT in terms of the set of actual eigenstates of the final nucleus. The expansion coefficients are the GT matrix elements for the individual states.

We can define a similar fictitious state, the collective Fermi state (CF), with respect to the $V_{\tau}(\tau_p \cdot \tau_1)$ interaction term. We know that the CF state corresponds to the isobaric-analog state (IAS) and is narrow.

In the extreme case of a nuclear Hamiltonian that depends only on the spatial coordinates of the nucleons, a supermultiplet symmetry would hold and the CF and CGT states would be sharp and degenerate. The spin-orbit force breaks this symmetry. It had long been conjectured,^{2,3)} however, that a degree of supermultiplet symmetry would persist. Experimental data were not available to support the calculations.

The present (p,n) data provide a picture of the GT strength distributions, as illustrated in Figs. 1 and 2. In heavy nuclei the GT strength lies in a broad but well-defined resonance at about the same energy as the IAS. In medium-weight nuclei the resonance is still well defined but some fragmentation is apparent. In light nuclei varying degrees of fragmentation are observed. In $^{26}\text{Mg}(p,n)^{26}\text{Al}$ the fragmentation is most pronounced, but even there it is worth noting that the largest single component of GT strength is in the peak closest to the IAS which may be considered a vestige of supermultiplet symmetry.

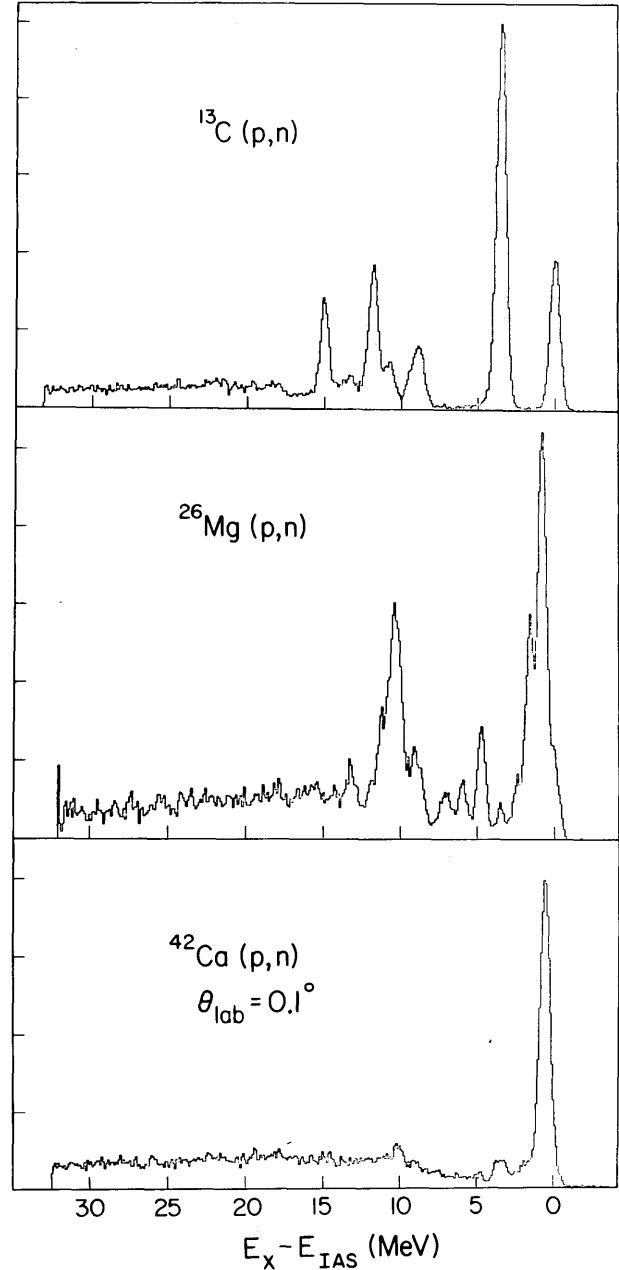


Figure 1. $^{13}\text{C}(p,n)$, $^{26}\text{Mg}(p,n)$, and $^{42}\text{Ca}(p,n)$ spectra obtained at $\theta_{\text{lab}} = 0^\circ$, $E_p = 160$ MeV. The IAS peaks in each spectrum are positioned at $E_x - E_{\text{IAS}} = 0$.

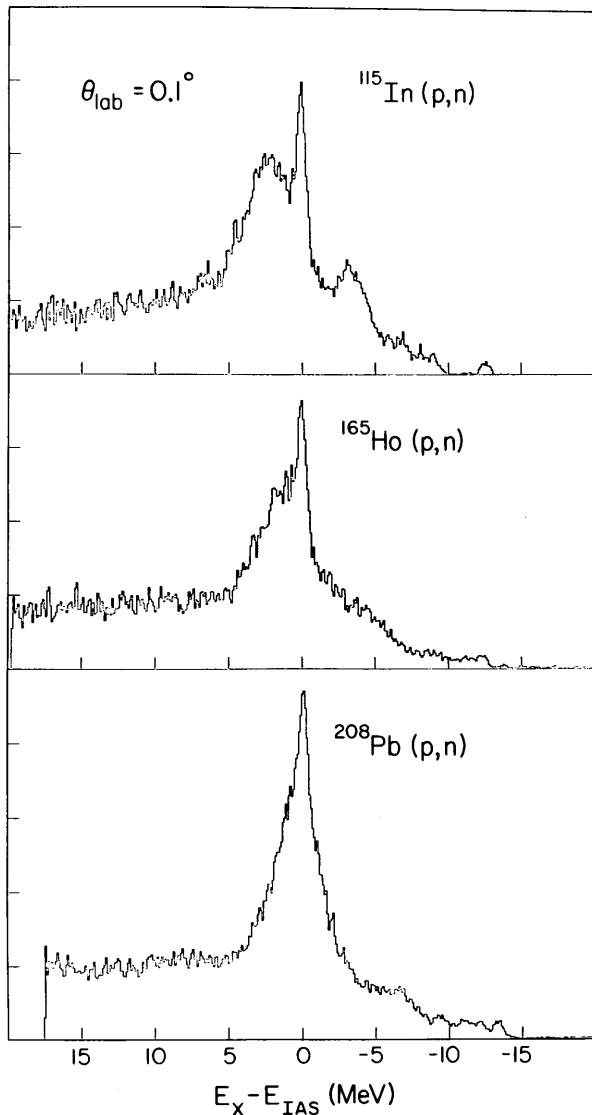


Figure 2. $^{115}\text{In}(p,n)$, $^{165}\text{Ho}(p,n)$, and $^{208}\text{Pb}(p,n)$ spectra obtained at $\theta_{\text{lab}} = 0^\circ$, $E_p = 160$ MeV. The IAS peaks are positioned at $E_x - E_{\text{IAS}} = 0$.

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HIGH-SPIN "STRETCHED" STATES EXCITED IN (p,n) REACTIONS

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The excitation of unnatural parity states of high angular momentum is an area of strong current interest¹⁻⁶⁾ in medium-energy physics. Isovector

excitations are especially interesting because of their strong sensitivity to the isovector-tensor part of the nucleon-nucleon force. In the momentum-transfer region