Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 940-941

4.13

Spin-flip Probabilities for the $^{40,48}Ca(\vec{p},\vec{n})$ Reactions at 135 MeV

J.W. Watson, B.D. Anderson, A.R. Baldwin, T. Chittrakarn, B.S. Flanders, R. Madey, P.J. Pella[†] and C.C. Foster[††]

Department of Physics, Kent State University, Kent, OH 44242, USA
[†]Department of Physics, Hendrix College, Conway, AR 72032, USA
[††]Indiana University Cyclotron Facility, Bloomington, IN 47405, USA

Spin-flip modes of excitation are known to be important at medium energies. The most direct technique for studying such excitations is polarization transfer. We present here polarization-transfer measurements for $(\vec{p},\vec{n})$ reactions on ^{40}Ca and ^{48}Ca at 135 MeV. We measured p_n, the polarization of the detected neutron, which is related to the incident proton polarization p_p, and the polarization-transfer coefficient $K_y^{y'}$ (Madison convention) as follows:

$$[1 + p_p A_y(\theta)]p_n = P(\theta) + p_p K_y^{y'}(\theta).$$

Here $A_y(\theta)$ and $P(\theta)$ are the analyzing power and the polarization function, respectively. Since A_y and P vanish identically at 0°, this expression simplifies to $p_n = p_p K_y^{y'}(0°)$. The relation between the spin-flip probability "S" and $K_y^{y'}$ is: $2S = (1 - K_y^{y'})$. S is expected[1] to take on characteristic values which depend on $\Delta\ell$, Δs and ΔJ for the transition. Specifically, all $\Delta s = 0$ transitions have $S = 0$, and "Gamow-Teller" (G-T) transitions ($\Delta\ell = 0$, $\Delta s = 1$, $\Delta J = 1$) should have spin-flip probabilities $S = 2/3$.

The experiment was performed with the "beam-swinger" at the Indiana University Cyclotron Facility. The average proton beam polarization was 77%. The flight path to the polarimeter was 35 m. The neutron polarimeter, which has an average analyzing power $\bar{A}_y = 0.275 \pm 0.010$ and an efficiency $\varepsilon = (2.40 \pm 0.24) \times 10^{-3}$, is described in detail in Ref. 2.

In Figure 1 we compare S spectra for both ^{40}Ca and ^{48}Ca with 1 MeV binning to reduce statistical fluctuations. Note that the region labeled "GTGR" (Gamow-Teller Giant Resonance) for ^{48}Ca, where S has a constant value of 2/3, extends down to about E_n = 115 MeV, which is 5 MeV beyond the GTGR peak. Our recent analysis[3] of cross-section data indicates that the continuum under and immediately adjacent to the GTGR is predominantly $\Delta\ell = 0$. This observation, coupled with our measured value of $S = 2/3$ implies that this region of the continuum is predominantly 1^+ strength. Thus we confirm our prior analysis[3] that nearly 20% of the G-T sum-rule strength is in the continuum underneath and adjacent to the GTGR. Consider now the region $90 \leq E_n(\text{MeV}) \leq 105$; in this energy interval, S is the same within statistical uncertainties of a few percent for these two targets. This result can be interpreted in several ways. One might argue that ^{40}Ca is a spin-saturated self-conjugate target and can have no G-T strength; therefore, the identical values of S for ^{40}Ca and ^{48}Ca imply that ^{48}Ca has no G-T strength in this part of the continuum, contrary to what is suggested in Refs. 4, 5 and 6. Alternatively, one might argue that both ^{40}Ca and ^{48}Ca have multi-particle-multi-hole ground-state correlations; these must, in fact, be the origin of the two weak low-lying 1^+ states populated in the $^{40}Ca(p,n)^{40}Sc$ reaction. Ground-state correlations can also give rise to G-T strength in the continuum; similar ground-state correlations might produce similar values of S in the continuum. The interpretation we prefer is that QFS (as observed earlier[7]) is the origin of the continuum because the observed value of $S \sim 1/2$ is to first order the value expected for QFS. Note that $S = 1/2$ when $p_n = 0$; p_n should be close to 0 (and S close to 1/2) for both targets because the polarization-transfer parameter "D_t" for p-n scattering near 180° is close to zero.[8] Considering these three arguments, we conclude that there is no solid evidence in these spin-flip spectra for or against the presence of residual G-T strength for ^{48}Ca in this part of the continuum ($90 \leq E_n(\text{MeV}) \leq 105$). We can neither confirm nor reject suggestions[4,5,6] that the continuum in this Q-value region (-30 to -45 MeV) contains a significant amount of "missing" G-T sum-rule strength.

This work was supported in part by the National Science Foundation.

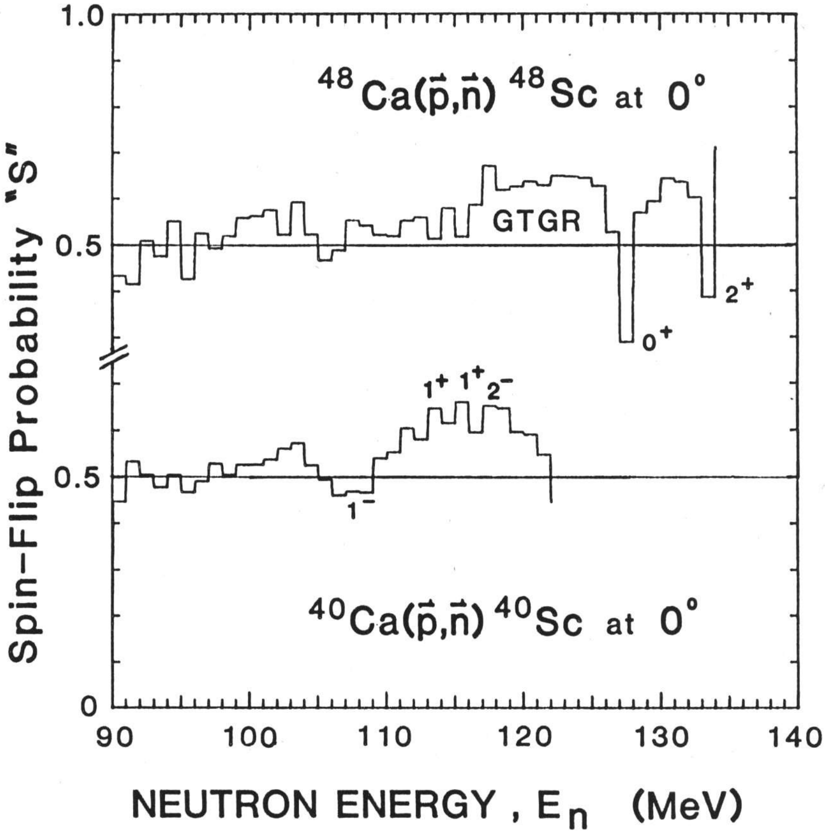

Figure 1. Spectra of the spin-flip probability S [$S = (1 - K_y^{y'})/2$] for the 135 MeV $(\vec{p},\vec{n})$ reactions on ^{40}Ca and ^{48}Ca at 0°.

References

1) W.D. Cornelius, J.M. Moss and T. Yamaya, Phys. Rev. C23 (1980) 1364.
2) R. Madey, J.W. Watson, B.D. Anderson, A.R. Baldwin and P.J. Pella, in Proceedings of the CEBAF Summer Workshop (June 3 to 7, 1985, Newport News, Virginia).
3) B.D. Anderson, et al., Phys. Rev. C31 (1985) 1161.
4) G.F. Bertsch and I. Hamamoto, Phys. Rev. C26 (1982) 1323.
5) F. Osterfeld, D. Cha and J. Speth, Phys. Rev. C31 (1985) 372.
6) Amir Klein, W.G. Love and N. Auerbach, Phys. Rev. C31 (1985) 710.
7) B.D. Anderson, et al., Phys. Rev. Lett. 46 (1981) 226.
8) P.M. Patel, et al., Phys. Rev. Lett. 8 (1962) 491; W.G. Collins, Jr., and D.G. Miller, Phys. Rev. 134 (1964) B575.