CONTRIBUTION OF A BINDING-ENERGY MISMATCH TO THE MIRROR ASYMMETRY IN GAMOW-TELLER TRANSTIONS IN A=10 NUCLEI

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The measured Gamow-Teller transition rates between the ground state of ^{10}B and the second $2_2^+, T = 1$ state in ^{10}Be and ^{10}C exhibit a large mirror asymmetry defined as $\delta = B(GT;^{10}\mathrm{B}\rightarrow^{10}\mathrm{C})/B(GT;^{10}\mathrm{B}\rightarrow^{10}\mathrm{Be})-1 = -(28\pm10)\%$. A calculation based on parentage expansions in the shell model and radial functions, whose asymptotic forms are matched to experimental separation energies, only explains about one third to one half of this asymmetry.

Zero-degree $(t,^3He)$ cross-sections have recently been measured [1] on ^{10}B and the Gamow-Teller transition strength $B(GT+)$ determined for three states in the daughter nucleus, ^{10}Be. Earlier, the mirror zero-degree (p,n) cross-sections on the same target nucleus were obtained [2] and the Gamow-Teller transition strength $B(GT-)$ extracted to two of the corresponding states in the daughter nucleus, ^{10}C. In the absence of any isospin-symmetry breaking mechanisms the $B(GT+)$ values should equal the $B(GT-)$ values for corresponding mirror transitions. The results from the two separate experiments just cited show a large mirror asymmetry. It is the purpose of this note to discuss the question: how much of this mirror asymmetry can be attributed to differences in the binding energies of the proton and neutron partaking in the Gamow-Teller transitions. The answer is only a fraction, typical mirror asymmetries calculated [3] are less than 10%.

Because Gamow-Teller transitions are described in terms of one-body operators, the most important feature for the evaluation of their matrix elements is the single-particle parentage expansions for the states involved. For example, for the $B(GT-)$ transition, ^{10}B is expanded in states of ^{9}B+n and ^{10}C in states of ^{9}B+p. An integration over the states of ^{9}B is performed leaving a single-particle matrix element between the proton and neutron to be evaluated. For the mirror $B(GT+)$ transition, ^{10}B is expanded in states of ^{9}Be+p and ^{10}Be in states of ^{9}Be+n. Because the binding energy of a proton in ^{10}C is not the same as that of a neutron in ^{10}Be, the mirror situation, an asymmetry in the calculated Gamow-Teller matrix elements can be expected. The extent of the asymmetry will reflect the degree of the binding-energy mismatch.

Here, however, there is a problem: the second 2_2^+ state in ^{10}C is unbound by 1.3 MeV. Probably the best way to proceed is to use Saxon-Woods functions for the interior part of the wavefunction, and at some selected channel radius, match this function to the appropriate continuum function using R-matrix theory [4]. The parameters of the R-matrix are chosen to fit the known width of the state. We have not done this in this note (but perhaps it should be done in the future). Rather we have computed the radial function for the proton over both internal and external regions as a single Saxon-Woods function whose asymptotic form is matched to a just-bound proton with a binding energy of $S_B^-(p) = 0.001$ MeV. Similarly the mirror neutron bound in ^{10}Be is described by a Saxon-Woods function matched to a neutron binding energy of $S_B^+(n) = 2.154$ MeV, rather than the experimental 0.854 MeV value in order to maintain the relative degree of binding-energy mismatch between $S_B^-(p)$ and $S_B^+(n)$. The calculated mirror asymmetry using these functions and the full parentage expansion given by the Cohen-Kurath wavefunctions, (8-16)POT [5], is -7.4%. This result is much less than the experimental value of $-(28 \pm 10)\%$.

Our result, however, is sensitive to the crude treatment of the unbound proton. If, for example, we use $S_B^-(p) = 0.3$ MeV or 0.6 MeV we obtain asymmetries of -5.9% or -4.8% respectively. If, further, we could trust an extrapolation of the values to the unbound value of $S_B^-(p) = -1.3$ MeV, we would obtain an asymmetry of the order of -16%, about half the experimental central value, but almost within the range of experimental error.

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