Gamow-Teller strengths from ^{11}B to ^{11}C as a test case of *ab initio* shell-model calculations

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It has become possible to understand the structure of light nuclei from a very basic point of view by various schemes of *ab initio* calculations. In particular, *ab initio* no-core shell-model (NCSM) calculations starting from very light nuclei have become possible up to *p*-shell nuclei. Recently, Navrátil and Ormand extended the calculations to include a realistic three-nucleon interaction (TNI) [1]. It was suggested that the TNI can affect various structural properties, such as excitation energies and quadrupole as well as magnetic moments of the ground states (g.s.). It was also shown that the TNI has a relatively large effect on Gamow-Teller (GT) ($\Delta L = 0$, $\Delta J^\pi = 1^+$) transition strengths. In particular, a large effect was predicted for the GT transition strengths in the $A = 11$ mirror nuclei ^{11}B and ^{11}C [1].

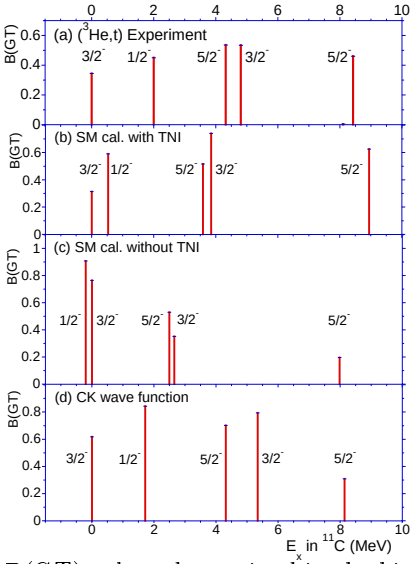

Figure 1: Experimental and shell-model B(GT) distributions. The J^π values of states are indicated. The B(GT) distributions are shown (a) for the present ^{11}B(^{3}He,t)^{11}C experiment, (b) for a NCSM calculation by Navrátil and Ormand including the TNI [1]. In the calculation, the Argonne V8' nucleon-nucleon potential [2] and the Tucson-Melbourne TM'(99) TNI [3] were used. (c) for a NCSM calculation without a TNI [1], and (d) for a shell-model calculation obtained by using the Cohen-Kurath interaction. Although the relative strengths of four states below 6 MeV are well reproduced, the total strength is about 40% larger than the experimental one.

The B(GT) values determined in the high-resolution ^{11}B(^{3}He,t)^{11}C experiment are plotted in Fig. 1(a). The results from the NCSM calculations [1] are shown in Figs. 1(b) and 2(c) for the results with and without the TNI, respectively. It is seen that the inclusion of the TNI significantly improves the agreement with the experimental results. The excitation energies as well as the strengths of five strongly excited states are reasonably reproduced. On the other hand, in the calculation without the TNI, the strengths are more or less shifted to the lower-lying states, and in addition the order of the g.s. and the first excited state is reversed. This suggests that it is essential to include the TNI in NCSM calculations. The total B(GT) value of 2.79 in the NCSM calculation with the TNI was larger than the experimental value of 2.30, but they differ by only 20%.

The effective interaction by Cohen-Kurath (CK) [4] is well accepted for the study of *p*-shell nuclei. The B(GT) distribution studied using the CK interaction is shown in Fig. 1(d). The agreement between the calculated and experimental excitation energies is excellent. However, the total calculated strength is about 40% larger than the experimental one. An improved shell-model interaction for *p*-shell nuclei has been proposed recently [5]. For details see Ref. [6].

References

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