Quadrupole excitation strengths in ^{11}B

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Quadrupole excitations are one of the most fundamental excitation modes in nuclei, and the excitation strengths are closely related to the nuclear deformation. Recently, the differences between the proton and neutron deformations in nuclei are of interest. From a view of naive macroscopic models, it is expected that the proton deformation is similar to the neutron deformation. However, antisymmetrized molecular dynamics calculations suggested large differences between the proton and neutron deformations in light $N \neq Z$ nuclei [1].

Since the electromagnetic probes are sensitive to the proton transition strengths, the proton strengths were extensively examined by the γ-decay measurements. For light self-conjugate ($N = Z$) nuclei, the neutron strengths are also obtained from the γ-decay measurements because the neutron strengths are similar to the proton transition strengths. For the other nuclei, however, the neutron strengths are not extracted from the γ-decay results. One possible method to obtain the neutron transition strengths is to measure the isoscalar quadrupole strengths by means of hadron scattering. Since the isoscalar quadrupole strength is given by a coherent sum of the proton and neutron transition strengths, the neutron strengths can be obtained from the isoscalar and proton strengths if the proton strengths are known from the γ-decay measurements. In the present work, the isoscalar quadrupole strengths in ^{11}B were determined by measuring the inelastic deuteron scattering.

The experiment was performed at the Research Center for Nuclear Physics, Osaka University, using a 200-MeV polarized deuteron beam. The detailed explanations for the experimental procedures have been given in Ref. [2] and references therein. The obtained isoscalar strengths $B(E2;IS)$ and electric quadrupole strengths $B(E2)$ taken from Ref. [3] are compared with the recent shell model calculation by Suzuki, Fujimoto, and Otsuka (SFO) [4] in Fig. 1. The upper panels show the experimental values while the middle panels show the shell model predictions using the bare charges of $e_p = 1$ and $e_n = 0$. The shell model calculation with the bare charges underestimates both the isoscalar and electric quadrupole strengths by a factor of 2. To improve the shell model predictions, the effective charges of $e_p^{eff} = 1.24$ and $e_n^{eff} = 0.23$ are used in the lower panels in Fig. 1. The shell model calculation with the effective charges reasonably well explains the experiment. The ratio of the isoscalar strengths to the electric quadrupole strengths are shown in Fig. 2. The relative strength for the $3/2_2^-$ state is not shown in Fig. 2 since the $B(E2)$ value for this state is still unknown. The ratio is expected to be two if the proton and neutron strengths are same, but the proton and neutron strengths differently change for each transition. The relative strengths are, nevertheless, well reproduced by the shell model calculation.

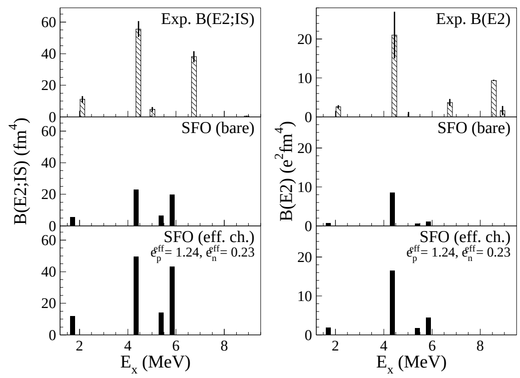

Figure 1: Measured isoscalar and electric quadrupole strengths are compared with the shell model predictions in Ref. [4].

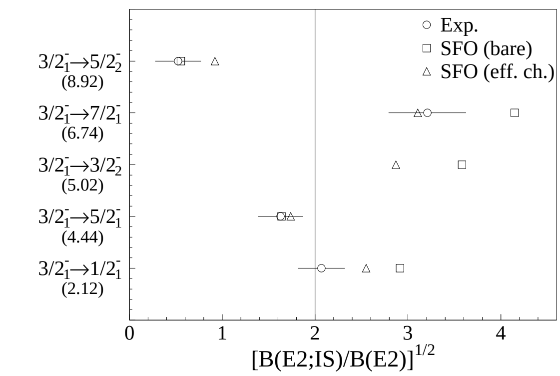

Figure 2: Ratio of the isoscalar quadrupole strengths to the electric quadrupole strengths for the several excitations in ^{11}B.

References

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