Five-body resonances of ^{8}C using the complex scaling method

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Recently, the new experiment on ^{8}C has been reported [1]. The ^{8}C nucleus is known as an unbound system beyond the proton drip-line and decays into many-body channels of ^{7}B+p, ^{6}Be+2p, ^{5}Li+3p and ^{4}He+4p. In this report, we present our recent study on the resonance spectroscopy of ^{8}C. We employ the cluster-orbital shell model of the ^{4}He+p+p+p+p five-body system, and describe the many-body resonances under the correct boundary conditions by using the complex scaling method. We adopt the Hamiltonian, the nuclear part of which reproduces the ^{4}He-n scattering data and the ^{6}He energy[2, 3]. The mirror nucleus of ^{8}C is ^{8}He, which is known as a neutron skin nucleus. It is interesting to examine the mirror symmetry between the proton-rich ^{8}C and the neutron-rich ^{8}He.

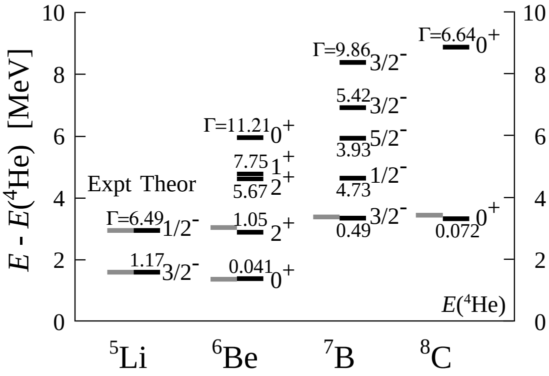

Figure 1: Energy levels of ^{5}Li, ^{6}Be, ^{7}B and ^{8}C measured from the energy of ^{4}He. Small numbers are theoretical decay widths in units of MeV.

We show the level structures of ^{5}Li, ^{6}Be, ^{7}B and ^{8}C in Fig. 1. It is found that the present calculations agree with the observations and predict more energy levels. In Fig. 2, we compare the excitation energy spectra of proton-rich and neutron-rich sides. The good symmetry is confirmed between the corresponding nuclei. The differences of excitation energies for individual levels are less than 1 MeV.

We calculate the pair numbers of four valence protons in ^{8}C, using the operator $\sum_{\alpha\le\beta} A^\dagger_{J^\pi,S}(\alpha\beta)A_{J^\pi,S}(\alpha\beta)$. Here, α and β represent the proton single-particle orbits and $A^\dagger_{J^\pi,S}$ ($A_{J^\pi,S}$) is the creation (annihilation) operator of a proton-pair with spin-parity J^π and the coupled intrinsic spin S. The total pair number is six for each state of ^{8}C. This quantity helps us to understand the pair coupling behavior of four protons. Figure 3 shows the pair numbers for ^{8}C ($0^+_{1,2}$). In the 0^+_1 state, the 2^+ neutron pair is close to five and the 0^+ pair is almost unity. This is obtained from a main configuration of $(p_{3/2})^4$ with the probability of 88% using CFP (1 and 5 for 0^+ and 2^+, respectively). The 0^+_2 state has almost two 0^+ proton pairs in addition to the 2^+ pairs. This is consistent with the $(p_{3/2})^2(p_{1/2})^2$ configuration with a probability of 93%; this configuration is decomposed into the pairs of 0^+, 1^+ and 2^+ with occupations of 2, 1.5, and 2.5, respectively. It is found that in the 0^+_2 state, the spin-singlet and the spin-triplet components are equally mixed in the 0^+ proton pair.

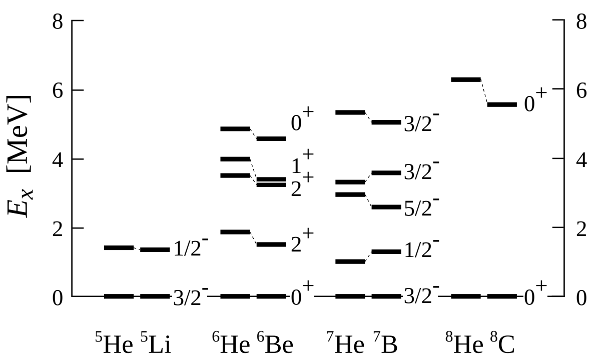

Figure 2: Excitation energy spectra of mirror nuclei.

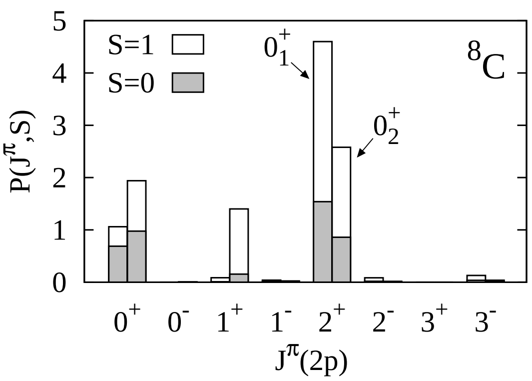

Figure 3: Pair numbers of the $0^+_{1,2}$ states of ^{8}C.

References

[1] R. J. Charity *et al.*, Phys. Rev. C**84**, 014320 (2011).
[2] T. Myo, Y. Kikuchi and K. Katō, Phys. Rev. C**84**, 064306 (2011).
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