$2\alpha + t$ cluster state in ^{11}B

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Alpha particle cluster is an important concept in nuclear physics for light nuclei. On the basis of the Ikeda diagram, the cluster structure is expected to emerge near the α-decay threshold energy. It has been suggested that the 7.65-MeV 0^+_2 state in ^{12}C, which locates at the excitation energy higher than the 3α-decay threshold by 0.39 MeV, has a 3α-cluster configuration.

It has been proposed that the 0^+_2 state is described by introducing a quite new concept of the nuclear structure, *i.e.*, this state has a dilute-gas-like structure where three α particles are weakly interacting and are condensed into the lowest s-orbit [1]. Similar dilute-gas states of α clusters have been predicted in self-conjugate $N = 4n$ nuclei. The next natural question addressed is whether such a dilute state of clusters exists in the other $N \neq 4n$ nuclei like ^{11}B.

Recently, an exotic character of the $3/2^-_3$ state at $E_x = 8.56$ MeV in ^{11}B was found in the measurement of the Gamow-Teller (GT) and spin-flip $M1$ strengths for excited states in ^{11}B and its analog in ^{11}C [2]. The GT and spin-flip $M1$ strengths for the $3/2^-_3$ state are abnormally quenched in comparison with the other states. The $3/2^-_3$ state in ^{11}B locates at the excitation energy lower than the α-decay threshold by 100 keV and is not well described by the shell-model calculations. Hence, it is very interesting to study the nuclear structure of this $3/2^-_3$ state in view of cluster physics.

In the present work, the isoscalar monopole and quadrupole excitation strengths in ^{11}B have been obtained by measuring the ^{11}B(d, d') reaction at $E_d = 200$ MeV at the Research Center for Nuclear Physics, Osaka University. The excitation strengths have been compared with the theoretical values by the antisymmetrized molecular-dynamics (AMD) calculation.

It is found that the AMD calculation excellently reproduces the measured excitation strengths in ^{11}B. Although the electric quadrupole strength for the $3/2^-_3$ state predicted by AMD is much smaller than the known value [3] reported in the previous (e, e') experiments, we examined the original papers [4, 5] and found that this value is quite unreliable due to the wrong assumption in the previous analyses. We have analyzed the existing (e, e') data again and found that those data are quite consistent with the present experimental and theoretical results.

The $3/2^-_3$ state is found to be strongly excited by the monopole transition and is considered to have a $2\alpha + t$ cluster wave function in the same manner as that the 0^+_2 state in ^{12}C has a 3α cluster structure. From the analysis of the monopole excitation strengths with the AMD calculations, the $3/2^-_3$ state is suggested to have a loosely bound $2\alpha + t$ cluster structure with a dilute density, for the first time.

References

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