

Microscopic coupled-channel study of molecular resonances in ^{12}Be

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Recently, the breakup experiment of ^{12}Be into $^6\text{He}+^6\text{He}$ has been performed using a 378 MeV ^{12}Be beam [1]. The results indicate the existence of the exotic $^6\text{He}+^6\text{He}$ molecular states in the 10 to 25 MeV excitation energy interval, with spins in the range of $4\hbar$ to $8\hbar$.

In order to investigate the nuclear structure of these exotic molecular states in ^{12}Be , we perform a microscopic coupled-channel (CC) calculation of $^6\text{He}+^6\text{He}$ elastic and inelastic scattering. We use the double-folding interactions based on the realistic nucleon-nucleon interaction, DDM3Y. In the present CC calculation, we take into account the excitation to the 2_1^+ state ($E_x=1.8$ MeV) and the 2_2^+ state ($E_x \sim 5$ MeV) of which existence is strongly suggested theoretically. The transition density to the 2_1^+ state is calculated by the microscopic $^4\text{He}+n+n$ cluster-model wave function [2], while that to the 2_2^+ one is done by the collective model assuming the quadrupole deformation [3]. The strength of the latter density is determined so as to reproduce the energy-non-weighted sum rule value of the soft-quadrupole mode from which the theoretical $B(E2:0^+ \rightarrow 2_1^+)$ value is subtracted [4].

We include the elastic (0^++0^+) channel and the $0^++2_1^+$, $2_1^++2_1^+$, $0^++2_2^+$ inelastic-channels in the CC calculation. In Fig.1, we show the $^6\text{He}+^6\text{He}$ molecular bands obtained by solving the CC equations. The double circles and squares show the bands in which the dominant component is the elastic and $[0^+ \otimes 2_1^+]_{I=2, L=J-2}$ channels, respectively, while the bands shown by the inverse triangles, circles, diamonds and double squares have the dominant component of the $[0^+ \otimes 2_2^+]_{I=2, L=J-2}$, $[2_1^+ \otimes 2_1^+]_{I=4, L=J-2}$, $[2_1^+ \otimes 2_1^+]_{I=4, L=J-4}$ and $[2_1^+ \otimes 2_1^+]_{I=2, L=J-2}$, channels, respectively. The resonances observed in the breakup-reaction experiment are also plotted in the figure by the solid squares. It is seen that the observed resonances coincide in energy and spin with the calculated resonances belonging to the molecular bands in which the inelastic-channel components are dominant. The channel coupling effects are not so strong for the inelastic channels and the populations of the dominant channel component are less than about 60~80 %. Therefore, the calculated molecular bands of the inelastic channels can be interpreted in terms of the so-called “weak coupling states” in which two interacting ^6He nuclei keep touching their surfaces and rotate to each other by almost keeping their identities.

References

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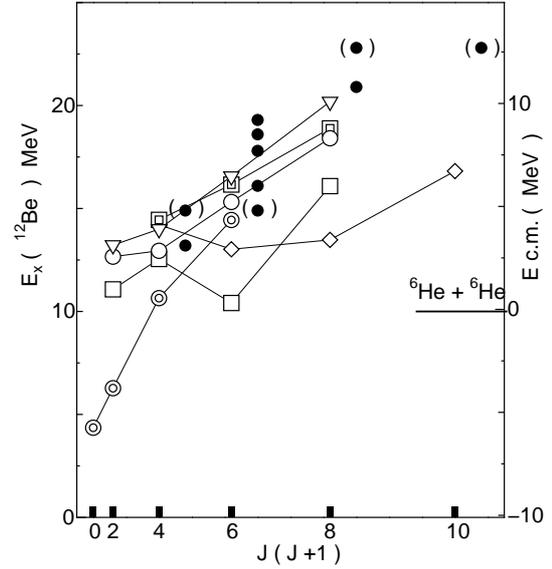


Fig. 1. Molecular bands of the $^6\text{He}+^6\text{He}$ system obtained by CC calculation. The solid squares in parentheses represent the spin unknown states observed in breakup experiment [1]. See text for details about each molecular band.