Sign of enhanced 3α matter radius in α + ^{12}C inelastic scattering

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In light nuclear systems, it is well known that cluster structures appear in excited states. One of characteristic properties in cluster structures is a prominent extension of nuclear radius. Typical examples are the Hoyle 0_2^+ state and its rotational excited state, 2_2^+, in ^{12}C, which have the developed 3α cluster structure. The matter radii of these 3α states are expected to be enhanced by about sixty percent in comparison to the radius of the ground state. However, the enhanced radius of the 3α state is not confirmed experimentally.

Recently we have proposed a spatial measure, "scattering radius", which characterizes a size of an exclusive reaction on the basis of the general coupled-channel formalism. In the present study, we apply the method of the scattering radius to the α + ^{12}C scattering, and the spatial size for the inelastic scattering to the 0_2^+ and 2_2^+ states, is evaluated.

First, we perform the microscopic coupled-channel calculation (MCC) for the α + ^{12}C inelastic scattering. In the MCC calculation, the α – ^{12}C nuclear interactions are derived by the folding procedure. We employ the microscopic ^{12}C transition density and the DDM3Y effective nucleon-nucleon interaction. As for the internal excitations of ^{12}C, the collective (2_1^+ and 3_1^-) and cluster states (0_2^+, 0_3^+ and 2_2^+) are included. The differential cross sections for the elastic and inelastic scattering are calculated in the energy range from E/A = 26 MeV to 96.5 MeV. Secondly, from the partial cross sections calculated in MCC, we define the effective orbital spin $\bar{L}$, which mainly contributes to the scattering to the individual channels. The scattering radii (R_{SC}) are derived from the simple relation of $\bar{L} = kR_{SC}$ with the incident momentum k.

The MCC calculations for the α scatterings nicely reproduce the differential cross sections of the various exit channels. From the evaluations of the scattering radii, we have found about 1 fm enhancement of R_{SC} in the 2_2^+ channel in comparison to that of the collective 2_1^+ channel. This 1 fm enhancement is considered to be a sign of the extended radius of 2_2^+ state, which has a well developed 3α cluster states. In the present report, we discuss the enhancement mechanism of the scattering radius in the 3α final channel, and their systematic analyses will be presented.