Alpha particle condensation in ^{12}C and nuclear rainbow scattering

S. Ohkubo[1], Y. Hirabayashi[2]
[1] Department of Applied Science and Environment, Kochi Women's University, Kochi 780-8515, Japan
[2] Information Initiative Center, Hokkaido University, Sapporo 060-0811, Japan

Much attention has been paid to alpha particle condensation in nuclei. The Hoyle state of ^{12}C, 0_2^+(7.65 MeV), has been suggested to be such a candidate state. For an alpha particle condensate, a physical quantity peculiar to condensation would appear. Because of the dilute property, the radius of a condensate is very large compared with a normal state. It is difficult to measure the radius of the excited Hoyle state and no experiment has been reported. Therefore it is very important to know whether the radius of the Hoyle state is very large.

We show that nuclear rainbow scattering [1] is very useful in confirming the large radius of the Hoyle state. The large radius means that the potential for the Hoyle state is extended compared with the normal ground state. The nucleus acts as a lens. The huge radius of the Hoyle state means that the refraction of an incident particle is much stronger than that for the normal ground state. On the other hand, it has been shown that inelastic prerainbow Airy structure can also be understood in a way similar to elastic scattering [2]. This suggests that inelastic prerainbow oscillation may also be useful for the study of the nuclear properties of the excited states of the target nucleus because the internal region of the interaction potential can be well determined even for inelastic channels.

We show that in alpha particle rainbow scattering from ^{12}C the Airy minimum (therefore the rainbow angle) for the Hoyle state is shifted considerably to a larger angle compared with that for the ground state in agreement with the dilute density distribution due to the alpha particle condensation [3]. This can be also confirmed in the experimental data in ^{3}He scattering from ^{12}C as a clear shift of the Airy minimum in the prerainbow oscillations at 34.7 MeV [4]. The present approach can be applied to other alpha condensates in $4N$ nuclei such as four alpha states in ^{16}O. Detailed discussion on the importance of rainbow and prerainbow scattering for the study of alpha particle condensation will be presented.

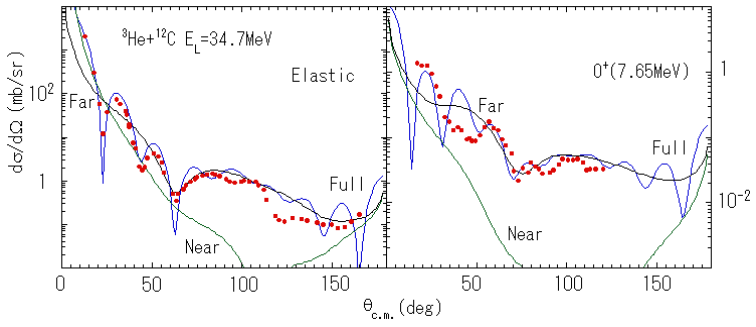

Figure 1: Calculated angular distributions for the ground and 0_2^+ (7.65 MeV) states of ^{12}C in ^{3}He+^{12}C scattering at 34.7 MeV are decomposed into farside (dashed lines) and nearside (dotted lines) contributions and compared with the experimental data (points).

1. D. T. Khoa, W. von Oertzen, H. G. Bohlen, and S. Ohkubo, J. Phys. **G 34**, R111 (2007).
2. F. Michel and S. Ohkubo, Phys. Rev. C **70**, 044609 (2004).
3. S. Ohkubo and Y. Hirabayashi, Phys. Rev. C **70**, 041602(R) (2004).
4. S. Ohkubo and Y. Hirabayashi, Phys. Rev. C **75**, 044609 (2007).