Fusion Reaction of Halo Nuclei: A Time-dependent Approach

K. Yabana, M. Ueda†, T. Nakatsukasa††

Institute of Physics, University of Tsukuba, Tsukuba 305-8571, Japan
†Akita National College of Technology, Akita, 018-8511, Japan
††Department of Physics, Tohoku University, Sendai 980-8578, Japan

Nuclei around the drip line are characterized by their small separation energy for fragmentation. The reaction theories for the drip line nuclei are requred to describe coupling to the continuum states. At medium and high incident energies, the Glauber theory and the eikonal approximation provide a simple and reliable scheme to describe the reactions. At low incident energies, however, even the basic picture of the reaction has not yet been established. For example, there are conflicting theoretical results about the role of the halo neutron on the fusion probability, whether it enhances or hinders.

To elucidate reaction dynamics at low incident energy, we have developed a time-dependent wave-packet approach where the reaction is described as a three-body problem consisting of the halo nucleon, core nucleus, and the target nucleus. Calculating the time evolution of the wave-packet solution, the three-body scattering observables can be calculated without any assumptions or approximations. The time-dependent wave-packet approach is also advantageous to obtain intuitive understanding of the reaction dynamics. We create an animation of the wave packet dynamics which clearly show the formation of the molecular-like state during the reaction as well as the significance of the breakup processes.

We have analyzed fusion reactions of single-nucleon halo nuclei. The significance of the breakup processes is clearly seen when the halo nucleon is bound very weakly. The effect of the halo nucleon on the fusion probability is found to be sensitive to the effective charge of the nucleon. Our three-body calculation indicates enhancement of the fusion probability for proton halo case, while hindrance for neutron halo case. A spectator picture of the halo nucleon during the collision could explain these observations. Some preliminary results of the reactions of neutron halo nuclei are published recently [1].

[1] K. Yabana, M. Ueda, T. Nakatsukasa, Nucl. Phys. **A722**, 261c (2003).