Exotic properties of light nuclei and their neutron capture cross sections

A. MENGONI[1,2], T. OTSUKA[1,3] and M. ISHIHARA[1,3]
[1]*RIKEN, Radiation Laboratory, 2-1 Hirosawa, Wako, Saitama 351-02, Japan*
[2]*ENEA, Applied Physics Section, v. Don Fiammelli 2, 40128 Bologna, Italy*
[3]*The University of Tokyo, Department of Physics, Hongo, Bunkyo-ku, Tokyo 113, Japan*

Light neutron-rich nuclei may exhibit "exotic" nuclear structure properties, such as an extended neutron cloud (halo) or a relatively thick neutron layer (skin), outside the nuclear surface. These properties have been recently investigated by means of radioactive ion beam experiments which sensibly contributed to enlarge the nuclear structure picture of light nuclei toward the neutron drip-line.

We have recently investigated some implication of these results in one of the basic reaction processes: the (n,γ) reaction. In particular, we have studied the influence of the neutron halo structure on the direct radiative capture (DRC) process [1,2]. This reaction mechanism may be responsible for the most part of the capture reaction rate in the particular condition in which the density of states is low enough to hinder the compound nucleus formation mechanism [3]. Furthermore, because the halo structure arises mainly from loosely bound s orbits, electric dipole γ-ray emissions can only be induced by incident p-wave neutrons. In fact, the p-wave DRC process in the neutron energy region of interest for nuclear astrophysics, is essentially determined by the E1 transition matrix elements $Q^{(1)}_{i\to f} = <\Psi_f|\hat{T}^{E1}|\Psi_i>$. These matrix elements are, in turn, very much sensitive to the tail component (halo) of the final capturing state wave function Ψ_f and very little sensitive to the treatment of the incident neutron scattering channel state Ψ_i [2]. The energy dependence as well as the strength of E1 emission due to incident p-wave neutrons is therefore strongly influenced by the neutron halo structure of the residual nucleus capturing state. Whether this state is the ground or an excited nuclear state makes no difference in this scheme.

We have calculated several neutron capture cross sections of light nuclei using the DRC model. The calculations for $^{12}C(n,\gamma)$ and $^{16}O(n,\gamma)$ reactions have been compared with recent experimental results from direct measurements. At the same time, we have compared the $^{10}Be(n,\gamma)^{11}Be$ DRC cross section with that derived from the experiment in the inverse kinematics (Coulomb dissociation of ^{11}Be). These calculations enabled us to assess quantitatively the DRC model in terms of reliability and sensitivity to the (few) parameters involved. The DRC model has been then employed to predict capture cross sections relevant to important astrophysical processes.

[1] T. Otsuka, M. Ishihara, N. Fukunishi, T. Nakamura, and M. Yokoyama, Phys. Rev. C **49**, R2289 (1994).
[2] A. Mengoni, T. Otsuka, and M. Ishihara, Phys. Rev. C **52** (1995), R2334.
[3] G. J. Mathews, A. Mengoni, F.-K. Thielemann and W. A. Fowler, ApJ **270** (1983) 740.