Direct and Semidirect Radiative Capture of Nucleons with Hartree-Fock BCS Theory

T. Watanabe[1], L. Bonneau and T. Kawano
Nuclear Physics, Los Alamos National Laboratory
Los Alamos, NM 87545, USA

Nucleon radiative capture is one of the most important process for nucleo-synthesis calculations in astrophysics. The nucleon capture takes place in two different mechanisms, which are the compound reaction and the direct/semidirect (DSD) process. In the compound reaction, an incoming particle once forms a compound state and it decays by emitting γ-rays. The compound capture cross sections become very small when many neutron channels open because of $\Gamma_n \gg \Gamma_\gamma$. For the incident nucleon energies above 5 MeV or so, the capture process can be described by the DSD theory only. In the DSD process, an incident particle is captured directly by the unoccupied bound state (direct), or once it excites a collective state and scattered into the bound state (semidirect). In this picture, the calculation is very sensitive to the radial wave functions of the bound state, which are often calculated with a single-particle model in the Woods-Saxon potential. For the astrophysical calculations, since experimental information of nuclear structure is uncertain or inaccessible, we apply a Hartree-Fock (HF) BCS model to generate the radial wave functions. The single particle spectra and those wave functions are calculated with the HF-BCS theory using Skyrme force, whose parameters are adjusted to nuclear masses, charge radii and single particle spectra. The DSD cross sections are given by calculating a transition amplitude to the HF-BCS states. We present some calculations with this model for the neutron capture by ^{208}Pb and ^{238}U, and compare with experimental data.

[1]Permanent address: Department of Applied Quantum Physics and Nuclear Engineering, Kyushu University, 6-10-1 Hakozaki, Fukuoka 812-8581, Japan