

Collective effects and resonances in (n,γ) reactions on neutron-rich nuclei: a continuum RPA approach

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The radiative neutron capture is one of the elementary processes which play key roles in the r-process nucleosynthesis. The nuclei on the r-process path have a small neutron separation energy of typically ~ 2 MeV, and hence the statistical neutron-capture model often adopted to describe the s-process may not be appropriate. In the present work, we formulate a novel theory [1,2] which describes the (n,γ) reaction in a single microscopic many-body framework with no statistical assumptions using the continuum random-phase approximation (cRPA) based on the nuclear density functional theory.

With the cRPA approach, it is possible to describe various excitation modes present in the (n,γ) reaction, including soft dipole excitation, the giant resonances as well as non-collective excitations and the single-particle resonances. Furthermore, it enables us to describe the (n,γ) reaction where the final states of the gamma transition are low-lying surface vibrational states. We demonstrate the theory by performing numerical calculation for the reaction $^{139}\text{Sn}(n,\gamma)^{140}\text{Sn}$. We discuss various new features which are beyond the existing models; presence of narrow and wide resonances originating from non-collective and collective excitations and roles of low-lying quadrupole and octupole vibrational states.

[1] T. Saito and M. Matsuo, Phys. Rev. C 104, 034305 (2021).

[2] T. Saito and M. Matsuo, arXiv.2208.09455

Experimental study on nuclear physics

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