The isovector imaginary neutron potential: a key ingredient for the r-process nucleosynthesis

S. Goriely[1], J.-P. Delaroche[2]
[1] Institut d'Astronomie et d'Astrophysics, Université Libre de Bruxelles, Campus de la Plaine, CP-226, 1050 Brussels, Belgium
[2]DPTA/Service de Physique Nucléaire, CEA/DAM Ile de France, BP 12, 91680 Bruyères-le-Châtel, France

The radiative neutron captures by exotic nuclei are known to be of fundamental importance in the rapid neutron-capture process (or r-process) invoked to explain the origin of approximately one half of the nuclides heavier than iron observed in nature. To estimate the neutron capture cross section, different nuclear ingredients need to be determined, including the optical model potential. Due to the specific requirements in r-process nucleosynthesis, the phenomenological potentials of Woods-Saxon type have long been replaced by the nucleon-nucleus optical potential [1] derived from a Reid's hard core nucleon–nucleon interaction by applying the Brückner–Hartree–Fock approximation to nuclear matter. This so-called JLM potential has recently been updated by [2] who empirically renormalized the energy dependence of the potential depth to reproduce scattering and reaction observables for spherical and quasi-spherical nuclei between ^{40}Ca and ^{209}Bi in a large energy range from the keV region up to 200 MeV. However, due to the lack of scattering data in the keV region, the low-energy extrapolation of the renormalization factor of the isovector component of the imaginary potential remains essentially unconstrained.

In this contribution, we show that the isovector contribution to the imaginary component of the microscopic JLM potential can be adjusted on experimental neutron strength function data. It is shown that the S- and P-wave neutron strength functions (S_0 and S_1) experimentally determined at energies ranging between 1 and 100 keV provide an extremely valuable set of constraints on the imaginary potential. In addition, it is found that such experimental data favours a strong isovector component that can have a drastic impact on the radiative neutron capture cross section for neutron-rich nuclei calculated in the framework of the Hauser-Feshbach statistical model. More specifically, at large neutron excesses, the enhanced renomalization factor needed to reproduce experimental neutron strength functions leads to a strong reduction of the imaginary component, i.e. the neutron absorption channel, and consequently significantly reduces the radiative neutron capture cross section.

If confirmed, this result strongly inhibits the resonant capture by exotic nuclei, so that the traditional r-process picture of the fast neutron captures during the nucleosynthesis r-process needs to be revisited in depth. The implication on the r-process nucleosynthesis will be discussed.

[1] J.P. Jeukenne, A. Lejeune, C. Mahaux, Phys. Rev. **C16**, 80 (1977)
[2] E. Bauge, J.P. Delaroche, M. Girod, Phys. Rev. **C63**, 024607 (2001)