Skyrme-TQRPA Calculations of Electron Capture on Neutron-Rich Nuclei in Pre-Supernova Environment

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The rates of electronic capture (EC) on nuclei largely determine the dynamics of various astrophysical phenomena, in particular, a collapse of the iron core at the late-stage evolution of massive star leading to a supernova outburst. To simulate this astrophysical phenomenon one needs a large-scale set of data on the probabilities of EC on nuclei [1]. The stellar EC's proceed in the environment characterized by extremely high temperature and matter density. In [2], the thermodynamically consistent method has been elaborated to calculate the EC rates on hot nuclei. Essentially, the method is the quasiparticle RPA extended to finite temperatures (TQRPA) in the framework of the thermo field dynamics [3]. The method allows to calculate temperature-dependent strength functions of the process taking into account both the types of nuclear transitions: when a hot nucleus gets energy as well as when hot nucleus loses it. In [4], the TQRPA has been combined with self-consistent microscopic Hamiltonian based on the Skyrme energy density functional. Here, we compute the EC rates on even-even neutron-rich nuclides ^{78}Ni and $^{76-80}$Ge which encounter at the late stage of the collapse. The contributions of allowed 0^+, 1^+ and first-forbidden $0^-, 1^-, 2^-$ transitions are considered. In agreement with our earlier study [2] we observe that unblocking effect for the Gamow-Teller transitions is quite sensitive to increasing temperature. For ^{78}Ni the EC cross sections were computed within the Donnelly-Walecka multipole expansion method [5]. It is found that not only thermally unblocked allowed 1^+ transitions but also thermally unblocked first-forbidden 1^- and 2^- transitions favour to EC.

References

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