Stellar electron-capture rates on nuclei based on a microscopic Skyrme functional

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Abstract

Weak interaction processes play a pivotal role in the life of a star, especially during the late stages of the evolution of massive stars. In particular, during the supernova core-collapse, electron capture on free protons and on exotic nuclei controls the neutronization phase, until the formation of an almost deleptonized central compact object, the neutron star.
In this work, electron-capture rates on nuclei for stellar conditions are calculated for ^{54,56}Fe and Ge isotopes, using a self-consistent microscopic approach. The single-nucleon basis and the occupation factors in the target nucleus are calculated in the finite-temperature Skyrme Hartree-Fock model, and the charge-exchange transitions are determined in the finite-temperature random-phase approximation (RPA). The scheme is self-consistent, i.e. both the Hartree-Fock and the RPA equations are based on the same Skyrme functional. Several Skyrme interactions are used in order to provide a theoretical uncertainty on the electron-capture rates for different astrophysical conditions.
The results of the calculations show that, comparing electron-capture rates obtained either with different Skyrme sets or with different available models, differences up to one-two orders of magnitude can arise.

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