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Study of equation of state for eletron capture in core-collapse supernovae

In the last decades the numerical simulations of core-collapse supernovae have greatly improved, treating now general relativity and multi-dimensional hydrodynamic phenomena such as convection, rotation, instabilities, neutrino transport and shock wave propagation. Although the remarkable advances, the best 3D models still fail to reproduce the characteristics of observed core-collapse supernovae. Furthermore, the nuclear inputs such as the equation of state (EoS) and electro-weak processes play a fundamental role in these simulations. In particular, the electron-capture process governs the neutronization of matter and determines the position of the formation of the shock wave, which ultimately leads to the supernova explosion. In the early stage of the core-collapse the electron-capture rate on nuclei dominates. The proper way to obtain the total electron-capture rate is to fold the individual rates with the nuclear distribution. This is however not trivial, because most of the core-collapse codes use EoSs based on single nucleus approximation. This motivated us to implement a perturbative treatment of the extended Nuclear Statistical Equilibrium (NSE) model into the widely used Lattimer and Swesty (LS) EoS. The NSE calculations depend on the masses of different nuclei, determined either experimentally or using a mass model; it is thus essential to know as precisely as possible the nuclear masses. The nuclei that play the most important role during the core collapse because of their electron-capture rates are located around 78Ni and 128Pd. An experiment, which aims to measure the masses of the nuclei of interest located around 78Ni with the JYFLTRAP Penning trap mass spectrometer at IGISOL, has been recently accepted. The precise experimental values of the masses thus obtained will be used then in the model. It constitutes the second and complementary part of my thesis.
During the school, I will present nuclear distributions obtained with this modified LS EoS for some points of the collapse trajectory, using on the one hand the original finite temperature liquid-drop model and on the other hand a more sophisticated mass functional. I will also present the online results of the first experimental run performed in June 2017.

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