Contribution ID: **8** Type: **not specified**

Modification of magicity toward the dripline and its impact on electron-capture rates for stellar core collapse

Monday 25 April 2016 15:00 (20 minutes)

The importance of microphysical inputs from laboratory nuclear experiments and theoretical nuclear structure calculations in the understanding of core collapse dynamics and the subsequent supernova explosion, is largely recognized in the recent literature. In this work, we analyze the impact of the masses of very neutron rich nuclei on the matter composition during collapse, and the corresponding electron capture rate. To this end, we introduce an empirical modification of the popular Duflo-Zuker mass model to account for possible shell quenching far from stability. We study the effect of this quenching on the average electron capture rate. We show that the preeminence of the closed shells with $N = 50$ and $N = 82$ in the collapse dynamics is considerably decreased if the shell gaps are reduced in the region of ^{78}Ni and beyond. As a consequence, local modifications of the overall electron capture rate of up to 30\% can be expected, depending on the strength of magicity quenching. This finding has potentially important consequences on the entropy generation, the neutrino emissivity, and the mass of the core at bounce. Our work underlines the importance of new experimental measurements in this region of the nuclear chart, the most crucial information being the nuclear mass and the Gamow-Teller strength. Reliable microscopic calculations of the associated elementary rate, in a wide range of temperatures and electron densities, optimized on these new empirical information, will be additionally needed to get quantitative predictions of the collapse dynamics.

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Session Classification: Afternoon session