Contribution ID: **19** Type: **Poster**

Impacts of multineutrons on nuclear compositions and neutrino reaction rates in core-collapse supernova

Tuesday, January 28, 2025 4:40 PM (1h 20m)

The neutrino reactions play a pivotal role in determining the dynamics of core-collapse supernovae such as the contraction of the proto-neutron star and the shock wave revival. However, most simulations have not considered the detailed neutrino reactions with light elements, which are found to be abundant in supernovae at subsaturation density [1]. Previous studies have shown the weak interactions may affect the shock wave revival [2, 3, 4]. Meanwhile, some experiments and theoretical calculations suggest the quasibound systems consisting of only multiple neutrons, or multineutrons [5]. They might appear in the central region, since the matter is neutron-rich and at high-temperature [6].
To investigate their impacts, we calculated the nuclear compositions and charge-current neutrino reaction rates in the central region of the core-collapse supernova, assuming the existence of the dineutron and tetra-neutron. Our results show that their presence suppresses the neutrino reactions that convert neutrons into protons, while enhancing reactions that convert protons into neutrons. The fast neutronization and contraction of the proto-neutron star may occur, leading to increased neutrino emissions and contributing to the supernova explosion or the early birth of neutron stars.

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Session Classification: Poster Presentation