Impact of Neutrino Collective Oscillation on Supernova Nucleosynthesis and Mass Hierarchy

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Binary neutron-star mergers (NSMs) and core-collapse supernovae (CCSNe, both neutrino-driven winds; ν-wind SNe and magneto-hydrodynamic jets; MHD Jet-SNe) are viable candidate astrophysical sites for the heavy r-process elements. In particular, the observed optical and near-infrared emissions from GW170817 are consistent with those from radiative decays of r-process nuclei which are predicted theoretically. However, specific rprocess elements have not yet been identified directly in either NSMs or CC-SNe, and it is still under the theoretical debate if the universality for heavy nuclides above the 2nd peak to actinides is explained by only the NSM r-process, SN r-process, or both [1, 2].

In this paper, we would like to propose an alternative approach to the universality especially on the 1st peak. The elements whose masses are in the range of A = 80-100 near the 1st r-process peak have several possible nucleosynthetic processes such as r-, s-, rp-, γ-, νp-processes, etc. Although the ν-wind SNe are presumed to be the leading candidate astrophysical site for the 1st r-process peak elements like As-Se-Br, an required neutron-rich condition ($Y_e < 0.5$) has been put into question by failures of robust models for SNe if one assumes only the neutrino heating source to trigger a successful explosion. However, we find that the νp-process operates strongly with amounts of free neutrons being supplied continuously in the proton-rich ($Y_e > 0.5$) materials via p(νe, e-)n reactions when one takes account of the effects of collective neutrino oscillations in coherent self-interacting neutrino scatterings (collective νp-process) [3]. We then find that the nuclear reaction flows can reach the production of abundant p-nuclei like ^{92}Mo, ^{96}Ru, etc. for the mass region of $A < 100$, which are in reasonable agreement with the observed abundance ratios of the solar-system pnuclei. This nucleosynthetic method turns out to be a unique probe indicating the still unknown neutrino-mass hierarchy [3]. We currently study extensively if our proposed collective νp-process and the r-process in CCSNe and NSMs can explain the universality.

References

[1] S. Shibagaki, T. Kajino, G. J. Mathews et al., ApJ **816** (2016), 79

[2] T. Kajino $\&$ G. J. Mathews, Rep. Prog. Phys. **80** (2017), 084901

[3] H. Sasaki, T. Kajino, T. Takiwaki et al., Phys. Rev. D **96** (2017), 043013