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Impact of Neutron Star Merger and Supernova Nucleosynthesis on the Element Genesis and Neutrino Physics

GW170817/SSS17a was an event of the century that opened a new window to multi-messenger astronomy and nuclear astrophysics. Optical and near-infrared emissions among many other observables suggest that their total energy release is consistent with radiative decays of r-process nuclei predicted theoretically although no specific r-process element was identified. Core-collapse supernovae (both MHD Jet-SNe and ν-SNe) are viable candidates for the r-process. MHD Jet-SNe explain the "universality" in the observed elemental r-process abundance pattern in metal poor stars. Neutron star merger (NSM), on the other hand, could not contribute to the early Galaxy for cosmologically long merging time-scale for slow GW radiation. Nevertheless, NSM is still a possible explanation for the solar-system r-process abundance. We propose a novel solution to this twisted problem by carrying out NSM and SN r-process nucleosynthesis calculations with Galactic chemo-dynamical evolution [1-3].
We also discuss the impact of SN nucleosynthesis on the physics of neutrino oscillations. The elements at A = 80-100 originate from many processes such as r-, s-, rp-, γ-, ν-, νp-processes [4,5]. We find that νp-process operates strongly with amounts of free neutrons being supplied even on proton-rich (Ye > 0.5) condition via p(ν, e+)n reactions when one takes account of the effects of collective neutrino oscillations [6]. Reaction flows can reach the production of abundant p-nuclei 94Mo, 96Ru, etc. This nucleosynthetic method turns out to be a unique probe indicating still unknown neutrino-mass hierarchy.

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