Cosmic evolution of r-process abundance pattern: Contribution from supernovae and neutron star mergers

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There are three possible astrophysical sites for the r-process nucleosynthesis; NDW-SN (neutrino driven winds from core-collapse supernovae (CCSNe)), MHDJ-SN (magnetohydrodynamically driven jets from CCSNe) and NSM (neutron star mergers). The GW170817/SSS17a, i.e. the neutron star merger, was an event of the century that opened a new window to multi-messenger astronomy and astrophysics. Optical and near-infrared emissions suggest that their total energy release is consistent with radiative decays of theoretical prediction of r-process nuclei although no specific r-process element was identified. However, NSM could not contribute to the very early Galaxy for long merging time-scale, as compared with main-sequence lifetime of their progenitors, due to too slow GW radiation. Nevertheless, NSM is still a one part of possible explanation for the present solar-system r-process abundance. On the other hand, CCSNe (both MHDJ- and NDW-SNe) are viable candidates for the r-process from the early phase of Galactic evolution. In particular, the MHDJ-SNe explain the universality in the observed elemental r-process abundance pattern in metal poor stars.

Ample studies[1] for Galactic chemical evolution have demonstrated that had shown evolution of light elements or had traced specific r-process elements. We here propose a theoretical model of isotopic evolution that the whole r-process isotopic abundance pattern can change as a function of cosmic time or metallicity for different time-varying contribution from supernova and neutron star merger r-process.

[1] F. X. Timmes, S. E. Woosley & Thomas A. Weaver, 1995, ApJ, 98,617