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Solving the mystery of r-process and νp-process

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The origin of both neutron-rich and proton-rich heavy elements has not yet been clearly understood although sixty years have already passed since B2FH (1957). Core-collapse supernova (SN) or binary neutron-star merger (NSM) is undoubtedly a viable candidate site for these heavy elements. We will first discuss the effects of neutrino interactions and oscillations on the r-process and νp-process nucleosyntheses which depend strongly on n/p ratio in the outflows from CCSN and NSM. We also discuss the critical roles of (n,p) and (n,γ) reactions on the proton-rich nuclei in the νp-process nucleosynthesis, and those of (n,γ) reactions, beta decays, and fission recycling on the neutron-rich nuclei in the r-process nucleosynthesis, respectively.
As for the origin of r-process (in neutron-rich outflows), magneto-rotationally driven jet (MHD-Jet) CCSN naturally explains the "universality"in the observed abundance pattern between the solar-system and extremely metal-poor halo stars in the Milky Way and Ultra-Faint Dwarf Galaxies. NSM has a serious difficulty that their arrival delays due to very slow GW radiation by at least 100 My, which therefore could not contribute to the early galaxies. We propose a model such that the MHD-Jet CCSN contributed first to enrich heavy elements in the early galaxies, then the NSM follows gradually towards the solar system [1-3].
In the proton-rich sides of heavy elements, the origin of ^{92,94}Mo, %^{96,98}$Ru and several others is a long standing mystery. Although X-ray bursts are the potential candidates for these p-elements, their frequency and ejection mechanism into space are unknown. We will propose an alternative site of the outflow from CCSN that could turn into proton-rich condition due to the quantum effects of neutrino collective oscillations and serve as vital astrophysical site for the production of these p-elements [4].
As such, both neutron-rich and proton-rich outflows from CCSN could be extremely significant source of heavy elements, where the neutrino effects and the (n,γ), (n,p), beta decay and fission reactions control the nucleosynthetic conditions.

References:

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