

Solving the mystery of r-process and ν p-process

Wednesday, 28 June 2017 10:40 (25 minutes)

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 ν p-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 ν p-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 $^{92,94}\text{Mo}$, $^{96,98}\text{Ru}$ 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:

- [1] Y. Hirai, Y. Ishimaru, T.R. Saitoh, M.S. Fujii, J. Hidaka & T. Kajino, *ApJ* 814 (2015), 4; Y. Hirai, Y. Ishimaru, T.R. Saitoh, M.S. Fujii, J. Hidaka & T. Kajino, *MNRAS* 466 (2017) 2472.
- [2] S. Shibagaki, T. Kajino, G.J. Mathews, S. Chiba, S. Nishimura & G. Lorusso, *ApJ* 816 (2016) 79; S. Shibagaki, T. Takiwaki & T. Kajino (2017), in preparation.
- [3] T. Kajino & G. J. Mathews, *ROPP*. (2017), in press.
- [4] H. Sasaki, T. Kajino, T. Takiwaki, T. Hayakawa, A.B. Balantekin & Y. Pehlivan, *PRD* (2017), submitted.

Presenter: KAJINO, Toshitaka (NAOJ, U. of Tokyo)

Session Classification: Session 6 (Chair: M.-K. Cheoun)