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Solving the mystery of r-process: mergers vs. supernovae

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The origin of heavy elements heavier than iron like Au and U are still unknown although sixty years have already passed since the benchmark paper B2FH on the origin of elements in the Universe was published in 1957. GW emitters of both binary neutron-star mergers (NSMs) and core-collapse supernovae (SNe) are viable candidates for the production site of heavy elements called r-process elements. SN models of magneto-rotationally driven jets (MHD-Jet SNe) naturally explain the ”universality”in the observed abundance pattern between the solar- system and extremely metal-poor stars in the Milky Way halo or recently discovered ultra-faint dwarf galaxies. However, full understanding of their explosion mechanism is still in progress. NSM models, on the other hand, have a serious difficulty that their arrival is delayed due to very slow GW radiation at least 100 My (”time-scale problem”), which could not contribute to the early galaxies. We will first discuss that our high-resolution N-body/SPH simulation of Galactic chemo-dynamical evolution solve this ”time-scale problem”partially, leaving a serious discrepancy in the early Galactic evolution [1,2]. We will then propose a new theoretical model such that the MHD-Jet SNe first contribute to the enrichment of heavy elements in the early galaxies, then the NSMs follow gradually towards the solar system [3-5]. Our new model satisfies the ”universality”and predicts several specific observational evidences for the time evolution of isotopic abundance pattern [5].
[1] Y. Hirai, Y. Ishimaru, T. R. Saitoh, M. S. Fujii, J. Hidaka, and T. Kajino, ApJ 814 (2015), 4.
[2] Y. Hirai, Y. Ishimaru, T. R. Saitoh, M. S. Fujii, J. Hidaka, and T. Kajino, MNRAS 466 (2017) 2472. [3] S. Shibagaki, T. Kajino, G. J. Mathews, S. Chiba, S. Nishimura, and G. Lorusso, ApJ 816 (2016) 79. [4] S. Shibagaki, et al. (2017) to be submitted.
[5] T. Kajino, and G. J. Mathews, Rep. Prog. Phys. (2017) in press.

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