Enrichment of *r*-process Elements in Dwarf Spheroidal Galaxies in Chemo-dynamical Evolution Model

HIRAI, Yutaka
(University of Tokyo/NAOJ)
ISHIMARU, Yuhri
(International Christian University)
SAITOH, Takayuki R.
(Tokyo Institute of Technology)
FUJII, Michiko S.
(University of Tokyo)
HIDAKA, Jun
(Meisei University/NAOJ)
KAJINO, Toshitaka
(NAOJ/University of Tokyo)

The rapid neutron capture process (*r*-process) is one of the main processes to synthesize elements heavier than iron. Recent astronomical high-dispersion observations have shown that there are large star-to-star scatters in extremely metal-poor stars of the Milky Way halo. Nevertheless, astrophysical sites of *r*-process have not yet been identified. Nucleosynthesis calculations suggest that binary neutron star mergers are the promising astrophysical site of *r*-process. In contrast, previous galactic chemical evolution studies pointed out that it is difficult to reproduce the observed *r*-process abundance in extremely metal-poor stars by neutron star mergers due to their long merger time and low occurrence rate [1]. However, most previous studies did not consider the galaxy formation process. Extremely metal-poor stars would have formed before the Milky Way halo gains large mass. It is thus required to calculate chemical evolution with models of the Milky Way progenitor haloes.

In this study, we performed a series of hydrodynamical simulations of galaxies assuming that neutron star mergers are the major astrophysical site of *r*-process [2]. The simulations were performed using *N*-body/hydrodynamic code, ASURA [3]. In ASURA, we calculate gas cooling, thermal feedback from supernovae, chemical evolution as well as *N*-body/hydrodynamic calculations. We assume neutron star mergers with a merger time of 100 Myr occur with 0.5 % of the rate of supernovae. We adopt the isolated dwarf galaxy model with its halo mass of $7 \times 10^8 M_\odot$ in order to perform high-resolution simulations.

Figure 1 shows [Eu/Fe] as a function of [Fe/H] predicted by this simulation. According to Figure 1, the dispersion of [Eu/Fe] appears at [Fe/H] ~ −3. This feature is consistent with observations of extremely metal-poor stars. This means that it is possible to explain the observed *r*-process abundance in extremely metal-poor stars by neutron star mergers with merger times of ~100 Myr. We find that the metallicity is constant over ~300 Myr from the onset of star formation due to low star formation rate suppressed by supernova feedback in dwarf galaxies. We confirm that merger times shorter than 500 Myr do not significantly affect the distribution of *r*-process elements. We moreover find that metal mixing in star-forming region avoids producing extremely *r*-process rich stars, which are inconsistent with the observation, due to the low rate of neutron star mergers. The *r*-process elements observed in the Milky-Way halo might originate in accreted dwarf galaxies. This study supports that neutron star mergers are the promising site of *r*-process elements on the point of chemo-dynamical evolution of galaxies.

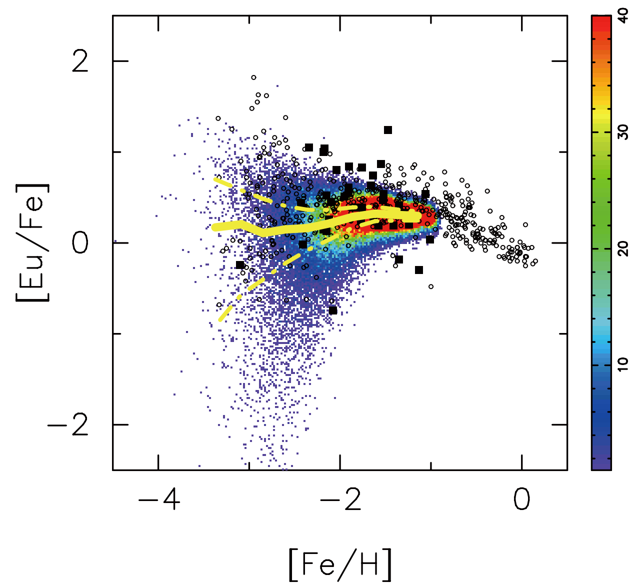

Figure 1: [Eu/Fe] as a function of [Fe/H] [2]. Color contour is the number of stars produced in this model. Yellow curve and dash-dotted curve are the median, first, and third quartiles of model prediction, respectively. Circles and squares are the observed values of stars in the Galactic halo and the Local Group dwarf galaxies, respectively. The observational data are taken from SAGA database [4].

References

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