Early chemo-dynamical evolution of dwarf galaxies deduced from enrichment of r-process elements

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Evolution of galaxies

r-process elements

Reflects the evolutionary history

?
r-process elements are produced with lower rate than the rate of whole supernovae.

Observed r-process abundance ratio

SAGA database (Suda et al. 2008, PASJ, 60, 1159)
Neutron star mergers with merger time of 100 Myr can be the site of r-process.
Star formation history of the Local Group dwarf galaxies

How they are related to the r-process abundance?
Method

N-body/Smoothed Particle Hydrodynamics (SPH) code, ASURA (Saitoh et al. 2008, PASJ, 60, 667; 2009, PASJ, 61, 481)

Dark Matter
(Gravity)

Conditions for star formation:
Density $> 100 \text{ cm}^{-3}$
Temperature $< 1000 \text{ K}$
$\nabla \cdot \mathbf{v} < 0$

+Effect of metal mixing in star-forming region

Star
(supernova feedback)

Gas (Hydrodynamics, SPH method)
Astrophysical sites of elements

r-process elements (Eu):

**Neutron-star mergers**

Merger time: **100 Myr**
NSM rate: **0.5 %** of SNe
(\(5 \times 10^{-5} \text{ yr}^{-1}\))

Fe:

Core-collapse Supergenovae

(Nomoto et al. 2006, Nucl. Phys. A, 777, 424)
My computational resources

- Cray XC 30
- Category: XC-B
Initial condition

Different central density
A, B, C, D

Different total mass
A, E, F
Metallicity distribution function

Steeper slope in higher central density models
Small scatters in $[\text{Mg/Fe}]$ as a function of $[\text{Fe/H}]$
High central density models have higher SFR → [Fe/H] increases faster

Hirai et al. (2016) MNRAS submitted
Effects of central density

Low

High

Eu appears higher metallicity in higher central density models

Hirai et al. (2016a) MNRAS submitted
Total mass of the halo does not greatly affect the increasing rate of [Fe/H] and SFH.

Hirai et al. (2016a) MNRAS submitted
Effects of total mass

Total mass of the halo does not strongly affect the $[\text{Eu/Fe}]$ vs. $[\text{Fe/H}]$

Hirai et al. (2016a) MNRAS submitted
Come from **low** central density sub-halos?

Come from **high** central density sub-halos?
Cosmological zoom-in simulation of the MW mass galaxies

Hirai et al. (2016b) in prep
Summary

• **Central density of halos** significantly affect the **early enrichment of r-process elements**

• **r-process elements would be a nice traces of the early chemical enrichment of galaxies**

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