Exploring the Origin of Neutron-capture Elements Through Heavy-element Enhanced Metal-poor Stars

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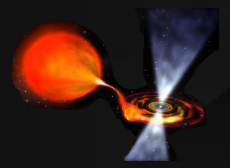
The Origin Of Heavy Elements

s-process →  → CEMP-s

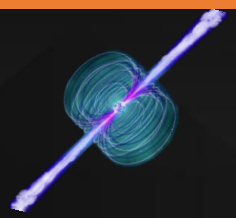
AGB Star

The astrophysical sites of the r-process ?

Sr, Ba, Eu...

LAMOST/Subaru VMP stars Sample

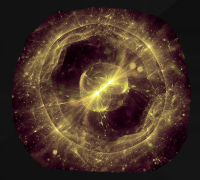
r-process



MRDSNe

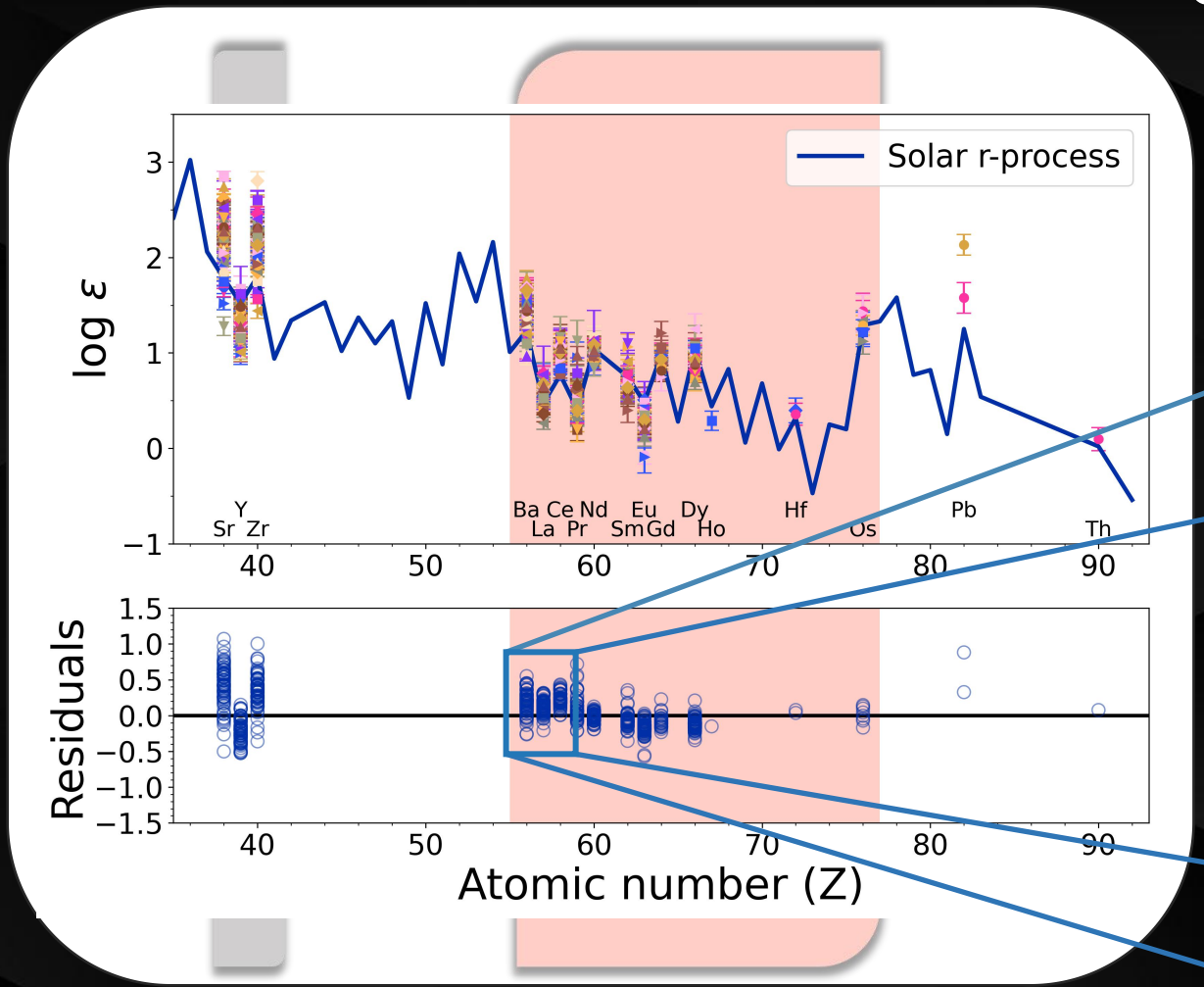
r-I/-II/-III

Limited-r

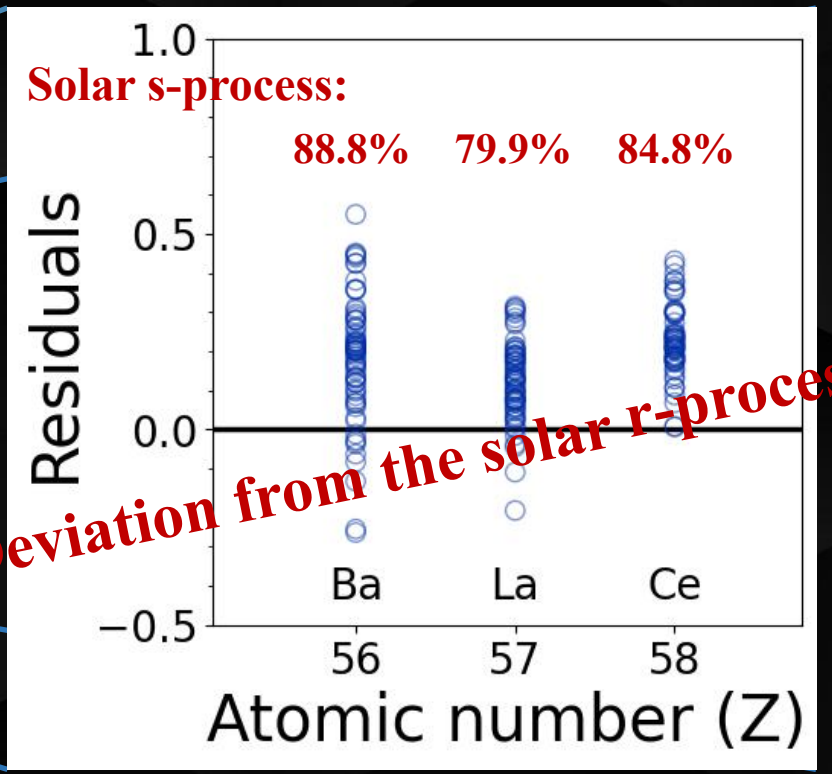


Collapsar

Global feature of r-process enhanced stars



- **Global distribution:**
  - ✓ **Z < 56 : Large deviation from the solar r-process**
  - ✓ **56 ≤ Z ≤ 77 : Fit well with the solar r-process**

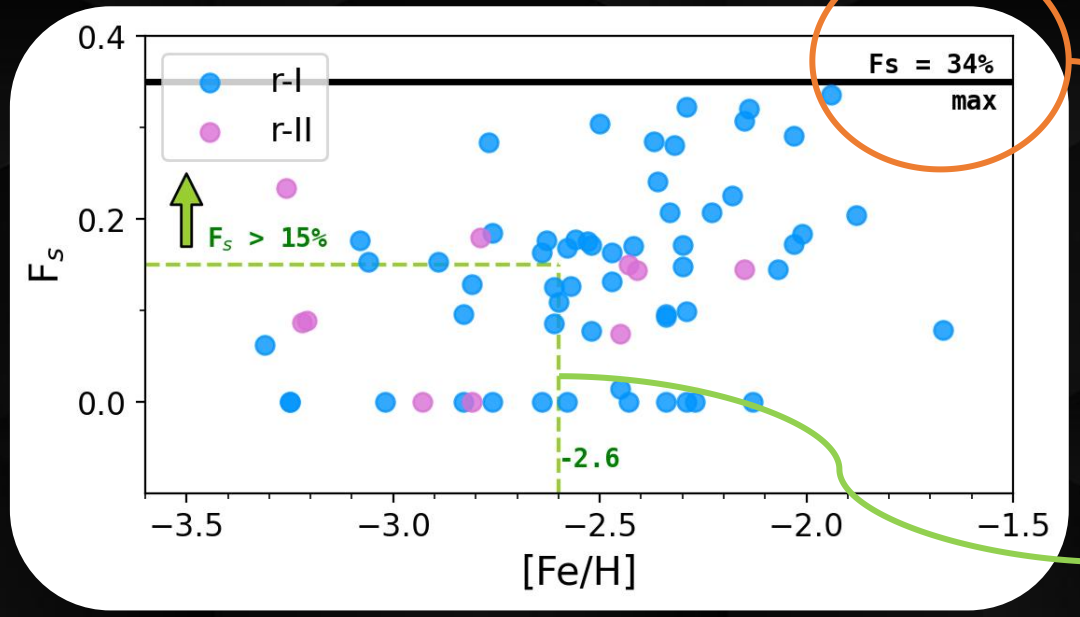


The contribution of s-process

$$\log\varepsilon_X = \log_{10}(F_r 10^{\log\varepsilon_{X,r}} + F_s 10^{\log\varepsilon_{X,s}})$$

$$F_r = \frac{10^{O_r}}{10^{O_r} + 10^{O_s}}$$ The contribution of the r-process

$$F_s = \frac{10^{O_s}}{10^{O_r} + 10^{O_s}}$$ The contribution of the s-process



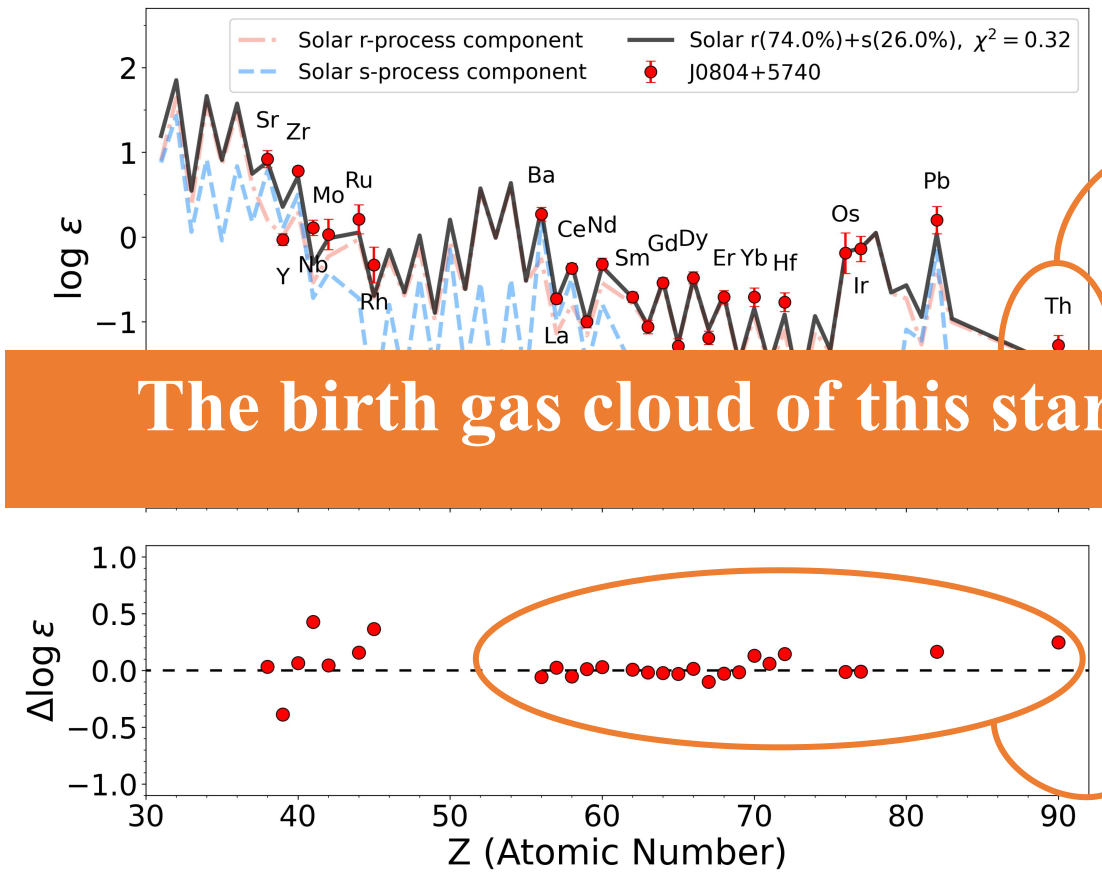
The contribution of s-process Fs < 34%

Dominated by the r-process

The contributionof r-process Fr > 66%

The s-process exhibts significant contribution (F_s>15%) at [Fe/H] ~ -2.6

One of the most interesting r-process enhanced stars

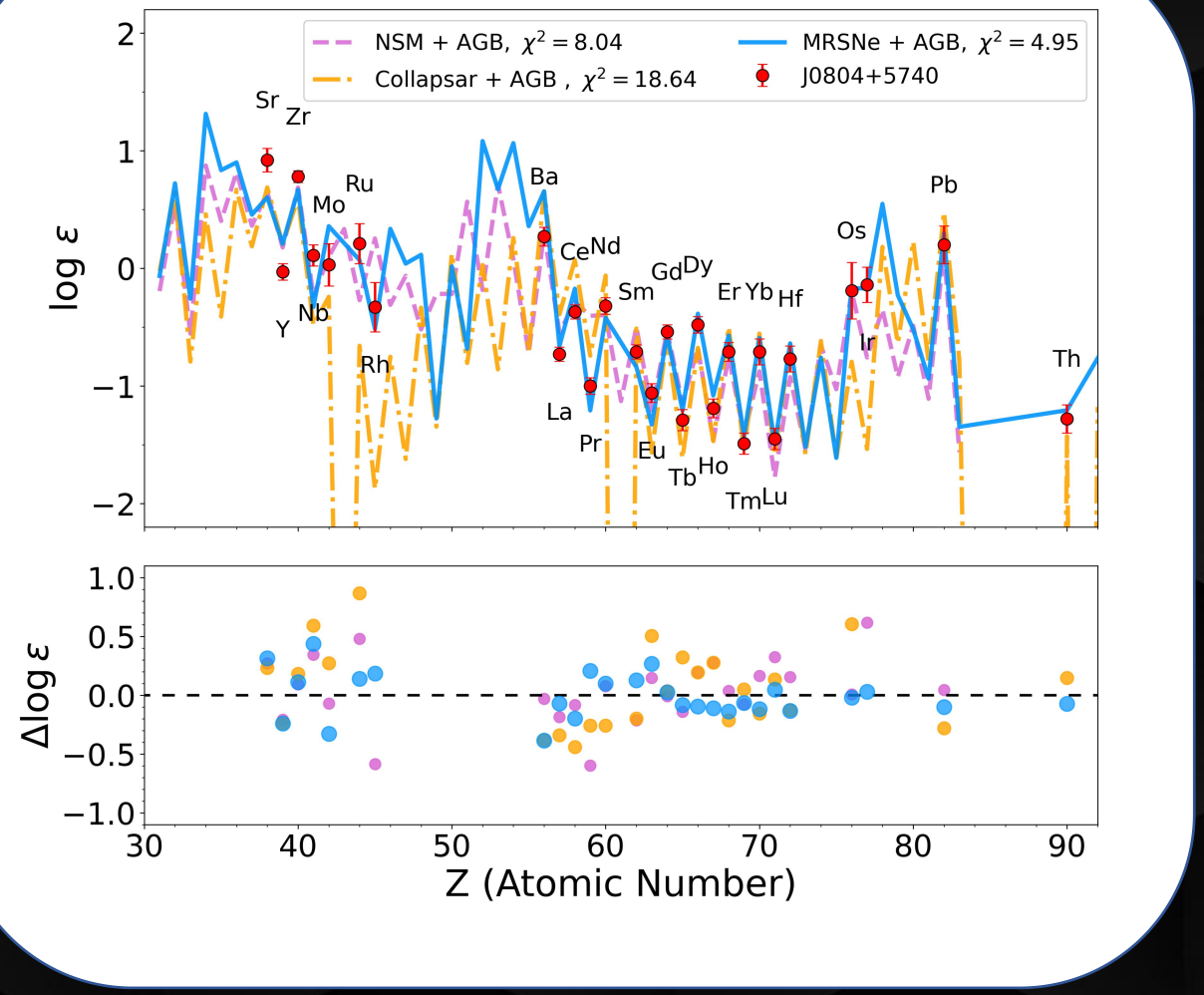


- **Actinide-boost** star
  - ✓ log ε (Th/Eu) = -0.22
- Abundance pattern :
- ✓ Solar r (Fr = 74%) + Solar s (Fs = 26%)

The birth gas cloud of this star has been polluted by the s-process

- ✓ **No carbon** enhancement
  - ➢ $[C/Fe]_{correct} = 0.15$
- ✓ **Binary system**
  - ➢ RV_{HR}-RV_{Gaia}= 0.28 km/s

The origin of this actinide-boost star

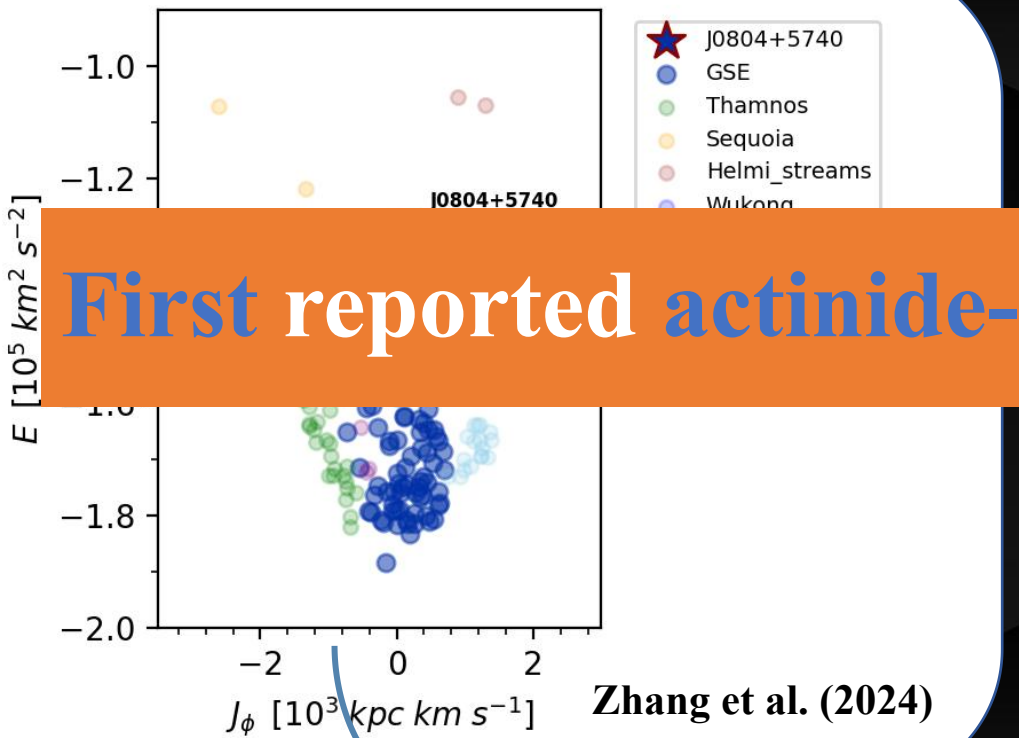


- **Best fit model:**
  - ✓ **MRDSNe r-process + AGB s-process**
- **r-process dilution mass:**
  - ✓ **$M \sim 10^6 M_\odot$**

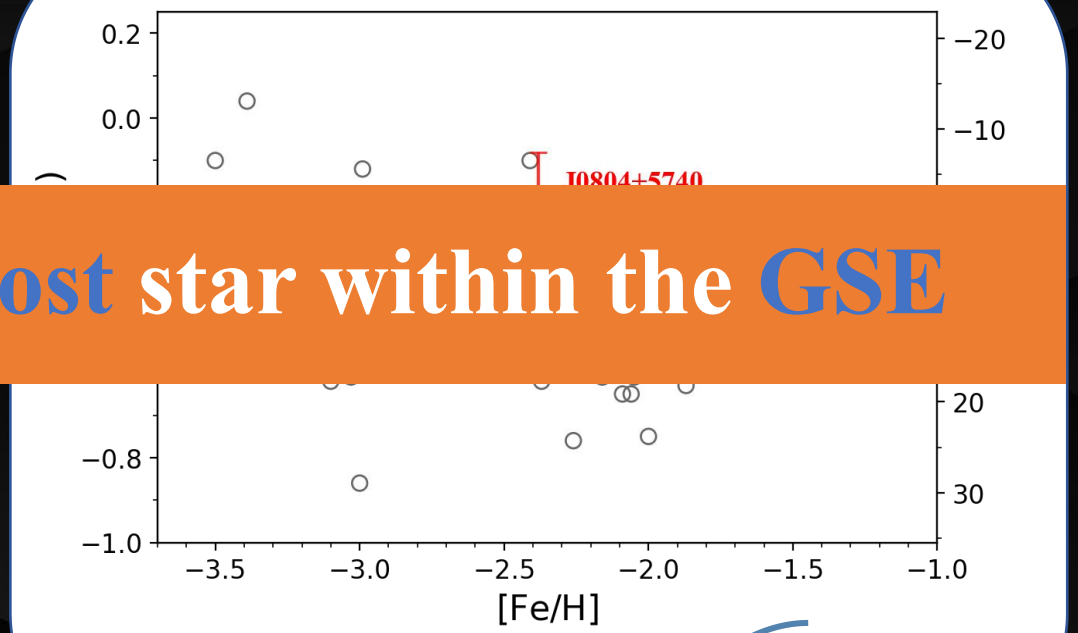
➢ **Originating from dwarf galaxies of similar mass**

➢ **A single intense r-process event**

First actinide-boost star within GSE



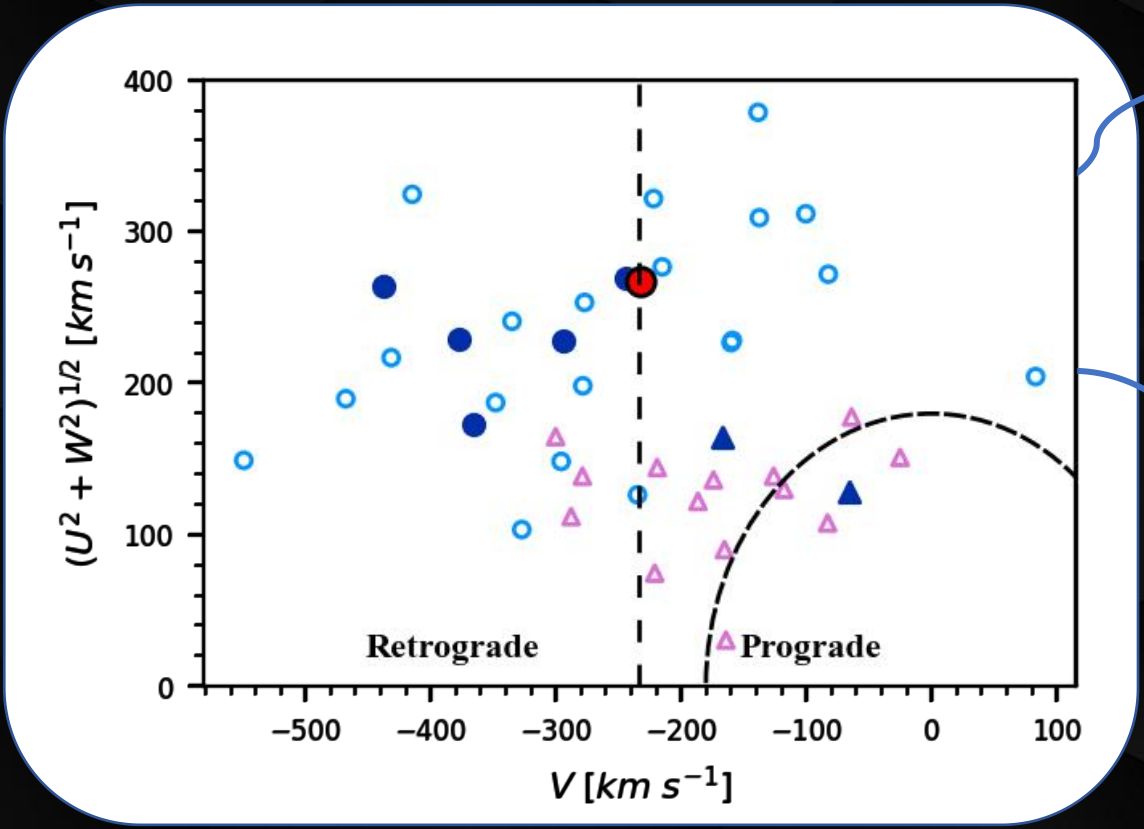
Zhang et al. (2024)



First reported actinide-boost star within the GSE

- It is a star within the **GSE** substructure
- Actinide-boost star
  - ✓ log ε (Th/Eu) = -0.22

Kinematic feature of actinide-boost star



- Method: Neural Networks (Li et al. 2024)
  - ✓ Ex-situ (circle)
  - ✓ In-situ (triangle)
- Actinide-boost stars (solid)
  - ✓ log ε (Th/Eu) > -0.35

75% of the actinide-boost stars are ex-situ stars

Summary

- The heavy elements abundance patterns of r-process enhanced stars fit well with the solar r-process
  - ✓ Most of the r-process enhanced stars polluted by the s-procss (Fs < 34%)
  - ✓ The s-process exhibts significant contribution (F_s>15%) at [Fe/H] ~ -2.6
- We reported the first actinide-boost stars within the GSE
  - ✓ Progenitor: MRDSNe r-process + AGB s-process
  - ✓ The r-process dilution mass: M ~ $10^6 M_\odot$
  - ✓ 75% of the actinide-boost stars are ex-situ stars


Thank You