Two α-poor stars with r-process enhancement

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Follow-up observation for α-poor stars with Subaru/HDS

The majority of Galactic halo stars are enhanced in α-elements (e.g. Mg, Si, Ca and Ti). Observed metal-poor halo stars preserve this pattern by exhibiting [Mg/Fe] ~ +0.4. However, a few of so-called α-poor stars with sub-solar [Mg/Fe] show severe departures from this trend. Similar stars have been found in satellite dwarf galaxies of the MW (e.g. Fornax, Sculptor, Draco, Carino and Sextans), suggesting the α-poor stars in the Galactic halo are the remnants of disrupted dwarf galaxies. Studies of such kind of halo stars would help us to understand the assembly history of the MW. We performed a search for α-poor stars from low-resolution LAMOST stellar spectra and have found hundreds of candidate α-poor stars in the Galactic halo. Nine of them have been confirmed to be α-poor stars by high-resolution spectroscopic analysis with Subaru/HDS.

R-process enhancement in two α-poor stars

It is remarkable that two of these nine confirmed α-poor stars exhibit extremely high [Eu/Fe] ratios. Figure 1 shows the [Eu/Fe] and [Eu/Mg] of the two r-rich α-poor stars comparing with Galactic stars from the literature. Most r-II stars (r-process-enhanced stars with [Eu/Fe] > +1) are found in the Galactic halo at extremely low metallicity ([Fe/H] < −2.5), and the fraction is quite low: less than 5% stars in this metallicity range. These extremely metal-poor stars would be formed from gas clouds that were affected by events that yielded a large amount of r-process elements (most likely mergers of binary neutron stars). These two r-rich α-poor are unique objects that show large enhancement of r-process elements like r-II stars but is just moderately metal poor. Such large excesses of r-process elements are not expected in stars with higher metallicity (moderately metal-poor stars), because the chemical composition of these stars is usually determined by contributions of a large number of nucleosynthesis events until the stars were formed, and any single event could not significantly change the abundance ratios.

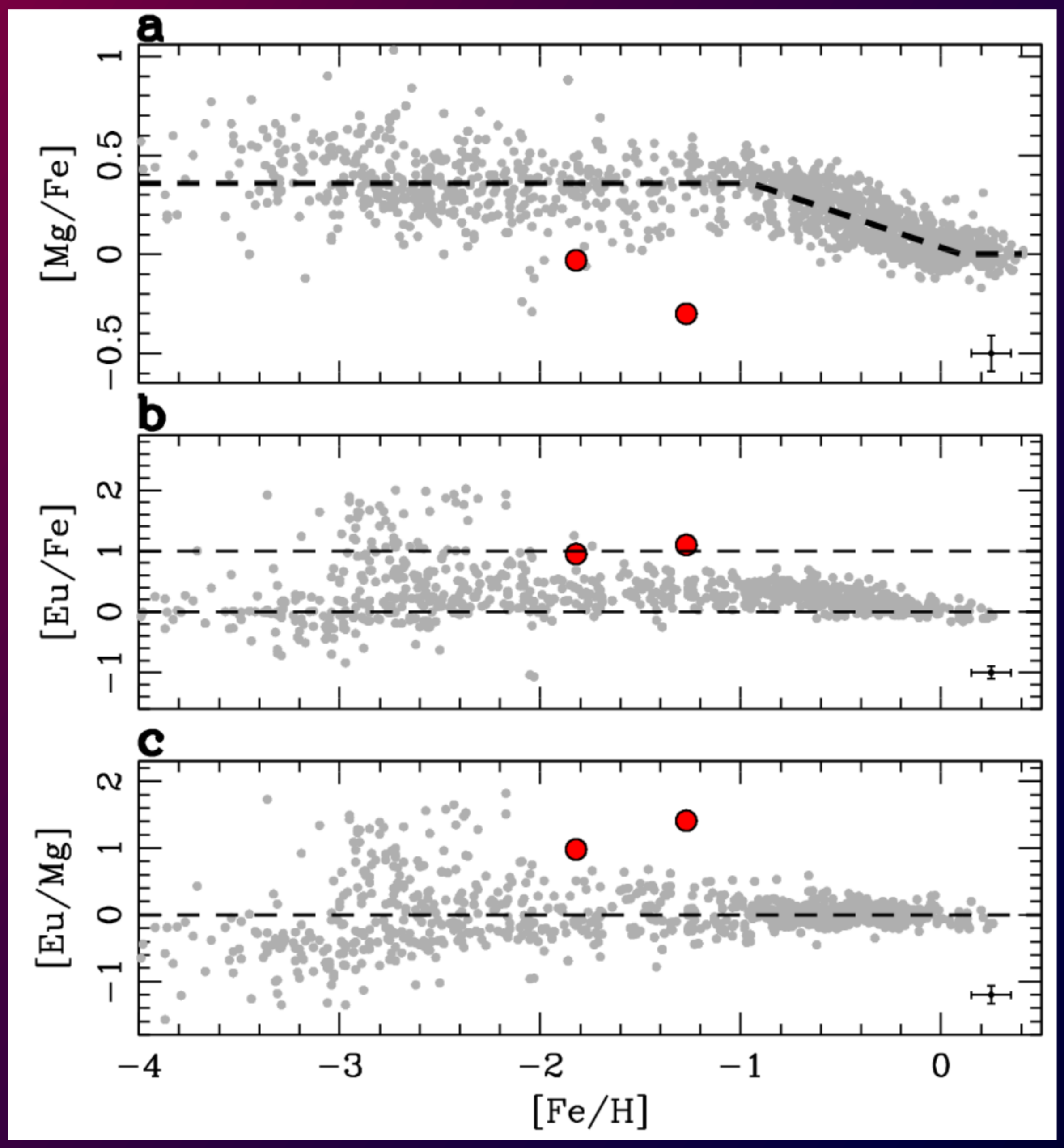

Figure 1: We have found two metal-poor stars (red circles) showing extremely high Eu abundances. Only a few of such moderately metal-poor r-II stars have been found in the Galactic halo and bulge. These two r-rich stars in our sample are unique among them for being deficient in α elements.

Similar stars in dwarf galaxies around the MW

Interestingly, such moderately metal-poor stars with large enhancement of r-process elements are found in dwarf galaxies around the MW. For instance, COS 82 in the Ursa Minor (UMi) dwarf galaxy has [Fe/H] = −1.4 and [Eu/Fe] = +1.2 with an r-process abundance pattern. The extremely large enhancement of r-process elements of these two α-poor stars (red filled circles in Fig. 2) are similar to this star in the UMi dwarf galaxy. Moreover, their sub-solar [Mg/Fe] ratios agree well with the trend in the UMi stars. The abundance pattern of these two stars suggest they have been formed in dwarf galaxies similar to UMi. They provide strong evidence for accretion of dwarf spheroidal galaxies from stellar chemical composition.

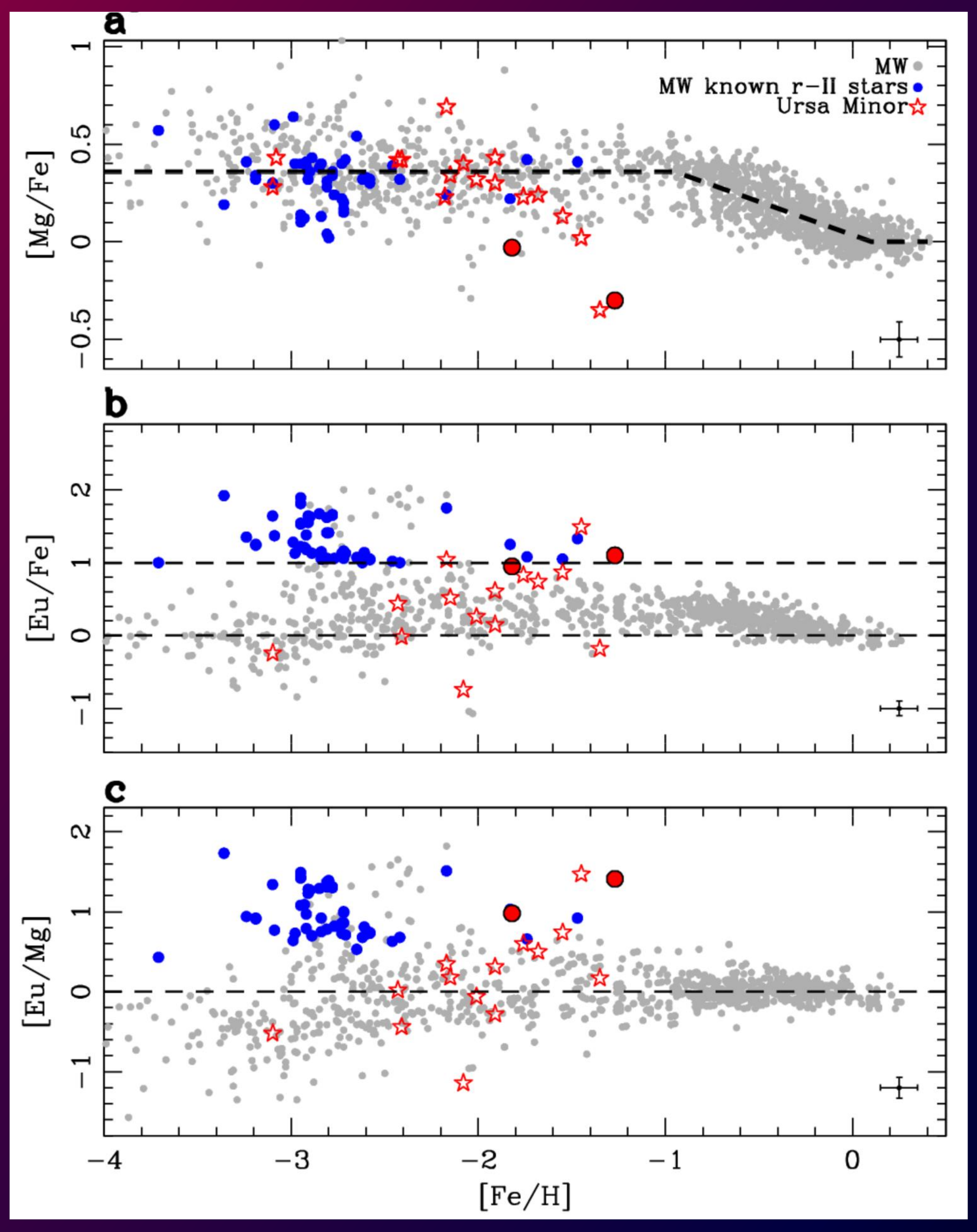

Figure 2: The abundance patterns of these two stars (red filled circles) suggest they have been formed in dwarf galaxies similar to UMi.

Summary and Conclusions

It is not easy to identify the record of accretion of dwarf spheroidal galaxies in chemical abundances of individual stars. The deficiency of α-elements and a large excess of r-process elements found in these two halo stars provide clear evidence for accretion of small galaxies that are similar to present-day dwarf galaxies. The α-element deficiency of metal-poor stars is regarded as a result of relatively slow chemical evolution of their birth site. The origin of r-process excess in moderately metal-poor stars may have been caused by a single r-process event in a protogalactic fragment with small mass. The discovery of such kind of stars in the Galactic halo could be the start of chemical identification of stars accreted from dwarf spheroidal galaxies.

References

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