P 11

Enrichment of Heavy Elements in the red giant S 15-19 in the Sextans Dwarf Spheroidal Galaxy

Satoshi Honda[1], Wako Aoki[2], Nobuo Arimoto[2] , Kozo Sadakane[3]

[1] (*Kyoto University, Kwasan Observatory*), [2] (*National Astronomical Observatory of Japan*), [3] (*Osaka Kyoiku University*)

We determined chemical abundances of the extremely metal-poor (EMP) star S 15-19 ([Fe/H]= ‐ 3.0) in the Sextans dwarf galaxy. While heavy neutron-capture elements (e.g., Ba) are deficient in dwarf galaxies in general, this object was shown to have an exceptional over-abundance of Ba ([Ba/Fe]~ +0.5) by a previous study (Aoki et al. 2009 A&A 502. 569), which is similar to those of r-process-enhanced stars found in the field halo. Our new high resolution spectroscopy for this object for the blue region reveals, however, that no clear excess of r-process elements like Eu appears in this object. Moreover, a significant excess of carbon ([C/Fe]= +1.0) and deficiency of Sr ([Sr/Fe] = ‐ 1.4) are found for this object. Taking the variation of radial velocities measured at the two different epochs into consideration, the origin of the excesses of heavy neutron-capture elements in S 15-19 is not the r-process, but is the s-process in an asymptotic giant branch (AGB) star that was the binary companion (primary) of this object. Carbon- and s-process-enhanced material should have been transferred to the surface of S 15-19 across the binary system.

Abundance studies for individual stars in dwarf galaxies

Dwarf galaxies around the Milky Way (MW) are believed to have a key to understanding the formation processes of the MW halo structure and chemical evolution in small galaxies.

Previous studies suggest that the abundance ratios of α-elements to Fe of EMP stars in most dwarf galaxies are as high as those of halo field stars, while the ratios are sometimes significantly lower at higher metallicity (Fig1).

Tolstoy et al. (2009, ARAA ,47.371)

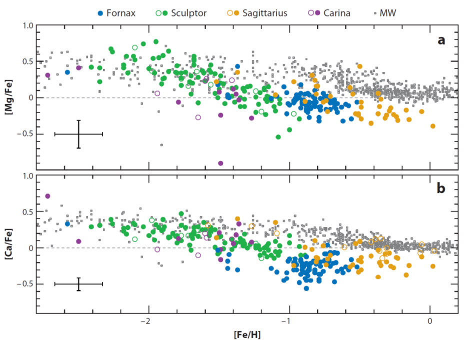
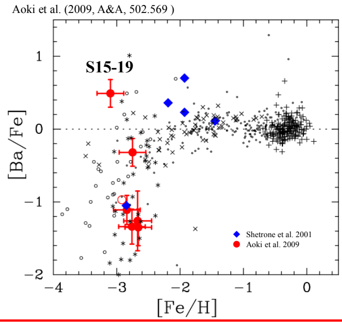


Fig 1 : [Mg/Fe] and [Ca/Fe] ratios in dwarf galaxies and MW stars. The behavior of α-elements (Mg, Ca, etc.) reflects the ratio of Type Ia and II supernovae. Chemical abundance trend of those dwarf galaxies is different from MW.

Aoki et al. (2009, A&A, 502.569)



Among the EMP stars in dwarf galaxies studied so far, the red giant S 15-19 ([Fe/H] = ‐ 3.0) in Sextans has an exceptionally high Ba abundance ([Ba/Fe]= + 0.5: Aoki et al. 2009). The value is as high as those of the r-process-enhanced stars in the field halo. If the origin of the Ba excess in S15-19 is the r-process, that indicates that large scatter of neutron-capture elements also appears in dwarf galaxies as found in the field halo (Fig 2).

Fig 2 : The abundances of Ba as a function of metallicity. Black indicates MW stars. Field halo EMP stars show large dispersion in the abundances of neutron-capture elements.

High resolution spectroscopy of the Ba-rich EMP star S 15-19

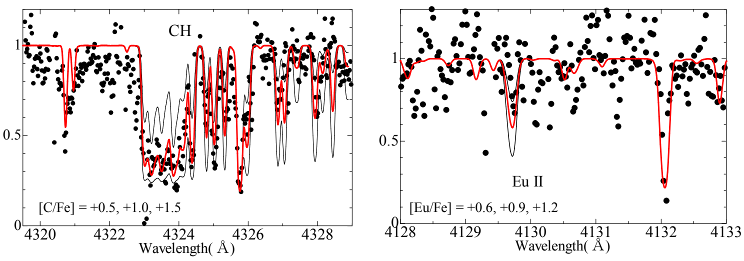


Fig 3 ,4 Spectral region around the CH feature at 4323 A and Eu feature at 4129A for S15-19. The observed spectrum is shown in filled circles, and synthetic spectra are shown by lines.

High resolution spectroscopy was carried out for S 15-19 on 2010 Feb. 9 (S10A-043) using Subaru/HDS. The spectrum covers 3760-5490 Å with a resolving power of 40,000 by 2 × 2 on-chip binning. This spectral range includes atomic lines of Eu, Sr, and CH molecular bands, which were not covered by the previous study (4400-7100 Å). Derived radial velocity is 223.60 ± 0.23 km/s. This value is by 3 km/s different from that obtained by the previous study (226.05 ± 0.11 km/s), suggesting that S15-19 belongs to a binary system.

Results and Discussion

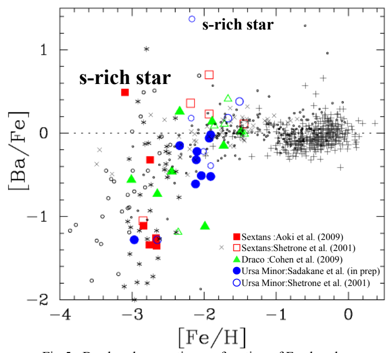


Fig 5 : Ba abundance ratio as a function of Fe abundance. The abundances of MW stars (without s-process rich stars) are shown by black symbols.

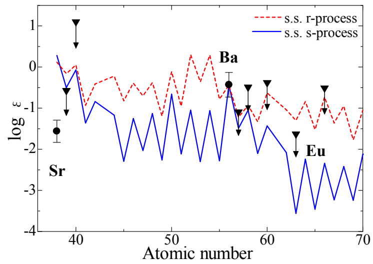


Fig 6 : Abundances of neutron-capture element, or upper limits, for S15-19 as a function of atomic number. The red and blue lines are the solar r- and s-process abundance patterns normalized at Ba.

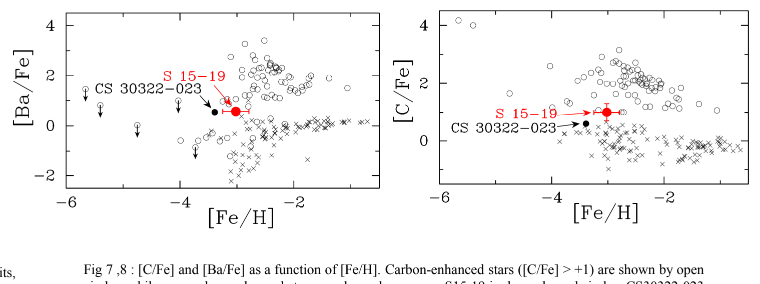


Fig 7 ,8 : [C/Fe] and [Ba/Fe] as a function of [Fe/H]. Carbon-enhanced stars ([C/Fe] > +1) are shown by open circles, while non-carbon-enhanced stars are shown by crosses. S15-19 is shown by red circles. CS30322-023 is classified into carbon enhanced object, taking its evolutionary stage and the large nitrogen-enhancement into account.

Our chemical abundance measurements for the red giant S 15-19 in the Sextans dwarf spheroidal revealed that this star has excesses of carbon ([C/Fe] = +1) and Ba ([Ba/Fe] = +0.4) but shows no clear excess of r-process elements ([Eu/Ba] < +0.5). A radial velocity variation is found between the two epochs of the past observing. This indicates that the excess of Ba in this star can be attributed to the s-process in an AGB star which was a companion (primary) of the binary to which S15-19 belongs, and carbon-rich material has been transferred from the AGB star across the binary system. The low Sr/Ba ratio ([Sr/Ba] = ‐ 1.9) also suggests the s-process at very low metallicity that efficiently yields heavier neutron-capture elements due to high neutron to seed nuclei ratios. Hence, we conclude that this object is a Carbon-Enhanced Metal-Poor (CEMP) star with excesses of s-process elements (CEMP-s). Since the origin of Ba of this object turned out to be s-process, no r-process enhanced EMP star is known at present in dwarf galaxies. This possibly indicates that dwarf galaxy may have history of the chemical evolution different from MW. However, since the sample size of EMP stars in dwarf galaxies studied with high resolution spectroscopy is still small, we cannot derive any definitive conclusion. Further researches on the abundance analysis of EMP star in dwarf galaxies will clarify the chemical evolutions of dwarf galaxy and nucleosynthesis of r-process.