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THE HISTORY OF GALACTIC DWARF SPHEROIDAL GALAXIES

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The stellar abundance pattern of n-capture elements such as barium is used as a powerful tool to infer how the star formation proceeded in dwarf spheroidal (dSph) galaxies. It is found that the abundance correlation of barium with iron in stars belonging to dSph galaxies orbiting the Milky Way, i.e., Draco, Sextans, and Ursa Minor have a feature similar to that in Galactic metal-poor stars.

Figure 1 shows the correlation of [Ba/Fe] with [Fe/H] for dSph stars (Schetrone et al. 2001), together with that for Galactic metal-poor stars (*crosses*; McWilliam 1998). Filled circles represent dSph stars with [Fe/H] shifted by Δ[Fe/H] = -0.6 dex. An excellent coincidence between two distributions appears: both metal-poor stars and dSph stars populate two separate branches in the [Ba/Fe]-[Fe/H] plane, i.e., the first branch, in which stars have positive [Ba/Fe] ratios (i.e., greater than the solar ratio), and the second branch, with the upper bound at [Ba/Fe]=-1. This feature can be reproduced by our inhomogeneous chemical evolution model in which stars are born from the matter swept up by individual supernova remnants (Tsujimoto et al. 2000).

The metallicities of metal-poor stars are determined by two factors: how much mass of heavy elements a supernova (SN) supplies and how much mass of interstellar matter (ISM) was eventually swept by a single SN explosion (Shigeyama & Tsujimoto 1998). The former is determined exclusively by each SN. On the other hand, the latter quantity is influenced by the environment, such as the velocity dispersion $\sigma_{\rm v}$ and density n of the ISM. If SNe in the Milky Way and those in dSph galaxies are similar, different environments should give rise to the Δ [Fe/H] discussed above. Since the mass $M_{\rm sw}$ swept up by an SN is much more sensitive to the velocity dispersion than to the density; $M_{\rm sw} \propto \sigma_{\rm v}^{-9/7} n^{-0.062}$, it is likely that a larger velocity dispersion in dSph galaxies at the star formation epoch enhanced the stellar [Fe/H]. Quantitatively, Δ [Fe/H]=–0.6 dex corresponds to a velocity dispersion of $\sigma_{\rm v} \sim 26$ km s^{-1}. The velocity dispersion $\sigma_\star$ of stars must have a similar value in equilibrium configuration. The present value of $\sigma_\star$ measured in Galactic dSph galaxies is about 9 km s^{-1}. These two significantly different velocity dispersions can be connected in the context of a galaxy losing mass by the tidal force of the Milky Way. As a result, the total mass of each dSph galaxy is found to have been originally $\sim$ 25 times larger than at present.

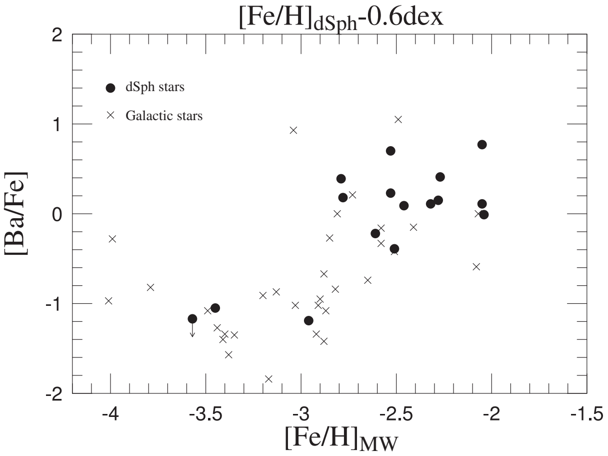

Fig. 1. Correlations of [Ba/Fe] with [Fe/H] for dSph stars (*filled circles*) and Galactic halo field stars (*crosses*). The data of dSph stars are shifted by the amount of Δ[Fe/H]=–0.6 dex (see the text).

The history of Galactic dSph galaxies that we have proposed is as follows. The proto-dSph galaxy consisted of gas and dark matter, and was approximately 25 times as massive as the present dSph galaxy. Star formation lasted for about two hundred million years; meanwhile, $\sim$ 5 percent of the gas converted into stars. Afterward, the remaining gas was dispelled by the last SN explosions. On the other hand, dark matter which surrounds stars has lost more than 90% of its mass through the tidal interaction with the Milky Way.

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