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Chemical Abundance Patterns in the Local Dwarf Galaxies in the CDM Universe

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Abstract. We present chemical properties of dwarf galaxies in a semi-analytic galaxy formation model. We find a good match with observations of the Local dwarf spheroidals. The supernova feedback is a key to understanding the different metal abundances of the Local Group dwarf spheroidals from those associated with the Milky Way.

We now have increasing evidence for the cold dark matter (CDM) model of the universe, which leads naturally to the hierarchical formation of galaxies. To realize this evidence, semi-analytic (SA) models of galaxy formation have been developed by several groups. The Mitaka model is one of the SA models (Nagashima & Yoshii 2004). We have found that this model well reproduces many aspects of observed galaxies such as luminosity functions, gas fractions, faint galaxy number counts, and so on.

We have made further additions to the Mitaka model to include a metal enrichment process due to type Ia supernovae (SNe Ia). Then Nagashima & Okamoto (2006, hereafter NO06) focused on Milky Way-like galaxies in the model and showed that the model well reproduces the observed iron metallicity distribution function (MDF) and the relation between [O/Fe] and [Fe/H] for the solar-neighborhood stars. Figure 1 shows examples of these distribution frequencies for disk and bulge stars. In panel (a), model disk stars shown by the gray scale match well with the observed stars, while the observed bulge stars provide a break point at larger [Fe/H] (panel b). The MDF for disk stars also agrees well with observations, and the MDF for bulge stars shows a slight lack of metal-rich stars. This disagreement might be solved when we introduce a top-heavy initial mass function for stars in a starburst (Nagashima, et al. 2005a; Nagashima et al. 2005b). Curves shown in panels (a) and (b) indicate the result given by Yoshii, Tsujimoto & Nomoto (1996, hereafter YTN96) based on the monolithic infall model.

Using the same model, we focus on dwarf galaxies around a Milky Way-like galaxy. Figure 2 shows [O/Fe] against [Fe/H] for four dwarf spheroidals in the model around the Milky Way-like galaxy. Symbols denote observed stars in the Local Group dwarf spheroidals. For reference, we overlay the result of YTN96 in each panel. It is evident that the break points move to lower [Fe/H] similar to the observations for stars in the Local Group dwarf spheroidals.

This difference from the case of the solar-neighborhood stars is caused by the supernova (SN) feedback due to SNe II, which is more efficient in dwarf galaxies with shallower gravitational potential wells. Because SNe expel gas and metals from galaxies, the metal enrichment does not proceed significantly, that is, the effective chemical yield decreases. Then, SNe Ia begin to explode and [O/Fe] is lowered at lower [Fe/H] than of the Milky Way's.

Of course, there might be other mechanisms explaining the observed metal abundances in the Local dwarf spheroidals. However, the SN feedback is required to explain the luminosity functions, and thus it is a natural mechanism for explaining the different metal abundances from the Milky Way's. The details will be shown in Nagashima & Okamoto (2008).

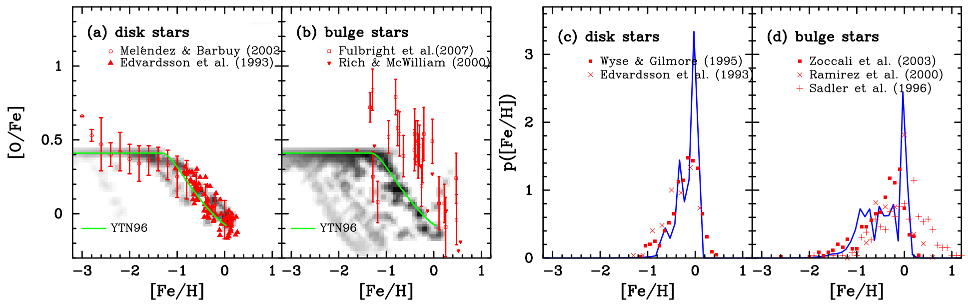

Figure 1. Frequency distributions of (a) disk and (b) bulge stars in the [O/Fe]-[Fe/H] plane. The solid curve indicates a result given by YTN96 based on a monolithic infall model. Iron MDFs for disk (c) and bulge (d) stars. The solid lines indicate the model prediction.

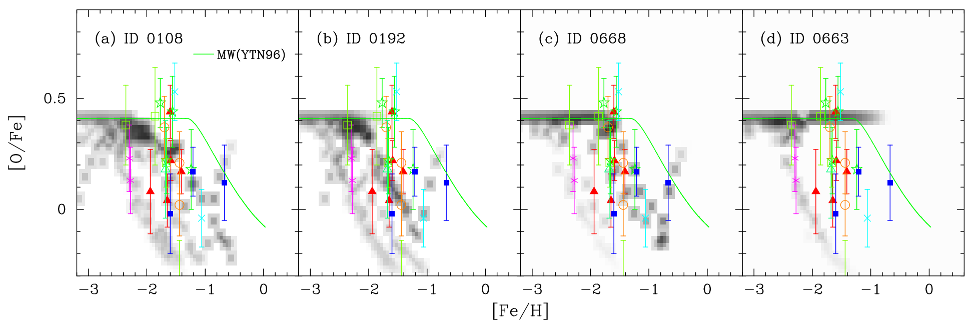

Figure 2. Frequency distributions of stars in the [O/Fe]-[Fe/H] plane for four dwarf spheroidals. The solid curve indicates YTN96 for the MW shown for reference. Symbols indicate observed stars in the Local dwarf spheroidals taken from Shetrone et al.(2001; 2003).

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