

Chemical abundance analysis of the Galactic outer halo stars with Subaru/HDS

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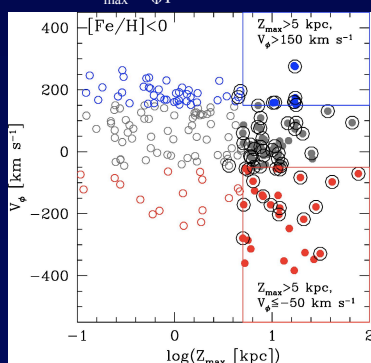
We present chemical abundances of 57 metal-poor ($[Fe/H] < -1$) halo stars whose orbit reach distances of more than 5 kpc above and below the Galactic plane ($Z_{max} > 5$ kpc). Based on the high-resolution spectra obtained with Subaru/HDS, chemical abundances of odd-Z, alpha, Fe-peak, neutron capture elements were derived. Our results suggest that the outer halo sample have lower $[Mg/Fe]$ ratios than the inner halo stars.

Motivations

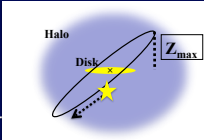
- Making constraints on the hierarchical assembly history of the MW halo using kinematics and chemical abundances of solar-neighborhood metal-poor stars as tracers.
- Examining chemical abundance inhomogeneity among nearby halo stars as a function of their kinematics, especially targeted at the *outer halo*
- Comparing the abundance ratios of the outer halo stars with metal-poor stars belonging to the MW satellite galaxies.

Sample kinematics

A plot of samples with known kinematics and abundance analyses on a Z_{max} - V_{ϕ} plane

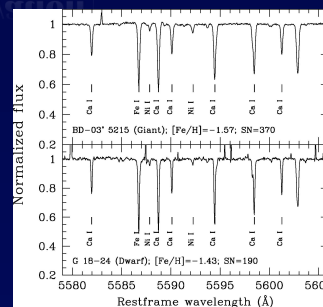


- The sample in this study (symbols marked with large open circles): 57 bright ($V > 13$ mag) metal-poor ($[Fe/H] < -1$) stars with $Z_{max} > 5$ kpc and various V_{ϕ}
- Samples from literature: Samples from Stephens & Boesgaard 2002; Gratton 2003, that include a large number of $Z_{max} \leq 5$ kpc stars



Subaru/HDS Observation

- Dates: July 26, 27 2008.
 - Spectral coverage: ~ 4050 - 6700
 - Wavelength resolution: $R \approx 50000$
 - Signal-to-noise ratio: > 100
 - Number of targets: ~ 30
- (Other half of the sample were already observed and analyzed in Zhang et al. 2009, in prep.)
- Data reduction: standard IRAF routines

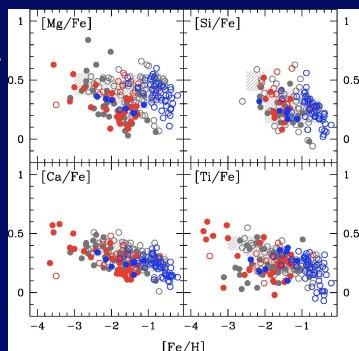


- Abundance analysis: Na, Mg, Si, Ca, Ti, Cr, Mn, Ni, Zn, Y, Ba + stellar atmospheric parameters (T_{eff} , $\log g$, v_{turb}) were derived in a homogeneous manner using an LTE-abundance analysis code (Aoki et al. 2009).

Results

Derived abundance ratios ($[X/Fe]$) as a function of metallicity ($[Fe/H]$)

- Z_{max} domains (Inner/outer halo)
 - Open symbols: $Z_{max} \leq 5$ kpc (Inner)
 - Filled symbols: $Z_{max} > 5$ kpc (Outer)
- V_{ϕ} domains
 - Blue: $V_{\phi} > 150$ km s⁻¹
 - Gray: $-50 < V_{\phi} \leq 150$ km s⁻¹
 - Red: $V_{\phi} \leq 50$ km s⁻¹.



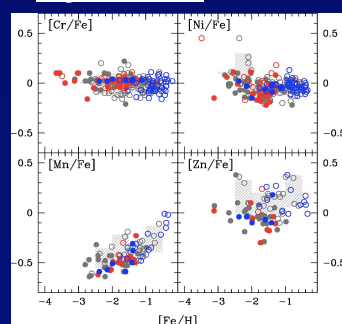
I. α -elements:

In the metallicity range of $-2 < [Fe/H] < -1$, the $[Mg/Fe]$ ratios are lower by ~ 0.2 dex for the outer halo sample compared to the inner counterparts.

Similar tendency is seen in the $[Ca/Fe]$ plot, although the difference is relatively modest.

For $[Fe/H] < -2$ samples, the inner and the outer halo samples are indistinguishable for these 2 elements, except for a few stars showing extremely high $[Mg, Fe]$.

II. Fe-peak elements:



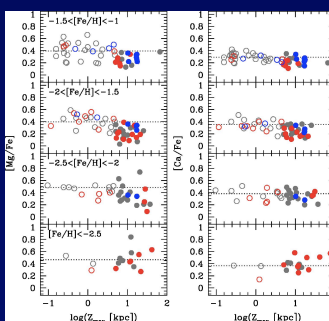
The $[Cr/Fe]$ and $[Ni/Fe]$ ratios among the outer halo sample are approximately solar values with a very small scatter (< 0.1 dex) in the surveyed $[Fe/H]$ range.

The $[Mn/Fe]$ ratios show a increasing trend with $[Fe/H]$.

The $[Zn/Fe]$ tend to be lower for the outer halo sample in the metallicity range of $-2 < [Fe/H] < -1$.

Discussions

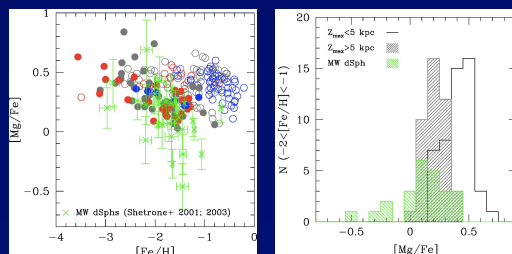
I. Abundance-kinematic relation - $[a/Fe]$ vs $\log(Z_{max})$ -



- For the $[Mg/Fe]$ ratio, the outer halo sample have lower values on average, especially for the metallicity range of $-1.5 < [Fe/H] < -1$.
- Because of our sample slection biased toward the high Z_{max} stars, presence of gradient with $\log(Z_{max})$ is unclear.

II. Comparison of $[a/Fe]$ with the MW satellites

- A $[a/Fe]$ comparison between the MW satellite samples and the MW *outer halo* sample -



- Both population partly overlap in the metallicity range of $-2 < [Fe/H] < -1$
- The lower $[Mg/Fe]$ tail (< -0.1) seen among the MW satellite samples is not reproduced with the outer halo sample.

* For other elements (Na, Y, Ba, etc) and more detailed discussions on each elements, please see Zhang et al. (2009 in prep.) and Ishigaki et al. (2009 in prep.)