Keck Observatory and Metal-poor stars

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JINA GCE Workshop

Photo Credit: Pablo McLoud
HIRES AND VERY DETAILED ABUNDANCE WORK

- Capable of resolution from $R \sim 25,000$ to 90,000
- Recent detector upgrade gives a wide wavelength coverage
- Workhorse instrument for abundances
Nearby metal-poor stars

- $[\text{Fe/H}] \leq -2.0$
- Can provide a window into early star formation environments, possibly even the first stars.

Lai et al. 2008
Keeping it “simple”

- Used Heger & Woosley models assuming only zero-metallicity progenitors.
- A way to deal with degeneracies, assume a characteristic progenitor.

Lai et al. 2008
Nearby metal-poor stars

- Origin of the elements and nucleosynthesis sites, e.g. the $s$-process and the $r$-process

$[\text{Fe}/\text{H}] = -2.8$  

$[\text{Fe}/\text{H}] = 0.0$

Lai et al. 2008
Nearby metal-poor stars

• Origin of the elements and nucleosynthesis sites, e.g. the $s$-process and the $r$-process

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Lai et al. 2008
Detailed abundances in dSph galaxies

Frebel et al. 2010

See Anna Frebel’s talk
ESI and efficiency

- Single object, $R \sim 6,000$
- $R$ of 6,000 $\neq$ $R$ of 40,000
- High throughput and large useable wavelength coverage ($\sim4000$ to 8000 Å)
- Can by itself measure many interesting elements and categorize metal-poor stars
- Devote high-resolution follow-up to interesting stars
We can measure C, Na, Mg, Ca, Ti, Cr, Fe, Sr, Ba, and Eu in metal-poor stars with ESI spectra.
ESI has enabled the discovery of new $r$-II stars and of a star with unusual (and sometimes unique) $\alpha$-element signatures.

Lai et al. 2009
DEIMOS/LRIS AND LARGE NUMBERS

• Multi-object / faint
• $R$ up to 2,000 (LRIS)
• $R \sim 6,000$ (DEIMOS)
• The main driver of both is / was extragalactic work.
Repurposed for galactic chemical evolution

- Great tools for examining dSph galaxies
- With new analysis methods, both overall metallicity and $\alpha$-element abundances are possible
- Larger data set can give a good statistical understanding of dSph populations
- Can give prime targets for higher resolution follow-up
DEIMOS Studies of dSphs

Kirby et al. 2009

DEIMOS has now been used to survey both the bright and ultra-faint dSphs for both overall metallicity and $\alpha$-elements.
Preliminary Results: Boötes I with LRIS-B

- Analyzed with the NSSPP (non-Segue Stellar Parameter Pipeline)
- It seems like $[\text{Fe/H}] \sim -3.8$ stars are a "common" feature in dSphs!
Metal-poor stars at Keck: Overview

- SDSS - SEGUE
- HK Survey
- HES survey etc.

LRIS
- Multi-object
- [Fe/H]
- Individual [α/Fe]
- [Fe/H] and [α/Fe]
- [C/Fe]

DEIMOS
- Multi-object
- [Fe/H]
- Individual [α/Fe]

ESI
- Single object
- [Fe/H]
- [C/Fe]
- Individual [α/Fe]
- Some neutron-capture

HIRES
- Single object
- "Everything"

R ~ 1000
- N ~ hundred to thousands

R ~ 30,000 to 80,000
- N ~ few to tens
Future Directions

• Resources vs. Resolution (statistics vs. accuracy)
• Some specific topics
  • more stars from different halo populations
  • dSph stars at all resolutions
  • $r$-II stars - quantify percentages by increasing numbers and/or more detailed measurements