

Closing remarks: Summary of Observational Studies and Future Prospects

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Extremely metal-poor stars: Lowest metallicity range

- New entries of Hyper Metal-Poor stars ($[\text{Fe}/\text{H}] < -5$) and Ultra Metal-Poor stars ($[\text{Fe}/\text{H}] < -4$)

Bonifacio, Aguado

- Carbon-enhancement
 - Li detection
 - bright star with Be measurement (no detection)
 - thin disc orbit?
- Very low-mass Ultra-Metal-Poor star

Schlaufman

- A binary companion with $0.14M_{\odot}$ and $[\text{Fe}/\text{H}] = -4$

Stars with $[\text{Fe}/\text{H}] < -4.5$

This should be updated including the presentations in this conference

object	Mag.	Teff	log g	[Fe/H]	[C/Fe]	A(Li)	[Mg/Fe]	[Ca/Fe]	Ref.
SM0313-6708	V=14.7	5125	2.3	<-7.3	>4.9	0.7	>4.0	>0.1	1
J0023+0307	<i>g=17.9</i>	5997	4.6	<-6.3*	>3.76	1.7	>3.33	>0.53	2
HE1327-2326	V=13.6	6180	3.7	-5.66	4.3	<0.7	1.65	0.25	3
HE0107-5240	V=15.1	5100	2.2	-5.39	3.7	<1.12	0.15	-0.09	4
SD1035+0641	<i>g=18.65</i>	6262	4.0	<-5.07	>3.5	1.9		>0.42	5
SD1313-0019	<i>V=16.9</i>	5200	2.6	-5.00	3.0	<0.8	0.44	0.25	6
SD1742+2531	<i>g=18.9</i>	6345	4.0	-4.80	3.6	<1.8	<0.27	0.26	5
HE0557-4840	V=15.45	4900	2.2	-4.75	1.6	<0.7	0.25	0.25	7
SD1029+1729	<i>g=16.9</i>	5811	4.0	-4.73	<0.9	<1.1	0.40	0.72	8
HE0233-0343	V=15.4	6100	3.4	-4.68	3.5	1.77	0.59	0.34	9

*The value estimated from Ca abundance. $[\text{Fe}/\text{H}] < -5.8$ is derived from Fe I lines.

(1)Keller et al. (2014); (2)Frebel et al. (2018); (3)Frebel et al. (2005);
(4)Christlieb et al. (2004); (5)Bonifacio et al. (2014); (6)Frebel et al. (2015);
(7)Norris et al. (2007); (8)Caffau et al. (2011); (9)Hansen et al. (2014)

Extremely metal-poor stars: new surveys

- Photometric survey:

Starkenburg

- PRISTINE with a narrow-band filter
- Spectroscopic follow-ups (e.g. WEAVE)

- Spectroscopic surveys and follow-ups:

Li, Zhang (poster)

- LAMOST (low-resolution → medium-resolution)
- EMP stars, alpha-poor stars

Young Sun Lee, Jeong, Jang (posters)

- SDSS+LAMOST follow-up for CEMP stars, UMP stars, Mg-enhanced stars

Lithium

- Li in Extremely Metal-Poor stars: cosmology or stellar physics

Bonifacio

- Detection of Li in stars with $[\text{Fe}/\text{H}] < -5$... $A(\text{Li}) \sim 1.8$

Gonzalez-Hernandez

- Li (isotopes) in double-lined spectroscopic binaries with $[\text{Fe}/\text{H}] = -3.8$... lower Li in the secondary

- Li-rich stars

Haining Li

- Li-enhanced giants and turn-off stars with low metallicity

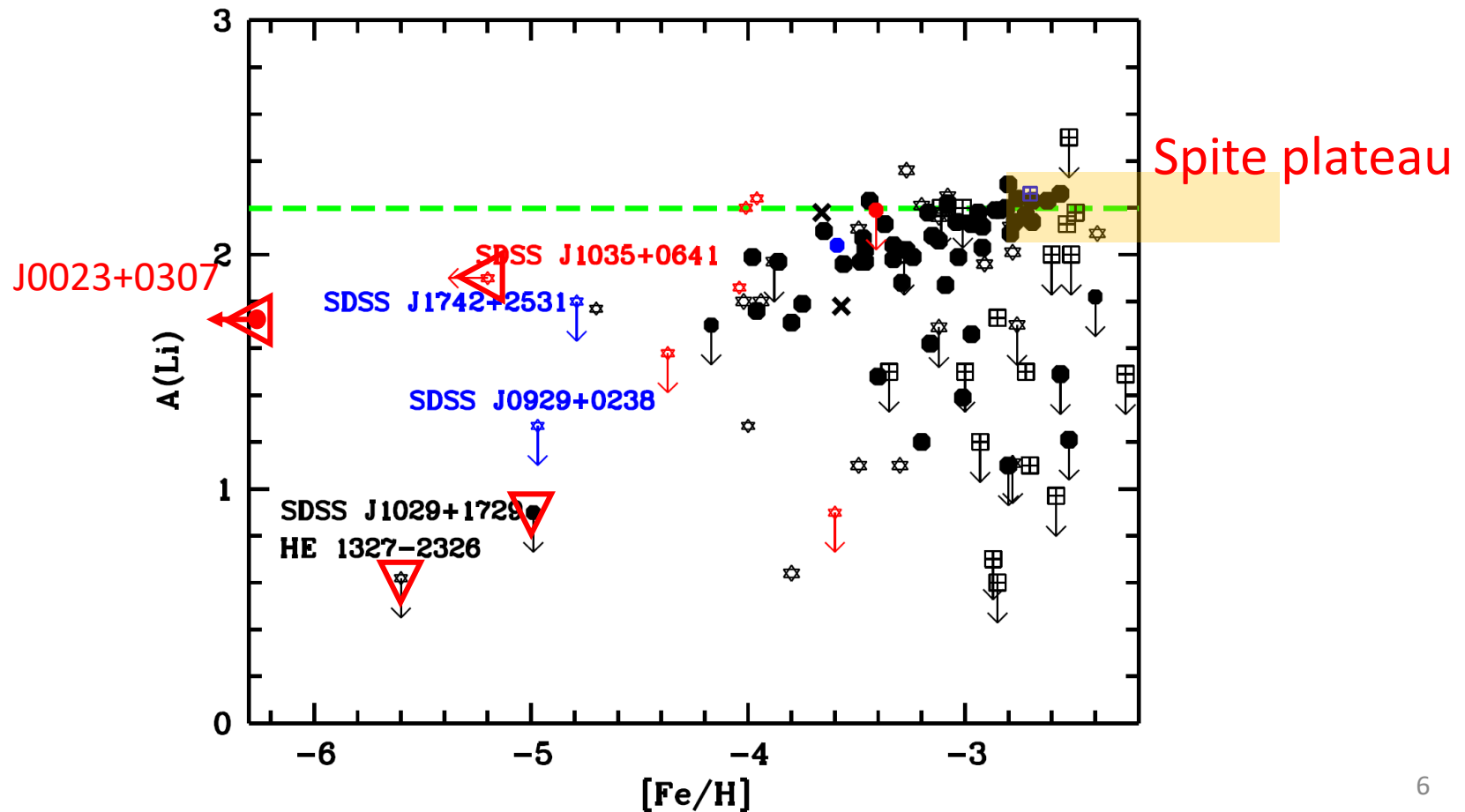
Kumar Yerra

- Li-rich giants ... most are red clump stars?

Li abundances

- Lower Li at lower metallicity (lower Fe abundance)?
- No correlation between C-excess and Li

Bonifacio et al. (2018) + Frebel et al. (2018)



Abundance analysis: non-LTE and 3D

- 3D NLTE analysis

Amarsi

C, N, O abundances ... change of C/O trend

- NLTE

Zhou (poster)

Ca I/II lines in NIR spectra

Carbon-Enhanced Metal-Poor (CEMP) stars

- Implications on first stars and galaxy assembly

Beers

- History, classification, frequency

Placco

- Constraints on first stars' mass distributions

Yoon

- Classification and dwarf galaxy stars

- Kinematics features

Beers, Young Sun Lee (poster)

- Frequency of CEMP stars in Inner Halo and Outer Halo

Dietz

- Gaia DR2 ... CEMP stars with thick disc kinematics?

Dwarf carbon stars

- Nearby Ultra/Extremely Metal-Poor stars

Yoon, Beers

- Candidate dwarf carbon stars with $[\text{Fe}/\text{H}] \sim -4$ from SDSS

Farihi

- Kinematics ... rotation lag

- *Binarity*

Whitehouse

Majority of dwarf carbon stars belong to binary systems

Heavy neutron-capture elements

- *r*-process in dwarf galaxy stars

Ji

- *r*-process-enhanced dwarf galaxy Ret II
- Dwarf galaxies with low neutron-capture elements

- *s*-process and *i*-process(?)

Suda

- Origins of neutron-capture elements in the lowest metallicity range from SAGA database

Cui (poster)

- Ba isotope ratios of a CEMP *r/s* star (reflecting *i*-process?)

Dwarf galaxies and galaxy formation

- Dwarf galaxies and streams

 - Tolstoy*

 - Ultra-faint dwarf galaxies found (apparently) close to Sgr/MC streams
 - Sculptor: CMD, velocity, abundance, proper motion, frequency of CEMP stars

 - Chiti*

 - Photometric studies of ultra-faint dwarf galaxies

- Galaxy formation

 - Tolstoy*

 - Scatter in α/Fe ratios reflecting accreted component (Gaia Enceladus)

 - Matsuno*

 - More retrograde component

 - Escala*

 - High α/Fe in M31 RGB stars ... extended halo structure

- Constraint on supernovae

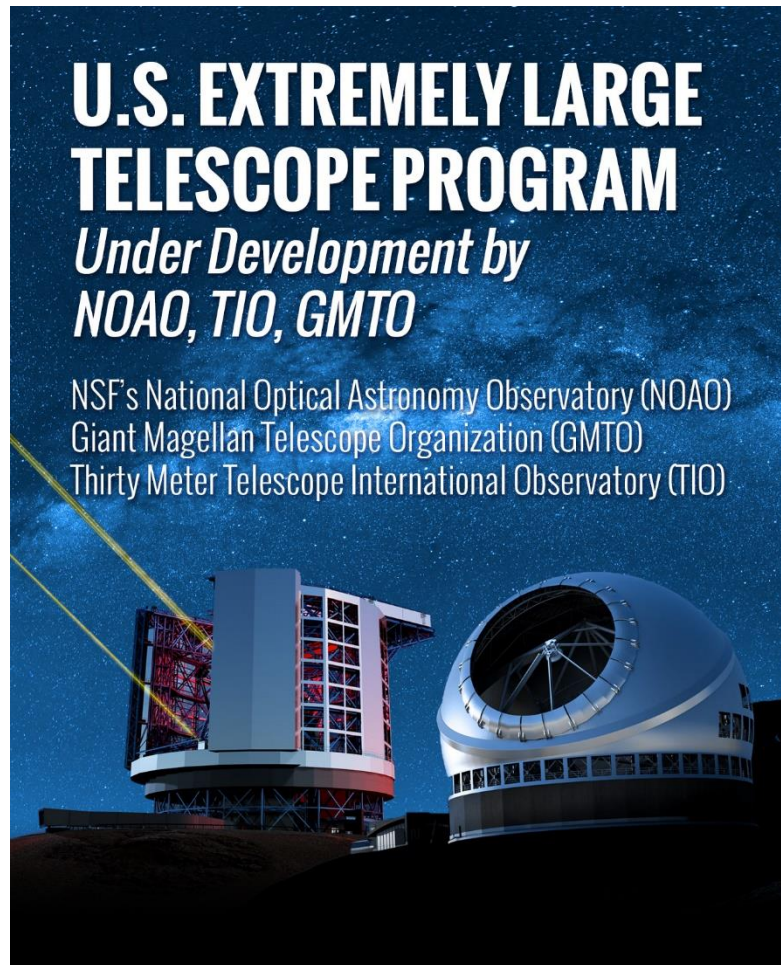
 - Kirby, De Los Reyes (poster)*

 - Progenitors of type Ia by abundance trends of iron-peak elements (Cr, Mn, Co, Ni)

Future prospect

- More information for GA from astrometry (*Gaia*) and seismology (Kepler and TESS)
- Large photometric and spectroscopic surveys
SkyMapper, **PRISTINE**, Subaru/HSC, ...
SDSS, LAMOST, GALAH, **WEAVE**, **4MOST**, **PFS**
- High-resolution spectroscopy for abundance measurements
 - Current telescopes: Keck/HIRES, VLT/UVES, **ESPRESSO**, Subaru/HDS, Maellan/MIKE, ...
 - **Extremely Large Telescopes from 2020s:**
E-ELT(39m), TMT(30m), GMT(24m)

TMT & GMT



TMT Science Forum (Dec. 10-12, 2018)

