

Carbon-enhanced metal-poor star candidates from LAMOST DR4

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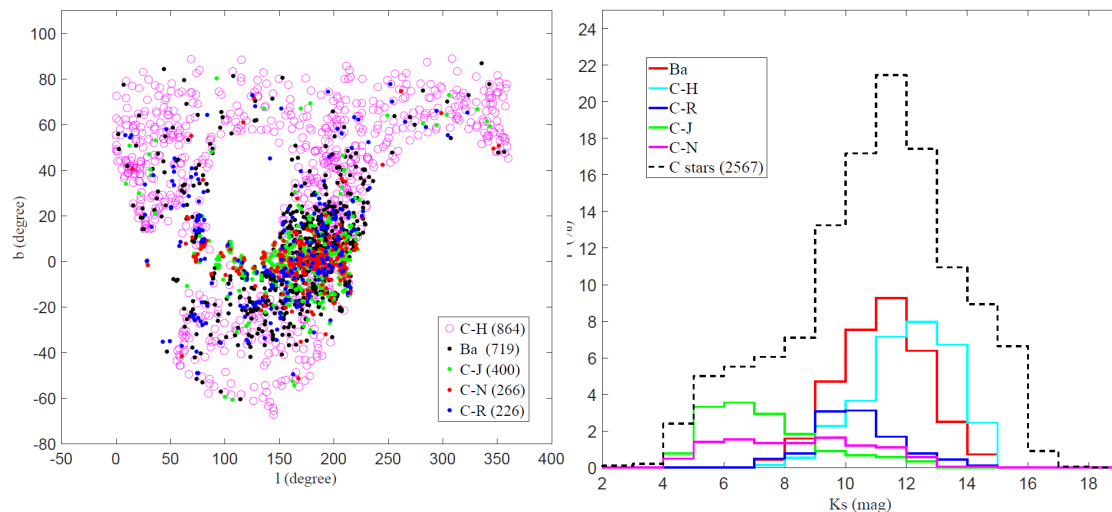
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Outline of the poster

- Carbon stars found in LAMOST DR4
- Classification of Carbon stars in this sample
- Carbon-enhanced Metal-poor star candidates
- Carbon-enhanced Main-sequence Turn off star candidate
- LAMOST Medium Resolution (MR) spectra

Carbon stars in DR4

- Sought out 2651 carbon stars (1415 newly discovered) using a rank-based Bagging TopPush method from 700 million LAMOST DR4 spectra
- In DR5, +800 carbon stars were found out.



Spatial and magnitude distribution of 2651 carbon stars in DR4

Classification of the Carbon Star sample

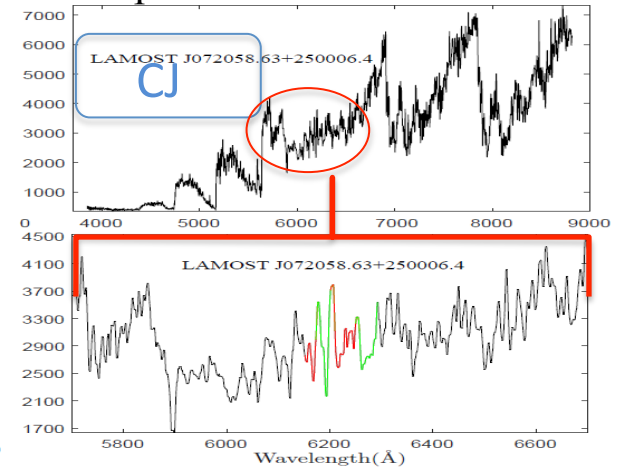
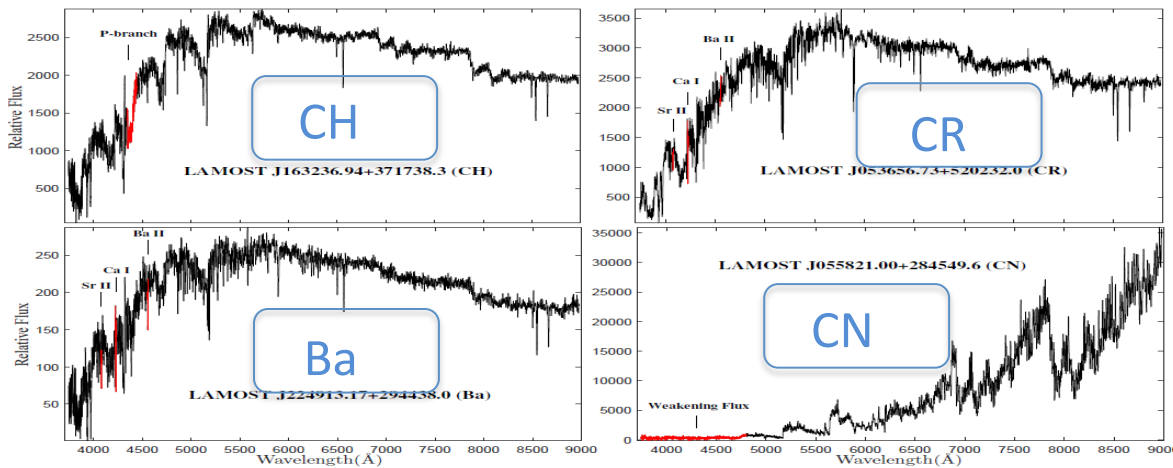
Sub-type	Criteria
C-H	1) Prominence of the secondary P-branch head near 4342 Å; 2) Strong CH band; 3) H β and Ba II at 4554 Å are clearly noticeable; 4) H α and Ba II at 6496 Å are noticeable; 5) Blend feature of Na I D1 and Na I D2 is not distinguishable; 6) Ca I at 4226 Å is marginally noticed.
C-R	1) Strong Ca I at 4226 Å; 2) Na I D1 and Na I D2 blended lines have two distinct dips; 3) Weak H β and Ba II at 4554 Å blended with atomic and molecular lines; 4) Weak H α and Ba II at 6496 Å blended with the CN bands around 6500 Å.
C-N	1) No flux at $\lambda < 4400$ Å; some very late type C-N can be flat even at $\lambda < 5000$ Å; 2) Strong Ba II at 6496 Å; 3) Weak H α and isotopic C bands.
C-J	1) A high isotope ratio of ^{13}C to ^{12}C with j index ≥ 4 .
Ba	1) Strong lines of s-process elements, particularly Ba II at 4554 Å and Sr II at 4077 Å.

Barnbaum et al (1996)

de Castro (2016)

2475 out of 2651 carbon stars are classified as five types: 864 C-H, 226 C-R, 400 C-J, 266 C-N stars, and 719 Barium stars.

176 can not be classified because of poor quality of spectra.



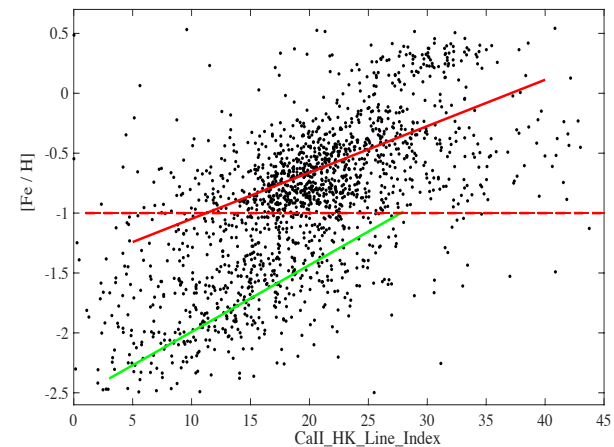
Carbon-enhanced Metal-poor star candidates

- Using the LASP to roughly estimate atmospheric parameters for the sample, and 642 with $[\text{Fe}/\text{H}]$ less than -1.0 , which are possibly CEMP candidates.

$[\text{Fe}/\text{H}]$	N	Barium	C-H	C-R	C-J	C-N	Unknown
$[-1.5, -1.0]$	297	40	222	2	10	0	23
$[-2.0, -1.5]$	249	3	219	2	7	0	18
$[-2.5, -2.0]$	96	0	87	0	2	0	7

- Matching them with APOGEE, 11 targets are obtained. The difference of metallicities between them is about ± 0.2 dex.

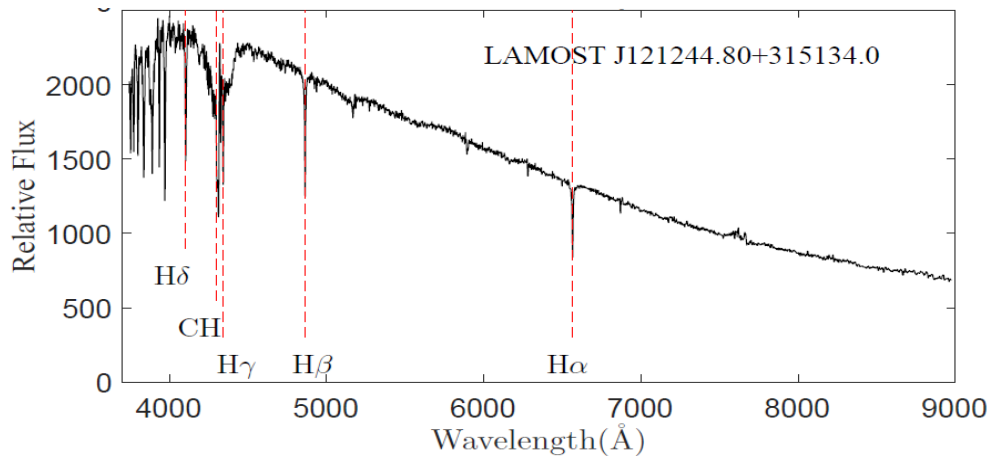
APOGEE-ID	$T_{\text{eff,LASP}}$	$\log g_{\text{LASP}}$	$[\text{Fe}/\text{H}]_{\text{LASP}}$	$T_{\text{eff,APO}}$	$\log g_{\text{APO}}$	$[\text{Fe}/\text{H}]_{\text{APO}}$
2122.2M11062363+4626401	4933	1.99	-1.79	4848	2.27	-1.64
2324.2M11294099+4746533	4925	2.14	-1.62	5145	3.04	-1.43
4481.2M13393889+1836032	4655	1.49	-1.5	4749	2.17	-1.32
4207.2M15162262-0101135	4345	0.68	-1.87	4411	0.88	-1.98
5131.2M16014326+0713580	4891	2.19	-1.31	4641	1.38	-1.84
4447.2M13481626-0049214	4805	1.75	-1.13	4707	1.92	-1.28
4524.2M17345415+3355426	4735	1.47	-2.05	4579	1.09	-1.83
4487.2M11501779+3444310	4704	1.62	-1.54	4822	2.24	-1.4
4451.2M15260048+3521309	4680	1.63	-1.63	4689	1.94	-1.54
4444.2M11031017+1043279	4666	1.24	-1.64	4860	2.16	-1.37
4127.2M12514923+2614333	4757	1.70	-1.64	4666	1.56	-1.61



- To check the relationship between EW of CaII HK lines $\sim [\text{Fe}/\text{H}]$, we fit the relationship for both $[\text{Fe}/\text{H}] > -1$ and $[\text{Fe}/\text{H}] < -1$ respectively.

Carbon-enhanced Main-sequence Turn off star candidates

- In the sample, 17 CEMP with strong Balmer absorption lines and C-H molecular bands are hotter than other types of carbon stars. However, the LASP has not give parameters for them in DR4, so we recur to Lee et al. (2008)'s method to calculate them.

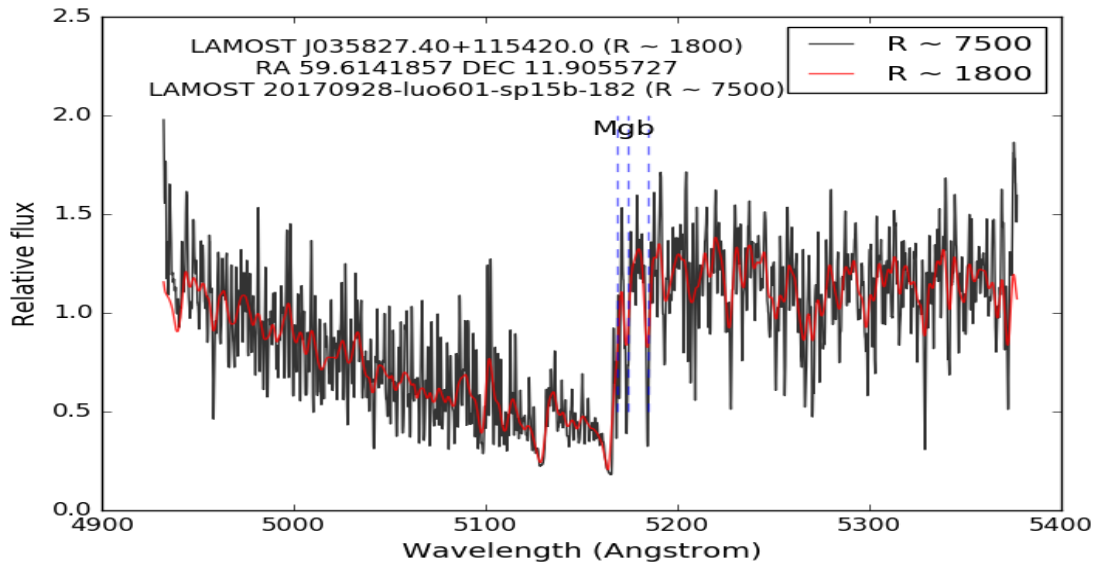
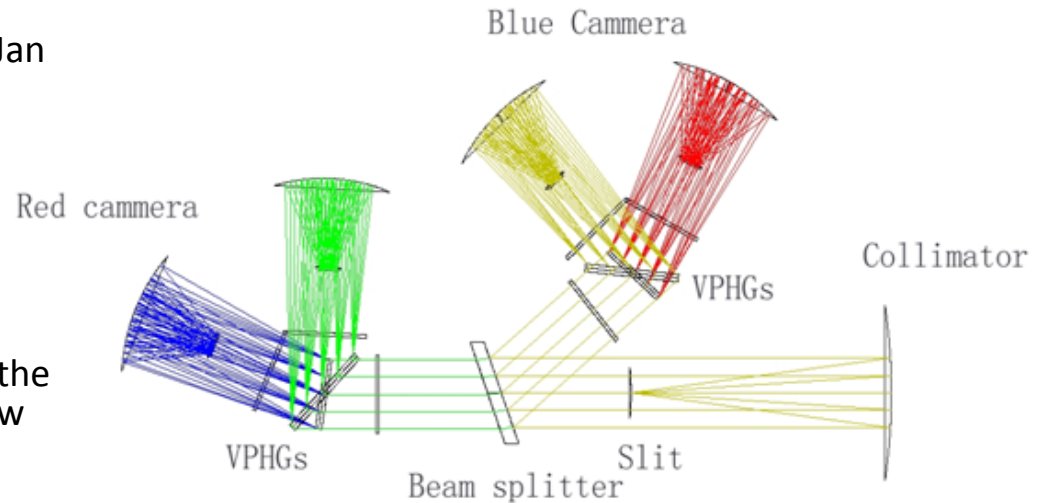


Designation	snr_r (degree)	Teff (degree)	log(g)	[Fe/H] (K)	SpType
CEMP-MSTO1	31	5982±44	3.87±0.07	-2.05±0.07	F2
CEMP-MSTO2	32	5624±41	3.90±0.08	-1.76±0.06	G0
CEMP-MSTO3	31	5858±45	3.90±0.09	-2.04±0.07	F0
CEMP-MSTO4	43	6068±40	4.02±0.06	-2.19±0.06	A7
CEMP-MSTO5	53	6001±36	3.91±0.06	-2.17±0.05	F2
CEMP-MSTO6	40	5847±40	3.74±0.07	-2.24±0.05	F4
CEMP-MSTO7	48	5943±37	4.04±0.05	-1.88±0.05	F0
CEMP-MSTO8	62	5997±41	4.00±0.06	-1.96±0.06	F0
CEMP-MSTO9	25	5831±50	3.73±0.09	-2.14±0.07	F5
CEMP-MSTO10	69	5919±21	3.68±0.04	-2.28±0.03	F5
CEMP-MSTO11	59	5861±25	4.01±0.04	-1.64±0.03	F5
CEMP-MSTO12	100	5866±23	3.92±0.04	-1.34±0.03	F2
CEMP-MSTO13	42	5768±43	3.66±0.08	-2.23±0.06	F5
CEMP-MSTO14	58	5913±34	3.98±0.06	-1.62±0.05	F5
CEMP-MSTO15	23	5698±45	3.31±0.1	-2.42±0.06	G3
CEMP-MSTO16	102	5920±25	3.68±0.04	-2.26±0.03	F2
CEMP-MSTO17	160	5850±22	3.90±0.03	-1.90±0.03	F5

- Teff higher than 5800 K and logg larger than 3.6 dex (except for one) suggests that they are likely located at the main-sequence turn off region on the HR diagram.
- [Fe/H] ranging from -1.6 to -2.4 dex (except for one) implies that these stars are likely to be carbon-enhanced metal-poor main sequence turnoff (CEMSTO) stars as mentioned in Aoki et al. (2008), and need high resolution follow up observation to identify them.

LAMOST Medium Resolution (MR) spectra

- 16 spectrographs will be finished on Jan 2018
(Now 11 finished)
- $R=7500$
- Spectral range
blue: 490-540nm
red: 630-680nm
- The Phase II survey will include both the medium resolution survey and the low resolution survey ($R\sim 1800$).



- Commissioning data has been collected since October.
- Left figure shows a spectrum of C-H carbon star both in the $R\sim 7500$ (black) and $R\sim 1800$ (red)

Thank you!