Stellar Populations as Building Blocks of Galaxies
Proceedings IAU Symposium No. 241, 2006
A. Vazdekis & R. F. Peletier, eds.

doi:10.1017/S1743921307008071

The Frequency of Carbon-Enhanced Metal-Poor Stars Based on SDSS Spectroscopy

B. Marsteller[1]†, T.C. Beers[1], T. Sivarani[1], S. Rossi[2], J. Knapp[3], B. Plez[4] and J. Johnson[5]

[1]Department of Physics and Astronomy, CSCE: Center for the Study of Cosmic Evolution, and JINA: Joint Institute for Nuclear Astrophysics, Michigan State University, East Lansing, MI 48824, USA

[2]Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Departmento de Astronomia, Universidade de São Paulo, Rua do Matão 1226, 05508-900 São Paulo, Brazil

[3]Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544

[4]GRAAL, UMR 5024 CNRS, Université de Montpellier-II, France

[5]Department of Astronomy, Ohio State University, 140 W. 18th Avenue, Columbus, OH 43210

Abstract. The publicly available stellar database from SDSS contains many hundreds of metal-poor stars with large enhancements of carbon. The Galactic extension of SDSS, SEGUE, will identify several thousand more. Many of these Carbon-Enhanced Metal-Poor (CEMP) stars are likely to be enhanced in s-process elements created by AGB companions and dumped to the surviving member of a binary pair through either Roche-Lobe mass transfer or the operation of a stellar wind (CEMP-s stars). Based on previous high-resolution investigation of CEMP stars, an interesting subset of this sample is expected to show little or no s-process enhancement (CEMP-no stars).

Utilizing a novel technique of automatically fitting [Fe/H] and [C/Fe] for a large number of stars from SDSS through spectral synthesis methods, we are able to derive a new estimate of the frequency of CEMP stars as a function of metallicity for the largest sample of stars to date. Using this approach, we can also measure abundances (or limits) for species such as Sr and Ba, which can be used to roughly separate CEMP stars into the CEMP-s and CEMP-no classes.

Keywords. stars: abundances, carbon, chemically peculiar, Galaxy: structure

---

Using a newly developed automated spectral synthesis technique (Marsteller et al, in preparation) on a sample of over 24,000 calibration stars (Stoughton *et al.* 2002) from the Sloan Digital Sky Survey (SDSS) through DR-5, we have determined the fraction of metal-poor stars which are enhanced in their carbon abundances ([C/Fe] $\geqslant +1.0$). Our calculated fractions can be seen in the left panel of Figure 1.

There exists a general trend, in the sense that the fraction of CEMP stars increases with declining metallicity, with the fraction peaking at $\sim$15% for stars with [Fe/H] $\leqslant$ -2.5. The drop in the fraction below this metallicity should be viewed as a scarcity of stars in the sample, rather than as a real drop in the fraction of these stars.

Due to the non-detection of carbon features in our medium-resolution spectra of warm ($T_{\rm eff} \gtrsim 6300$ K) very metal-poor ([Fe/H] $\lesssim$ -2.0) stars, we were unable to estimate a true fraction of CEMP stars; stars that had no determined carbon abundance were automatically included as non-CEMP objects. All listed fractions should thus be considered hard lower limits due to this incompleteness.

† Present address: Michigan State University, East Lansing, Michigan 48824, USA

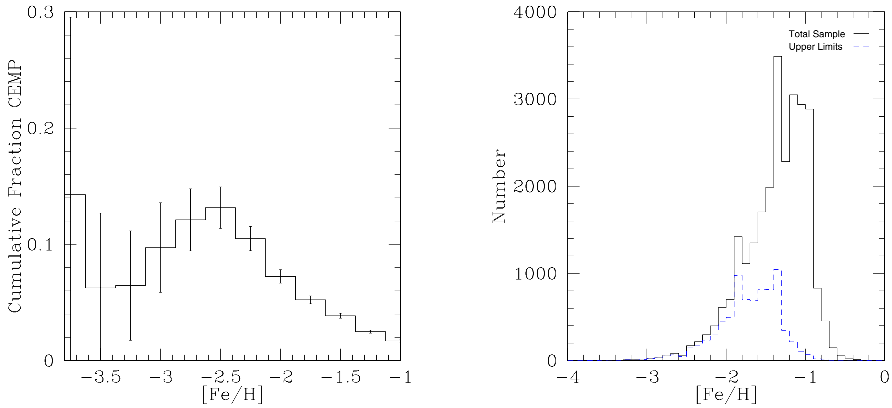

Figure 1. Cumulative fraction of CEMP stars as a function of metallicity (left panel) and metallicity distribution function (right panel) of the full sample (solid line), and for stars with no estimated [C/Fe], due in part to their high temperatures (dashed line). Note the severe incompleteness, especially for [Fe/H] $\lesssim$ -2.0.

This reduction was most severe below [Fe/H] ~ -2.0 (Figure 1, right panel), so even the value of 15% at [Fe/H] $\leqslant -2.5$ is quite high, suggesting a true fraction much larger than this. And although these fractions are consistent with several previous findings (Cohen *et al.*, 2005; Frebel *et al.*, 2006), they in fact more strongly support the larger values reported by Marsteller *et al.*(2005) and Lucatello *et al.*(2006), once the incompleteness has been considered. A more complete discussion of this issue can be found in Marsteller *et al.* (in preparation).

In an attempt to statistically recover some information from the regions of incompleteness, we assume that a similar shape of the high end of the [C/Fe] distribution exists for all ranges of temperature. Even with the incompleteness of this sample, there are strong indications that **at least** 30% of stars with [Fe/H] $= -3.5$ are carbon-enhanced.

While the exact source of this carbon is largely uncertain, several mechanisms have been suggested. It could have been produced by massive primordial stars, through internal production and deep mixing in low-mass stars of extremely low metallicity, or through the transfer of material from an intermediate-mass AGB star to its lower mass-binary companion. By whatever mechanism it originates, our large fractions of CEMP stars at low [Fe/H] suggest that carbon is produced quite prodigiously in the early universe, at least relative to elements such as iron.

Acknowledgements

B.M., T.C.B., and T.S. acknowledge partial support from grant AST 04-06784, as well as from grant PHY 02-16783, Physics Frontier Center/Joint Institute for Nuclear Astrophysics (JINA), awarded by the US National Science Foundation.

References

Cohen, J.G., Shectman, S., Thompson, I., McWilliam, A., Christlieb, N., Melendez, J., Zickgraf, F.-J., Ramirez, S., & Swenson, A. 2005, ApJ, 633, L109

Frebel, A., *et al.* 2006, ApJ, 652, 1585

Lucatello, S., Beers, T. C., Christlieb, N., Barklem, P. S., Rossi, S., Marsteller, B., Sivarani, T., & Lee, Y. S. 2006, ApJ Letters, 652, L37

Marsteller, B., Beers, T.C., Rossi, S., Christlieb, N., Bessell, M., & Rhee, J. 2005, Nuclear Physics A, 758, 312

Stoughton, C., *et al.* 2002, AJ, 123, 485

https://doi.org/10.1017/S1743921307008071 Published online by Cambridge University Press