The General Assembly of Galaxy Halos: Structure, Origin and Evolution
Proceedings IAU Symposium No. 317, 2015
A. Bragaglia, M. Arnaboldi, M. Rejkuba & D. Romano, eds.

doi:10.1017/S1743921315006808

Clues on the first stars from CEMP-no stars

Arthur Choplin[1], Georges Meynet[1], André Maeder[1], Raphael Hirschi[2], Sylvia Ekström[1] and Cristina Chiappini[3]

[1]Geneva Observatory, Geneva University,
CH–1290 Sauverny, Switzerland
email: arthur.choplin@unige.ch
[2]Astrophysics group, Keele University,
Lennard-Jones Lab., Keele, ST5 5BG, UK
[3]Leibniz-Institut fuer Astrophysik,
An der Sternwarte 16, 14482 Potsdam, Germany

Abstract. The material used to form the CEMP-no stars presents signatures of processing by the CNO cycle and by He-burning from a previous stellar generation called spinstars. We compare the composition of the ejecta (wind + supernova) of a spinstar model to observed abundances of CEMP-no stars. We show that observed abundances as well as the isotope ratio $^{12}C/^{13}C$ may be reproduced by the spinstar ejecta if we assume different mass cuts when adding the supernova material to the wind ejecta.

Keywords. stars: evolution, rotation, massive, abundances, nucleosynthesis, chemically peculiar

1. Introduction

CEMP-no stars (Carbon Enhanced Metal Poor stars with no signature of s or r processes) are chemically peculiar objects that dominate the stellar populations at [Fe/H] < -3 (Aoki *et al.* 2010, Norris *et al.* 2013). The "spinstar scenario" (Meynet *et al.* 2010), suggests that CEMP-no stars formed in a region previously enriched by a fast rotating, low metallicity, massive star, experiencing mixing, mass loss and eventually a supernova at the end of its life.

We discuss a 32 $M_\odot$ spinstar model computed with the Geneva code. Absolute amounts of C, N, O, F, Ne, Na, Mg, Al as well as isotope ratios $^{12}C/^{13}C$, $^{24}Mg/^{25}Mg$ and $^{24}Mg/^{26}Mg$ in the ejecta are compared to observed CEMP-no abundances.

2. Results

Fig.1 shows the [X/H] ratios (left panel) and 3 isotope ratios (right panel). The grey line is the initial composition of the model which is a modified α-enhanced mixture (α-mod) : initial abundances of α-elements are enhanced and [C/N], [O/N] and $^{12}C/^{13}C$ ratios are set to 2, 1.6 and 30, according to suggestions of Maeder *et al.* (2014) for [C/N] and [O/N] and to prediction of galactic chemical evolution models at low metallicity of Chiappini *et al.* (2008) for $^{12}C/^{13}C$. The black lines are patterns in the ejecta when considering either the wind only, or the wind plus supernova obtained for various M_{cut}, M_{cut} being the mass coordinate inside the star delimiting the expelled part from the part which is kept into the remnant.

The effects of the CNO cycle and the Ne-Na Mg-Al chains are visible in every pattern (except in the $M_{cut} = 10 M_\odot$ one). When the CNO cycle operates, ^{12}C and ^{16}O are transformed into ^{14}N and ^{13}C during the evolution, explaining the higher [N/H] ratios compared to [C/H] and [O/H]. $^{12}C/^{13}C$ ratios are close to the CNO equilibrium value

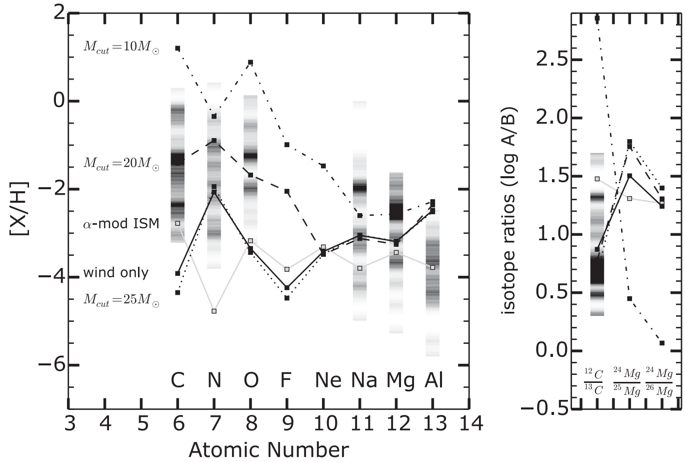

Figure 1. Predicted and observed [X/H] ratios (left) and isotope ratios ^{12}C/^{13}C, ^{24}Mg/^{25}Mg and ^{24}Mg/^{26}Mg (right). Density map of observed CEMP-no are represented by rectangles colored from white (no CEMP-no at this value) to black. Black lines are predicted patterns in the ejecta considered : wind only (full line), wind + supernova with $M_{cut} = 25$ (dotted), 20 (dashed) and 10 $M_\odot$ (dot-dashed). The grey line corresponds to the initial composition of the spinstar.

(log(^{12}C/^{13}C) $\sim$ 0.7), showing also that the major part of those ejecta was processed by the CNO cycle. Also some Ne and Mg were transformed into ^{23}Na and ^{27}Al owing to the Ne-Na Mg-Al chains so that [Na/H] > [Ne/H] and [Al/H] > [Mg/H] in the final ejecta.

About 2 $M_\odot$ of the He-burning shell was ejected in the fourth case ($M_{cut} = 10M_\odot$). The associated pattern bears indeed the signature of He-burning : [C/H], [O/H] and ^{12}C/^{13}C are several dex higher than previous patterns. It is worthwhile to remark that ^{12}C/^{13}C is a relevant isotope ratio to constrain M_{cut} : if too deep layers are expelled, part of the He-burning region is expelled and ^{12}C/^{13}C increases a lot, lying clearly outside of the observed values. Interesting also is the [Ne/H] ratio which have raised by $\sim$ 2 dex. This is due to the reaction ^{16}O(α,γ)^{20}Ne and to the destruction of ^{14}N in the He-core through ^{14}N(α,γ)^{18}F(,$e^+\nu_e$)^{18}O(α,γ)^{22}Ne. Isotopes ratios ^{24}Mg/^{25}Mg and ^{24}Mg/^{26}Mg are lowered by $\sim$ 1 dex in this case because of the synthesis of ^{25}Mg and ^{26}Mg through ^{22}Ne(α,n)^{25}Mg and ^{22}Ne(α,γ)^{26}Mg in the He-core.

The models can explain large parts of the observed scatter in [X/H] and ^{12}C/^{13}C ratios, except for [Al/H], which is always overestimated by at least 1 dex. Since [Al/H] ~ -3.8 in the ISM, dilution of the ejecta with the initial ISM would allow [Al/H] values of -3.8 at best, but not lower, where more than half of the observed CEMP-no are lying. Aluminum surproduction is the biggest discrepancy between models and observations and should be investigated in a future work.

References

Aoki, W. 2010, *Carbon-Enhanced Metal-Poor (CEMP) stars*, Proc. IAU Symposium No. 265, p. 111

Norris, J. E., Yong, D., Bessell, M. S., *et al.* 2013, *ApJ*, 762, 28

Meynet, G., Hirschi, R., Ekstrom, S., *et al.* 2010, *A&A*, 521, A30

Maeder, A., & Meynet, G. and Chiappini, C. 2014, *A&A*, 576, A56

Chiappini, C., Ekström, S., Meynet, G., *et al.* 2008, *A&A* (Letters) 479, L9-L12

https://doi.org/10.1017/S1743921315006808 Published online by Cambridge University Press