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S-process in low-mass extremely metal-poor stars

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Abstract. We present post-processing s-process calculations for the core He-flash of a $1M_\odot$ star with and $Z = 10^{-8}$. Our model shows neutron densities larger than $10^{14}cm^{-3}$, resulting in the production of s-process elements. The model reproduces the C, O, Sr, and Ba abundances of the star hyper metal-poor star HE0107-5240 within a factor of 4.

1. INTRODUCTION

Extremely metal-poor (EMP) stars experience mixing of protons into helium-rich layers during the core He-flash or the early TP-AGB phases (proton ingestion episode, PIE), resulting in the occurrence of a secondary flash: the hydrogen flash. Stars with mass $M < 1.2M_\odot$ experience PIE during the core He-flash. The violent ignition of helium burning gives rise to a convective zone, the so called helium convective zone (HeCZ), that expands in mass until it reaches H-rich layers and protons are dredge-down. Protons are, then, captured by ^{12}C producing ^{13}C, through the reaction chain $^{12}C(p,\gamma)^{13}N(\beta)^{13}C$. Subsequently, neutrons might be released by α captures on ^{13}C. Proton ingestion continues until a second flash happens (the H-flash) and the convective zone splits into two at the position of maximum energy release by hydrogen burning. The upper convective zone expands, eventually reaching and merging with the bottom of the envelope. This leads to surface enrichment in H-burning products and might lead to enrichment in s-process elements.

Here we investigate the PIE during the core He-flash as the possible origin for the composition of the matter that later polluted the surface of the hyper metal-poor star HE0107-5240. To this aim, we perform s-process calculations during the core He- flash of a $1M_\odot$ model with $Z = 10^{-8}$.

2. METHOD

We used the Garching Stellar Evolution Code, GARSTEC [4], to perform core He-flash calculations. The code was modified in order to include the isotopes involved in the NeNa and MgAl chains and to include a neutron sink to allow for nucleosynthesis post-processing calculations. S-process was calculated in a post-processing unit that includes 580 isotopes (starting from ^{30}Si) and more than 1000 reactions. All the important branching points were included and the network terminates with the α decays in the Po isotopes.

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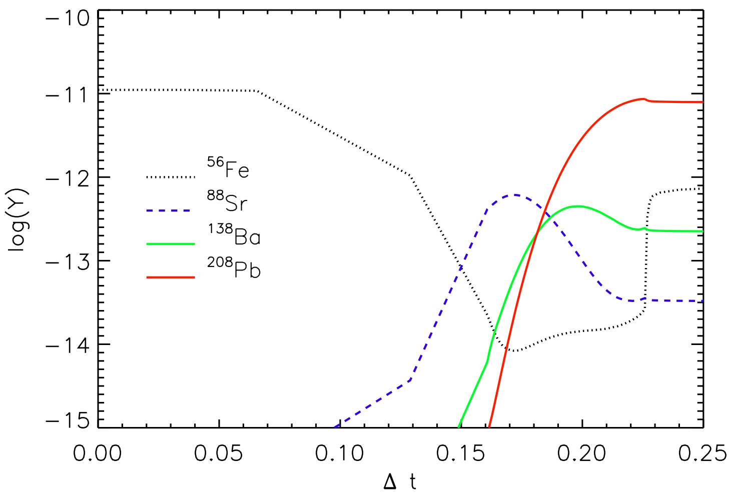

Figure 1. Evolution of the abundances of isotopes ^{56}Fe, ^{88}Sr, ^{138}Ba, and ^{208}Pb. Time is given in years and starts at the beginning of the PIE. These abundances were sampled at the position 0.4 $M_{\odot}$ and is representative of the entire convective zone.

Table 1. [X/Fe].

Element	Surface	Diluted	Observed (HE0107-5240)
C	6.49	3.70	3.70
O	5.39	2.37	2.30
Sr	1.67	-0.82	-0.52
Ba	3.37	0.29	0.82

3. RESULTS

^{13}C produces neutrons through the reaction ^{13}C(a, n)^{16}O during the PIE. The neutron density reaches values larger than 10^{14}cm^{-3} near the bottom of the HeCZ. This leads to the production of s-process elements as shown in Figure 1, which is qualitatively in agreement with recent core He-flash calculations by [1]. Our model surface s-process abundances (Table 1) are more than 2 dex smaller than those derived by [1], due to the different time history of the neutron density combined with a larger convective region. The discrepancy between these models probably reflects the uncertainties in modeling the PIE. Recent 3D simulations of PIE during the AGB phase [3] have shown that the convection prescription used in 1D models might not give an accurate picture of the phenomena. For instance, the intershell in the 3D calculations are richer in protons than those using 1D stellar evolution codes.

From the viewpoint of the binary scenario, where the abundance patterns observed in EMP stars are the result of mass-tranfer from an evolved companion, our models could reproduce the abundance of C, O, Sr and Ba within a factor of 4 for the hyper metal- poor star HE0107-5240 [2], assuming that dilution of the transferred material occurs in the HE0107-5240 envelope.

References

[1] Campbell, S. W. and Lugaro, M. and Karakas, A. I., A&A **522**, (2010) 6-9

[2] Christlieb, N. and Gustafsson, B. and Korn, A. J. and Barklem, P. S. and Beers, T. C. and Bessell, M. S. and Karlsson, T. and Mizuno-Wiedner, M. ApJ **603**, (2004) 708

[3] Stancliffe, R. J. and Dearborn, D. P. and Lattanzio, J. and Heap, S. A. and Campbell, S. W, ApJ (2011) in press, (arXiv1109.1289S)

[4] Weiss, A. and Schlattl, H., Ap&SS **623**, (2008) 99-106