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The nature of *s*-process nucleosynthesis in low mass AGB stars based on individual Barium star observations

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Abstract.

Barium stars are now primaries in a binary system with a former asymptotic giant branch (AGB) star. Here we compare some available AGB nucleosynthesis models and the observed *s*-process abundances of individual Ba star measurements to constrain the nature of the *s*-process in low mass AGB stars. After correcting the models with a dilution factor calculated for [Ce/Fe], we found that some of the sample stars show higher abundances for light *s*-process elements than the model predictions. This might be attributed to diffusive mixing in the stars.

Keywords: stars: abundances, stars: AGB and post-AGB, nuclear reactions, nucleosynthesis, abundances

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s-process based on individual Ba stars**1. Introduction**

Barium (Ba) stars are the higher metallicity counterparts of carbon enhanced metal-poor (CEMP) stars. They are in a binary system where a former asymptotic giant branch (AGB) star (now evolved to a white dwarf) contaminated the companion with *s*-process elements enhanced material. This companion is now observed as a giant or dwarf star with spectral class from G to K with overabundance of *s*-process elements and is called a Ba star [1].

The elements of the first (Sr, Y, Zr) and the second (Ba, La, Ce, Nd, Sm) *s*-process peak are widely used in the literature to determine the properties of the slow neutron capture process. By comparing some of the available AGB nucleosynthesis models and the observed *s*-process abundances of individual Ba star measurements we can constrain the nature of the *s*-process in low mass AGB stars.

2. Sample stars and abundances

Here we use the abundances from the available largest, self-consistent sample of 169 giant Ba stars [2]. The metallicity range of the sample is between -0.6 and solar. Based on high resolution spectra the abundances for the *s*-process elements Y, Zr, La, Ce and Nd were determined. In this sample a star is considered as a Ba star if $[s/\text{Fe}] \geq 0.25$ (where $s = \text{Y} + \text{Zr} + \text{La} + \text{Ce} + \text{Nd}$). We follow the same criteria for the AGB models, only models with $[s/\text{Fe}] \geq 0.25$ were taken into account in the comparison. However, we have to note, that the presented $[\text{La}/\text{Fe}]$ abundances might be overestimated due to the saturation of the lines in some of the sample stars [3].

3. Results

Masses for 28 Ba stars out of our sample were estimated by [4] and we have started a project to compare to the stellar models individually. Here we show a comparison of AGB models and the available *s*-process element abundances from [2] for 4 individual stars. Dilution factors were calculated for each model to match the $[\text{Ce}/\text{Fe}]$ ratio of the observations, since this element shows the lowest errorbar among the available *s*-process elements in our dataset. The difference between the normalised and the original models is given as δ for each of the models (Equation (1)). The masses and metallicities of the models are the closest to the estimated mass and metallicity of each Ba star (figure 1).

$$\delta = \frac{10^{[\text{Ce}/\text{Fe}]_{\text{deC}} - 1}}{10^{[\text{Ce}/\text{Fe}]_{\text{model}} - 1}} \quad (1)$$

Interestingly, for the two lowest mass stars (bottom panels) the light *s*-element abundances are higher than predicted, which requires somewhat lower neutron exposures (potentially due to diffusive mixing, see [5]). We note that the mass of the primary AGB star must have been higher than the mass of the observed secondary Ba star, however

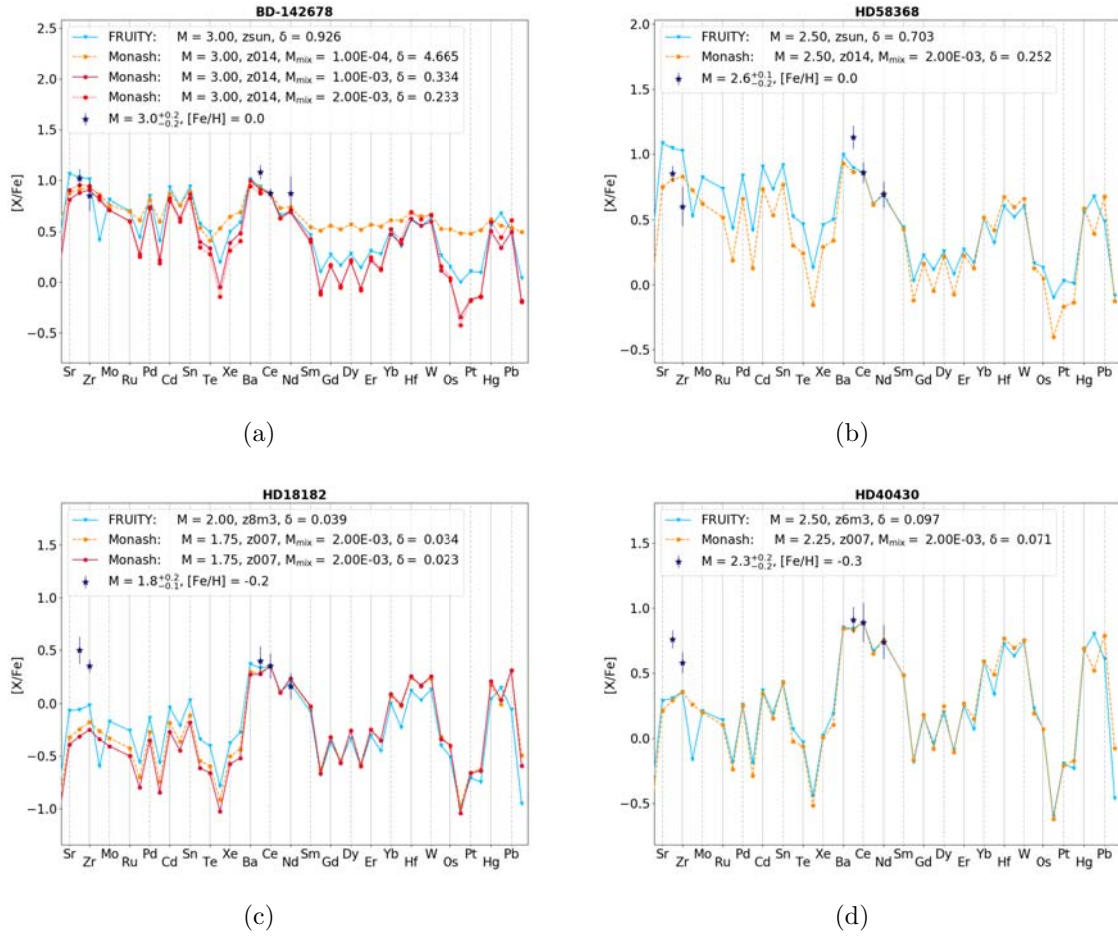
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Figure 1. Measured *s*-process abundances for 4 Ba stars and final surface abundances of different nonrotating AGB models with the closest mass and metallicity. FRUITY stands for models from [6], while Monash label indicates the models from [7], where M_{mix} indicates the mass (in solar masses) of the partial mixing zone leading to the formation of the ^{13}C neutron source. δ (Equation (1)) means the dilution factor applied to the original models to match the model $[\text{Ce}/\text{Fe}]$ values to the observed abundances. The estimated mass and metallicity of the Ba star is given from [4]. Note that the La abundances may be overestimated due to the saturation of the lines [3].

observationally the masses of stars in these binary systems are relatively close (see figure 14 in [4]).

4. Future work

We will further investigate the dilution due to mass transfer and its implication in relation to each individual binary system in our study. [4] also derived initial AGB masses for each system studied here, hence we can compare the Ba star abundances with the appropriate mass AGB models, instead using the models with the closest mass to the Ba star. Additionally the point of diffusive mixing needs to be further investigated

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in relation to these objects. With the derivation of Rb, Sr and Nb abundances (in progress) we will be able to set more constraints on individual Ba stars and on the nucleosynthetic processes in low mass AGBs.

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