Why Galaxies Care About AGB Stars:
A Continuing Challenge through Cosmic Time
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Carbon and oxygen isotopes in AGB stars. From the cores of AGB stars to presolar dust

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Abstract. Isotopic ratios are a powerful tool for gaining insights into stellar evolution and nucleosynthesis. The isotopic ratios of the key elements carbon and oxygen are perfectly suited to investigate the pristine composition of red giants, the conditions in their interiors, and the mixing in their extended atmospheres. Of course the dust ejected from red giants in their final evolution also contains isotopically tagged material. This red giant dust is present in the solar system as presolar dust grains. We have measured isotopic ratios of carbon and oxygen in spectra from a large sample of AGB stars including both Miras and semiregular variables. We show how the derived ratios compare with expectations from stellar models and with measurements in presolar grains. Comparison of isotopes that are affected by different types of nucleosynthesis provides insights into galactic evolution.

Keywords. stars: abundances, stars: evolution, stars: AGB and post-AGB

1. Introduction

The surface carbon and oxygen isotopic ratios found in AGB stars are modified by nucleosynthesis and mixing processes in the stellar interior over the lifetime of the star. A network of processes during H- and He-burning lead to phases of enrichment and depletion of ^{12}C, ^{13}C, ^{17}O, and ^{18}O. The ashes of these fundamental nucleosynthesis processes can appear at the surface as a consequence of a deep mixing.

We present the continuation of a work obtaining the above mentioned isotopic abundances in long period variables (LPVs). Results on Miras and SRa have been published elsewhere (Hinkle *et al.* 2016). There we show that it is possible to estimate the initial masses of LPVs due to the sensitivity of oxygen and carbon isotopic ratios on stellar mass. Here we report on measurements of isotopic ratios for the smaller amplitude cousins of these variables, namely a sample of SRbs. The observational material for this project is drawn entirely from the archives of the Kitt Peak National Observatory (KPNO) 4m Mayall Telescope Fourier Transform Spectrometer (FTS). Isotopic ratios have been determined using a differential curve-of-growth technique described in detail in Hinkle *et al.* 2016.

2. Results

Preliminary results are shown in Fig. 1. Our sample consists of 35 M-type stars, 9 S-type stars and 3 C-type stars. A large fraction of SRb stars shows a carbon isotopic

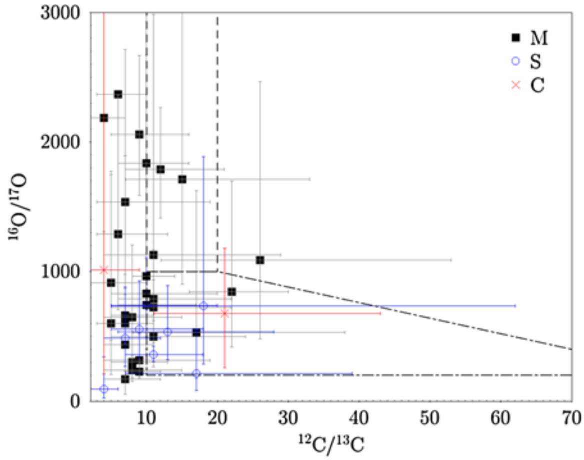

Figure 1. Carbon versus oxygen isotopic ratio measurements for our sample of SRb variables. M-stars are marked by filled squares, S-stars by open circles, and C-stars by crosses. Error bars give the maximum possible range for the respective isotopic ratios. Dashed lines mark the area of model predicted ratios for stars with $M \leqslant 1.5\ M_\odot$, while the dashed dotted lines indicate the range for $1.5M_\odot < M < 3\ M_\odot$.

ratio below 10, while only very few Mira/SRa stars are found in that range. In contrast, only very few SRbs show $^{12}C/^{13}C$ values above 20. Such low values indicate an FDU composition without significant third dredge up changes. $^{12}C/^{13}C < 10$ implies extra-mixing on the RGB with $T_{max} = 23 - 24$ MK. Exposing the material to such temperatures should lead to a depletion of ^{18}O, and indeed we observe this effect in our data.

Their location in a $^{16}O/^{17}O$ vs. $^{12}C/^{13}C$ diagram suggests, by comparison with stellar evolution models (Hinkle *et al.* 2016), typical masses of M-type SRbs of 1.5 $M_\odot$ and below. All C- and S-type stars in our sample of SRbs show masses $> 1.5\ M_\odot$. There is no obvious distinction between intrinsic and extrinsic S-stars.

The isotopic composition measured in AGB stars will also go into the dust grains formed in the circumstellar environment of these objects. We can thus compare the isotopic ratios found in stars with the ratios in presolar dust grains found in meteorites (e.g. Nittler *et al.* 2008). In our previous paper, we made a comparison with the values for Miras and SRa and found an offset towards higher $^{18}O/^{16}O$ values relative to the solar value and the bulk of the presolar grains, which is likely due to galactic evolution. For SRbs, this offset is not seen suggesting an on average higher age of SRbs compared to SRas and Miras as is also indicated by the somewhat lower mass estimates from the $^{16}O/^{17}O$ ratios.

References

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