Why Galaxies Care About AGB Stars:
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On the circumstellar effects on the Li and Ca abundances in massive Galactic O-rich AGB stars

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Abstract. We explore the circumstellar effects on the Li and Ca abundances determination in a complete sample of massive Galactic AGB stars. The Li abundance is an indicator of the hot bottom burning (HBB) activation, while the total Ca abundance could be affected by overproduction of the short-lived radionuclide ^{41}Ca by the *s*-process. Li abundances were previously studied with hydrostatic models, while Ca abundances are determined here for the first time. The pseudo-dynamical abundances of Li and Ca are very similar to the hydrostatic ones, indicating that circumstellar effects are almost negligible. The new Li abundances confirm the (super-)Li-rich character of the sample Li-detected stars, supporting the HBB activation in massive Galactic AGB stars. Most sample stars display nearly solar Ca abundances that are consistent with predictions from the s-process nucleosynthesis models. A minority of the sample stars show a significant Ca depletion. Possible reasons for their (unexpected) low Ca content are given.

Keywords. stars, AGB, abundances, evolution, reactions, nucleosynthesis, atmospheres, late-type.

1. Observational data and models

We have used high-resolution (R $\sim$ 50,000) optical echelle spectra for the sample of massive Galactic AGB stars by García-Hernández *et al.* (2006, 2007) and the spectra of the super Li-rich AGBs reported by García-Hernández *et al.* (2013). By using a modified version of the spectral synthesis code Turbospectrum, we have obtained the Li and Ca abundances (from the 6708 Å Li I and 6463 Å resonance lines, respectively), applying new pseudo-dynamical model atmospheres developed by us (Zamora *et al.* 2014; Pérez-Mesa *et al.* 2017).

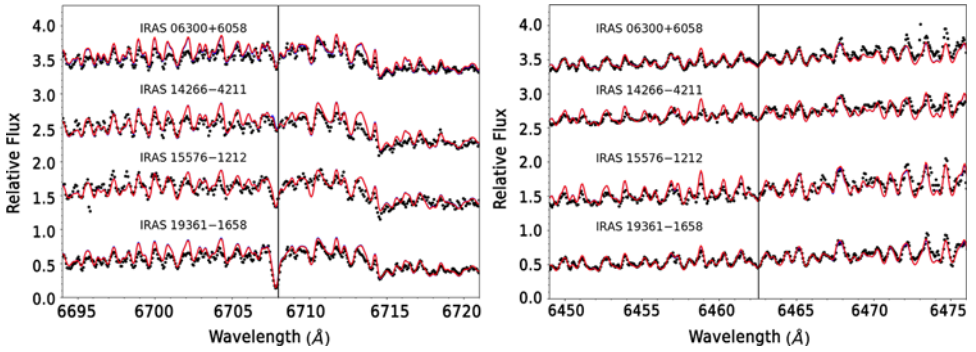

Figure 1. The Li I 6708 Å (*left*) and Ca I 6463 Å (*right*) spectral regions in four massive Galactic AGB stars. The pseudo-dynamical models (red lines) that best fit the observations (black dots) are shown. Note that the best hydrostatic models (blue lines) are indistinguishable.

2. Lithium

The new Li abundances derived from our pseudo-dynamical models are very similar (typically within 0.1 dex) to those obtained with the hydrostatic ones. Fig. 1 displays examples of the observed spectra and the best synthetic fits from hydrostatic and pseudo-dynamical models in the spectral region around Li I 6708 Å.

The new Li abundances obtained from extended atmosphere models confirm the Li-rich (and super Li-rich, in some cases) character of the sample stars with detected Li I lines, supporting strong activation of the HBB process in massive Galactic AGB stars. This is in good agreement with theoretical predictions for solar metallicity massive AGBs from nucleosynthesis models such as ATON (Ventura & D'Antona 2009), Monash (Karakas & Lugaro 2016) and NuGrid/MESA (Pignatari *et al.* 2016), but at odds with the FRUITY database (Cristallo *et al.* 2015) which predicts no Li production by HBB in such stars.

3. Calcium

The new pseudo-dynamical Ca abundances are identical to the hydrostatic ones (see Fig. 1). Most sample stars display nearly solar (within the estimated errors or considering possible NLTE effects) Ca abundances that are consistent with the available *s*-process nucleosynthesis models for solar metallicity massive AGB stars (e.g., Karakas & Lugaro 2016, Pignatari *et al.* 2016) which predict an important ^{41}Ca production but no change in the total Ca abundance. A minority of the sample stars seem to show, however, a significant Ca depletion (by $\sim$ -1.0 dex). Possible reasons to explain their apparent and unexpected Ca depletion are missed opacities in the stellar atmosphere models or Ca depletion into dust (see Pérez-Mesa *et al.* 2018 for more details).

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