Why Galaxies Care About AGB Stars: A Continuing Challenge through Cosmic Time
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Mass loss rates of Li-rich AGB/RGB stars

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Abstract. A sample of AGB/RGB stars with an excess of Li abundances is considered in order to estimate their mass loss rates. Our method is based on a correlation between the Li abundances and the stellar luminosity, using a modified version of the Reimers formula. We have adopted a calibration based on an empirical correlation between the mass loss rate and stellar parameters. We conclude that most Li-rich stars have lower mass loss rates compared with the majority of AGB/RGB stars, which show no evidences of Li enhancements, so that the Li enrichment process is probably not associated with an increased mass loss rate.

Keywords. stars: abundances, stars: mass loss, stars: AGB and post-AGB

1. Introduction

Several AGB/RGB stars present some Li enrichment, characterized by abundances $\epsilon(\mathrm{Li}) = \log(\mathrm{Li/H}) + 12 > 1.5$. Li enrichment has sometimes been associated with enhanced mass loss rates, and some Li-rich giants show evidences of mass loss and chromospheric activity. However, there are also suggestions in the literature that no important mass loss phenomena are associated with these stars. In this work, we estimate the mass loss rates of a sample of Li-rich AGB/RGB stars based on a correlation between the Li abundance and the stellar luminosity. We use a modified Reimers formula calibrated by an independently derived empirical correlation between the mass loss rate and stellar parameters. As a result, we estimate the mass loss rates of a large sample of AGB/RGB stars with well determined Li enhancements.

2. Determination of mass loss rates

We have adopted a sample containing 159 Li-rich stars for which reliable determinations are available for the Li abundances as well of some stellar parameters, such as the effective temperature T_{eff} and gravity $\log g$. For details, see Maciel & Costa (2016) and Maciel & Costa (2018). The full table containing the data and results can be retrieved from http://www.astro.iag.usp.br/∼maciel/research/research.html. In the adopted correlation between the Li abundances and the stellar luminosity, the lithium enhancements show some dispersion for each selected luminosity, since for some stars Li may have been more strongly destroyed than for others. However, there is an upper envelope suggesting that the maximum Li enrichment increases with the stellar luminosity. Choosing the maximum contribution at each bin as representative of the Li enhancement process, and adopting 9 luminosity bins, we are able to derive a polynomial fit to the maximum abundance at each luminosity bin. From this relation, the luminosity can be obtained. Since the observed Li abundance may have any value lower or equal to the maximum value, the corresponding luminosity is generally a lower limit. The mass loss rates ($M_\odot$/yr) are obtained with a modified version of the Reimers formula given by

$$\frac{dM}{dt} = 4 \times 10^{-13}\, \eta\, \frac{(L/L_\odot)\,(R/R_\odot)}{(M/M_\odot)}. \tag{1}$$

The η parameter is taken as a free parameter, to be determined on the basis of an adequate calibration. The adopted procedure is as follows: from the Li abundance, we estimate the luminosity using the obtained fit. From the luminosity and the effective temperature, the stellar mass can be estimated from recent detailed evolutionary tracks for giant stars; using the stellar gravity, the radius can be obtained. We have calibrated the Reimers formula using an empirical formula derived by van Loon *et al.* (2005), which is based on the modelling of the spectral energy distributions of a sample of red giants in the Large Magellanic Cloud. The formula can be written as

$$\log \frac{dM}{dt} = \alpha + \beta \ \log\left(\frac{L}{10000\, L_\odot}\right) + \gamma \ \log\left(\frac{T_{\rm eff}}{3500\,{\rm K}}\right), \tag{2}$$

where the mass loss rates are given in $M_\odot$/yr, and the constants are $\alpha = -5.64 \pm 0.15$, $\beta = 1.05 \pm 0.14$ and $\gamma = -6.3 \pm 1.2$. This corresponds to an approximately linear logarithmic relation between the mass loss rate and the stellar luminosity, in agreement with predictions from dust radiative driven winds.

3. Results and discussion

Adopting the polynomial fit with luminosities derived from the $L(\epsilon)$ correlation, we derive the distribution of the mass loss rates of the sample stars. The same is done using Eq. (2.1), which is calibrated to get the same distribution from Eq. (2.2). We derive the best fit parameter, finding $\eta = 5.7$. The derived mass loss rates as a function of the luminosity for our stellar sample are then essentially the same both for the modified Reimers formula and the rates obtained by the empirical formula by van Loon.

There are many reliable determinations in the literature of the luminosities and mass loss rates of AGB/RGB stars with no evidences of Li enhancements. As an example, we have taken into account data from Gullieuszik *et al.* (2012), Groenewegen *et al.* (2009), and Groenewegen & Sloan (2018), selecting O-rich objects. We find that most of these objects have higher luminosities and mass loss rates compared with the Li-rich stars, with very few exceptions. It can then be concluded that the Li-rich objects are generally associated with mass loss rates much lower than in the case of the majority of AGB/RGB stars, which are Li-poor objects. In other words, Li enhancements seem to be a low-luminosity feature associated with lower mass loss rates compared with the majority of these stars.

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References

Groenewegen, M. A. T., Sloan, G. C., Soszyński, I., Peterson, E. A. 2009, *A&A*, 506, 1277

Groenewegen, M. A. T., & Sloan, G. C. 2018, *A&A*, 609, A114

Gullieuszik, M., Groenewegen, M. A. T., Cioni, M. R. L., *et al.* 2012, *A&A*, 537, A105

Maciel, W. J., & Costa, R. D. D. 2016, In: G. A. Feiden (ed.), *The 19th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun*, Zenodo. http://doi.org/10.5281/zenodo.59278

Maciel, W. J., & Costa, R. D. D. 2018, *AN*, 339, 168

van Loon, J. Th., Cioni, M. R. L., Zijlstra, A. A., Loup, C. 2005, *A&A*, 438, 273