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Mass loss rates of Li-rich AGB/RGB stars: Data from the LAMOST survey

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Abstract. Li-rich AGB/RGB stars have poorly known mass loss rates, in contrast with their Li-poor counterparts for which the rates are well determined. In our previous work, we have used GAIA data and applied two different methods to estimate the mass loss rate of a sample of about 150 Li-rich giants. We concluded that their mass loss rates and luminosities are usually much lower than in the case of the majority of Li-poor objects, so that the Li enhancements are probably not related to increased mass loss rates from these stars. Recently, the LAMOST survey has dramatically increased the number of known Li-rich stars, reaching over two thousand objects. In the present work, we have applied our methods to obtain estimates of the mass loss rates of these stars, which could be successfuly accomplished for over 1400 objects from the catalogue. We have compared their mass loss rates with those of Li-poor stars and confirmed our previous conclusions in the sense that Li-rich stars have lower rates and luminosities compared with Li-poor objects. Moreover, the increased sample indicated a much better correlation of the mass loss rates with the stellar luminosities, stressing the effect of the stellar radiation pressure as the origin of the winds in these stars.

Resumo. As taxas de perda de massa das estrelas AGB/RGB ricas em Li não são bem conhecidas, em contraste com as estrelas pobres em Li. Em trabalhos anteriores, usamos dados do GAIA e aplicamos dois métodos diferentes para estimar a taxa de perda de massa de uma amostra com cerca de 150 estrelas ricas em Li. Concluimos que suas taxas e luminosidades são geralmente muito mais baixas do que no caso dos objetos pobres em Li, de modo que o excesso de Li não está provavelmente relacionado com uma maior taxa de perda de massa. Recentemente, o levantamento LAMOST aumentou dramaticamente o número de estrelas ricas em Li conhecidas, alcançando mais de dois mil objetos. Neste trabalho aplicamos nossos métodos para obter taxas de perda de massa destas estrelas, o que foi possível para mais de 1400 objetos do catálogo. Comparamos suas taxas de perda de massa com as as taxas das estrelas pobres em Li e confirmamos nossa conclusões anteriores, no sentido de que as estrelas ricas em Li têm taxas e luminosidades mais baixas comparadas com as estrelas pobres em Li. Além disso, a amostra aumentada indica uma correlação muito melhor entre as taxas e as luminosidades, enfatizando o efeito da pressão da radiação estelar na origem dos ventos destas estrelas.

Keywords. Stars: AGB and post-AGB – Stars: mass-loss – Stars: abundances

1. Introduction

Most AGB/RGB stars are Li-poor, with abundances $\epsilon((\text{Li}) = \log n(\text{Li})/n(\text{H}) + 12 < 1.5$. However, a fraction of these objects have Li enhancements which are attributed to different scenarios, such as the Cameron-Fowler mechanism, binarity, or the presence of planets. The Li enhancements are also sometimes associated with an increased mass loss. We have approached this problem by developing different methods to estimate the mass loss rates [Maciel & Costa (2018, 2019, 2020, 2021), in particular Method 1, which uses a modified Reimers formula based on a correlation of the Li abundances and the stellar luminosity, and Method 2, based on a direct correlation of the mass loss rates and stellar parameters, such as the effective temperature and luminosity [van Loon et al. (2005)]. In this work we extend our calculations by (i) considering data from the GAIA archive [Brown et al. (2018)] plus other recent independent data, and (ii) considering the recent catalogue of Li-rich giant stars based on LAMOST data [Casey et al. (2019)].

2. The Data

The data used in this work was described in detail in our previous work [Maciel & Costa (2018, 2019, 2020, 2021)]. The first sample contains 163 objects with data from the GAIA archive, including effective temperatures, gravity, masses and luminosities complemented by some objects with incomplete GAIA data, for which we have adopted parameters from the literature. The second sample uses the recent catalogue of Li-rich giants by Casey et al. (2019) based on the LAMOST survey, with a total of 2330 objects, of which 1457 stars have the necessary data to estimate the mass loss rates. As discussed in our previous work, the mass loss rates of Method 1 can be written as a function of the stellar luminosity, radius and mass, following the conditions implied by the Reimers formula, with a new independent calibration. For Method 2, the rates can be simply written as a function of the stellar effective temperature and luminosity, with an adequate calibration based on Magellanic Cloud giant stars [van Loon et al. (2005)].

3. Results and Discussion

The main results are shown in figure 1, corresponding to Method 1 (blue) and Method 2 (red). Each panel shows the derived mass loss rates in $M_\odot$/yr as a function of the luminosity. The left panels show GAIA data complemented by literature data (163 stars) and the right panels show the results from the LAMOST catalogue (1457 stars). The lines in the figures show linear least-squares fits to the data of the form $\log dM/dt = A + B \log L/L_\odot$, as given in table 1, where r is the correlation coefficient. The luminosities and mass loss rates are similar or generally larger and spread over a larger range compared with our previous work [Maciel & Costa (2018, 2019)], indicating a more realistic distribution of the stellar luminosities. In agreement with our previous work, the mass loss rates of Li-rich stars are usually much lower than for Li-poor stars, which can reach rates up to 10^{-5} $M_\odot$/yr for luminosities in the range $3.5 < \log L/L_\odot < 6.5$ [see for example Groenewegen et al. (2009), Groenewegen & Sloan (2018) and Gullieuszik et al. (2012)].

It is remarkable that the results of both samples are very similar, in the sense that the mass loss rates have a similar depen-

Table 1. Linear fits

	n	A	B	r
Method 1				
GAIA + Lit.	163	−10.678 ± 0.081	1.095 ± 0.052	0.855 ± 0.438
Catalogue	1457	−11.420 ± 0.018	1.414 ± 0.010	0.963 ± 0.110
Method 2				
GAIA + Lit.	163	−10.699 ± 0.064	1.047 ± 0.041	0.896 ± 0.342
Catalogue	1457	−11.227 ± 0.012	1.378 ± 0.007	0.983 ± 0.070

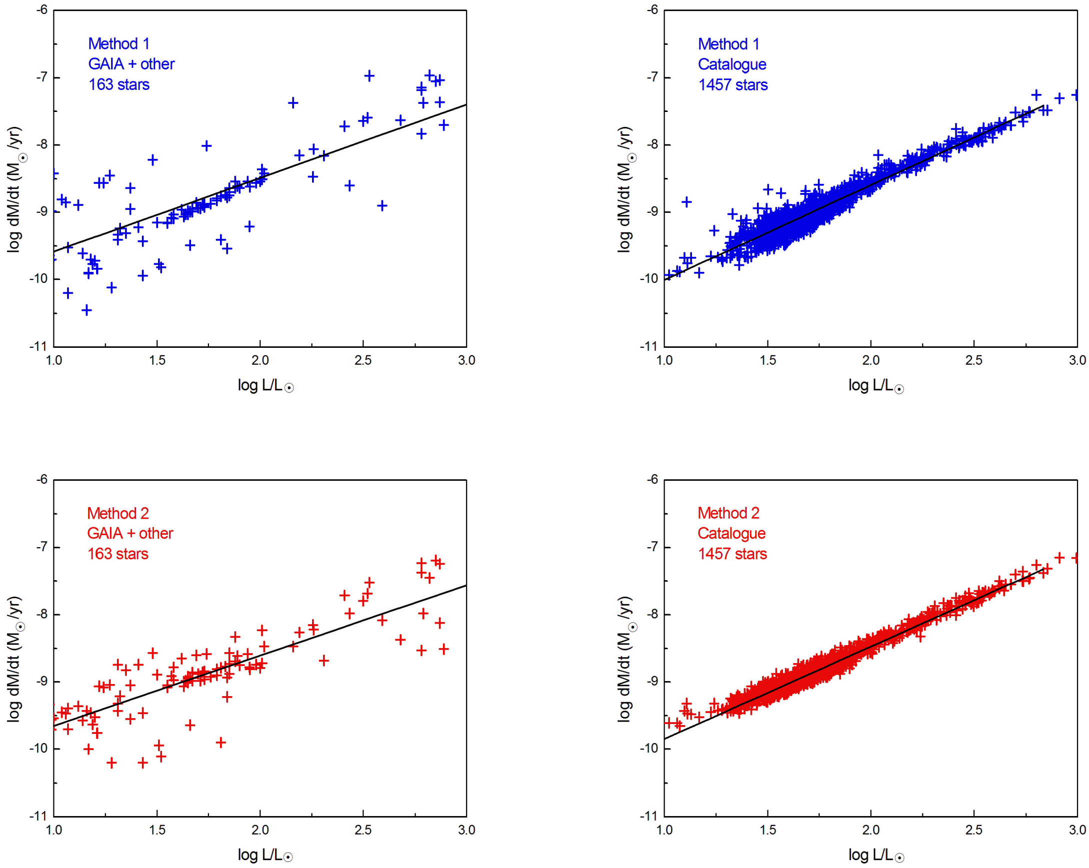

Figure 1. Mass loss rates of Li-rich AGB/RGB stars as a function of the stellar luminosity.

dence on the luminosities, which is to be expected for radiation-driven stellar winds. From the linear fits shown in the table we estimate that the mass loss rate $dM/dt \propto L^x$, where the exponent is the range $1.2 < x < 1.6$, with an average $x \simeq 1.4$ approximately, which accounts for the effect of parameters other than the luminosity. These results confirm our previous conclusion that there seems to be no association of enhanced mass loss rates with Li-rich AGB/RGB stars.

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