Boletim da Sociedade Astronômica Brasileira, **31**, no. 1, 82-83

An estimate of the mass loss rates of Li-rich AGB/RGB stars

W. J. Maciel[1] & R. D. D. Costa[1]

[1] IAG/USP e-mail: wjmaciel@iag.usp.br, e-mail: roberto.costa@iag.usp.br

Abstract. We consider a large sample of AGB/RGB stars with excesses in the Li abundance in order to estimate their mass loss rates. We adopt a correlation between the Li abundances and the stellar luminosity, and used a modified version of Reimers formula, calibrated on the basis of 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. Therefore, it appears that the Li enrichment process is not associated with an increased mass loss rate, as sometimes suggested in the literature.

Resumo. Consideramos uma grande amostra de estrelas AGB/RGB com excesso de Li com o objetivo de estimar suas taxas de perda de massa. Adotamos uma correlação entre a abundância de Li e a luminosidade estelar, e usamos uma versão modificada da fórmula de Reimers, calibrada a partir de uma correlação empírica entre a taxa de perda de massa e parâmetros estelares. Concluimos que a maior parte das estrelas ricas em Li tem taxas mais baixas em comparação com a maior parte das estrelas AGB/RGB, as quais não apresentam evidências de excessos de Li. Portanto, o processo de enriquecimento de Li não é associado com uma alta taxa de perda de massa, como sugerido em alguns trabalhos.

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

1. Introduction

Most AGB/RGB stars are Li-poor, in the sense that they present low Li abundances, which are characterized by abundances ϵ(Li) = log (Li/H) + 12 < 1.5. However, some of these stars show well determined Li enhancements, so that their abundances are higher than the quoted value. Li-enrichment has been associated with large mass loss rates in some papers in the literature, altough there are also suggestions 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 have used a modified Reimers formula calibrated by an empirical correlation between the mass loss rate and stellar parameters that was independently derived. As a result, we estimate the mass loss rates of a large sample of AGB/RGB stars with known Li enhancements.

2. The data

Our sample contains 159 Li-rich stars for which reliable determinations are available for the Li abundances. Some stellar parameters (effective temperature T_{eff} and gravity $\log g$) are also known for these objects. For a detailed discussion see Maciel & Costa (2018). The data used in this work are the same as in our previous papers (Maciel & Costa 2012, 2015), including some new data by Maciel & Costa (2016) and Casey et al. (2016). The original sources are: Brown et al. (1989), Mallik (1999), Gonzalez et al. (2009), Monaco et al. (2011, 2014), Kumar et al. (2011), Lebzelter et al. (2012), Kővári et al. (2013), Martell & Shetrone (2013), Lyubimkov et al. (2012), Casey et al. (2016), Ruchti et al. (2011) and Kirby et al. (2012, 2016).

3. Determination of the mass loss rates

The correlation between the Li abundances and the stellar luminosity shows 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, as shown in Fig. 1 for a selected sample containing 57 Li-rich stars (empty circles).

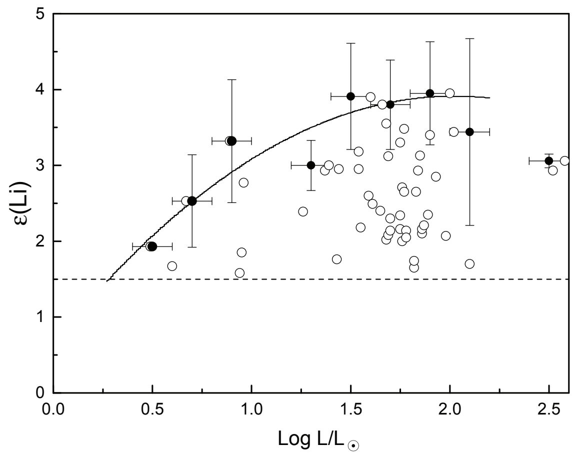

Figure 1. Li abundances as a function of the luminosity for Li-rich stars. Empty circles: data for stars with well-determined abundances and luminosities; filled circles: maximum abundances in each luminosity bin; solid line: a fit of the maximum abundances; dashed line: adopted baseline value for Li-rich stars, ϵ(Li) = 1.5.

Using the maximum contribution as representative of the Li enhancements (filled circles in Fig. 1), we obtain a correlation from which the luminosity can be obtained from the Li abundances (solid line). We have adopted a modified version of the Reimers formula for the mass loss rates, using the η parameter as a free parameter, to be determined on the basis of an adequate calibration. We have then calibrated the Reimers formula using

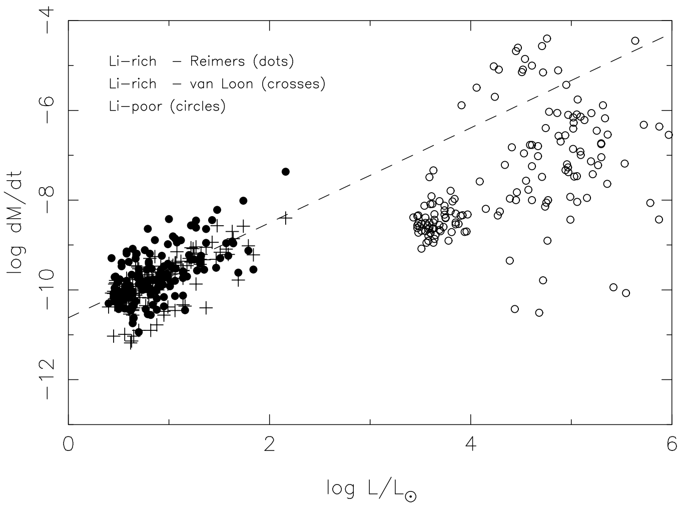

FIGURE 2. Mass loss rates as a function of the luminosity for AGB/RGB stars. Filled circles: Li-rich stars using the modified Reimers formula; Crosses: Li-rich stars using the van Loon formula; empty circles: Li-poor stars with well derived mass loss rates and luminosities. Dashed line: a linear correlation for Li-rich stars, shown for illustration purposes only.

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. In this case, the mass loss rates can be determined from the stellar luminosity and effective temperature. It should be mentioned that this correlation corresponds to an approximately linear logarithmic relation between the mass loss rate and the stellar luminosity, which is in agreement with the predictions from dust radiative driven winds.

4. Results

Taking the van Loon formula into account, we derive the distribution of the mass loss rates of our sample stars. This procedure is also followed using the Reimers formula, which is then calibrated to obtain the same distribution as the van Loon formula. The parameter that presents the best fit is found to be $\eta = 5.7$. Fig. 2 shows the derived mass loss rates as a function of the luminosity for our sample. In this figure the filled circles on the left side of the figure are the results using the modified Reimers formula, while the crosses indicate the rates obtained by the empirical formula by van Loon. The dashed line shows a linear correlation obtained for Li-rich stars for illustration purposes.

We have searched the literature for a sample of AGB/RGB stars with no evidences of Li enhancements, but with accurate mass loss rates and luminosities. We have included in Fig. 2 data from Gullieuszik et al. (2012), Groenewegen et al. (2009), and Groenewegen & Sloan (2018), selecting the O-rich objects (empty circles). It can be seen that most of these objects have higher luminosities and mass loss rates compared with the Li-rich stars, with very few exceptions. Therefore, we can conclude that the Li-rich objects are mainly associated with mass loss rates much lower than for the majority of AGB/RGB stars, which are Li-poor objects. This means that the Li enhancements are probably a low-luminosity feature associated with lower mass loss rates in comparison with the majority of Li-poor stars.

Acknowledgements. Acknowledgements. This work was partially supported by CNPq (Process 302556/2015-0) and FAPESP (Process 2010/18835-3 and 2018/04562-7).

References

Brown, J. A., Sneden, C., Lambert, D. L., Dutchover, E. 1989, ApJS, 71, 293
Casey, A. R., Ruchti, G., Masseron, T., et al. 2016, MNRAS, 461, 3336
Gonzalez, O. A., Zoccali, M., Monaco, L., Hill, V., Cassisi, S., Minniti, D., Renzini, A., Barbuy, B., Ortolani, S., Gomez, A. 2009, A&A, 508, 289
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., de Grijs, R., van Loon, Th., Girardi, L., Ivanov, V. D., Oliveira, J. M., Emerson, J. P., Goardalini, R. 2012, A&A, 537, A105
Kirby, E. N., Fu, X., Guhathakurta, P., Deng, L. 2012, ApJ, 752, L16
Kirby, E. N., Guhathakurta, P., Zhang, A. J., et al. 2016, ApJ, 819, 135
Kővári, Zs., Korhonen, H., Strassmeier, K. G., Weber, M., Kriskovics, L., Savanov, I. 2013, A&A, 551, A2
Kumar, Y. B., Reddy, B. E., Lambert, D. L. 2011, ApJ, 70, L12
Lebzelter, T., Uttenthaler, S., Busso, M., Schultheis, M., Aringer, B. 2012, A&A, 538, A36
Lyubimkov, L. S., Lambert, D. L., Kaminsky, B. M., Pavlenko, Y. V., Pokland, D. B., Rachkovskaya, T. 2012, MNRAS, 427, 11
Maciel, W. J., Costa, R. D. D. 2012, Mem. Soc. Astron. Italiana, 22, 103
Maciel, W. J., Costa, R. D. D. 2015, Why galaxies care about AGB stars III, ASP CS 497, 313
Maciel, W. J., Costa, R. D. D. 2018, Astron. Nach. 339, 168
Maciel, W. J., Costa, R. D. D. 2016, The 19th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, ed. G. A. Feiden, https://zenodo.org/record/59278#.V6iCq6JwspI
Mallik, S. V. 1999, A&A, 352, 495
Martell, S. L., Shetrone, M. D. 2013, MNRAS, 430, 611
Monaco, L., Villanova, S., Moni Bidin, C., Carraro, G., Geisler, D., Bonifacio, P., Gonzalez, O. A., Zoccali, M., Jilkova, L. 2011, A&A, 529, A90
Monaco, L., Boffin, H. M. J., Bonifacio, P., Villanova, S., Carraro, G., Caffau, E., Steffen, M., Ahumada, J. A., Beletsky, Y., Beccari, G. 2014, A&A, 564, L6
Ruchti, G. R., Fullbright, J. P., Wyse, R. F. G., et al. 2011, ApJ, 743, 107
van Loon, J. Th., Cioni, M. R. L., Zijlstra, A. A., Loup, C. 2005, A&A, 438, 273