WHY GALAXIES CARE ABOUT AGB STARS III:
A CLOSER LOOK IN SPACE AND TIME
ASP Conference Series, Vol. 497
Kerschbaum, Wing, and Hron, eds.

Li-rich AGB/RGB Stars: Abundance Correlations with Stellar Properties

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Abstract. We consider a large sample of Li-rich AGB/RGB stars and search for correlations between the Li abundances and other stellar parameters, such as the effective temperature, gravity, luminosity, radius, etc. Our results show that some of these correlations are statistically meaningful, particularly those involving the radius and luminosity, which may throw some light on the Li production mechanisms in these stars.

1. Li-rich Giant Stars

Lithium abundances in RGB/AGB stars remain a puzzle, in the sense that most stars have very low Li-abundances, while a small fraction of these stars, known as Li-rich giants, present an excess of lithium, given by ϵ(Li) > 1.5. Several surveys have been performed recently to increase the number of known Li-rich stars, especially among K giants and RGB/AGB objects. Several mechanisms have been suggested to explain the Li excess in these stars, such as the non-effectiveness of the dilution effect, the increase in the atmospheric Li abundance by the ingestion of planets or brown dwarfs, the Cameron-Fowler ^{7}Be transport mechanism, and the production of Li by thermohaline mixing. Whatever the mechanism might be, convection continues to dilute the newly created lithium, which is exposed to higher temperatures and destroyed. Therefore, the Li-rich phase is expected to be of short duration, and this explains the small number of Li-rich stars.

In order to clarify the mechanisms responsible for the enhancement, we have considered possible correlations of the Li abundance with various stellar parameters. The data used in this investigation include 79 stars and come from recent determinations in the literature. We have used the references cited in Maciel & Costa (2012) supplemented by Brown et al. (1989), Mallik (1999), Garcia-Hernandez et al. (2007), Gonzalez et al. (2009), Monaco et al. (2011), and Kumar et al. (2011).

2. Correlations of the Li Abundance with Stellar Parameters

It has recently been shown that, in opposition to a completely flat Spite plateau, there seems to exist an almost linear relationship between ϵ(Li) and [Fe/H]. In a previous study (Maciel and Costa 2012), we have shown that this relationship also applies on average to the metal-rich giants (Figure 1a). However, when one plots the individual giant stars, the dispersion is very large, so that other stellar parameters are probably affecting the Li enhancements.

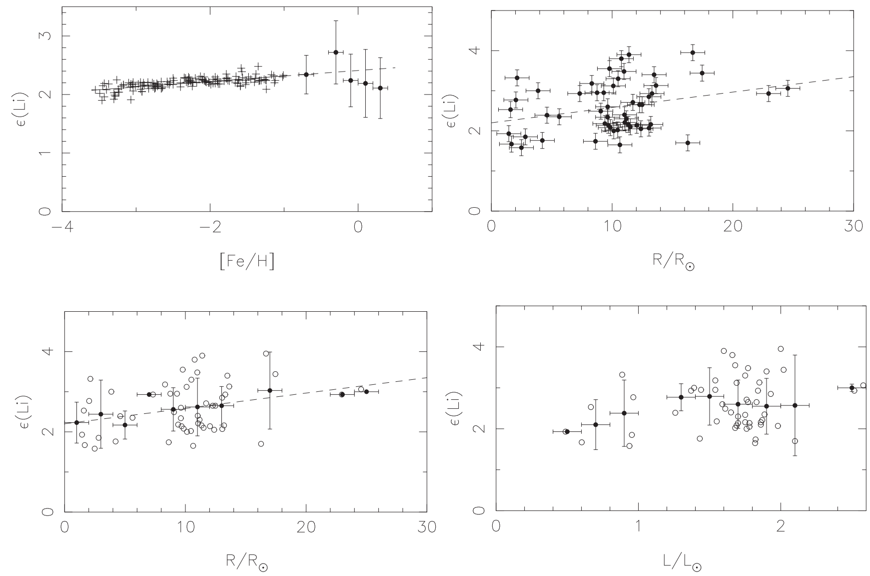

Figure 1. Correlations of the Li abundance in Li-rich stars with stellar parameters.

For the effective temperature, stellar gravity, and mass, we did not find any correlation with the Li abundances. However, a definite correlation is found between ϵ(Li) and the stellar radius. This correlation seems to hold within a restricted range, as shown in Figures 1b and 1c, where we have excluded the few stars with radii larger than 40 $R_\odot$. The dashed line shows a linear fit to the data. The correlation is more clearly seen in Figure 1c, where we superimpose the average abundances using 2 $R_\odot$ bins over the individual data. Another positive correlation was found with the stellar luminosity (Figure 1d), which is expected, since $L \propto R^2\, T_{\rm eff}^4$.

Some additional information can be obtained by placing the stars on the HR diagram. Apparently, Li-rich giants cluster along three different locations on the HR diagram: the RGB luminosity bump, the red giant clump, and the early AGB. Most stars seem to be located near the luminosity bump on the HR diagram, a region between luminosities $\log L/L_\odot$ = 1.5 and 2.2, where the giant evolution is slower, thus producing a bump in the luminosity function of the RGB. Exceptions are the very luminous giant stars that do not fit well in the correlations between ϵ(Li) and the stellar radii and luminosities. It is possible that the Li enhancement in these stars is due to a different mechanism from that of the bump or clump Li-rich stars.

Acknowledgments. This work was partially supported by FAPESP and CNPq.

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