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Survey for Li-rich K giants

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Abstract. We present results from an ongoing survey of searching Li-rich K giants among low mass giants along the Red Giant Branch (RGB). A sample of 2500 stars with accurate astrometry have been selected from Hipparcos catalogue covering both the RGB luminosity bump and the red clump regions on the HR diagram. Lithium abundances have been determined for half of the sample from low resolution spectra using line depth ratio method. Results confirm the rarity of Li-rich K giants, just under 1%, in the solar neighbourhood. This study increased the total number of known Li-rich K giants by a factor of two. The analysis of high resolution spectra of candidate Li-rich K giants showed that the K giant HD 77361 is highly enriched in lithium (log ϵ(Li) = 3.82) and at the same time has anomalously low carbon isotopic ratio (^{12}C/^{13}C = 4.3). The results put important constraints on the theoretical modelling of the stellar structure and the mixing process, particularly, of the K giants.

Keywords. stars: late-type, abundances, individual (HD 77361), statistics – surveys

1. Li-rich K giants

Lithium is an important indicator of mixing processes in the stars on the Red Giant Branch (RGB). The expansion of convective envelope alters the surface chemical composition of lighter elements in the red giants. According to the classical stellar evolution theory (Iben 1967), any K giant with a surface lithium abundance exceeding log ϵ(Li) $\sim$ 1.4 can be characterized as Li-rich K giant (hereafter LRKG). The discovery of first LRKG (Wallerstein & Sneden 1982) has challenged the concept of gradual depletion of lithium on RGB. Since then, a dozen K giants were identified as LRKG. Charbonnel & Balachandran (2000) located all the known Li-rich stars on the Hertzsprung-Russell diagram using the Hipparcos parallaxes (Perryman *et al.* 1997). Most of them are fast rotators and show infrared excess. The origin of the anomalous lithium in these stars is not well understood. We have initiated a systematic survey to search for LRKG along the RGB, to pin down the source of lithium by studying the correlations between high lithium and other stellar parameters, and to estimate the fractional content of lithium contribution from the K giants to the Galaxy.

2. Samples and observations

We have selected 2500 sample giants along the RGB, sourced from Hipparcos catalog (Perryman *et al.* 1997, van Leeuwen 2007). We have restricted the survey to bright (mv $\leqslant$ 8) and nearby stars (d $\leqslant$ 200 pc), with accurate parallaxes ($\leqslant$ 15% error). Further, the sample stars were subjected to the following criteria: declination ($-60 \leqslant \delta \leqslant +80$), spectral type (K or late G) or $T_{\rm eff}$ ($4200 \leqslant T_{\rm eff} \leqslant 5000$ K) and luminosity ($1.0 \leqslant \log (L/L_{\odot}) \leqslant 2.5$). The last two criteria (luminosity and temperature) ensure that the sample covers the luminosity bump and/or red clump region on the HR diagram.

High quality low resolution spectra of sample stars were obtained using 2 m Himalaya Chandra Telescope (HCT), Hanle, 1 m Carl Zeiss telescope, and 2.34 m Vainu Bappu Telescope (VBT), Kavalur with resoultion R∼3500, R∼6000, R∼1500, respectively.

Along with the sample stars, we also made observations of known Li-rich giants, for which Li abundance was independently determined from high resolution spectra. An empirical relation is obtained between known Li-abundance and the ratios of line depths between Li I 6707 Å and Ca I 6717 Å., The derived relation is good to use for K giants with Li abundance log ϵ(Li) $\geqslant$ 1.0. The method is useful to efficiently eliminate K giants with low Li abundance and select LRKG based on line depth ratios.

3. Results & discussion

Preliminary results from the analysis of 1100 spectra are presented here. We could detect Li I line at 6707Å for Li abundances exceeding 0.6 dex. Li I line is seen in only 39% of the sample stars. The remaining 60% of stars in the sample are considered normal with log ϵ(Li) < 0.6. The corresponding uncertainty in the derived abundance from the empirical relation is significantly large owing to the uncertainty in the line depth ratios. We found a dozen new K giants with Li significantly above the expected value and considered them as Li-rich K giants, which confirm the rarity of LRKG.

Detailed analysis from high resloution (R∼65000) spectra of one of the new LRKG HD 77361 at the RGB bump shows anomalous high lithium (log ϵ(Li) = 3.82) and low carbon isotopic ratio (^{12}C/^{13}C = 4.3), which is different from the other known super Li-rich K giants. Results for HD 77361 do not fit with any of the explanations put forward for the source of enhanced Li in the photospheres of K giants: first dredge-up, extra deep mixing associated with cool bottom processing, lithium flash scenario, extra mixing triggered by spinning up the K giants with external angular momentum. The free mixing of material between hydrogen burning shell and the bottom of convective outer layer due to erasing the μ-barrier seems to be favored for the enrichment of products in the envelope, and hence the enhancement of surface lithium abundance and ^{13}C. We refer to Kumar & Reddy (2009) for a detail discussion.

4. Acknowledgement

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References

Charbonnel, C. & Balachandran, S. C. 2000, *A&A*, 359, 563
Iben, I. J. 1967, *ApJ*, 147, 624
Kumar, Y. B. & Reddy, B. E. 2009, *ApJ* (Letters), 703, L46
Perryman, M. A. C., Lindegren, L., Kovalevsky, J. *et al.* 1997, *A&A*, 323, L49
van Leeuwen, F. 2007, *A&A*, 474, 653
Wallerstein, G. & Sneden, C. 1982 *ApJ*, 255, 577