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Lithium enrichment in the Galaxy: A study using the *GALAH* and *Gaia* surveys

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Abstract. Here, we explore the enrichment of Lithium in the Galaxy using a large sample of stars common among large spectroscopic surveys such as the *GALAH* and astrometric survey by the *Gaia* satellite. For this study we used about 60,000 low mass ($M \leqslant 2M_{\odot}$) dwarfs from the *GALAH* survey. Further, we discuss Li enrichment among giant stars based on a sample of 52,000 low mass giants, of which 335 are Li-rich with A(Li) $\geqslant 1.80 \pm 0.14$ dex, culled from the *GALAH* survey. These low mass giants appears to be one of the promising source of Li enrichment in the Galaxy as their atmospheric Li can be added to the ISM through mass loss.

Keywords. Surveys; Galaxy: evolution; Galaxy: abundances; Stars: evolution; Nucleosynthesis

1. Introduction

Li is one of the three primordial elements produced in the Big Bang Nucleosynthesis (BBN), apart from H and He. BBN Models in combination with space experiments such as Wilkinson Microwave Anisotropy Probe (WMAP) predict primordial Li abundance, A(Li) $= 2.72 \pm 0.06$ dex (Cyburt *et al.* 2008). However, observation in metal-poor dwarfs shows comparatively lower Li, A(Li) $= 2.27 \pm 0.03$ (Lind *et al.* 2009) On the other hand present value of Li abundance, as measured in meteorites and in young stars, is A(Li) = 3.32 dex which is about 10 times higher than the Li found in metal poor dwarfs and about 3 times higher than the value predicted by BBN models. There are a few sources that are identified to contribute to Li enhancement in the Galaxy such as cosmic ray spallation in ISM (Mitler 1972), novae explosions (Tajitsu *et al.* 2015) and nucleosynthesis in evolved stars. However none of these sources is confirmed to contribute such high Li throughout the Galaxy. In general, stars are sinks for Li as Li burns at relatively low temperatures of about $2.5 \times 10^6 K$. Beyond this secular trend, Li is sensitive to enhanced mixing during first dredge-up which leads to rapid depletion of Li. However, in particular conditions, evolved stars such as red giant branch (RGB) stars are known to produce Li in their interiors via Cameron-Fowler mechanism (Cameron & Fowler 1971). A small fraction (about 1%) of low mass RGB stars are known to have unexpectedly higher Li abundance (Wallerstein & Sneden 1982). In the next section we discuss evolution of these giants based on data from large spectroscopic survey and discuss how these giants can be one of the promising source of Li enrichment in the Galaxy.

2. Results and discussion

To study the evolution of Li in the Galaxy we selected a sample of about 60,000 low mass ($M \leqslant 2M_{\odot}$) dwarfs, with reliable stellar parameters ($Flag_{cannon}$=0) and small error in Teff ($\sigma_{\rm Teff} \leqslant 150$ k) and parallax ($\sigma_{\pi}/\pi \leqslant 0.2$), from cross-match of the second data release of the *GALAH* spectroscopic survey (Buder *et al.* 2018) and the *Gaia* astrometric survey (Gaia Collaboration *et al.* 2018). Li versus [Fe/H] for these dwarfs is shown in

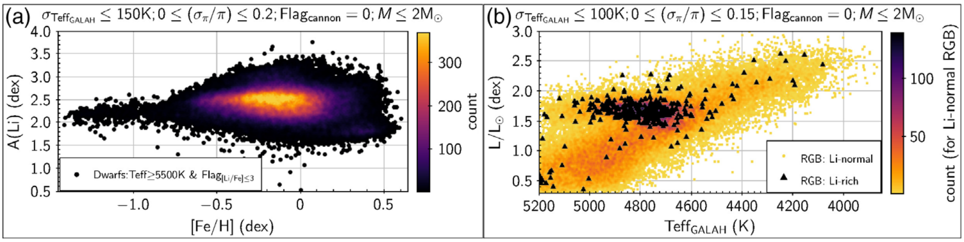

Figure 1. a) Li versus [Fe/H] for low-mass dwarfs selected from the *GALAH* survey. b) HR diagram showing location of Li-rich giants with the complete RGB sample in the background.

Figure 1a which suggests that Li has evolved in the Galaxy with large enrichment in the disk compared to the halo. The metal-poor dwarfs ([Fe/H] < -0.8 dex) are having constant Li of about 2.2 dex but with a very slight increasing trend with increase in metallicity. This slight but significant increasing trend with [Fe/H] is understood to be because of the presence of cosmic ray interactions in the early Galaxy (Ryan *et al.* 2000). In case of metal-rich dwarfs ([Fe/H] $\geqslant -0.8$ dex), the increase in Li with increase in [Fe/H] is very rapid. To account for this higher Li a galactic Li enrichment source is required. The Li enrichment in the low-mass giants appears to be one such source. To understand the evolution of Li in the low mass giants we selected a sample of about 52,000 low-mass giants (with accurate and reliable stellar parameters) from the cross-match of the *GALAH* and *Gaia* survey, of which 335 giants are Li-rich with A(Li) $\geqslant 1.8$ dex. Distribution of these giants is shown in Figure 1b which suggests that most of the Li-rich giants are red clump (RC) stars. Also most of the Li-rich giants are metal rich ([Fe/H] > -0.7 dex) and kinematically more prevalent in the thin disk compared to the thick disk and halo (Deepak & Reddy 2019).

3. Conclusion

Metal-poor dwarfs (with [Fe/H] $\leqslant -0.8$ dex) shows a constant Li abundance of about 2.2 dex, but with a slightly increasing trend which is understood to be because of presence of cosmic ray interactions in the early Galaxy (Ryan *et al.* 2000). On the other hand, Li in the metal-rich dwarfs (with [Fe/H] $\geqslant -0.8$ dex) shows sharp increase of Li with [Fe/H] suggesting a continuous rapid evolution of Li in the Galaxy. Our study of RGB giants suggest that most of the Li-rich giants are in He-core burning phase with in-situ nucleosynthesis as the main source of enrichment. Further studies are needed to find the fraction of low-mass Li-rich giants evolving to AGB phase before the enriched Li in their atmosphere depletes. This will further help to find the fractional contribution of low-mass giants towards the Li enrichment in the Galaxy.

This work has made use of the GALAH survey which includes data acquired through the Australian Astronomical Observatory. This work has also made use of data from the European Space Agency (ESA) mission *Gaia* (https://www.cosmos.esa.int/gaia), processed by the *Gaia* Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the *Gaia* Multilateral Agreement.

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