LAMOST study of Li-rich stars in the Milky way disk and halo: Is Li-rich episode(s) in giants universal?

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Stellar Archaeology as a Time Machine to the First Stars
Kavli IPMU, Tokyo, 3rd Dec 2018

in Collaboration with
Li, H & Zhao, G (China), Aoki, W., Matsuno, T., Suda, T., (Japan)
- Product of Big-Bang Nucleosynthesis
- Isotope - $^6\text{Li}$
- Fragile element - destroys at $2.5 \times 10^6$ K in stellar interiors
Evolution of Li in the Universe

Source for Galactic Li enrichment

- Cosmic ray spallation
- Supernovae
- Novae
- AGB Stars
- RGB stars

Role of RGB stars in Galactic Li enrichment is not well understood!
Li in RGB stars

- Li gets depleted in low mass stars during first dredge-up due to expanding convective envelope on red giant branch

Iben (1967)        Lind+2009
Li-rich giants, $A(\text{Li}) > 1.5 - 1\%$ of RGB stars

Some of these Li-rich giants show other anomalies like low carbon isotopic ratios, infrared excess, and rapid rotation.

No clear correlations are found between Li and other peculiarities!
Li-rich giants in Milky way disk & halo, dwarf spheroidals

Does Li-rich episode(s) during low mass star’s evolution is universal?
LAMOST survey sample

Large Sky Area Multi-Object Fibre Spectroscopic Telescope (LAMOST) DR5 contains 8 million spectra.

LAMOST spectra with strong Li line in stars on various parameter space.
Identifying Li-rich giants: Line Ratio method from Kumar+18

Estimated errors for LAMOST spectral resolution spectra $\approx 0.35$ dex
New Li-rich giants from LAMOST

Disk

Halo

Li-rich disk and halo stars in Milky Way
Observations of high resolution spectra

- High resolution (R~60000) spectra of LAMOST Li-rich disk stars are mostly observed using three telescopes: Subaru telescope at Hawaii, 2.7-m Harlan J.Smith telescope at McDonald Observatory, and 2-m HCT at Hanle
- All Li-rich halo stars are observed from Subaru telescope
- Near-UV high resolution spectra for Be measurements are also obtained from Subaru HDS
Low and high resolution spectra of Li-rich giants

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Li-rich disk and halo stars in Milky Way
Abundance measurements from high resolution spectra

Standard procedure: $T_{\text{eff}}$, logg, [Fe/H], $\xi_t$ and synthetic spectra from well tested linelist, LTE Kurucz model atmospheres, MOOG, NLTE Li corrections from Lind et al. (2009). Sample measurements are shown below,
Li abundances from low and high resolution spectra

Li abundances from high resolution spectra are also used to calibrate relations from Lamost spectra.
New Li-rich giants from Disk and Halo

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Li-rich disk and halo stars in Milky Way
Li-rich Halo giants: preservation from its progenitors?

- Li-rich turn-off stars/subgiants
  - Internal mechanism - Diffusion?
  - Planet Ingestion?
  - External pollution: Novae/Upper RGB/AGB
Li-rich Halo giants: preservation from its progenitors?

It is clear from figure that high Li in RGB stars are preserved from its progenitors after experiencing the first dredge-up.

Li-rich episode on RGB in halo stars?
Li-rich disk stars: Increasing Red clump stars

Kumar+11, ApJL

Singh+18

Bharat Kumar+18, ApJL

Bharat Kumar+(in preparation)
Li-rich Halo & Disk giants: planet engulfment scenario - Unlikely

Our Be analysis from near-UV Subaru spectra of Li-rich disk giants also shown the absence of Be-enrichment.

Aguilera-Gomez+2016
LAMOST survey increased Li-rich stars to 10 fold to existing catalog spanning large metallicity range covering disk and Halo of Milky Way

Added more Li-rich stars to turnoff/subgiant branch and red clump phase of low mass star’s evolution

High Li in halo RGB stars seems to be preserved from its progenitors. However, need more Li-rich turnoff/subgiants to confirm it. Li-rich episode on RGB of halo stars needs more investigation.

More Li-rich stars in disk are found to be at red clump

External pollution through novae or binary mergers seems to be a possible sources for Li anomaly in Li-rich turn-off stars/subgiants in halo and Li-rich core He-burning stars in disk, respectively

Need a revisit to ”1% of RGB stars are Li-rich”, which may put constraints on RGB star’s Li contribution to Galactic Li enhancement
Thanks for your attention