Lithium destruction and production observed in red giant stars

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in collaboration with:

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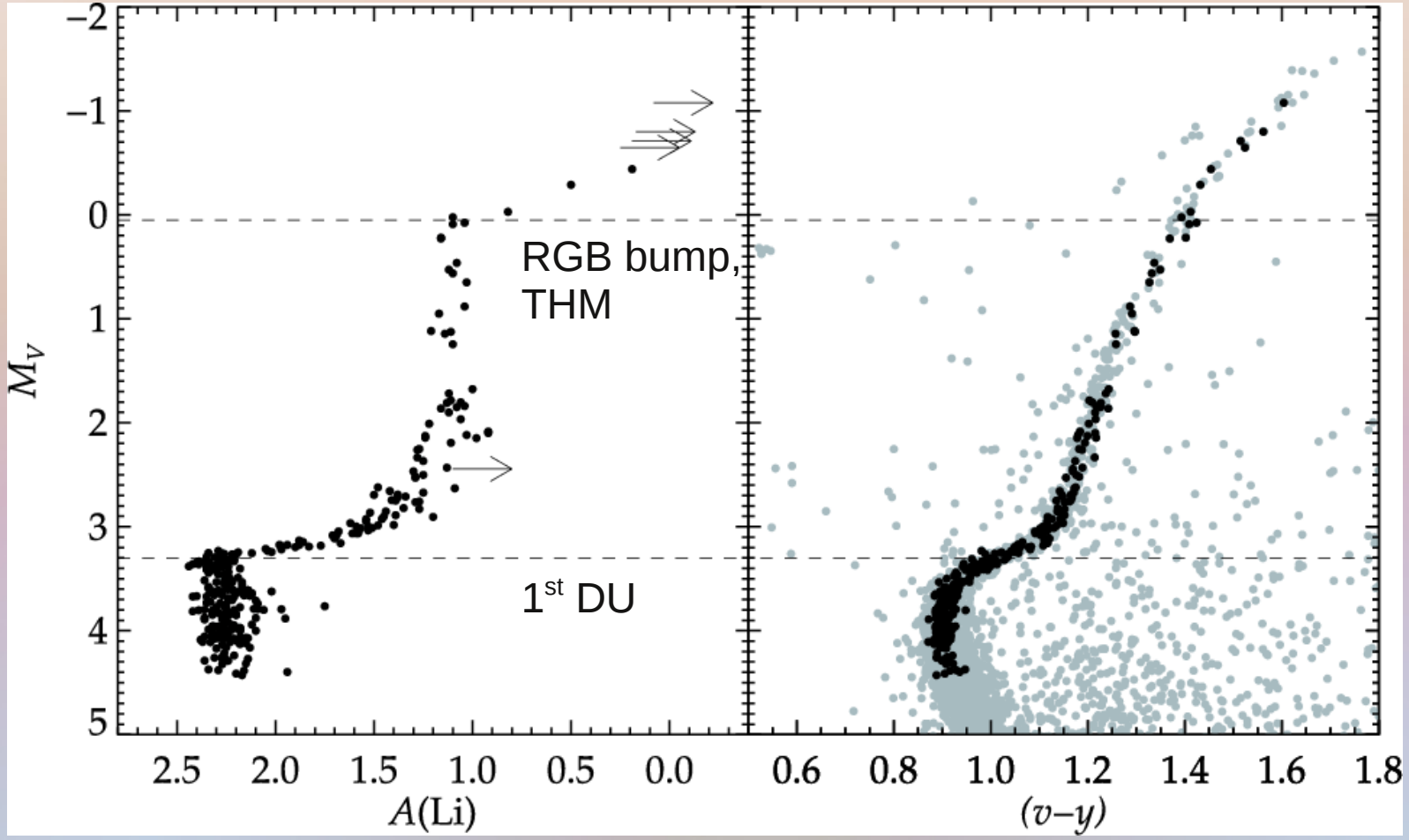
Overview

3 topics:

- Lithium survey in Galactic bulge RGBs (Lebzelter, Uttenthaler et al. 2012)
- Correlation between Lithium and TDUP indicator technetium (Tc) in O-rich low-mass AGBs
- Lithium and hot bottom burning in long-period Miras (AGB)

Destruction of Li throughout low-mass stellar evolution



Lind et al. 2009

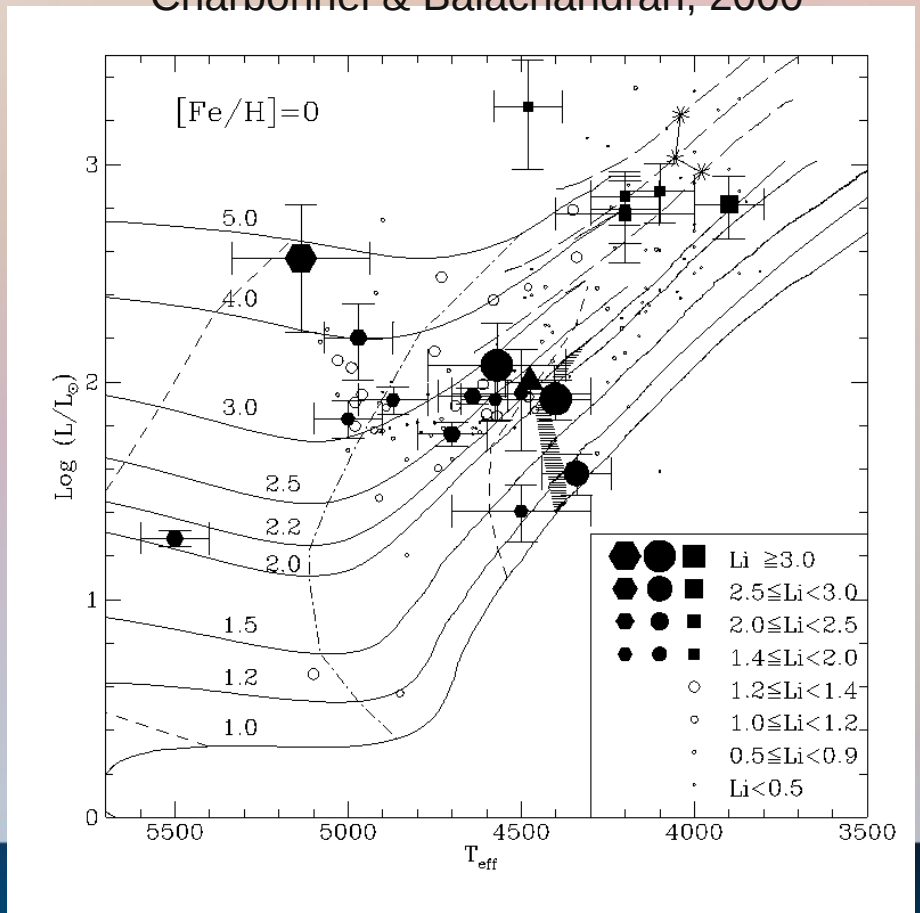
Motivation for the Lithium Bulge survey

1 – 2% of K-type giants are known to be abnormally rich in Li.

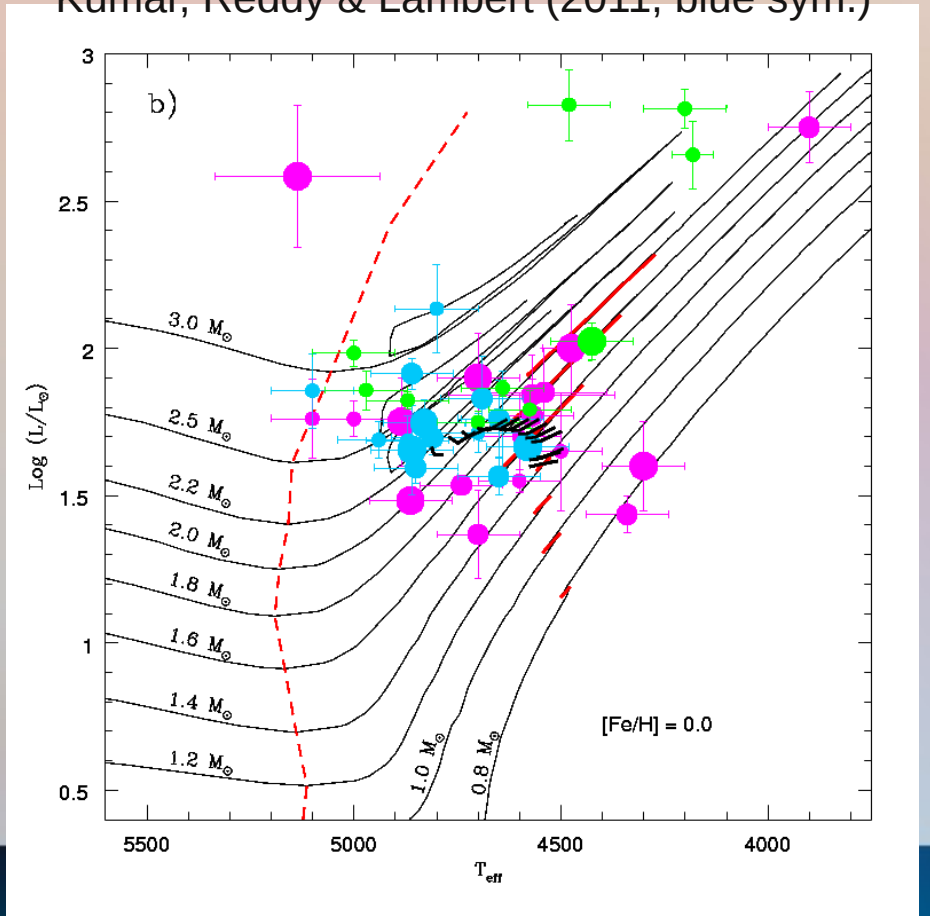
This disagrees with results of "standard models" of stellar evolution.

Previous claims for distinct Li-rich episode for low-mass stars at the RGB bump, and for intermediate-mass stars at the early AGB.

Charbonnel & Balachandran, 2000



Kumar, Reddy & Lambert (2011, blue sym.)

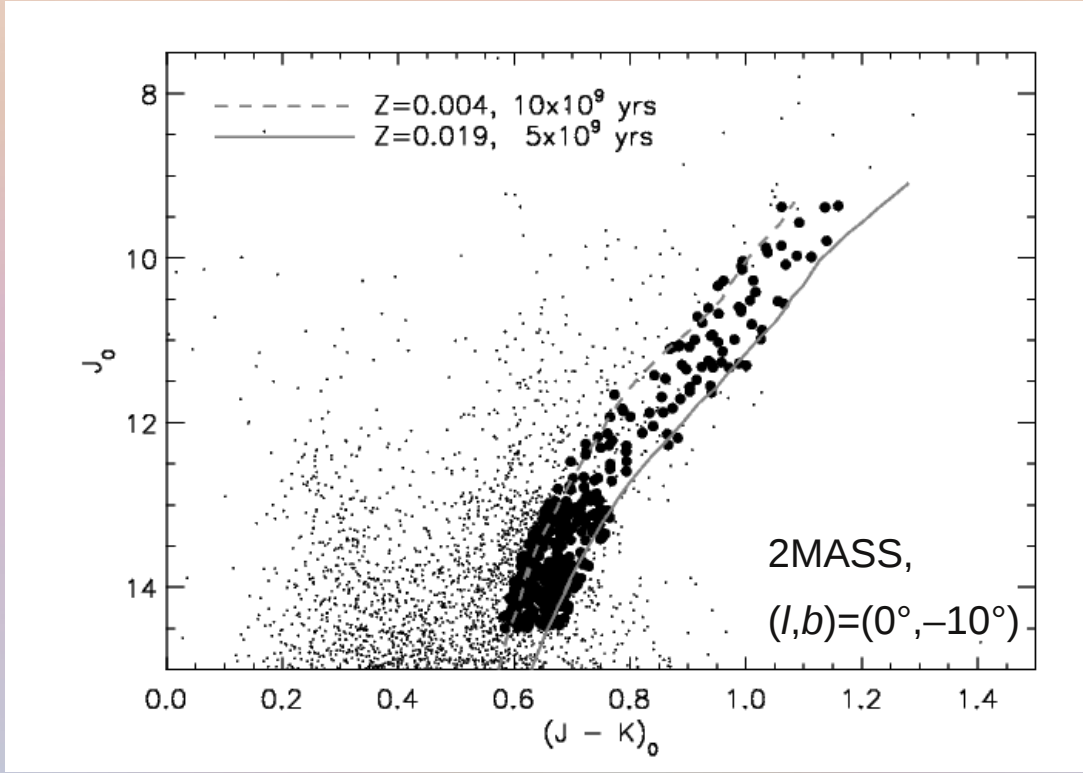


Further motivation

Previous detection of Li-rich AGB stars in the Galactic bulge

(Uttenthaler et al. 2007). How much Li is already present in RGB stars?

Bulge offers a huge number of low-mass giant stars at roughly equal distance!



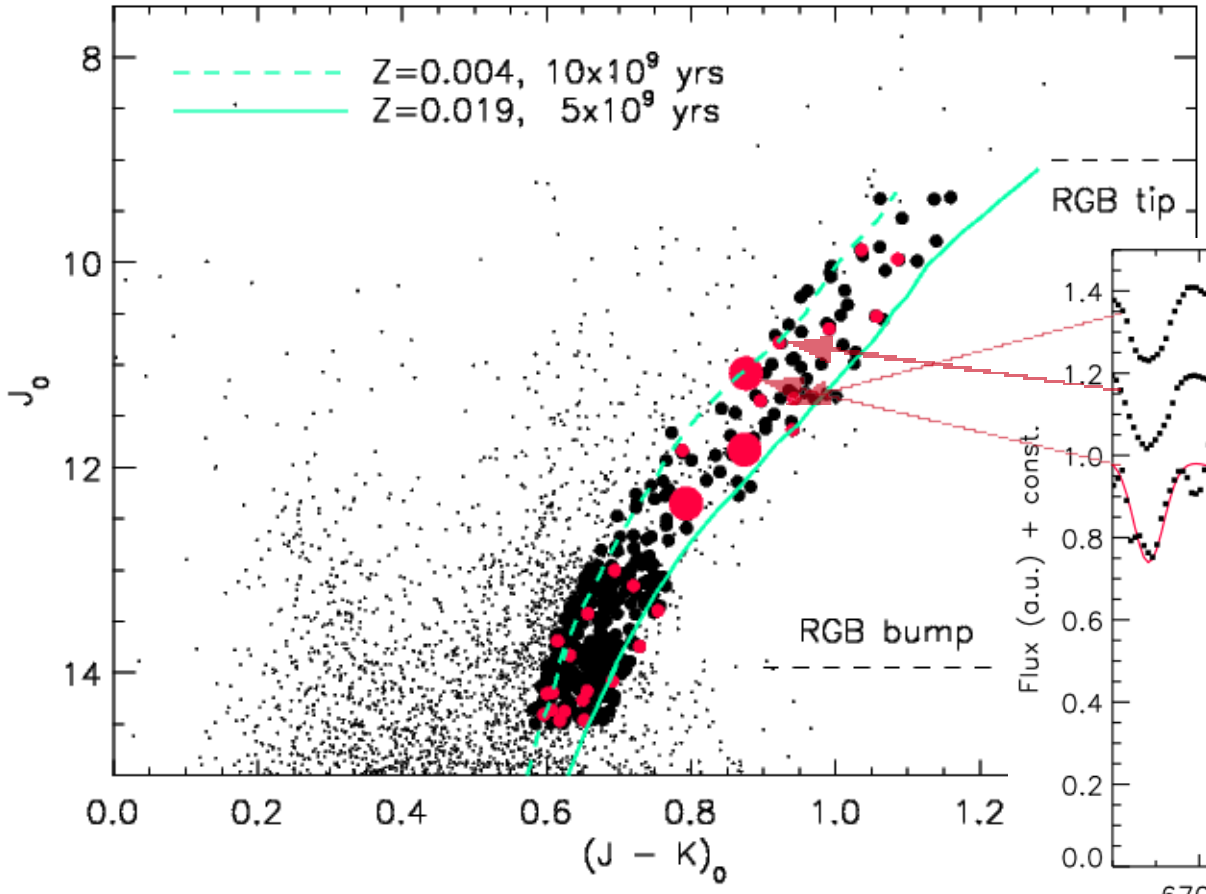
~400 bulge RGB stars observed with FLAMES@VLT

Published in Lebzelter, Uttenthaler, et al., 2012, A&A, 538, 36

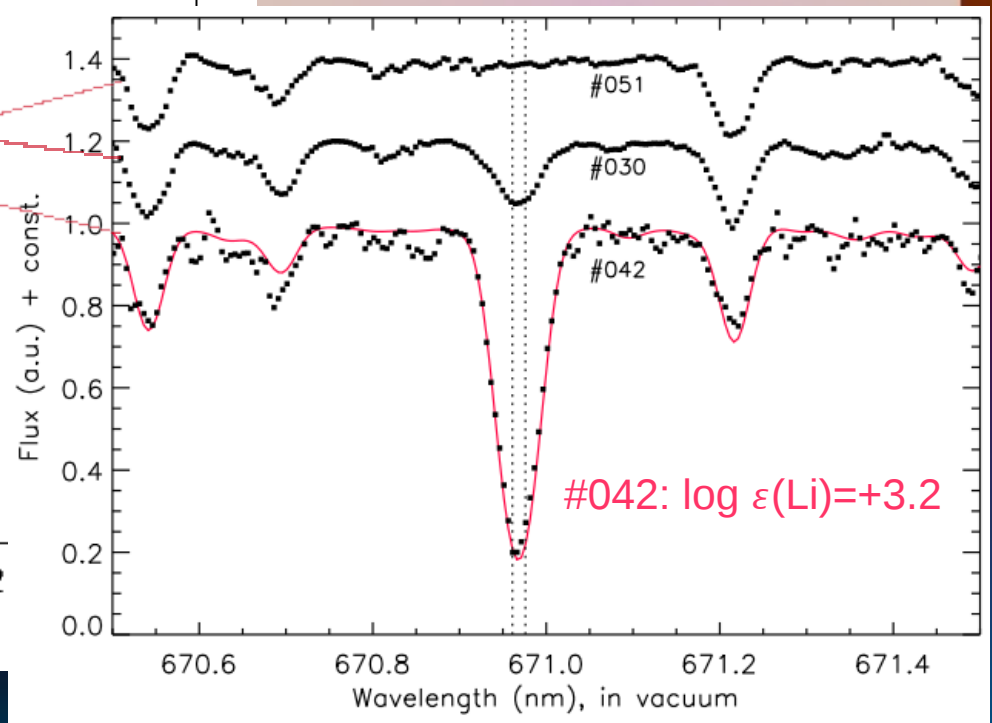
Results

- Li already present on the RGB.
  Use asteroseismology to disentangle RGB from E-AGB stars!

- No distinct episode of Li enhancement



- Li-detected (log ε(Li)≤1.5)
- Li-rich stars (log ε(Li)>1.5)

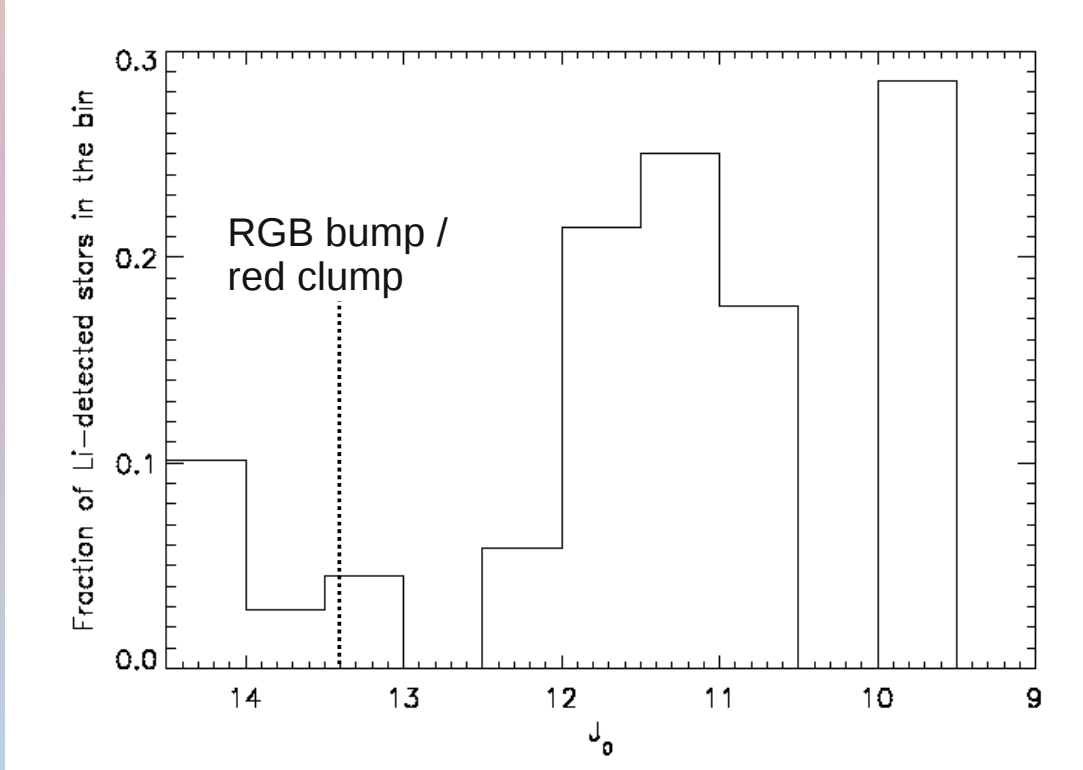


Fraction of Li-detected stars

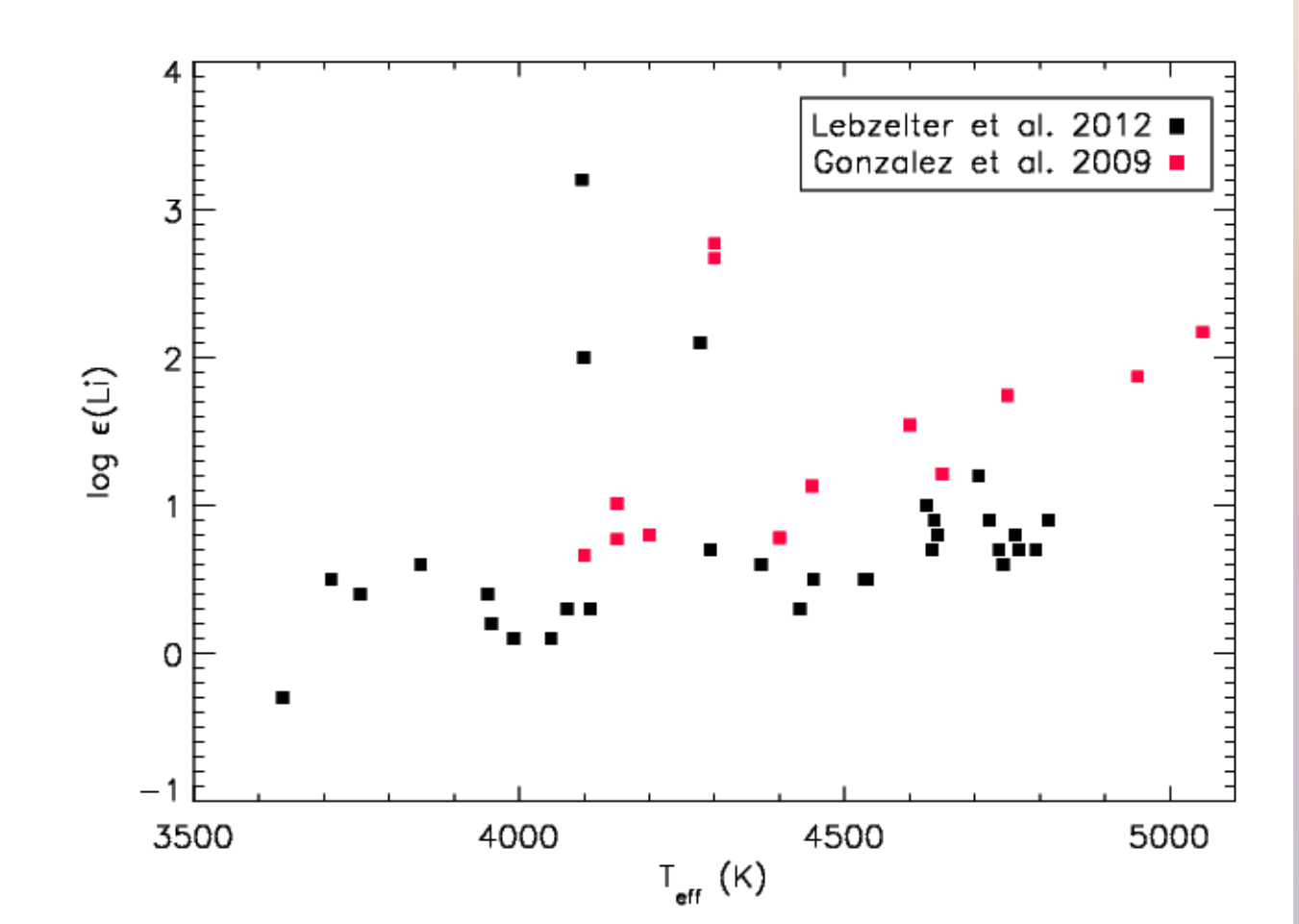
Fraction of Li-detected stars is higher on the upper RGB, but no obvious concentration at a certain magnitude.

Same conclusion in other recent studies (Gonzalez et al. 2009, Monaco et al. 2011, Ruchti et al. 2011).

A distinct episode of Li enhancement on the RGB is very questionable.



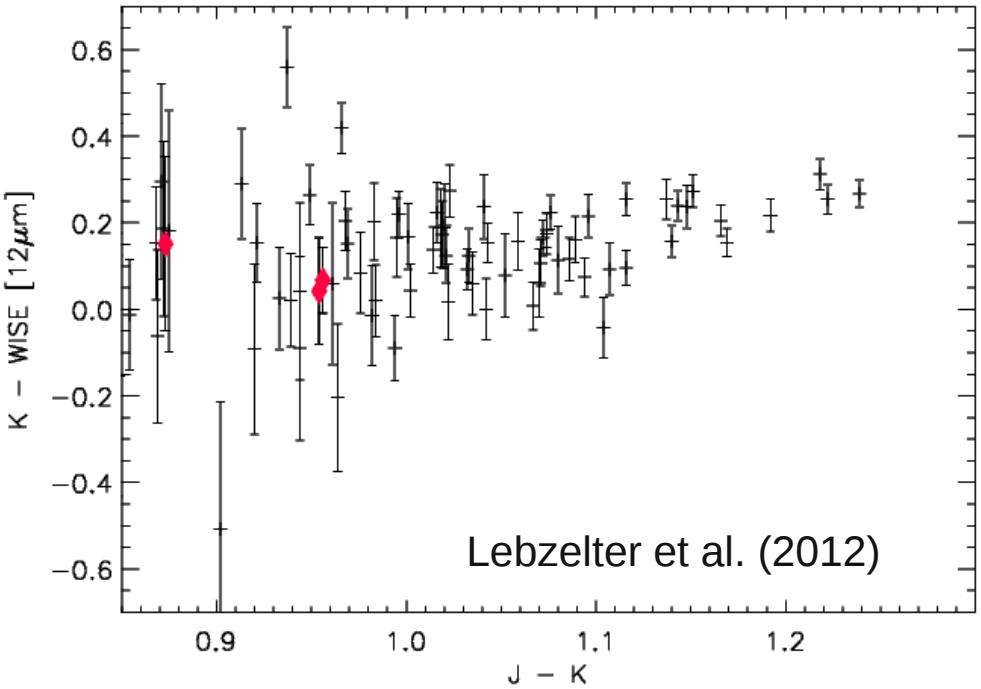
Trend of log ε(Li) with T_{eff} for Li-detected stars

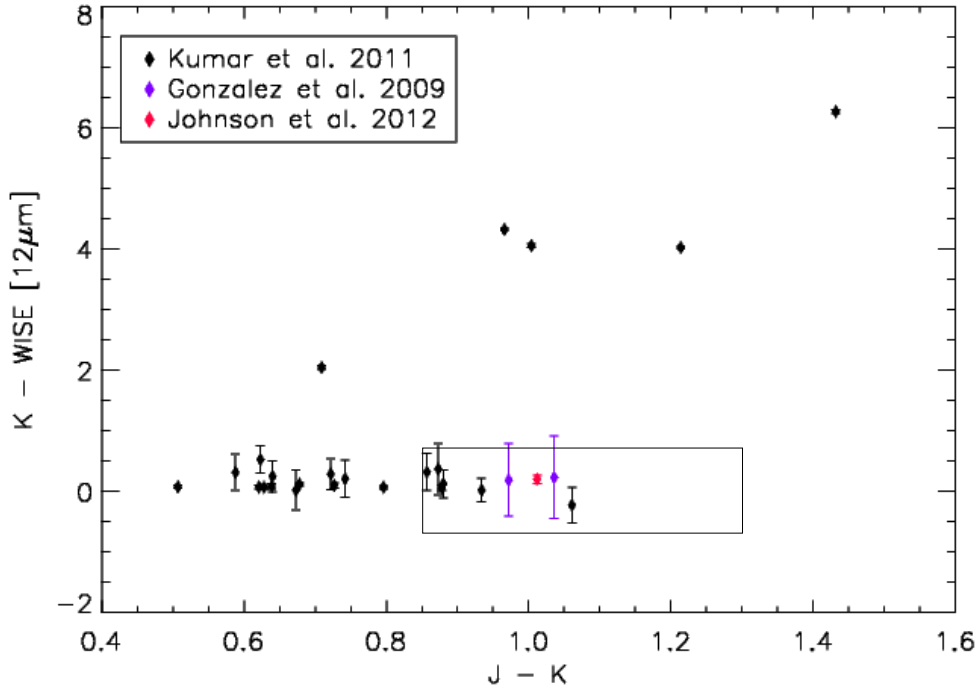


Where does this trend come from, and what does it tell us?

Enhanced mass loss from Li-rich stars?

cf. de La Reza et al. (1996, 1997)





Photospheric colours ⇨ No enhanced dust mass-loss rate from Li-rich stars!

Most of K – [12] red stars are either T Tauri or post-AGB stars.

⇨ Externeal mechanism of Li enhancement (planet engulfment) unlikely!

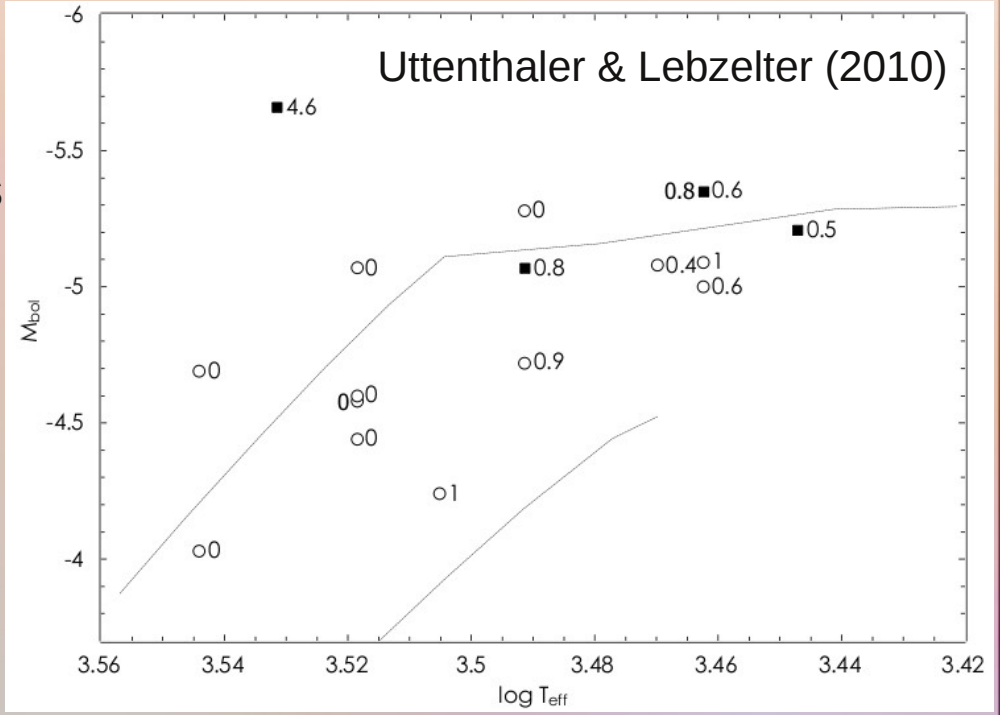
Internal mechanism: Magnetic fields? (Busso et al 2007, Palmerini et al. 2011)

Lithium in low-mass AGB stars (Miras)

AGB: Correlation between Li and TDUP indicator Tc

Analysis of Li and the radio-active s-process element technetium (Tc) shows that these elements tend to go together, and that more luminous stars tend to have Li with a higher probability.

Uttenthaler et al. 2007
Uttenthaler & Lebzelter 2010
Uttenthaler et al. 2011



O-rich disc AGB stars:
p(Li | Tc no) = 43.8 %
p(Li | Tc yes) = 80.0 %

Dredge-up of Li in low-mass AGB stars predicted by standard models (Karakas et al. 2010).

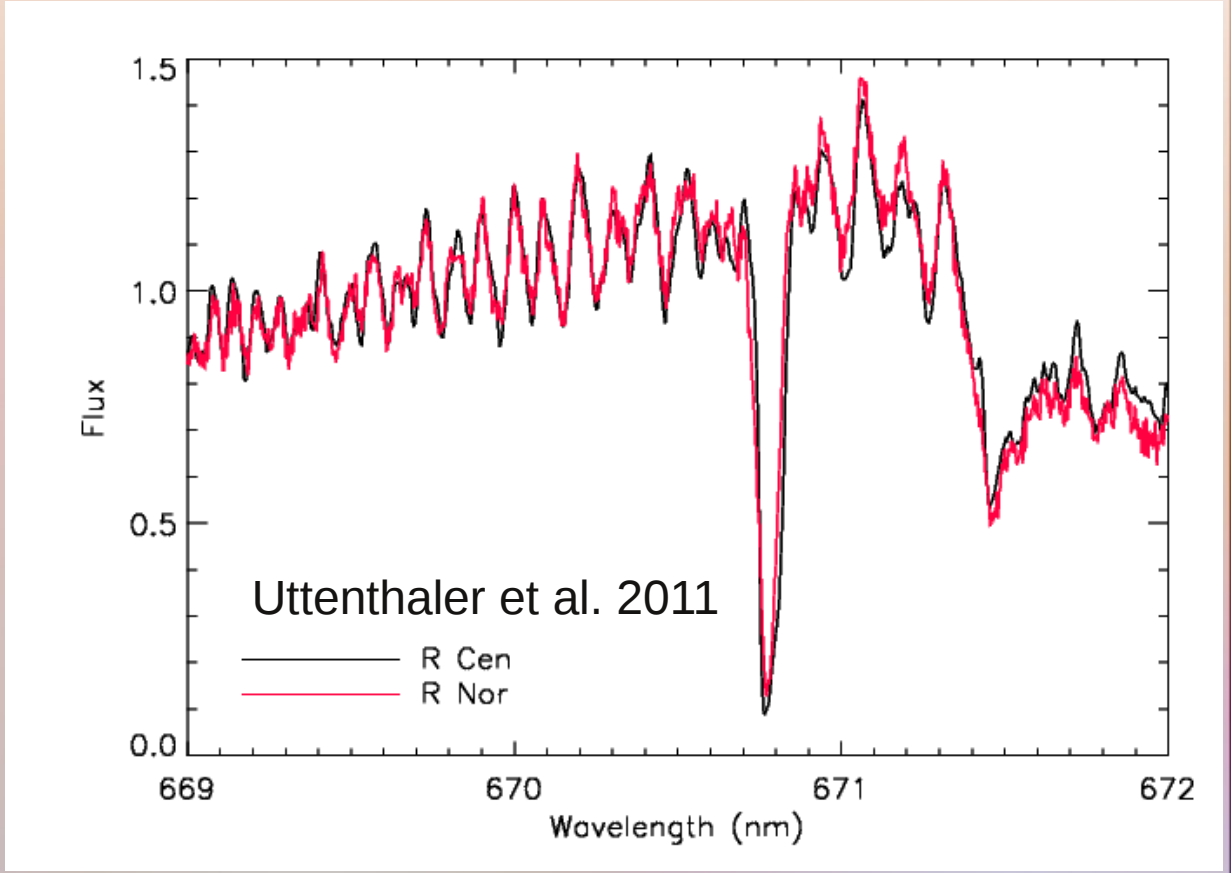
Lithium and hot bottom burning in long-period Miras

Lithium and hot bottom burning in long-period Miras

Galactic super Li-rich Miras indentified by García-Hernández et al. 2007.
Li very enhanced for P ≥ 400d.

Also the O-rich Miras R Nor (P=496d, Uttenthaler et al. 2011) and R Cen (P=538d) are found to be extremely enhanced in Li: log ε(Li)=+4.8!

Long pulsation period and high Li abundance are indicators of intermediate-mass AGB stars ($M \gtrsim 4\ M_{\odot}$).



These stars can be of importance in the cosmological context (Lind et al. 2009).

Thanks for your attention!

Note: The colour of the 671 nm Li transition
is approximately the same as that of my shirt.

Conclusions

1) Lack of distinct episode of Li enhancement in low-mass RGB stars.

2) No mass loss from Li-rich stars ➔ internal enrichment mechanism?!

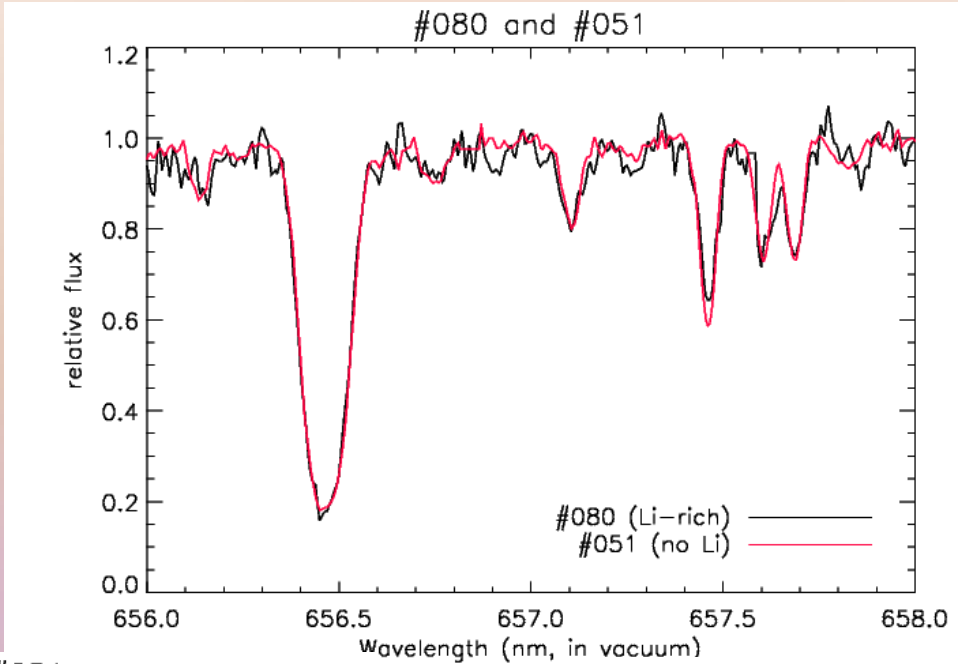
3) Trend of log ε(Li) with T_{eff}

4) Fraction of Li-detected stars on the upper RGB comparable to fraction of Li-rich AGB stars. Li might be "inherited" from the RGB.

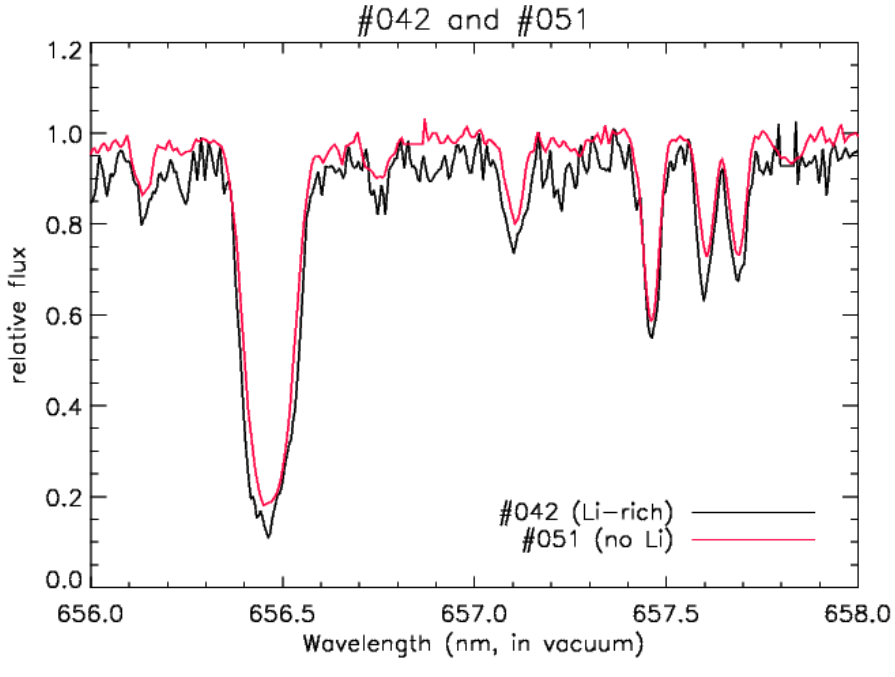
5) Dredge-up of Li in low-mass AGB stars.

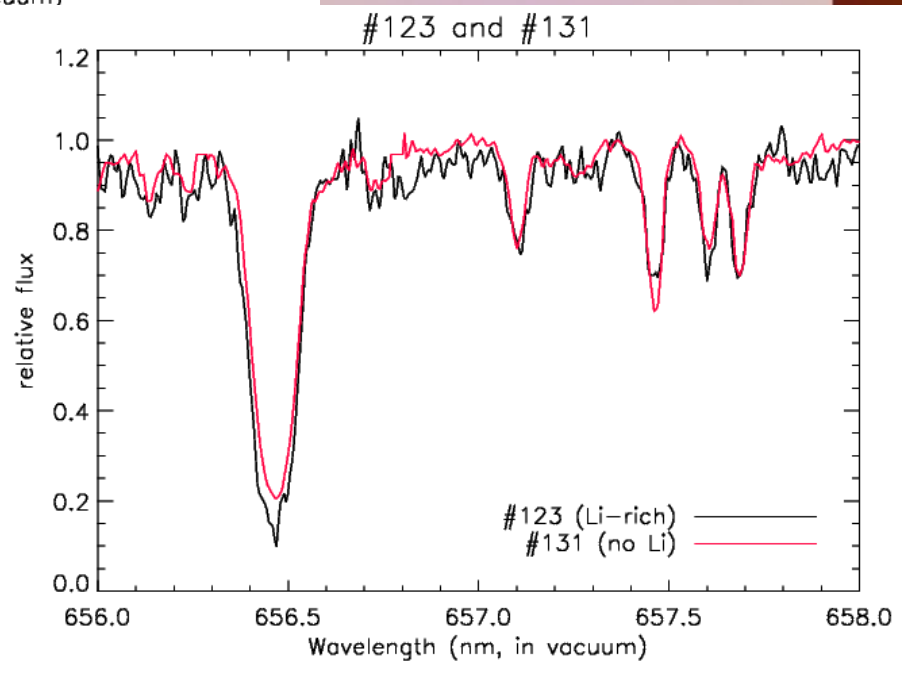
6) Extreme Li abundance an indicator of high mass of long-period Miras, enrichment of ISM with Li in some phases.

Enhanced mass loss from Li-rich stars?

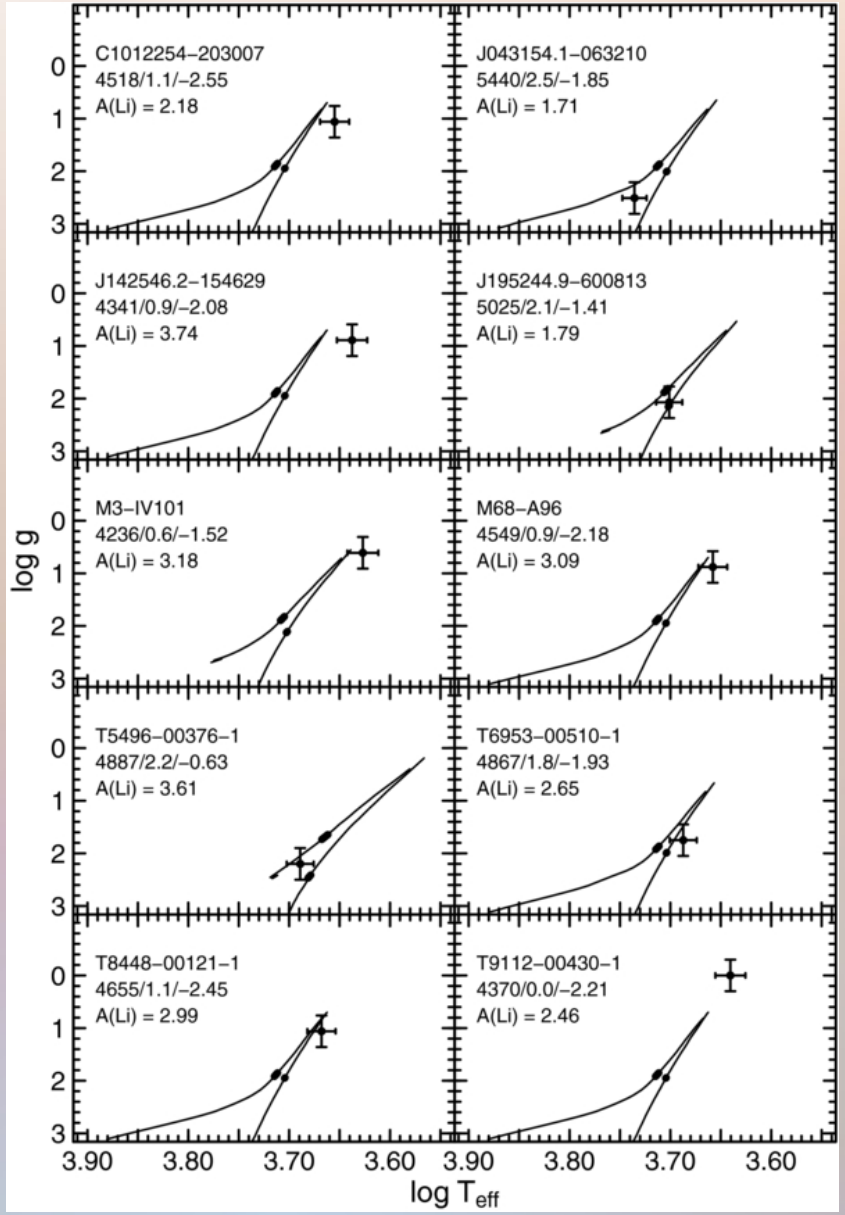


No asymmetries in Hα line profile, no gas mass loss!

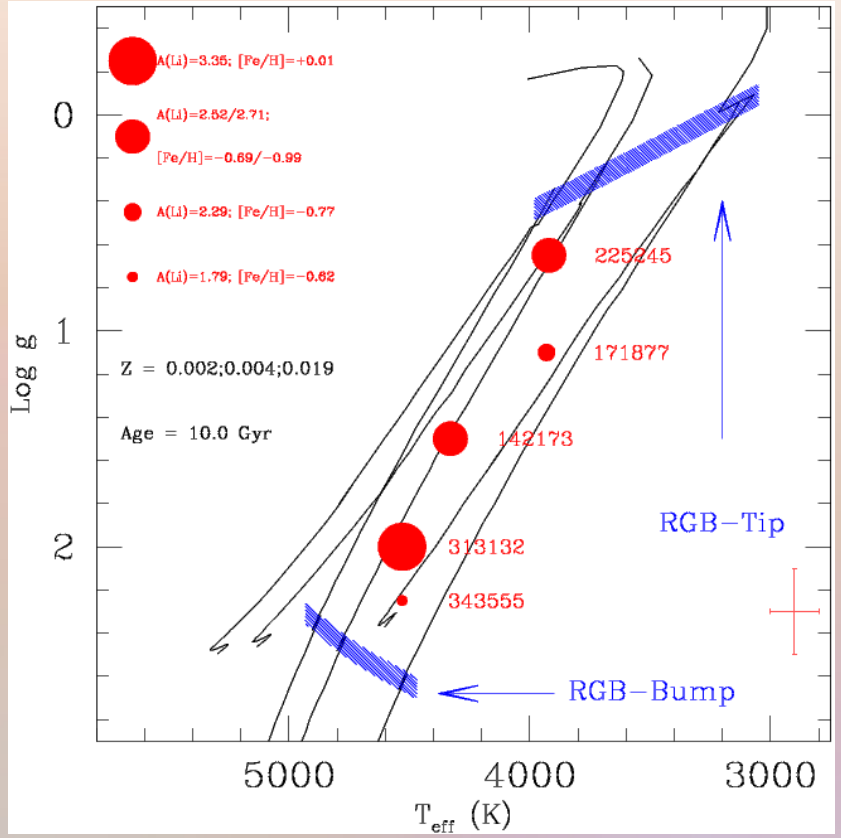




No particular Li-rich phase found in recent studies



Ruchti et al. (2011, low-metallicity stars from RAVE)



Monaco et al. (2011, Li-rich giants in the Thick Disk, 824 sample stars)

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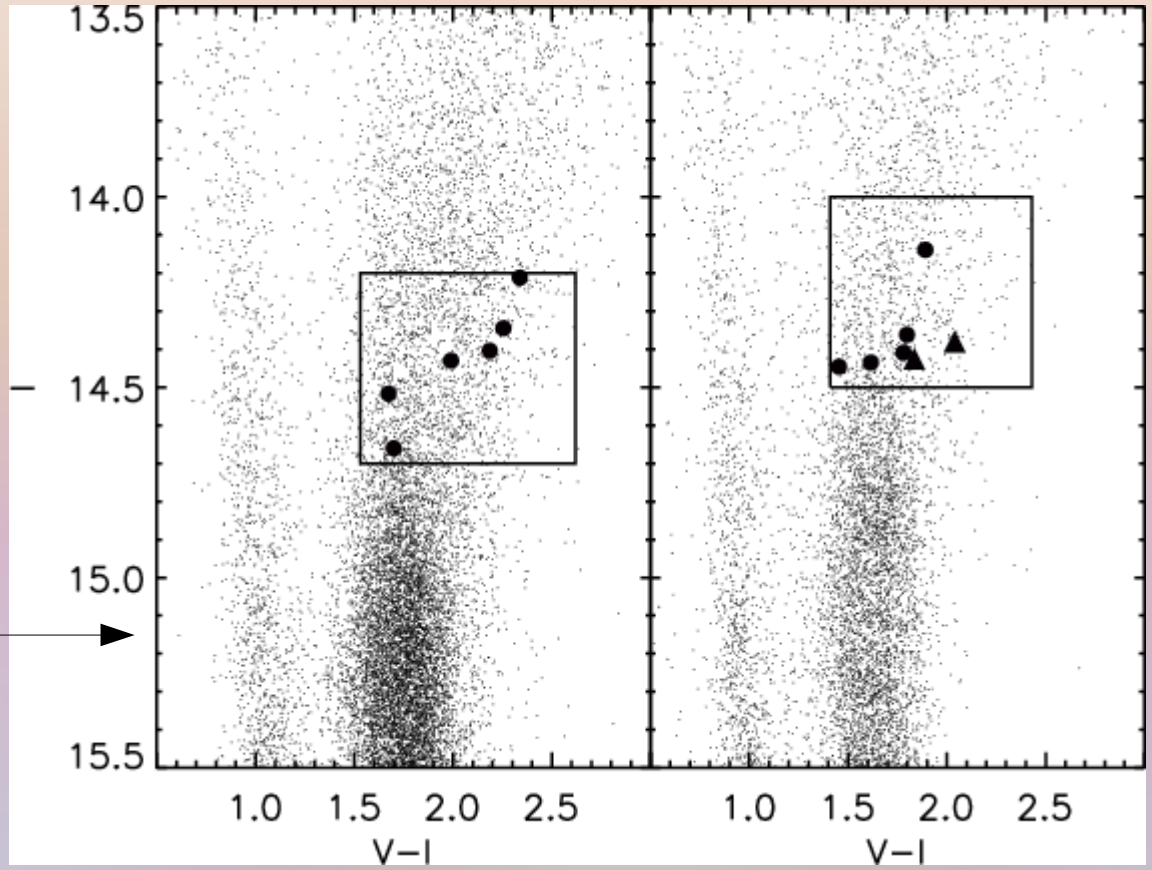

Gonzalez et al., 2009