Li overabundance in giants. Evidence of planet engulfment?

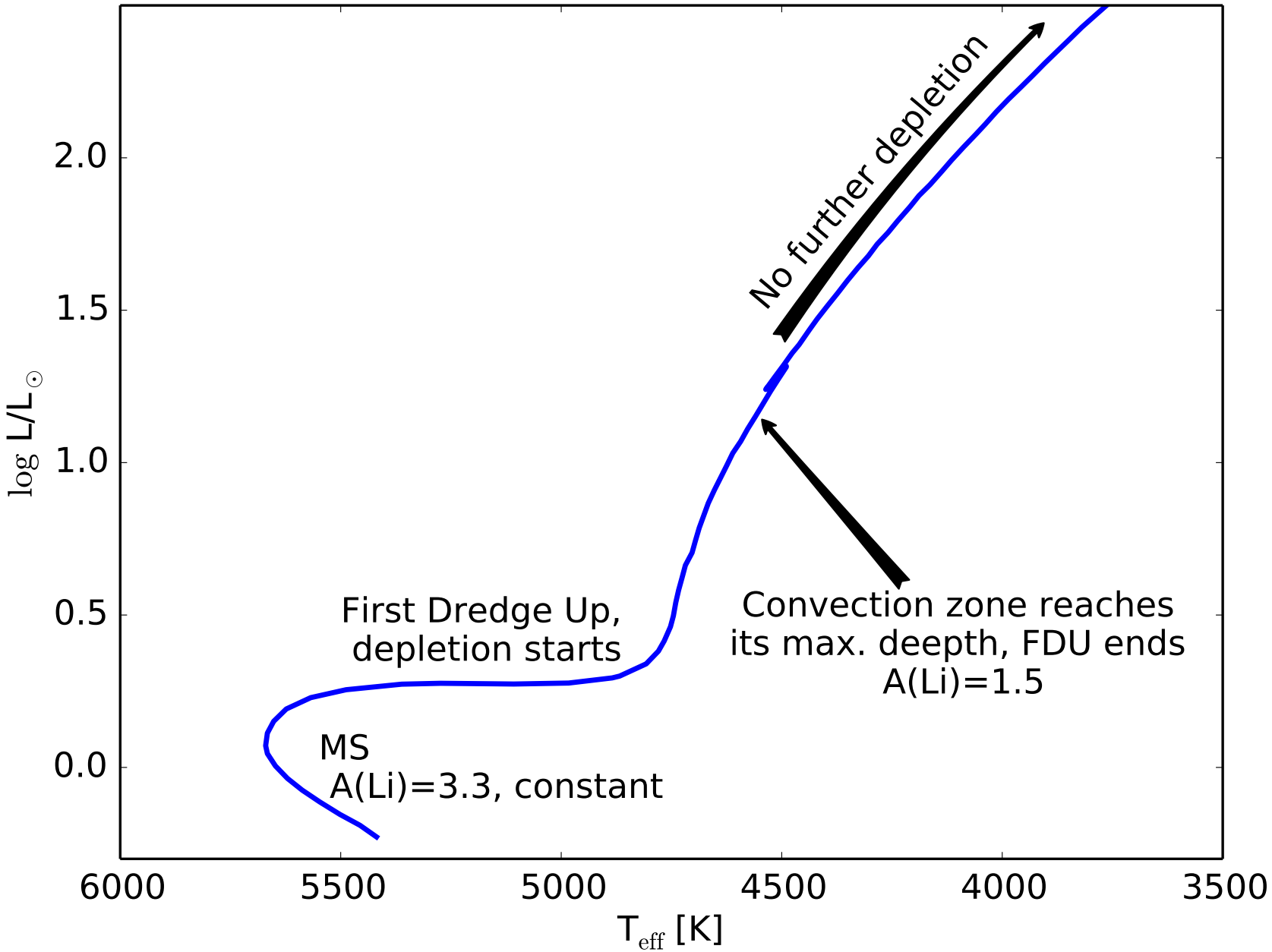
Monika Adamów

and the PTPS Team:

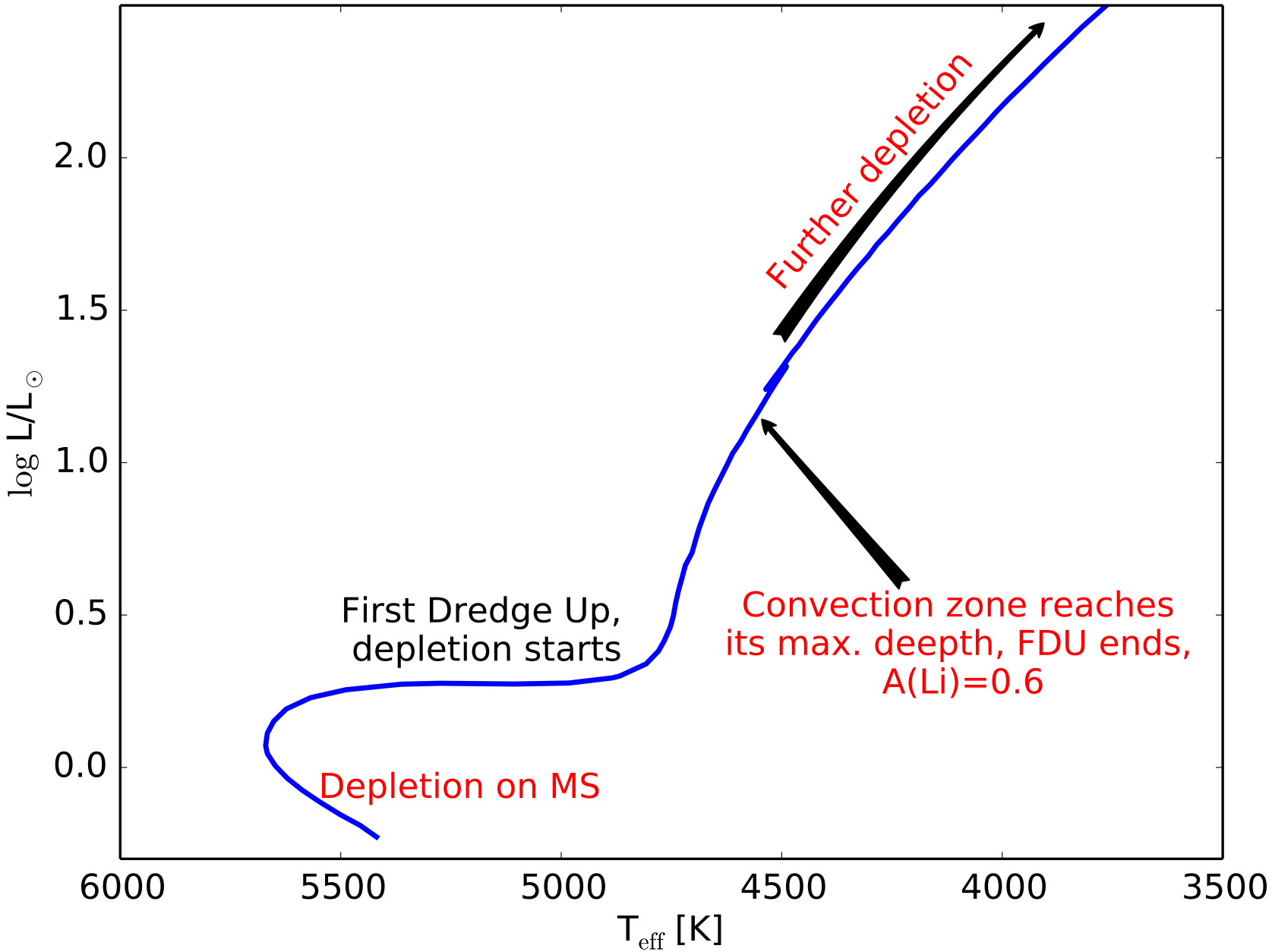
A. Niedzielski, A. Wolszczan, E. Villaver, G. Nowak, P. Zieliński, B. Deka, M.Adamczyk, K. Kowalik

adamow@astri.umk.pl
madamow@astro.as.utexas.edu

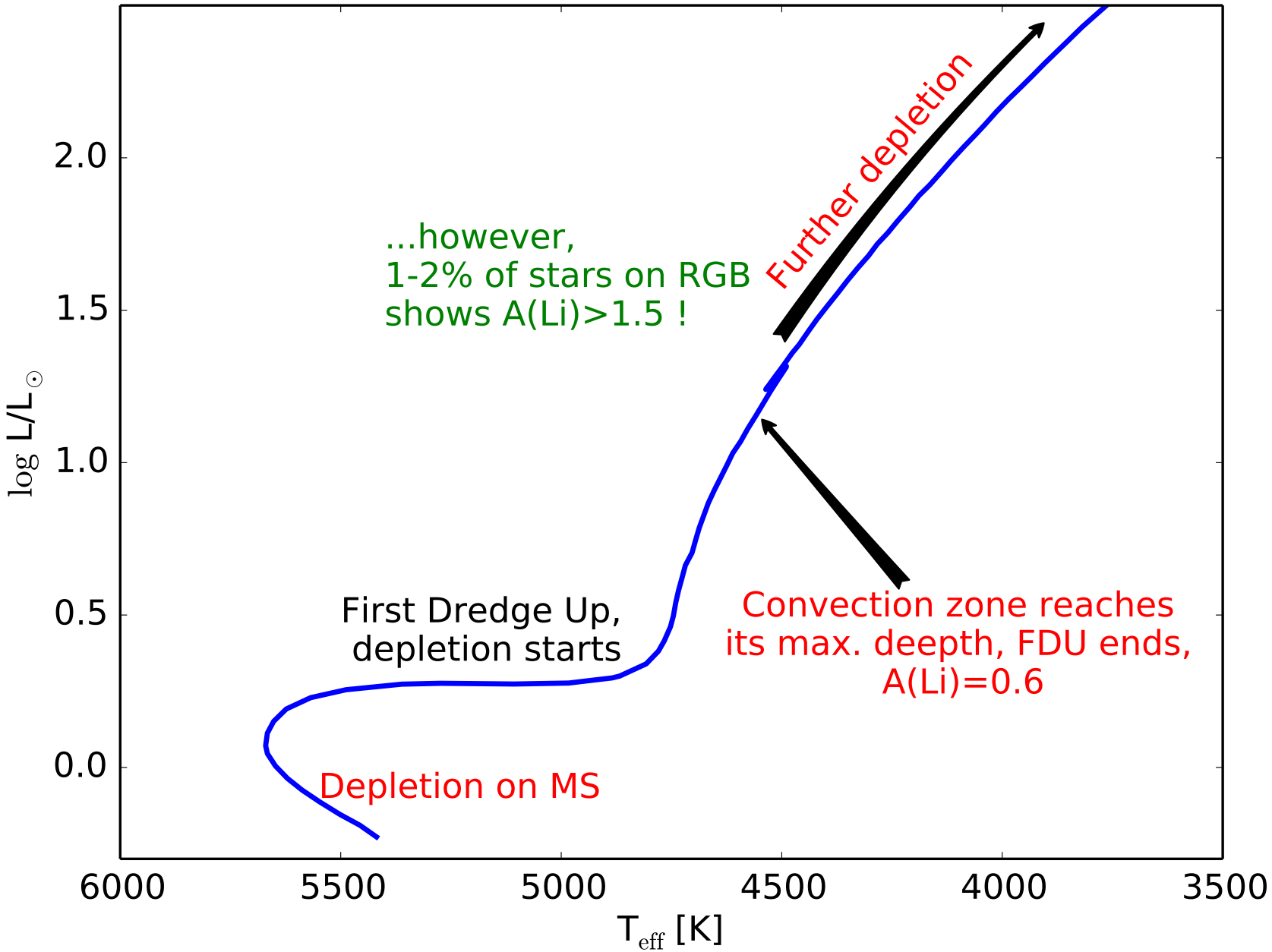
A(Li) evolution for Sun-like star – theory



A(Li) evolution – observations



A(Li) evolution – observations



Lithium enhancement in giants

Two ways to enhance Li abundance in RGB star:

1) star produces Li in its interior - works for AGB stars, not easy for RGB stars

2) star accretes lithium rich material, like:

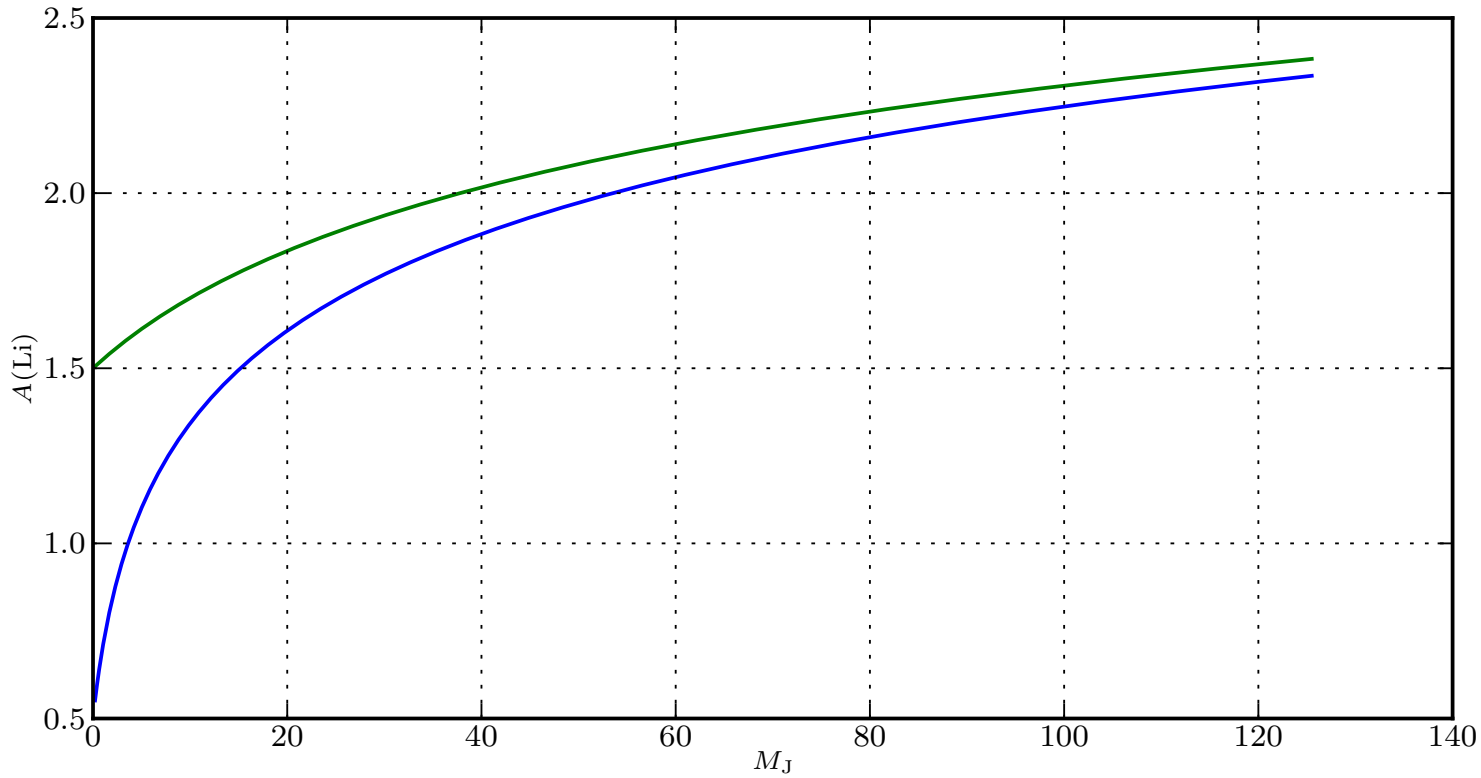
- planets or brown dwarfs,
- supernovae remnants,
- material from more evolved stellar companion

Engulfment episode

Associated phenomena:

- faster rotation
- changes in chemical composition (Li, Be, C enrichment)
- enhanced mass loss, visible in far infrared
- impact on planetary system

Engulfment episode - the bigest problem



Melo et al. 2005, Carlberg et al. 2012

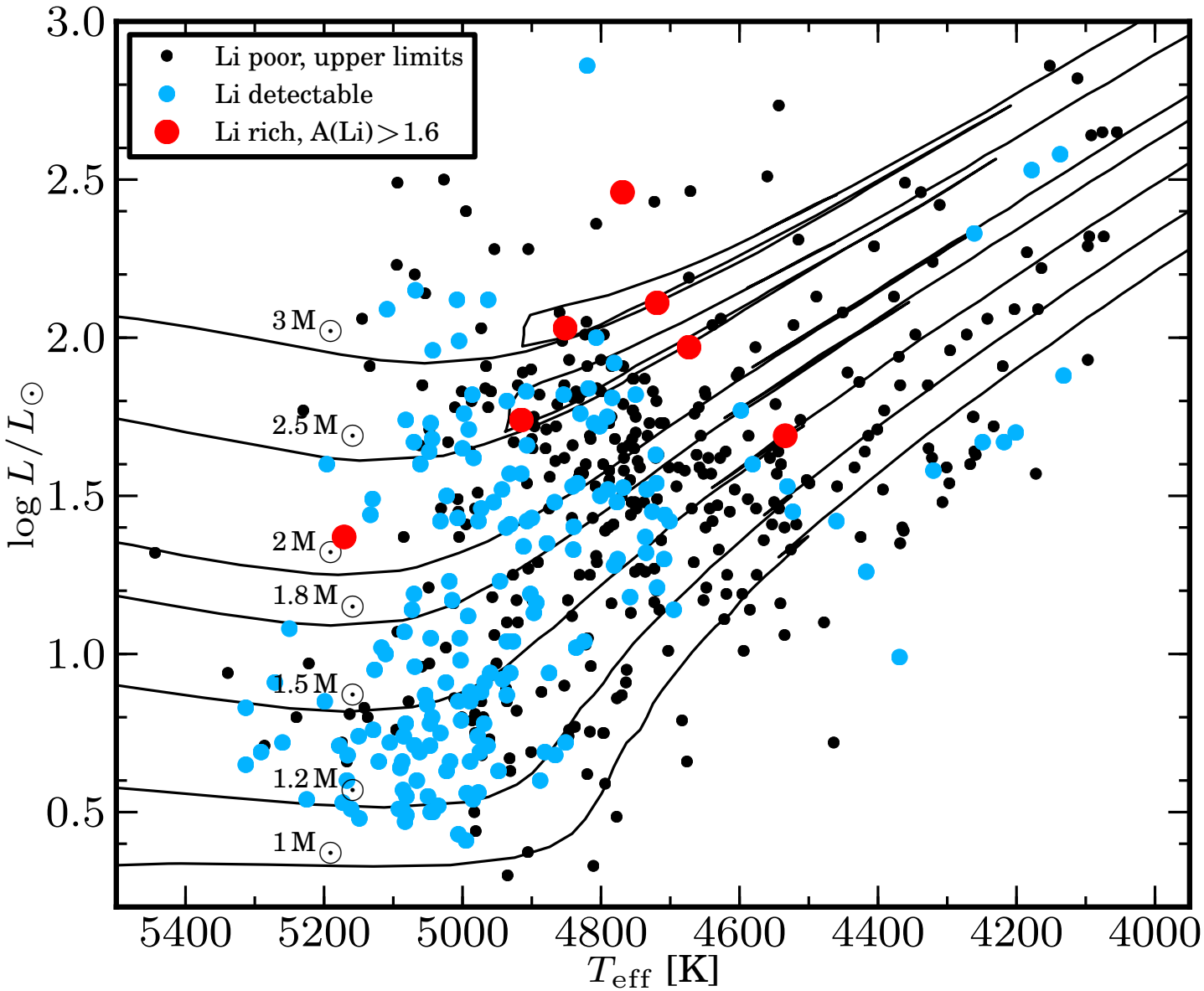
Engulfment episode

- faster rotation
- changes in chemical composition (Li, Be, C enrichment)
- enhanced mass loss, visible in far infrared
- impact on planetary system
- ... maybe it is a factor that triggers Li production?

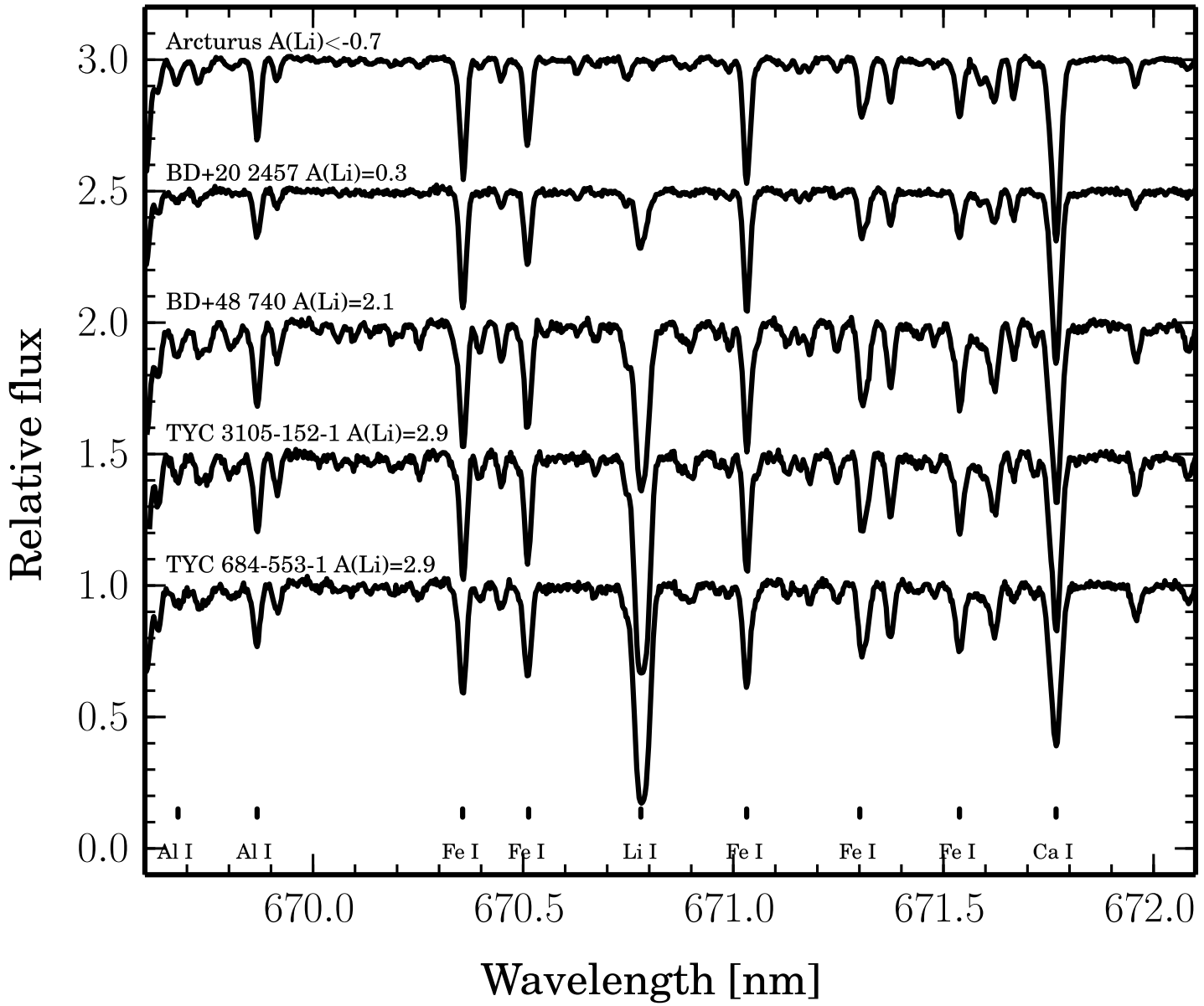
PTPS project

- **P**ennState-**T**oruń **P**lanet **S**earch for planets around intermediate-mass evolved stars.
- Main objective - Investigating evolution of planetary systems with aging hosts.
- Observations done with HET since 2004 for ≈1000 stars, mostly giants
- \+ HARPS-N spectra from *TAPAS* project
- Bonus: Lots of data to study stellar astrophysics, **including evolution of Li abundance from MS to early AGB**.

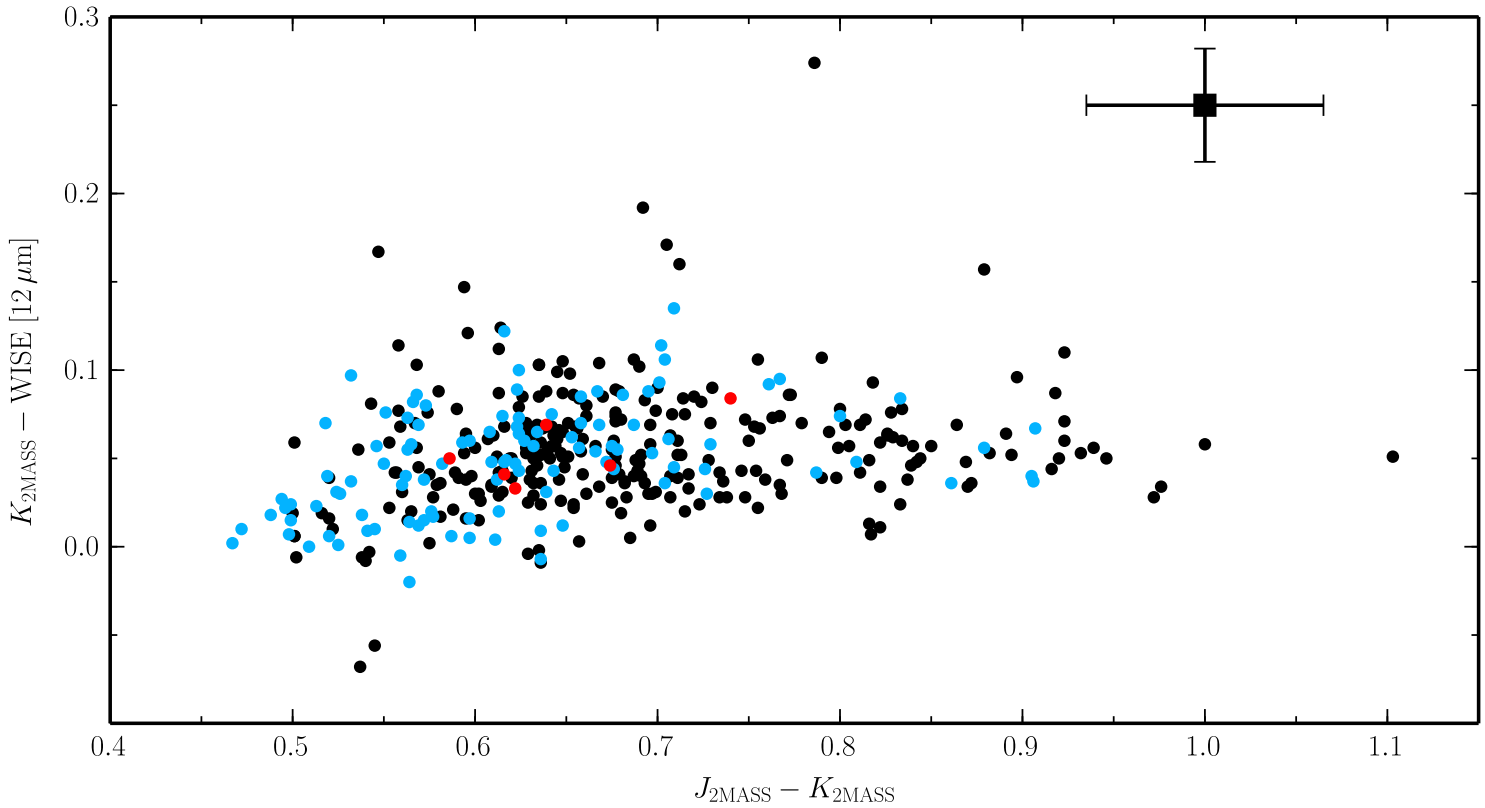
A(Li) for PTPS giants



A(Li) for PTPS giants



Li vs. infrared excess

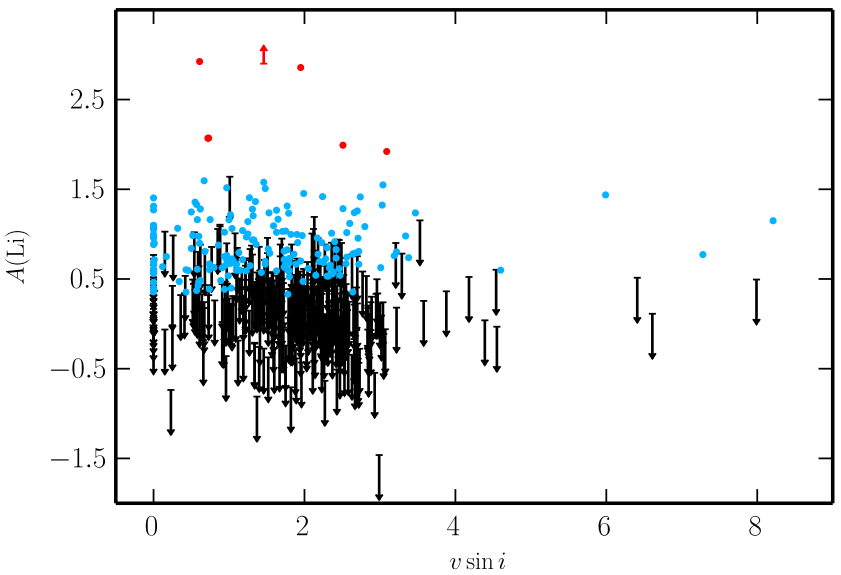


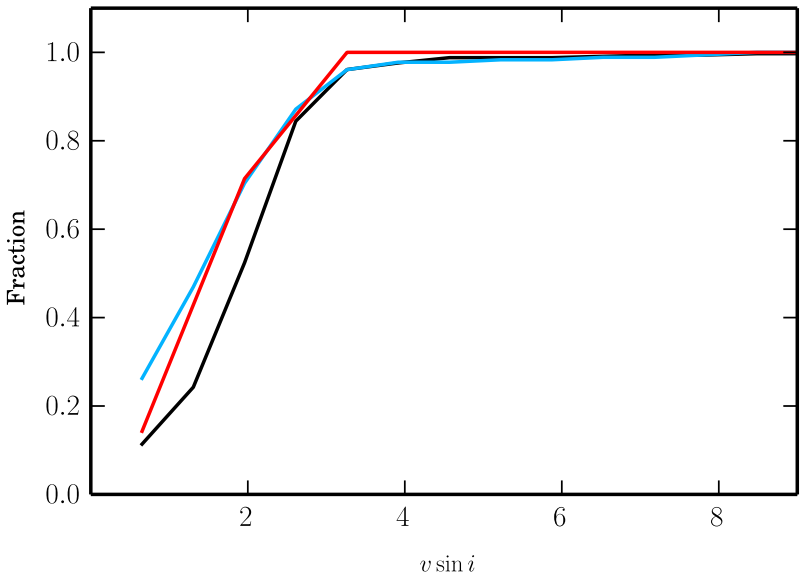
See also Lebzelter et al. 2012

No signs of engulfment !

Li vs. rotational velocity

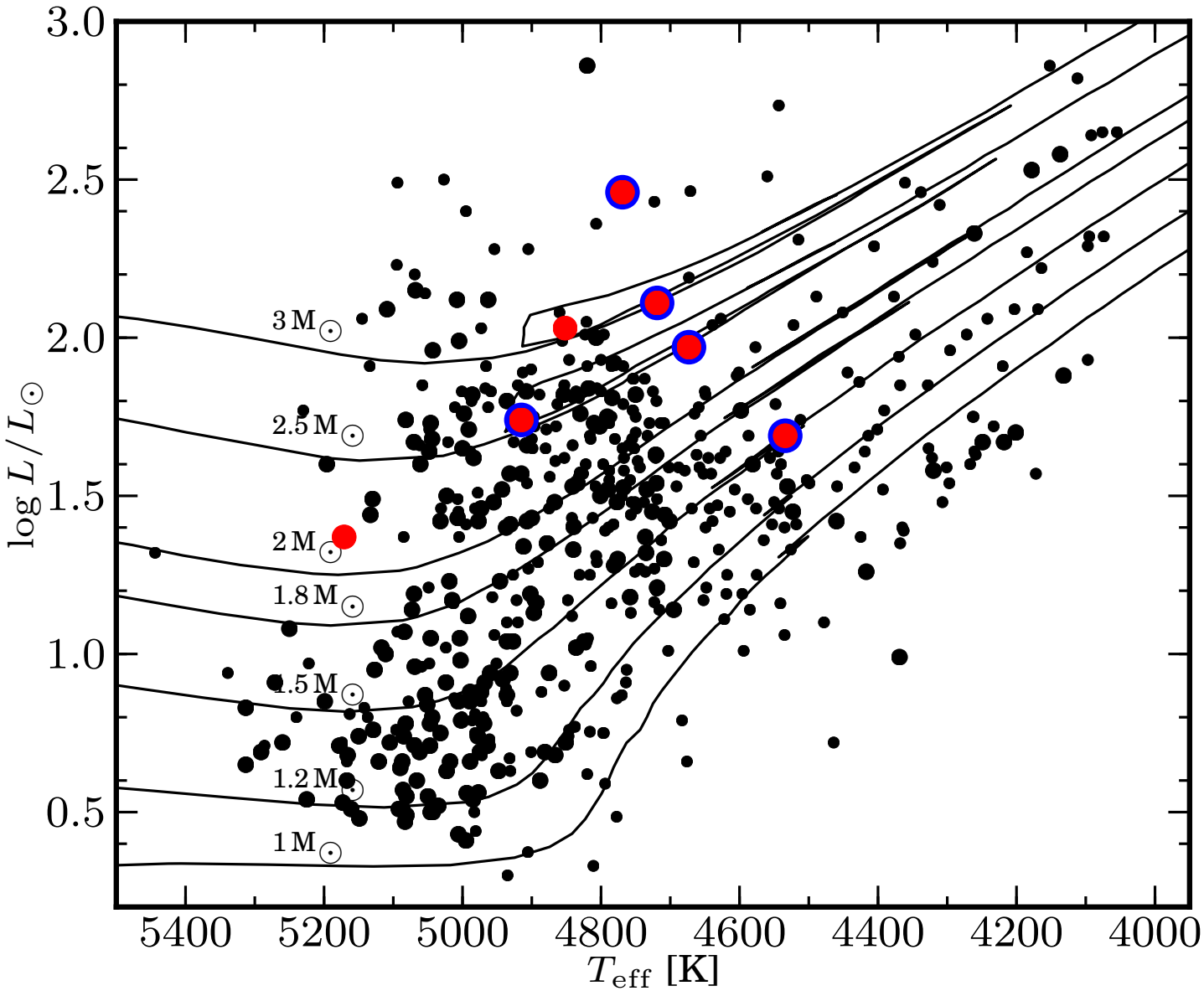
During engulfemnt, orbital angular momentum of planet might be transferred to a star.



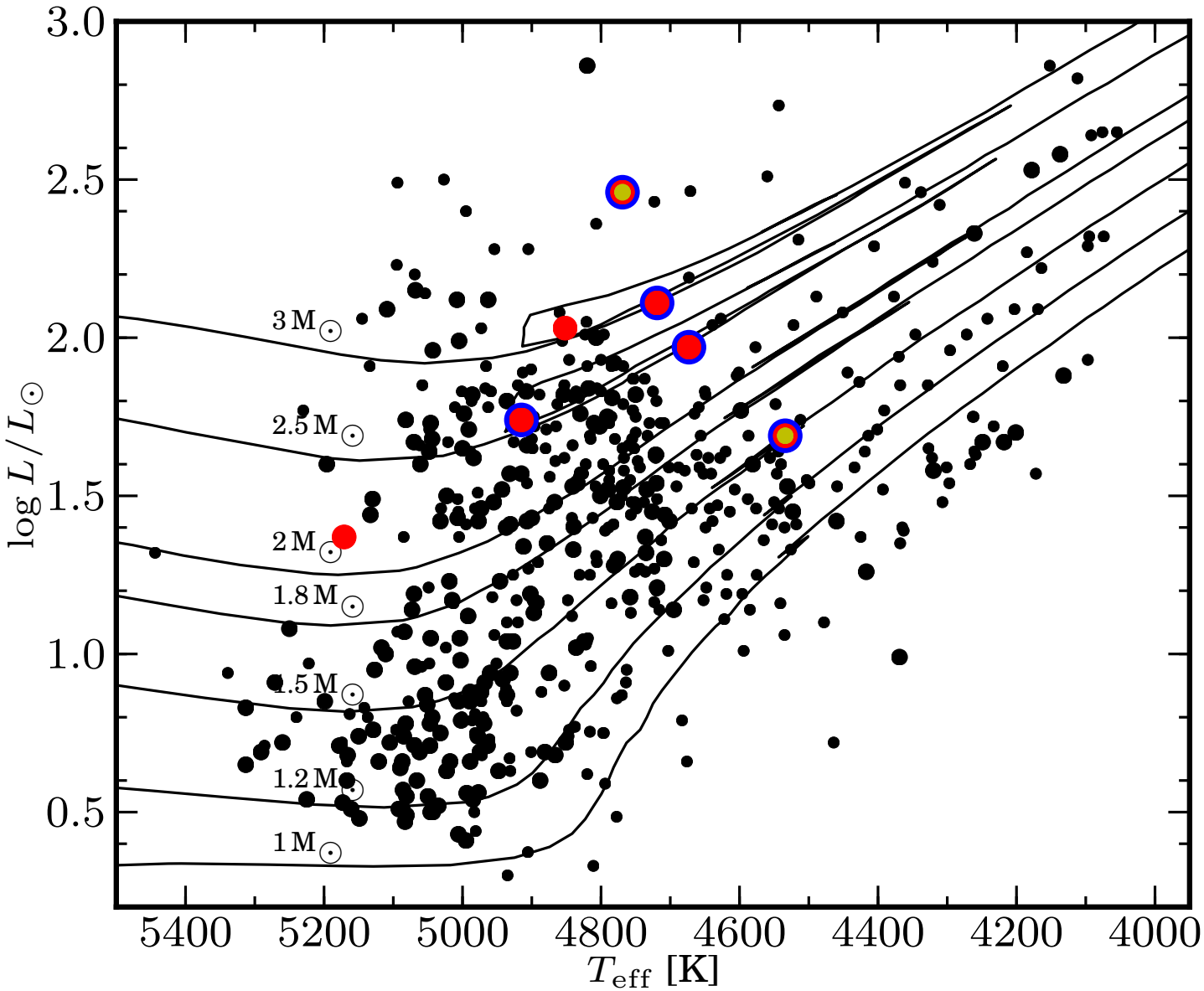


No signs of engulfment !

Li in giants


3.0
2.5
2.0
1.5
1.0
0.5
log $L/L_\odot$
3 M$_\odot$
2.5 M$_\odot$
2 M$_\odot$
1.8 M$_\odot$
1.5 M$_\odot$
1.2 M$_\odot$
1 M$_\odot$
5400
5200
5000
4800
4600
4400
4200
4000
$T_{\rm eff}$ [K]

Li in giants

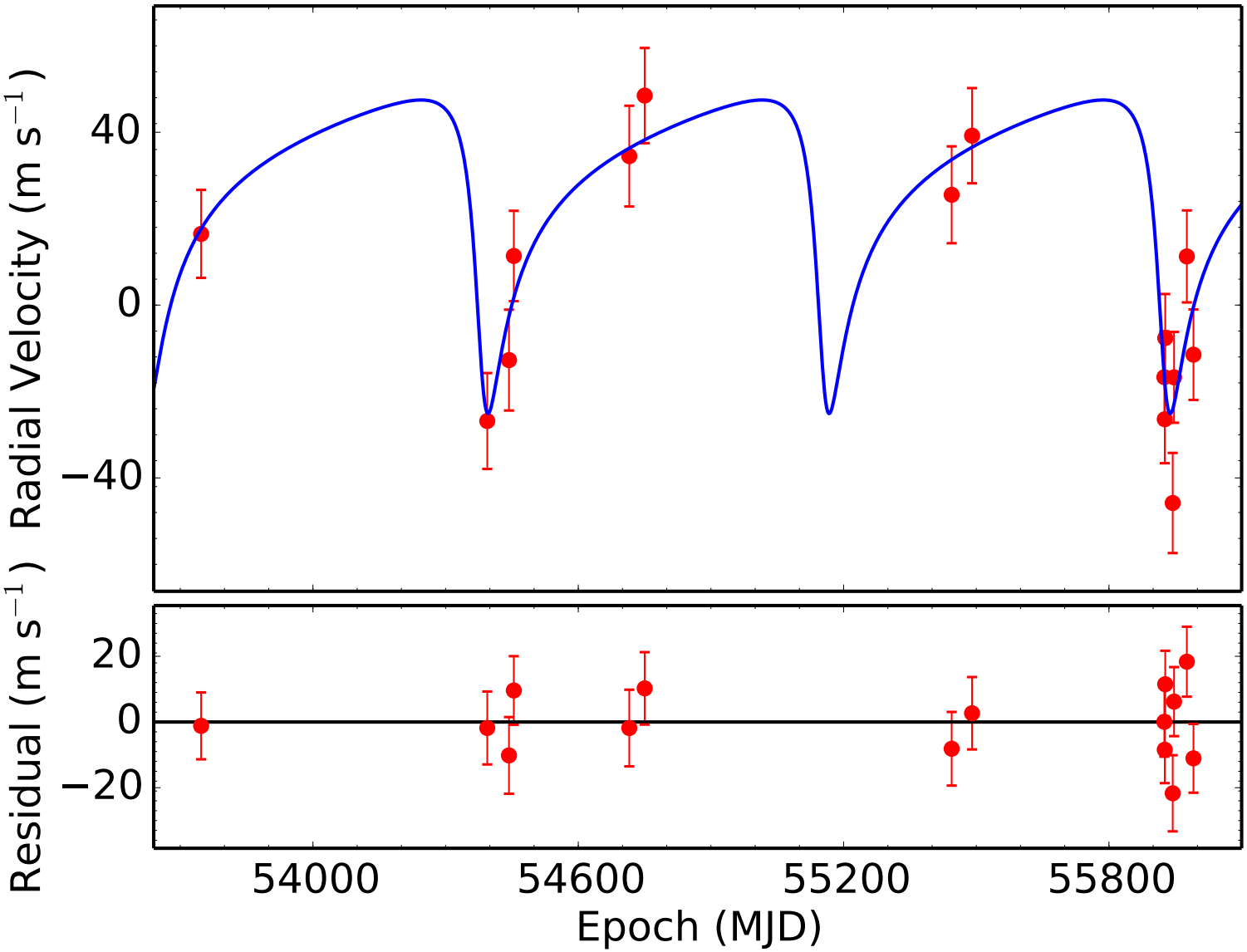

3.0
2.5
2.0
1.5
1.0
0.5
log $L/L_\odot$
3 M$_\odot$
2.5 M$_\odot$
2 M$_\odot$
1.8 M$_\odot$
1.5 M$_\odot$
1.2 M$_\odot$
1 M$_\odot$
5400
5200
5000
4800
4600
4400
4200
4000
$T_{\rm eff}$ [K]

BD+48 740 - Adamów et al. 2012

- T_{eff}=4534, $\log g = 2.48$, $M = 1.5 M_{\odot}$, slow rotator
- A(Li)=2.1
- after 15 epochs of RV measurements - candidate for planetary host
- no signs of stellar activity that could mimic RVs in bisectors, Ca H&K, or photometry
- planet on a very eccentric orbit $e = 0.67$
- a case of planet engulfment?

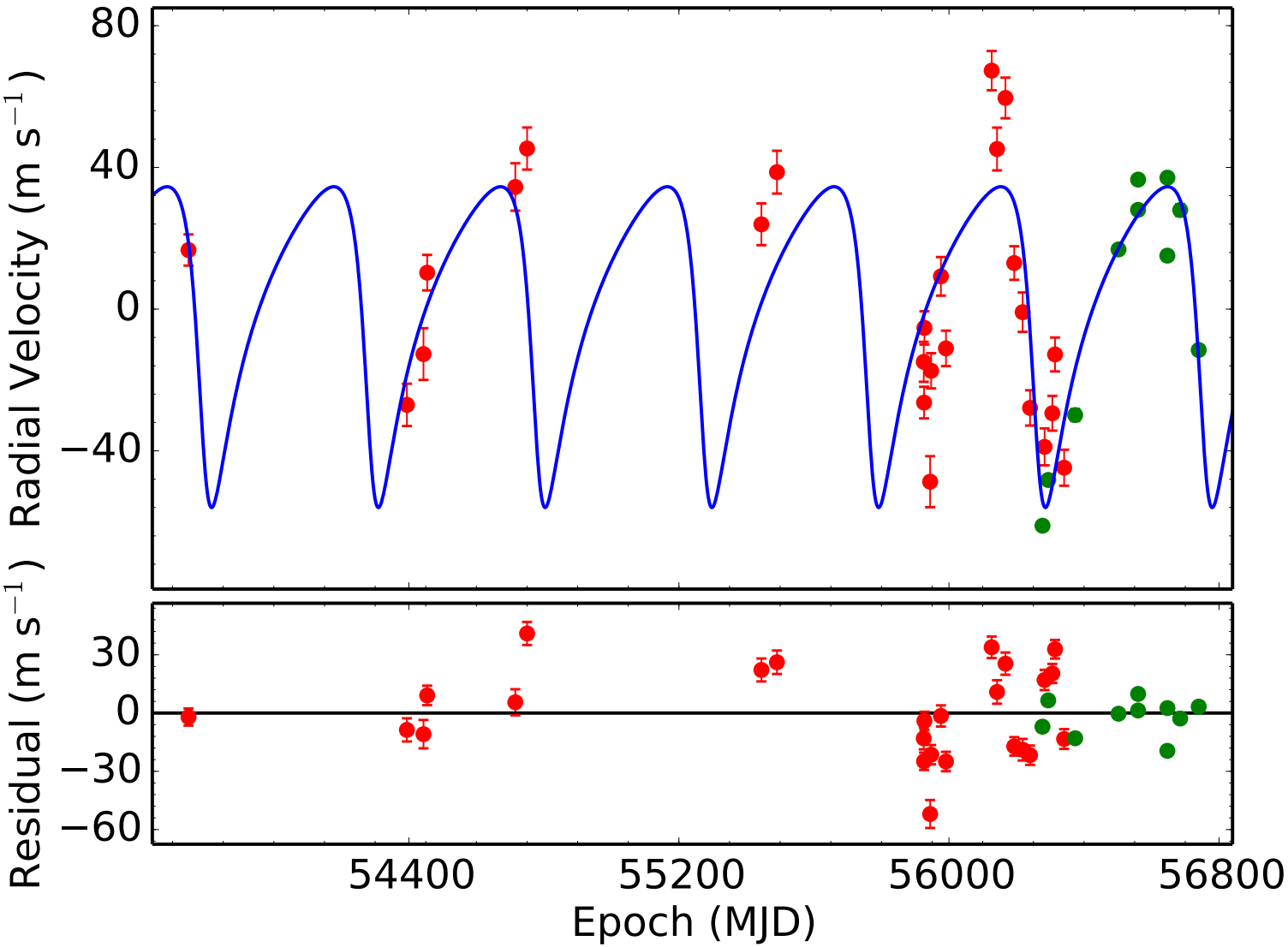
BD+48 740

$P = 777^d$, $e = 0.67$



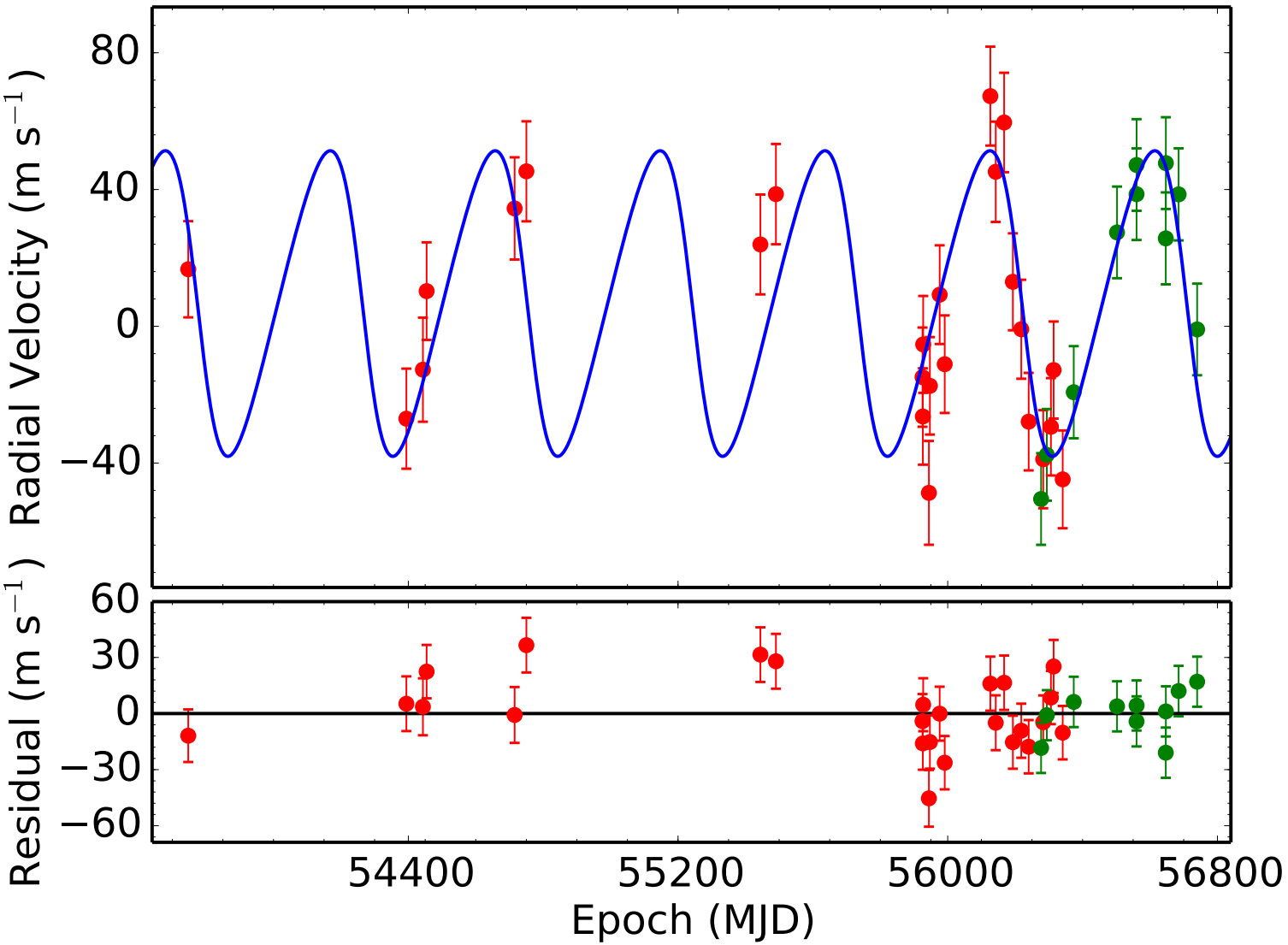
BD+48 740

$P = 494^d$, $e = 0.47$



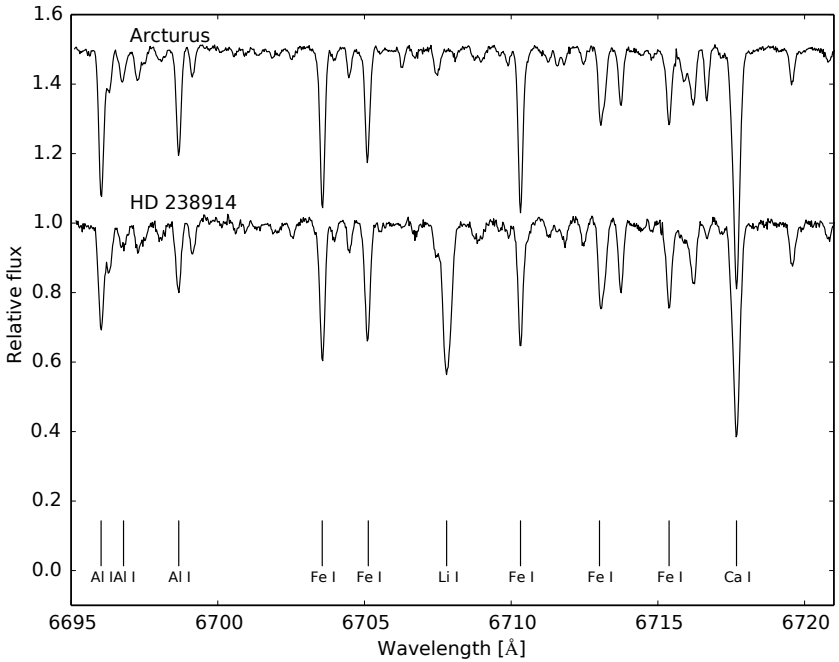
BD+48 740

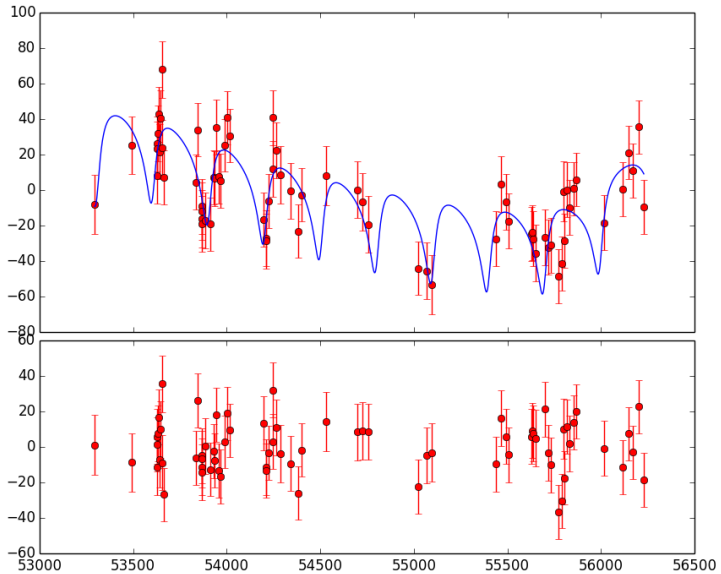
$P = 489^d$, $e = 0.19$



HD 238914

Adamów et al. 2014, Niedzielski et al. in prep.





HD 238914

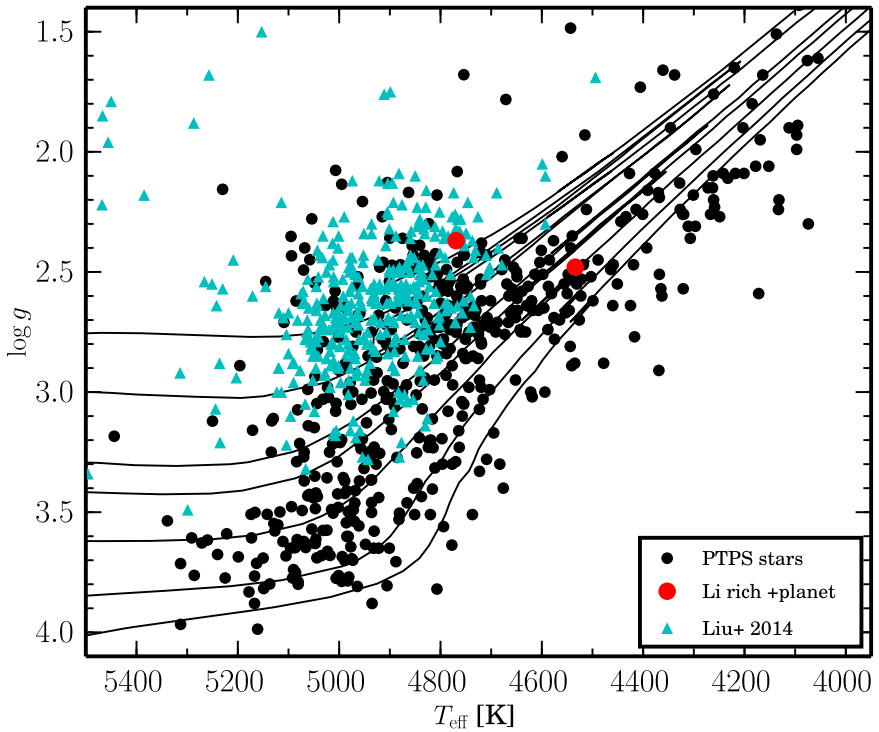
Parameter	HD 238914
V (mag)	8.79±0.01
Spectral type	K7
T_{eff} (K)	4769 ±45
$\log g$	2.37 ± 0.18
[Fe/H]	-0.25 ±0.09
$\log L_\star/L_\odot$	2.46 ± 0.62
A(Li)	2.0 ± 0.03
$v_{rot}\, sin\, i_\star$ ($\mathrm{km\,s^{-1}}$)	2.5 ± 0.5
$M_\star/M_\odot$	1.9 ± 0.2
$R_\star/R_\odot$	24.9 ± 3.3
Age [Gyr]	1.2 ±0.4
$P_{rot}\, sin\, i_\star$ (days)	837±432
K_{osc} ($\mathrm{m\,s^{-1}}$)	36^{+140}_{-29}
P_{osc} (days)	$1.1^{+0.5}_{-0.4}$

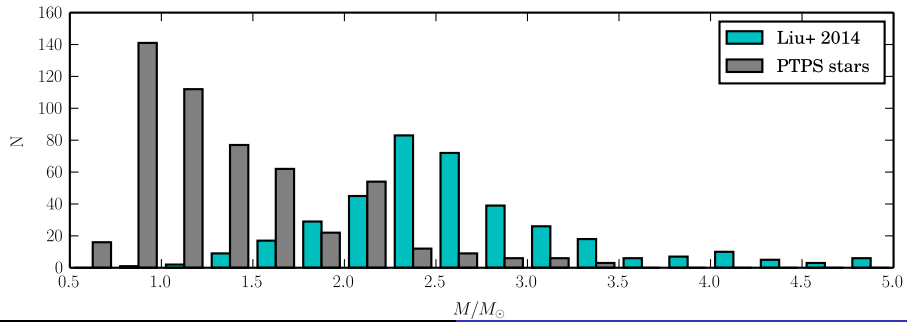
ORBITAL PARAMETERS OF HD 238914

Parameter	c	b
P (days)	3010 ± 250	298.8 ± 1.6
T_0 (MJD)	56230 ± 110	53603 ± 11
K ($\mathrm{m\ s^{-1}}$)	27.6 ± 4.5	23 ± 5
e	0.4 ± 0.17	0.47 ± 0.12
ω (deg)	300 ± 17	210 ± 20
$m_2 \sin i$ ($\mathrm{M_J}$)	2.7 ± 0.9	1.02 ± 0.27
a (AU)	5.06 ± 0.45	1.085 ± 0.042
V_0 ($\mathrm{m\ s^{-1}}$)	-4.4 ± 3.1	
$\sqrt{\chi^2_\nu}$	0.89	
σ_{RV}	14.35	
N_{obs}	71	

Li in planetary searches

Liu et al. 2014, Adamów et al. 2014





Summary

- Engulfment episode may contribute to Li enhancement, but is unlikely to be the only source of lithium for giants with A(Li) $\gtrapprox$ 2
- Is it possible that the presence of close-in planets influences processes in stellar interior?
- It seems to be unlikely, that there is only one universal mechanism of Li enrichement
- Studying Li abundance for giants that are targets of a planet search gives unique opportunity to investigate Li enhancement in connection of a presence of stellar companions.
- A lot of work needs to be done to better understand how engulfment works.

Wallerstein & Sneden, ApJ 1982

Such putative planetary systems, however, might be good candidates for the search for extraterrestrial intelligence because the inhabitants of their outer planets might be screaming for help as they watch their inner planets disappear into their central star.