Beryllium Abundances in Li-Rich Red Giants

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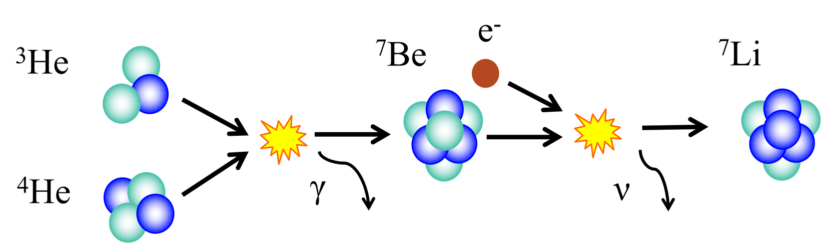
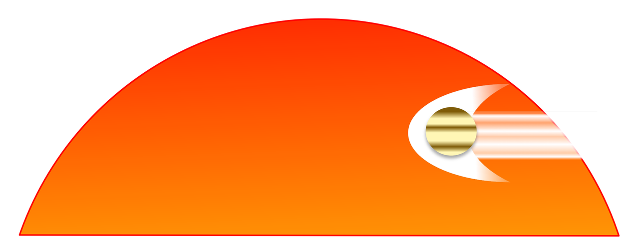
Why Are Some Red Giants Li-Rich?





Li Nucleosynthesis?

★ ^{7}Li can be created below the convection zone (where $T > 10^7$ K) and quickly mixed to cool regions ($T < 3\text{x}10^6$ K) where ^{7}Li is long lived.

★ Maximum replenishment: arbitrarily large A(Li)†, depending on $A(^3\text{He})$ and mixing details.

Companion Engulfment?

★ Hot/warm Jupiter engulfment can add planetary Li to stellar atmosphere.

★ Maximum replenishment: A(Li) ~ 2 dex under simple assumptions of stellar and companion compositions and sizes.

†$A(\text{X}) \equiv \log N_\text{X} - \log N_\text{H} + 12$, for some element X

Choosing the Stellar Samples

Li-synthesis candidates (2):

★ $^{12}\text{C}/^{13}\text{C} < 15$ (indicative of deep mixing)

Engulfment candidates (5):

★ $^{12}\text{C}/^{13}\text{C} > 15$ (no deep mixing),

★ $v \sin i > 5$ km/s (some spin-up)

Planet host candidates (1):

★ taken from literature

Table 1. Stellar Parameters

Star	$T_{\rm eff}$ (K)	log g (dex)	[Fe/H] (dex)	ξ (km s^{-1})	$v \sin i$ (km s^{-1})	$A(\text{Li})_{\rm NLTE}$ (dex)	$^{12}\text{C}/^{13}\text{C}$	Source	Notes[b]
HD 120602	5000	3.00	−0.08	1.50[a]	5.0	2.07	16	K11	PPE
HD 108471	4970	2.80	−0.01	1.57[a]	4.1	2.10	25	K11	PPE
HD 133086	4940	2.98	+0.02	1.51[a]	···	2.14	7	K11	ILS
Tyc3917-01107-1	4769	2.37	−0.25	1.54	2.5	1.99	···	A14,Z12	CPH
Tyc1058-02865-1	4758	3.04	−0.17	1.63	6.0	1.44	···	A14,Z12	PPE
HD 150902	4690	2.55	+0.09	1.65[a]	···	2.65	5	K11	ILS
HD 148293	4640	2.50	+0.08	1.67[a]	1.2	2.16	16	K11	PPE
HD 112127	4340	2.10	+0.09	1.80[a]	1.6	2.95	19	K11	PPE
	4400	2.05	+0.01	1.72	2.7	···	34	C12	

[a] Estimated using relationship in Holtzman et al. (2015).

[b] PPE – possible planet engulfment, ILS – internal lithium synthesis, CPH – candidate planet host

Table from Carlberg+ 2018, in prep.

Spectral Synthesis & AMOEBA Fitting

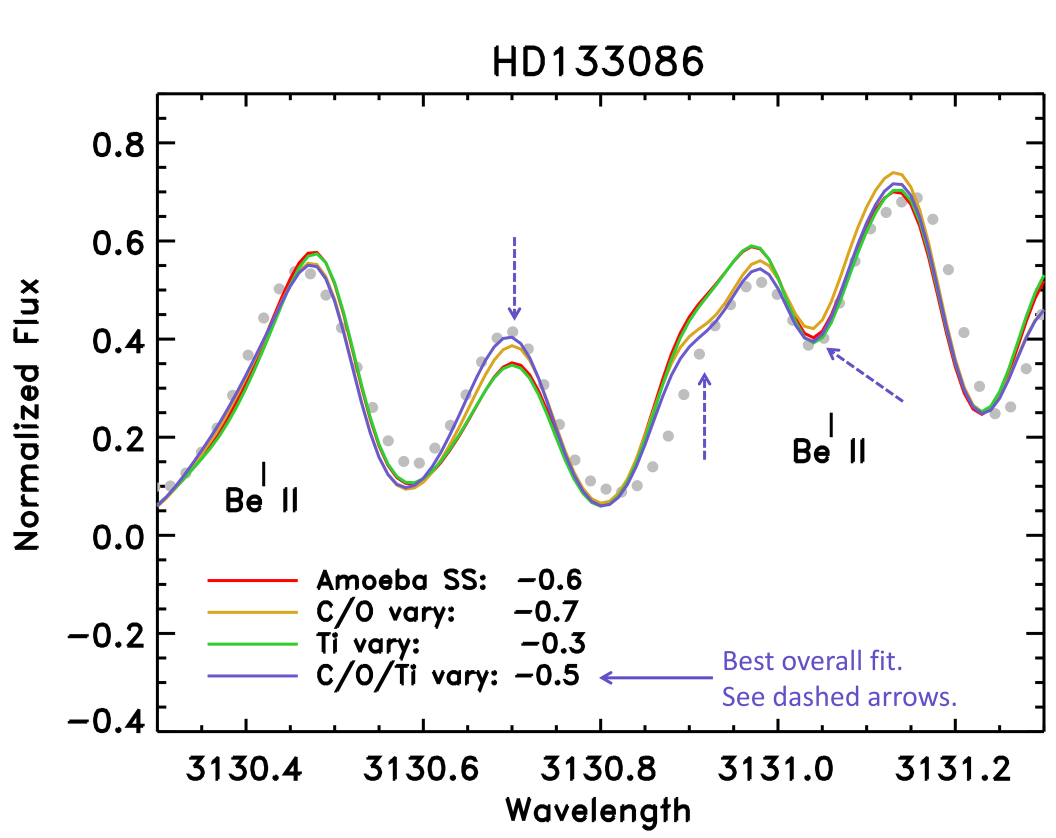


Figure 1: Best fit A(Be) for 4 AMOEBA fitter runs, varying the number of free parameters.

Synthetic spectra created with:

★ MARCS spherical models (Gustaffson+ 2008)
★ MOOG 2014 (Sneden 1974)
★ a NEW line list (Carlberg+ 2018)
★ updated continuous opacities (Carlberg+ 2018)

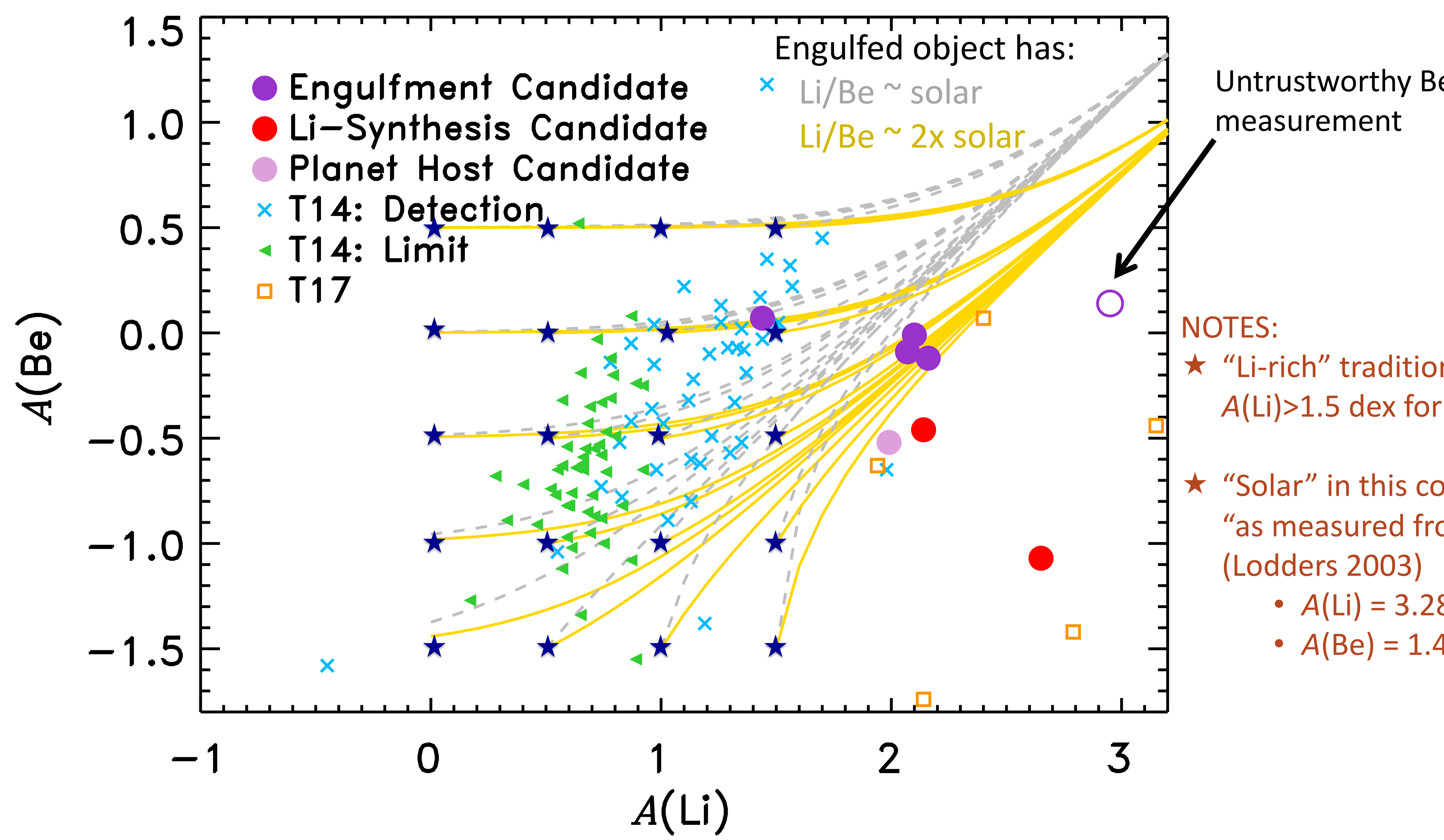
Why use an automated fitter?

Molecular equilibrium chemistry makes it difficult to intuit how a change in the input abundances affects the output spectrum.

Multiple AMOEBA fits are run

1. adopting scaled solar abundances only,
2. allowing C and O to vary,
3. allowing Ti to vary,
4. allowing C, O, and Ti to vary.

Beryllium Results



NOTES:

★ "Li-rich" traditionally means $A(\text{Li}) > 1.5$ dex for red giants

★ "Solar" in this context means "as measured from meteorites" (Lodders 2003)

- A(Li) = 3.28 dex
- A(Be) = 1.42 dex

Figure 2: Observed A(Be) and A(Li) for the sample of Li-rich red giants studied here (circles) and from a large sample of red giants in the literature (small triangles, x's and squares). The curved lines show families of models predicting how stellar Li and Be change from their initial values (blue stars) when engulfing bodies with solar (dashed gray) and 2x solar (solid gold) ratios of Li to Be.

Conclusions

★ "Engulfment candidates" and "Li synthesis candidates" generally fall on different regions of the A(Be) vs. A(Li) plot. → Most of the Li-rich red giants from T17 are expected to have low $^{12}\text{C}/^{13}\text{C}$, given their location in Fig. 2.

★ Abundances of the engulfment candidates are best reproduced by engulfing companions that have Li/Be ~ 2x solar.

★ Larger samples of Li-rich giants with both Be and $^{12}\text{C}/^{13}\text{C}$ are needed confirm this apparent relationship.

References:

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