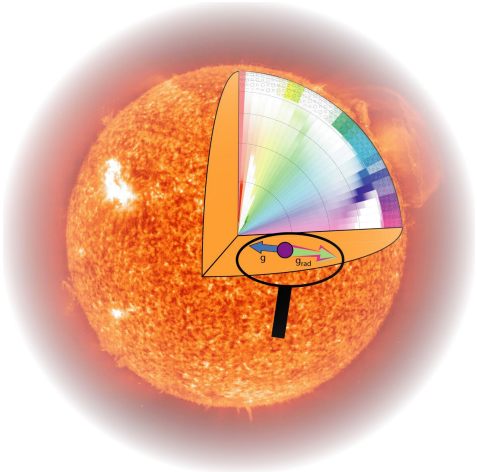
Le Soleil est-il une étoile chimiquement particulière?



Morgan Deal, IA, Porto

COMPETE 2020
FCT Fundação para a Ciência e a Tecnologia
POCI-01-0145-FEDER-030389
PNPS Programme National de Physique Stellaire
ia instituto de astrofísica e ciências do espaço

What can affect chemical elements in main-sequence stars?

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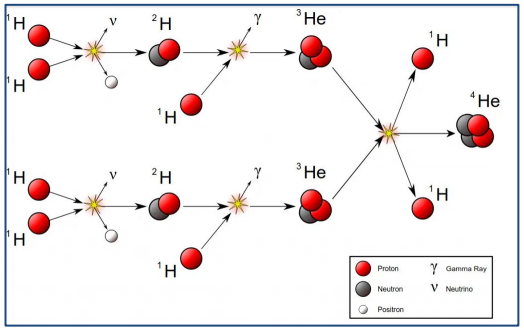
Nuclear reactions



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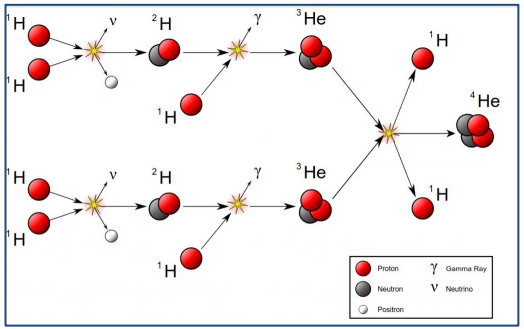

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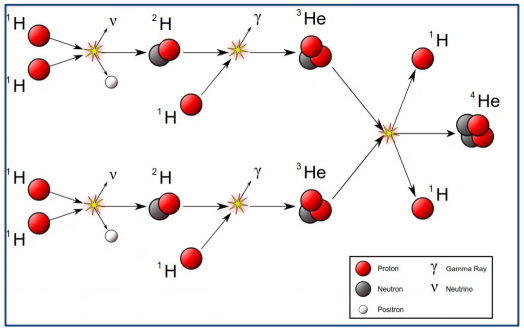

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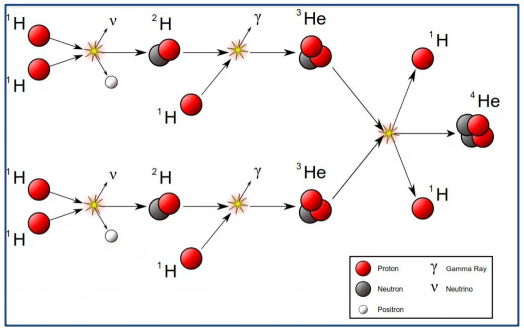

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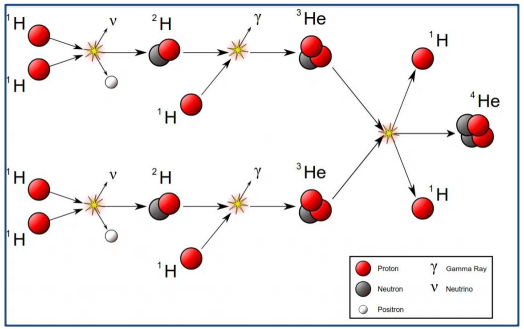

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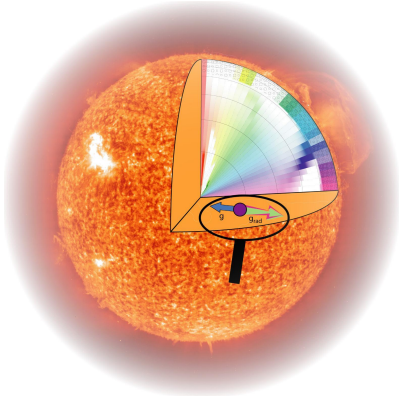

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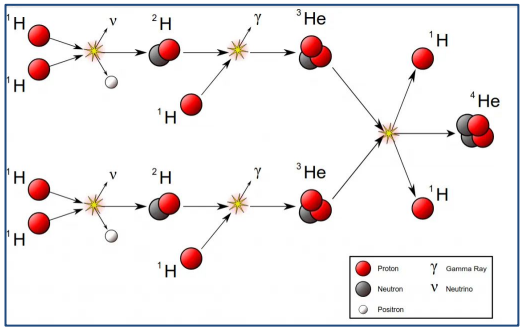

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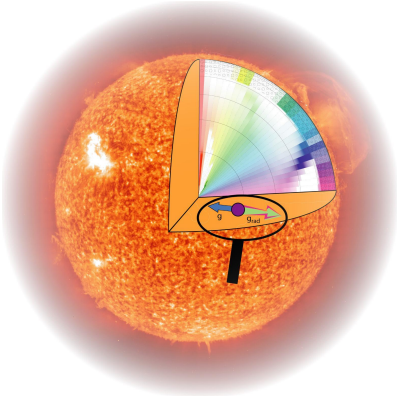

- ➔ Convection
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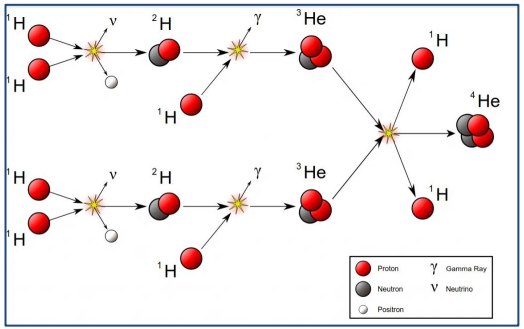

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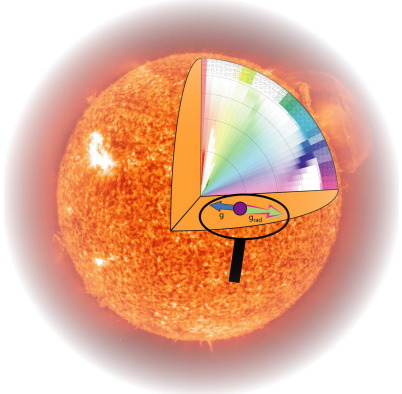

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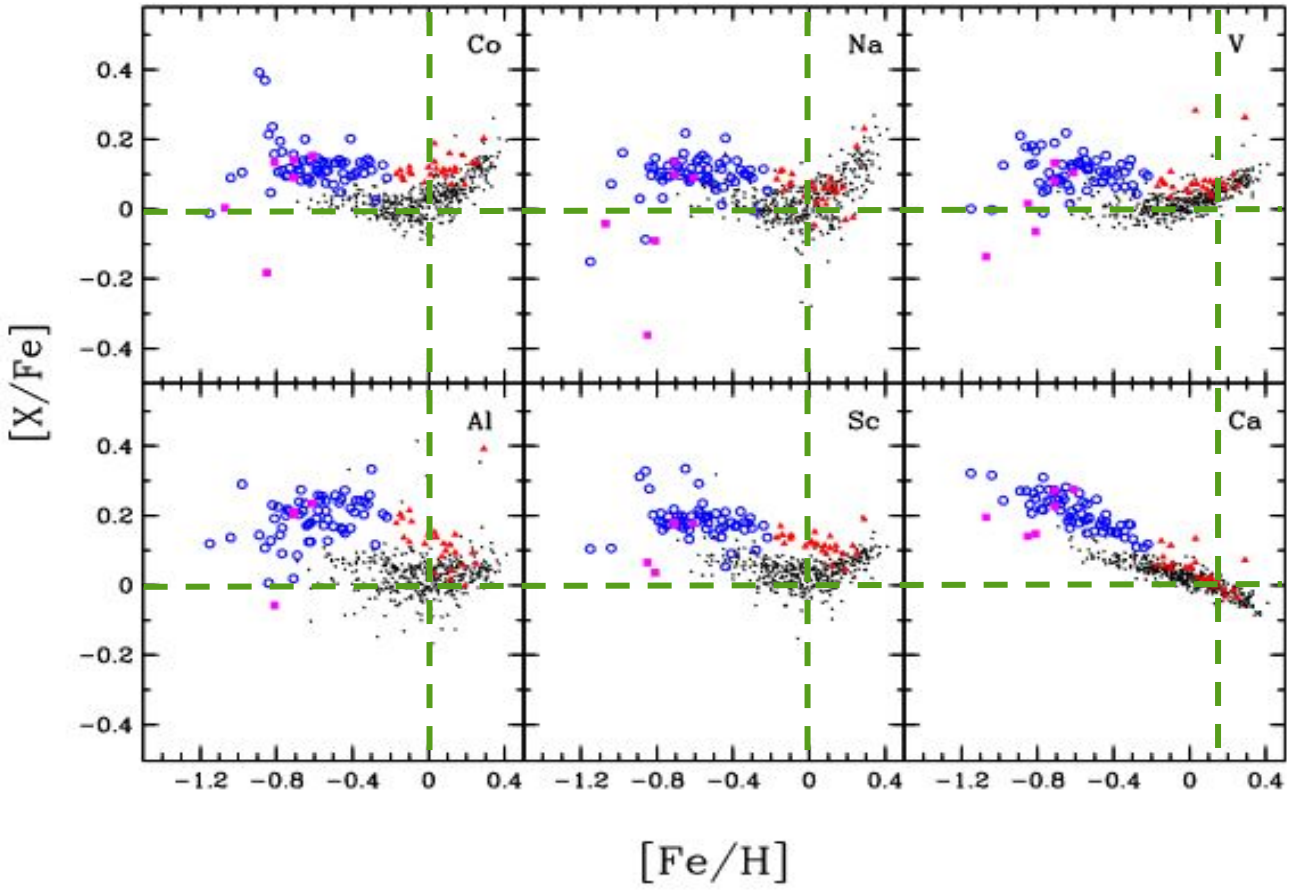
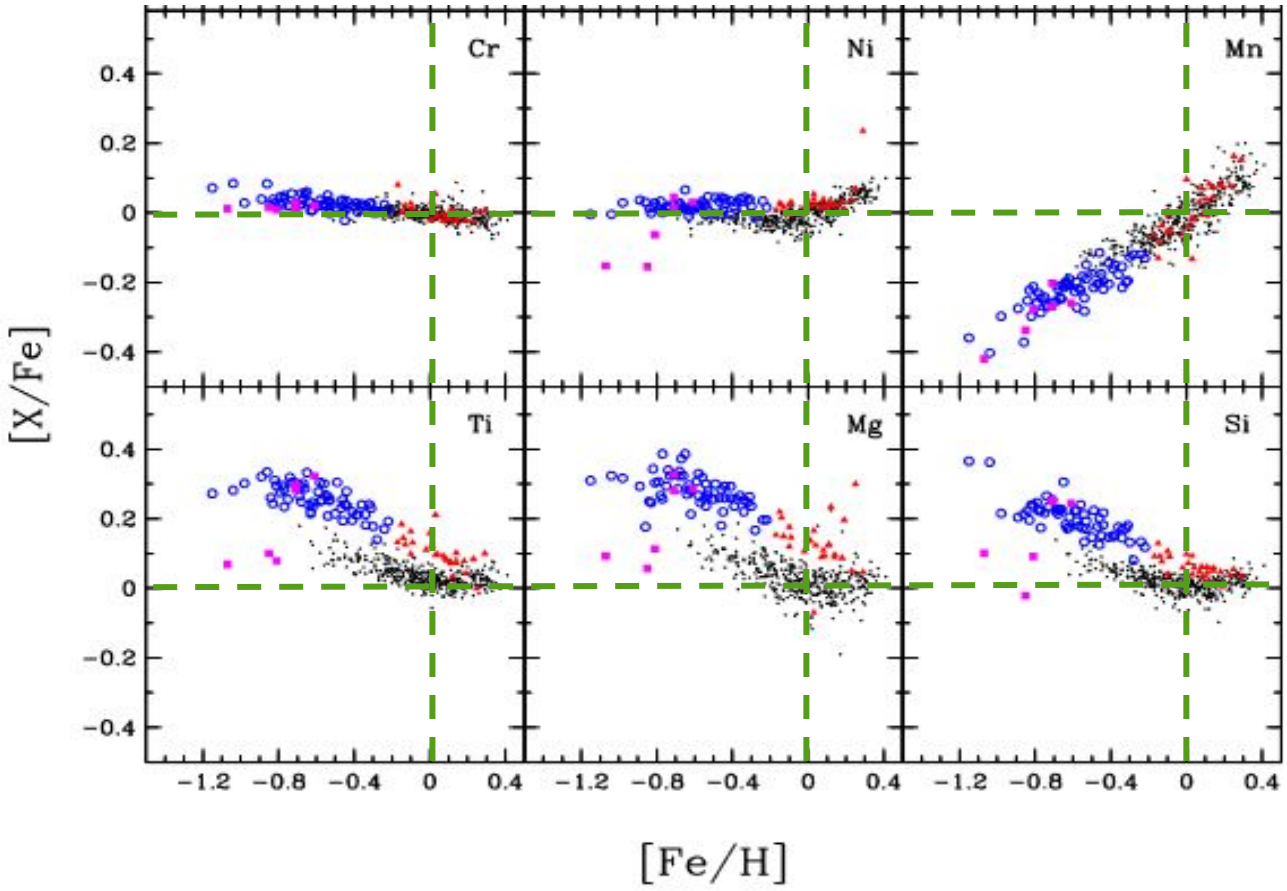


$T_{eff} = T_{\odot} \pm 300K$

Thick disk
Thin disk
high-α metal-rich stars
Halo stars

Adibekyan et al. 2012



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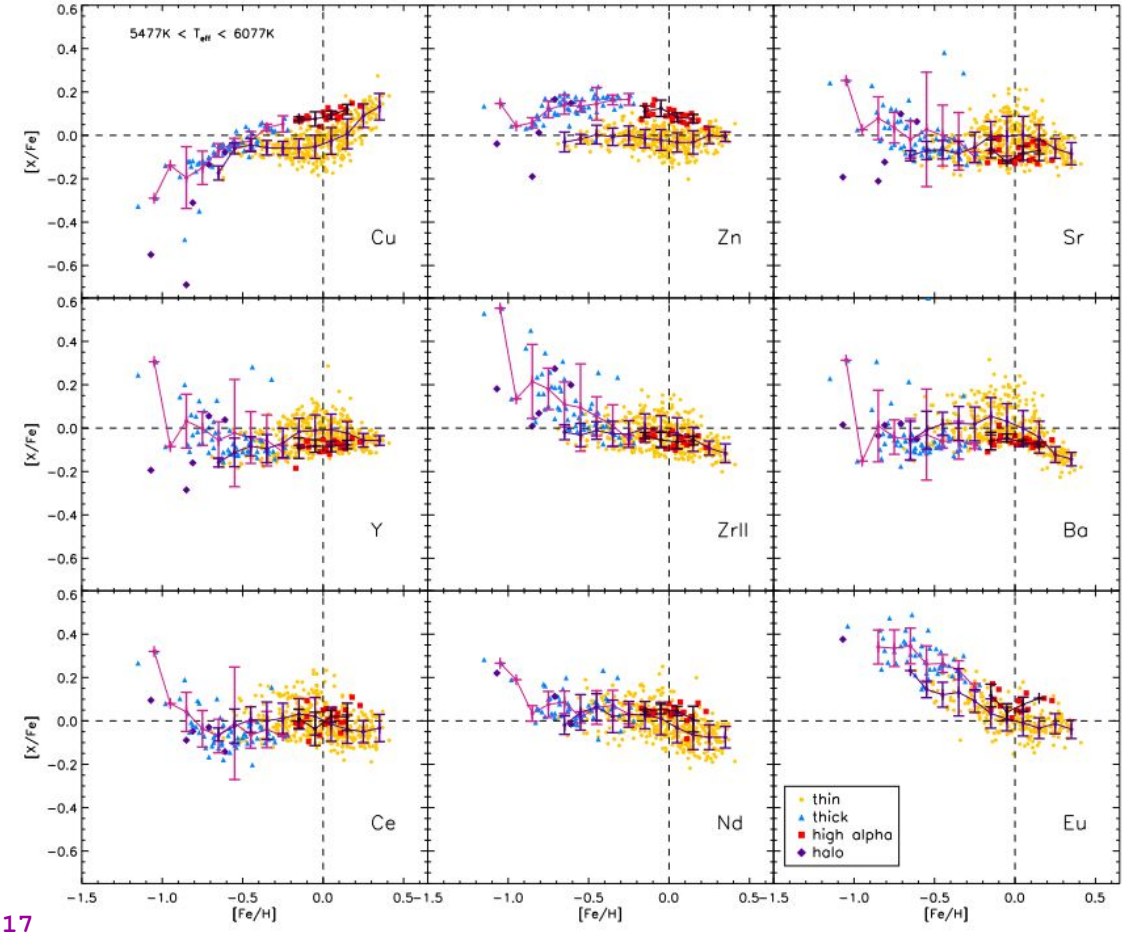

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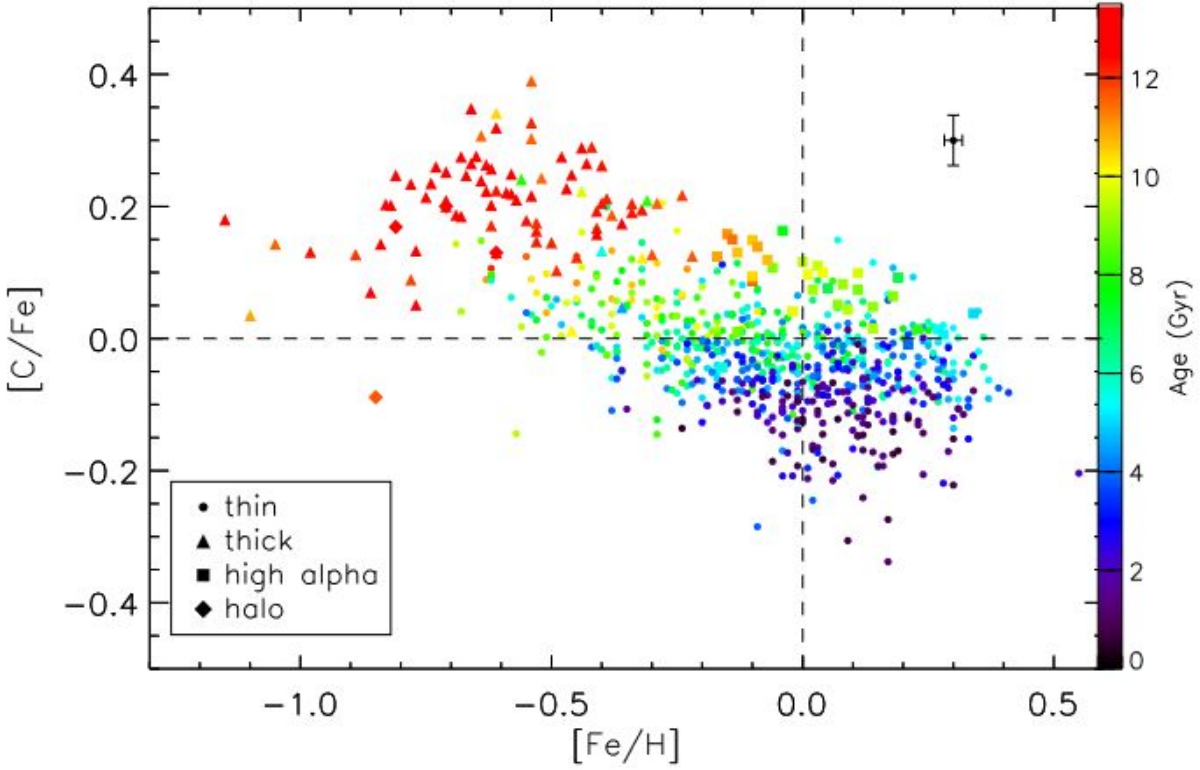
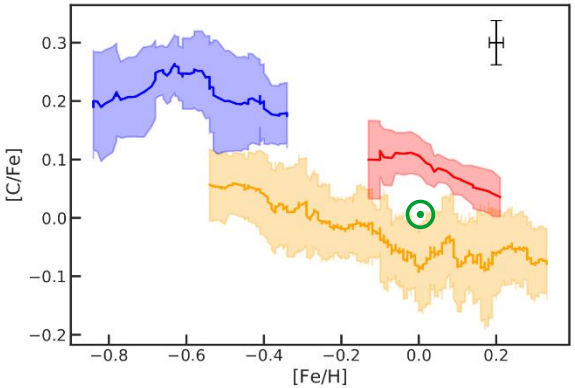
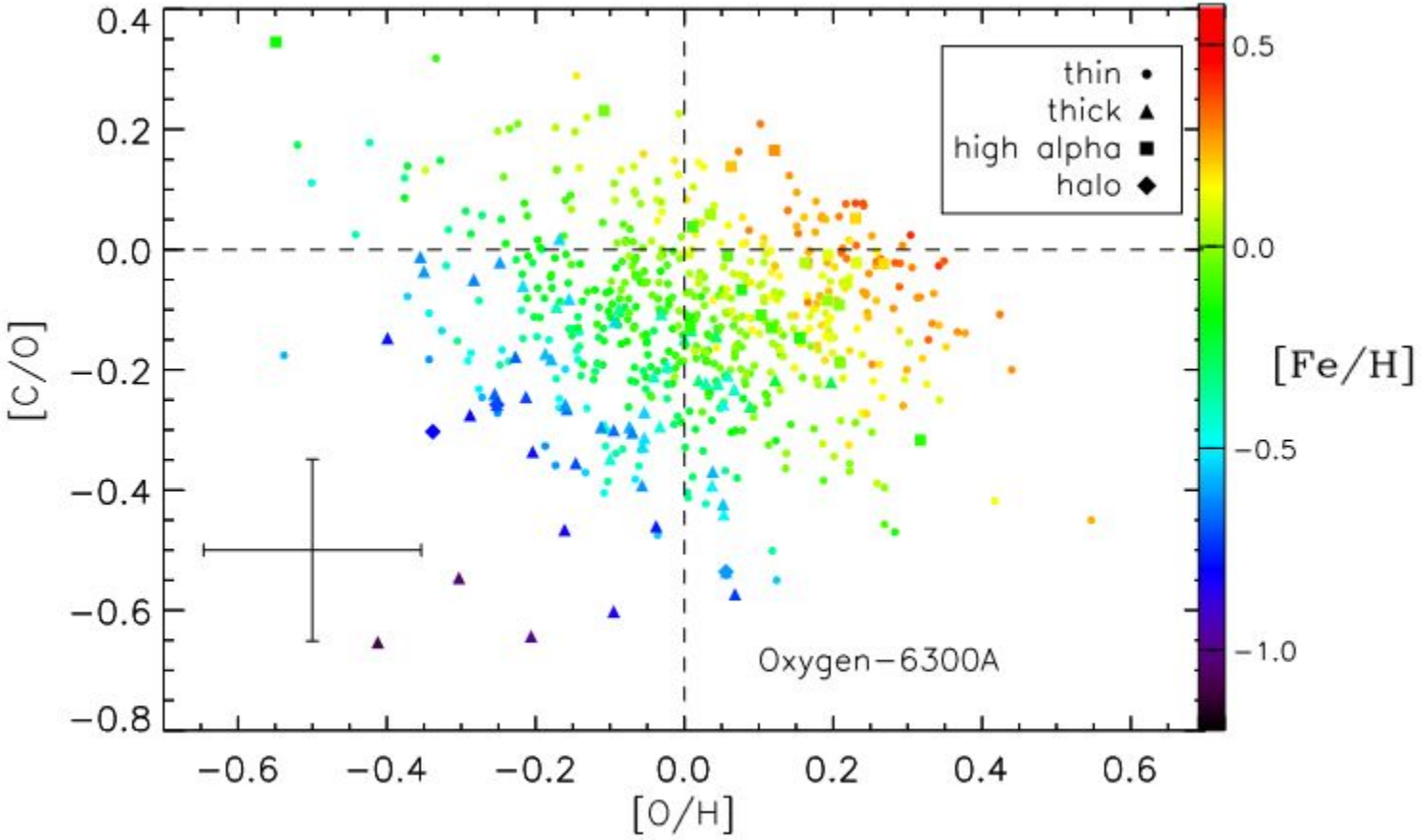


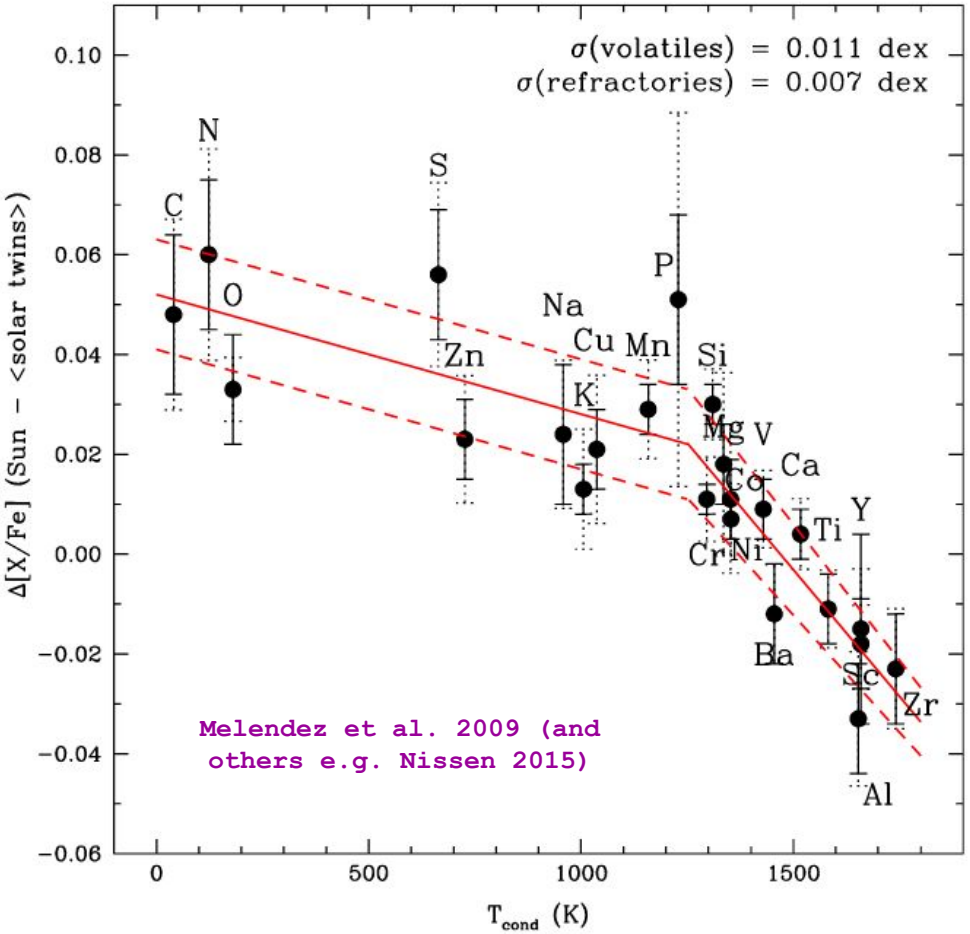


Possible carbon-rich nature of the Sun

Delgado-Mena et al. 2021



Delgado-Mena et al. 2021



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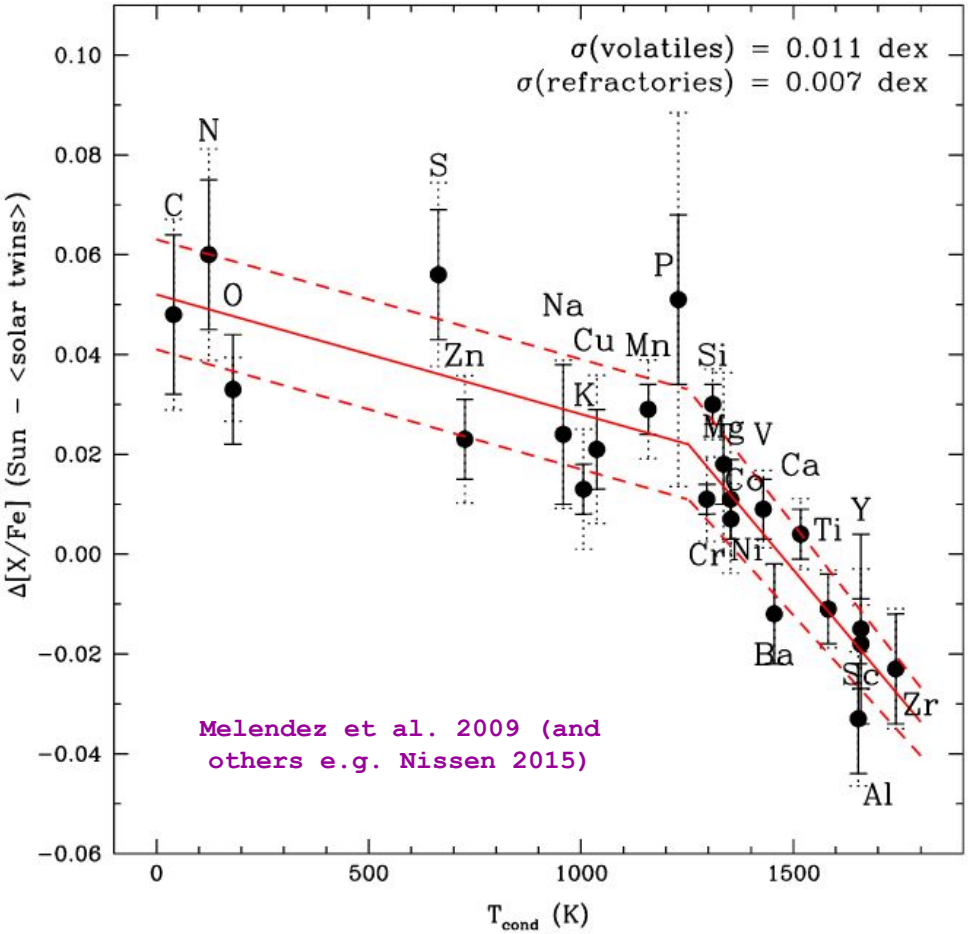
➔ 6% of the solar twin are more deficient in refractories than the Sun (Bedell et al. 2018)



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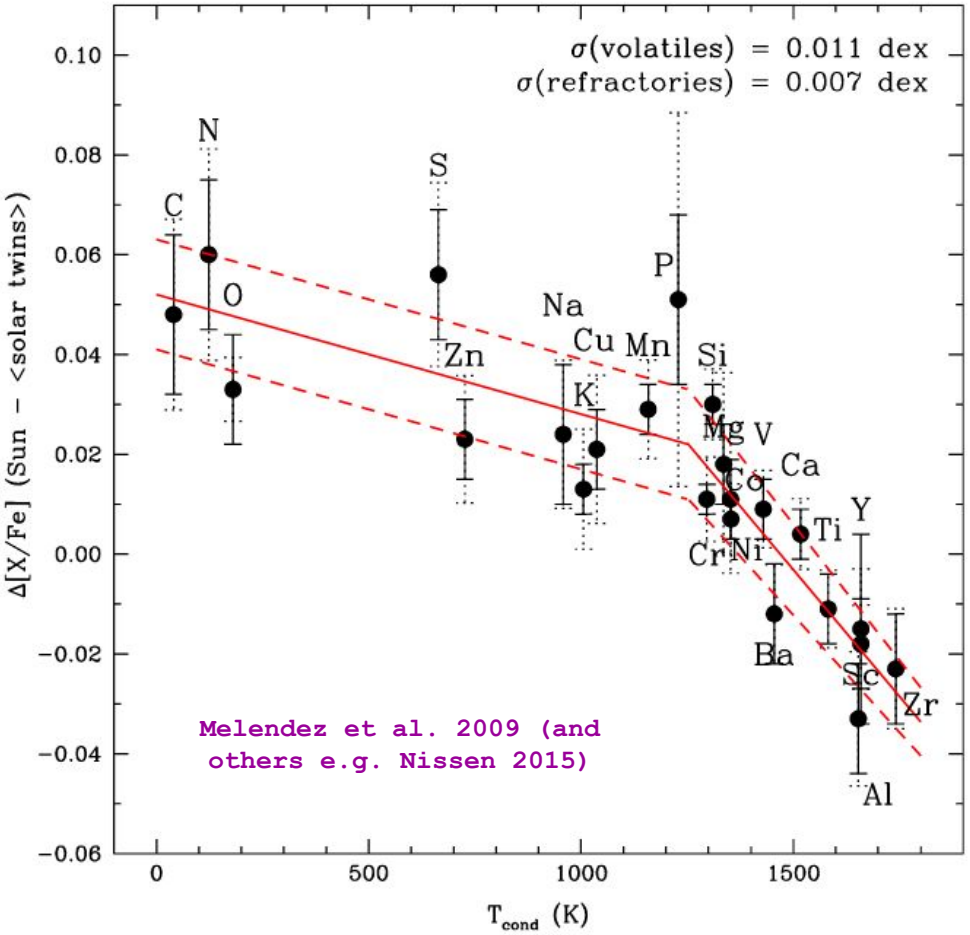

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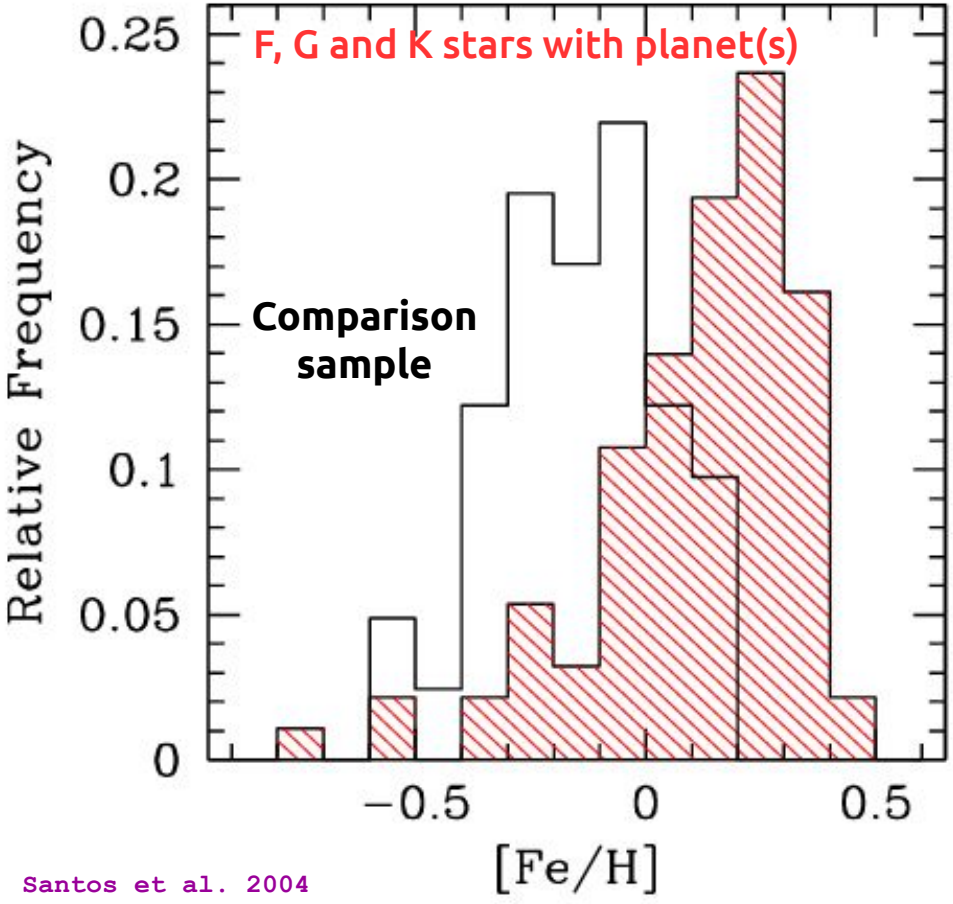
- ➔ 8% of the systems have Jupiter mass planets (TBD)



Santos et al. 2004

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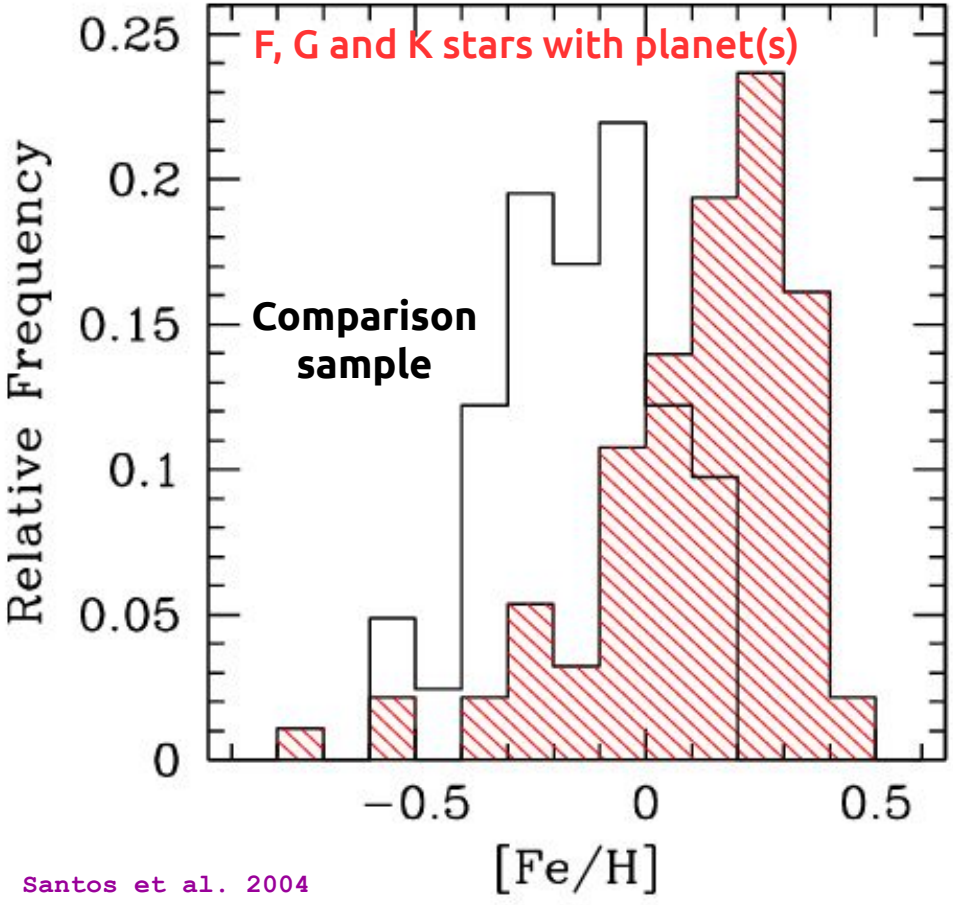

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- ➔ Planet engulfments/accretion
  - ¼ of solar like stars (Spina et al. 2021)
  - Better solar models (Kunitomo & Guillot 2021)

A&A 519, A87 (2010)
DOI: 10.1051/0004-6361/201015137

Astronomy & Astrophysics

Lithium depletion in solar-like stars: no planet connection

P. Baumann[1], I. Ramírez[1], J. Meléndez[2], M. Asplund[1], and K. Lind[3]

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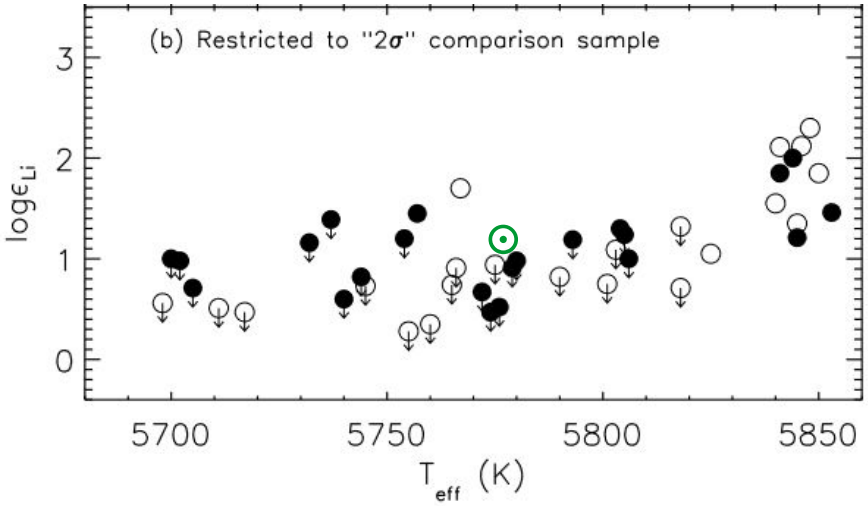
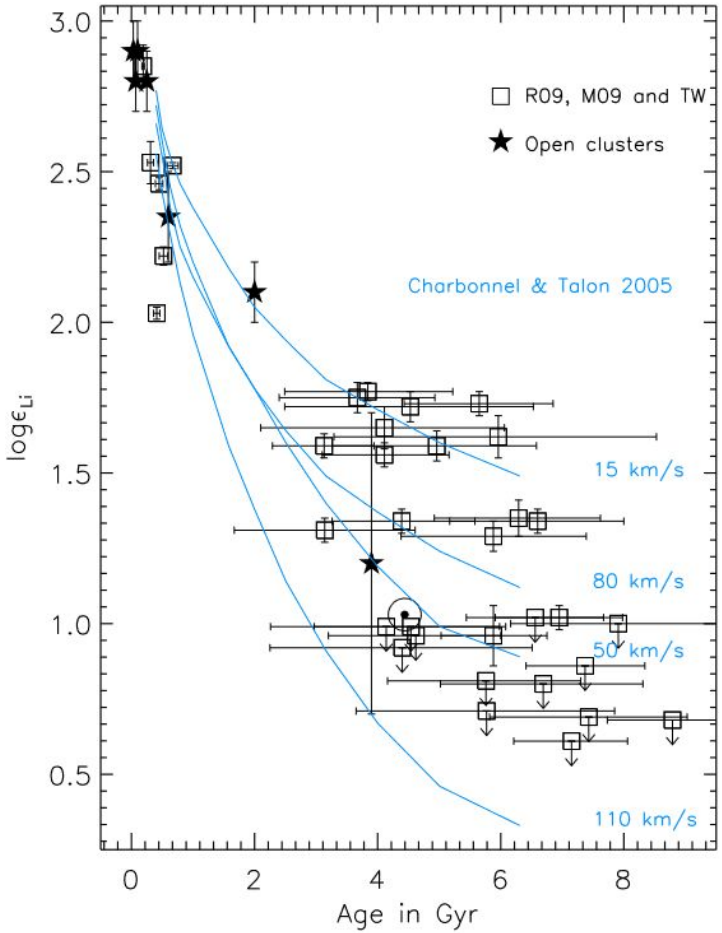
e-mail: [pbaumann,ivan,asplund]@mpa-garching.mpg.de
[2] Centro de Astrofisica da Universidade do Porto, Rua das Estrelas, 4150-762 Porto, Portugal
e-mail: jorge@astro.up.pt
[3] European Southern Observatory(ESO), Karl-Schwarzschild-Str. 2, 85748 Garching, Germany
e-mail: klind@eso.org

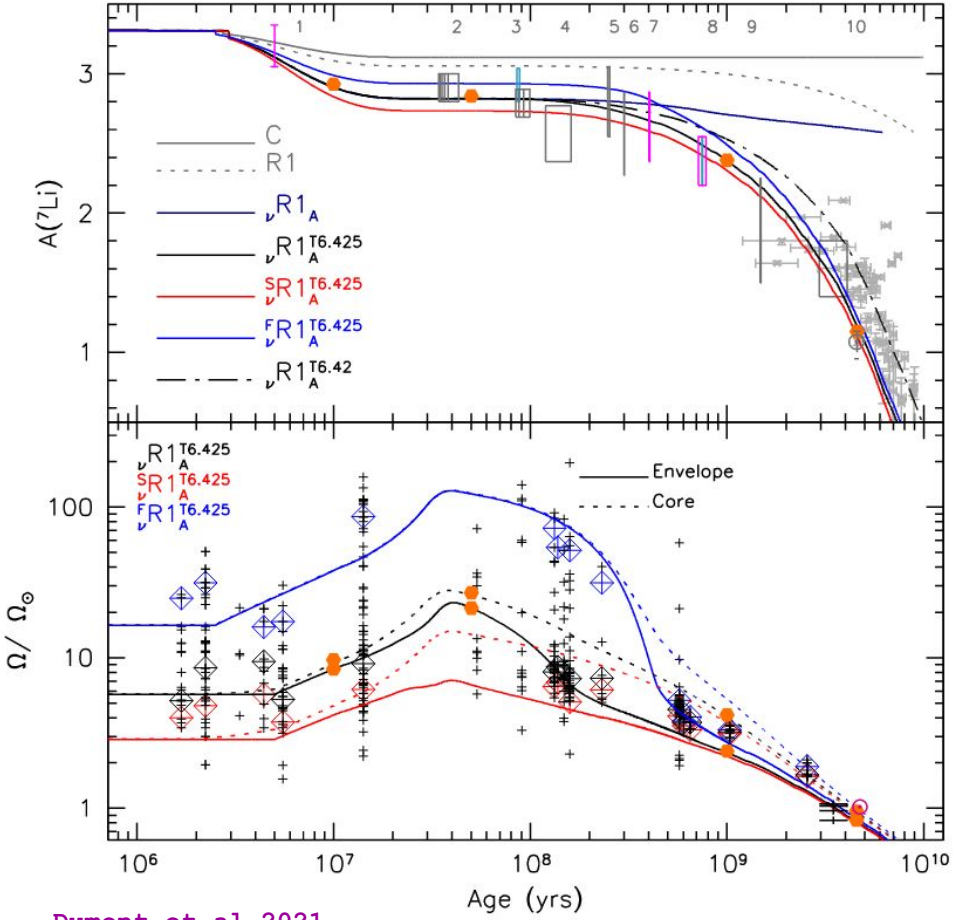
Received 2 June 2010 / Accepted 24 June 2010

Baumann et al. 2010





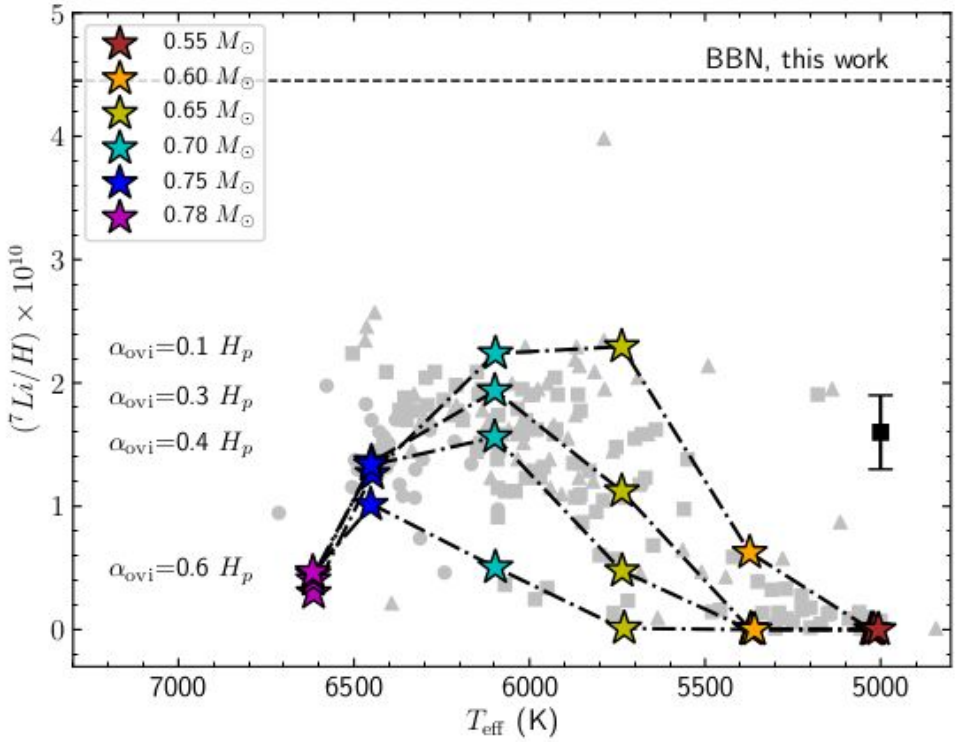
Baumann et al. 2010



Dumont et al.2021

Solar-like stars

- ➔ **Atomic diffusion** (without radiative accel.)
- ➔ **Rotation**
- ➔ **Penetrative convection**
- ➔ **Additional turbulence** (to account for missing processes)



Deal & Martins 2021

Pop. II stars

- ➔ **Atomic diffusion** (without radiative accel.)
- ➔ **Rotation**
- ➔ **Penetrative convection**

A&A 562, A92 (2014)
DOI: 10.1051/0004-6361/201321493

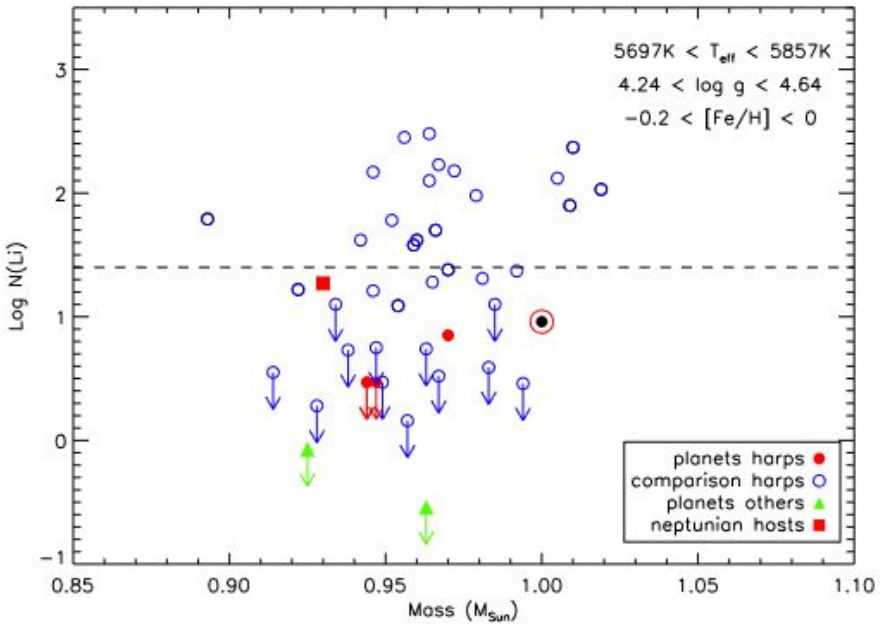
Astronomy & Astrophysics

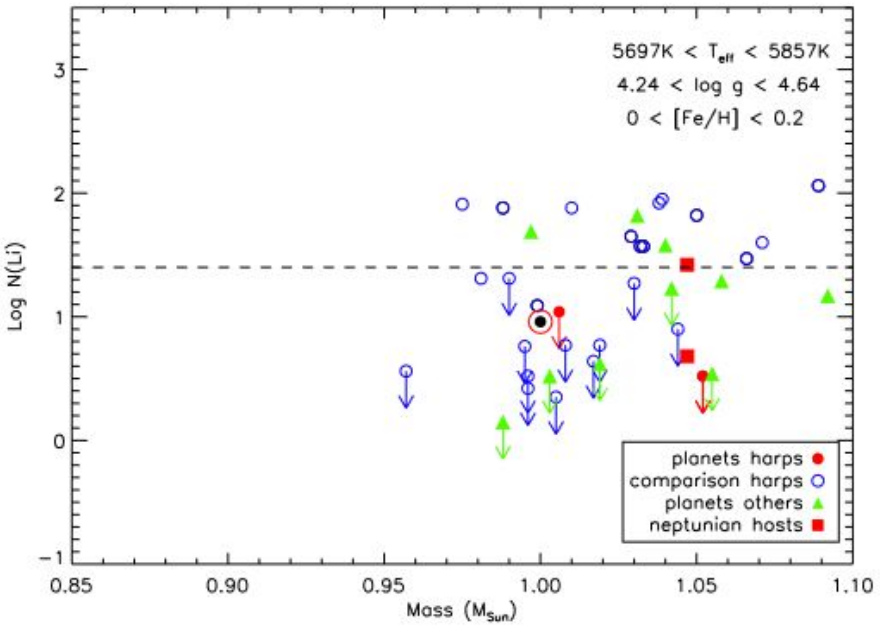
Li depletion in solar analogues with exoplanets

Extending the sample⋆,⋆⋆

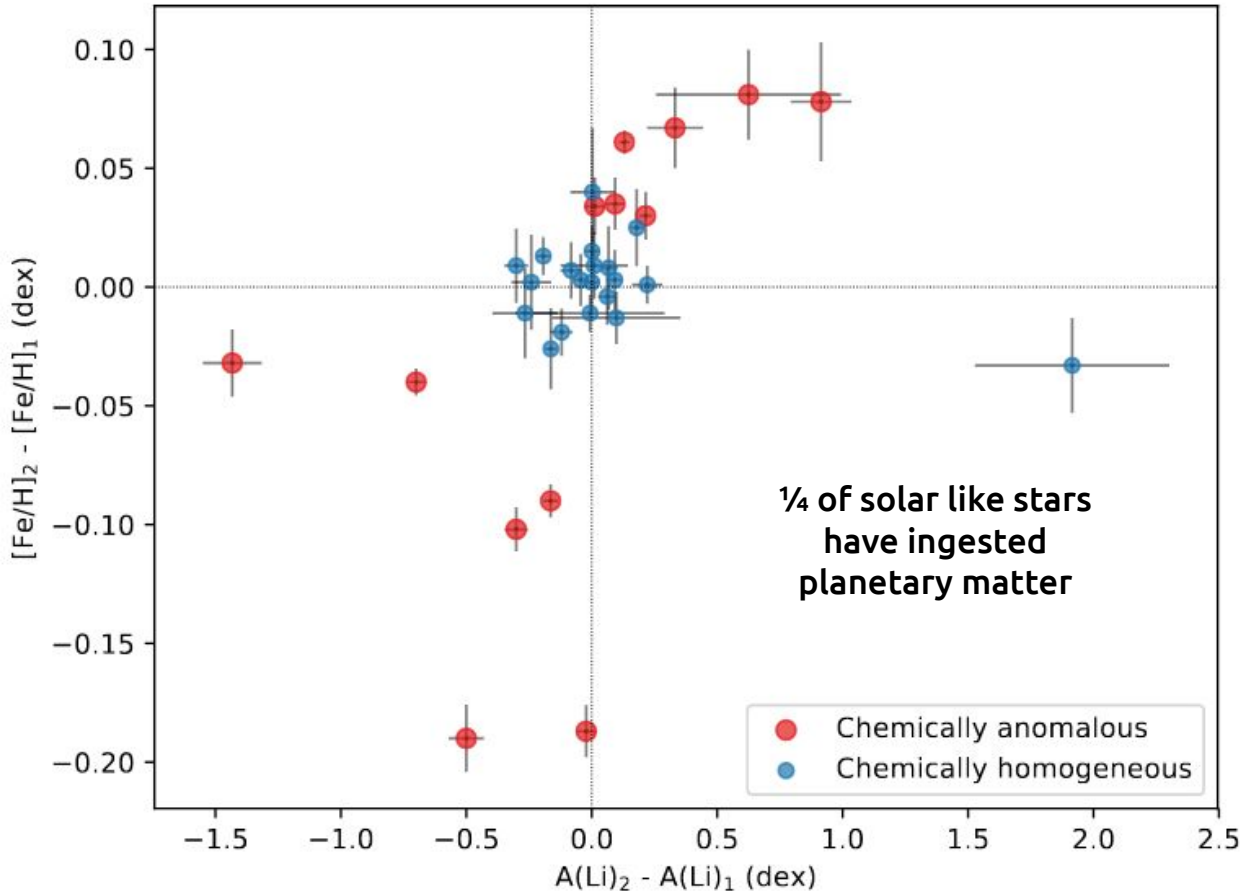
E. Delgado Mena[1], G. Israelian[2,3], J. I. González Hernández[2,3], S. G. Sousa[1,2,4], A. Mortier[1,4], N. C. Santos[1,4], V. Zh. Adibekyan[1], J. Fernandes[5], R. Rebolo[2,3,6], S. Udry[7], and M. Mayor[7]

Delgado-Mena et al. 2014





Delgado-Mena et al. 2014



Spina et al. 2021

➔ 16 Cygni system :

- binary system (A and B)
- solar type stars
- same initial chemical composition
- same age
- A hosts a red dwarf
- B hosts a planet

	16 Cyg A	16 Cyg B
Mass ($M_\odot$)	1.11±0.02	1.07±0.02
T_{eff} (K)	5813±18	5749±17
Log *g*	4.282±0.017	4.328±0.017
planet(s)	no	yes
A(Li)	1.27±0.05	$\leq$ 0.60
A(Be)	0.99±0.08	1.06±0.08

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- Accretion of lithium rich planetary matter on 16 Cyg A

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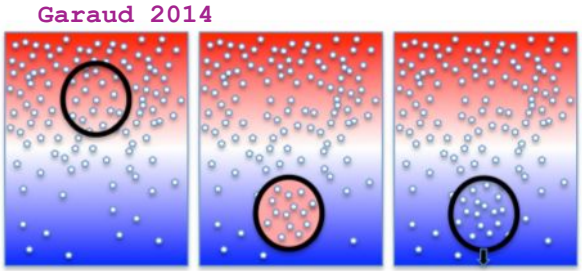
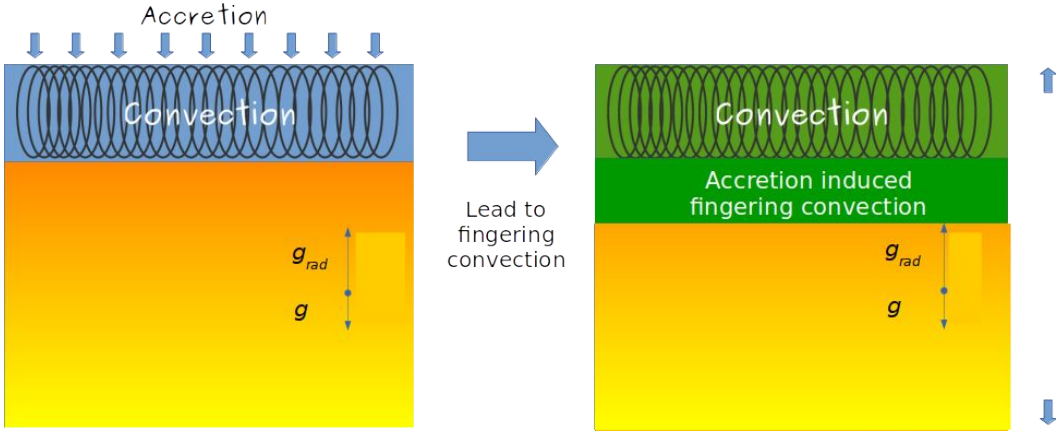
➔ Deal et al. 2015: Accretion of planetary matter on 16 Cyg B

➔ Thermohaline convection

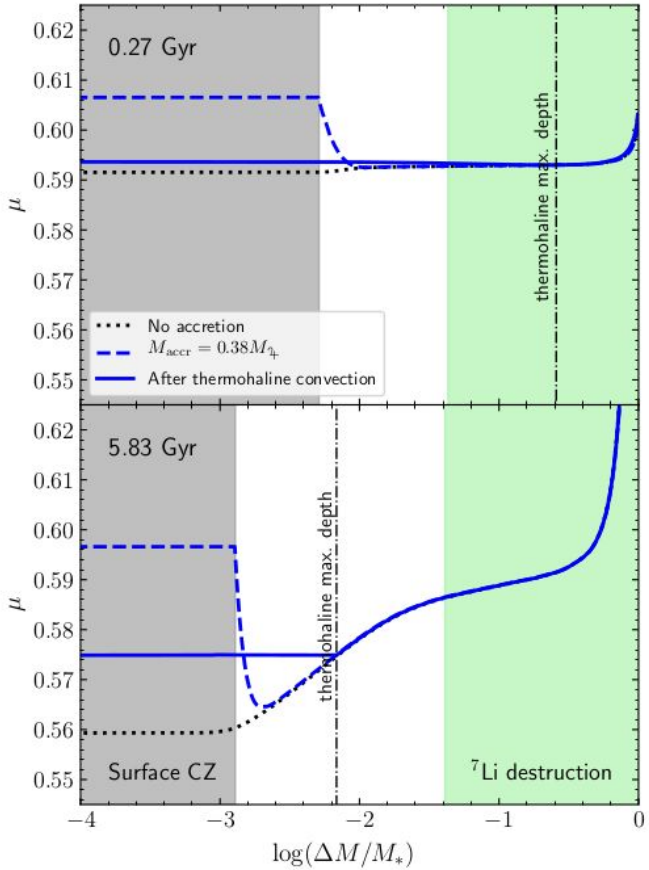


- unstable mean molecular weight gradient
- stable temperature gradient

Apply on stellar cases : Planetary matter accretion, elements accumulation due to radiative accelerations, evolved stars, ...



Impact of accretion: the 16 Cyg case



Deal, Richard & Vauclair 2015 (see also 2021 for CEMP-s stars)

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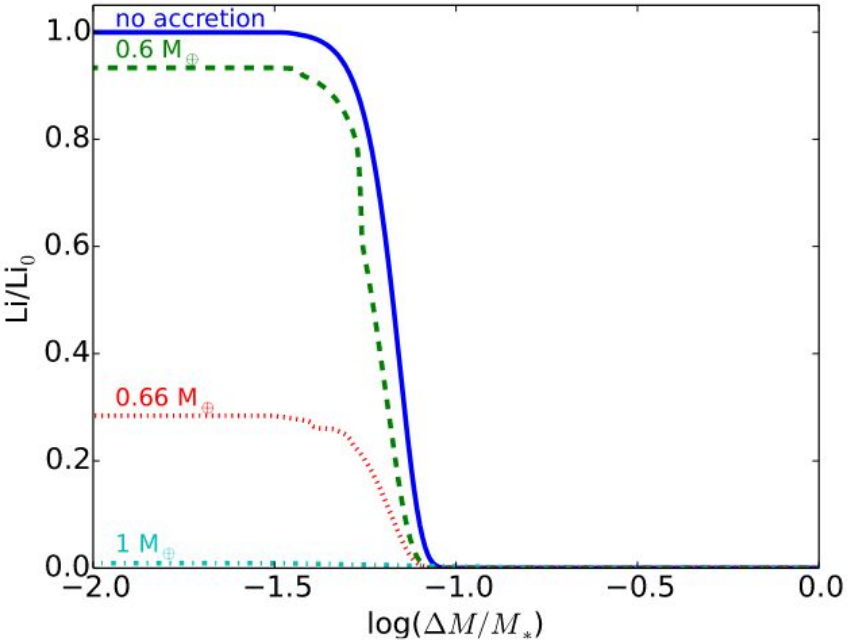

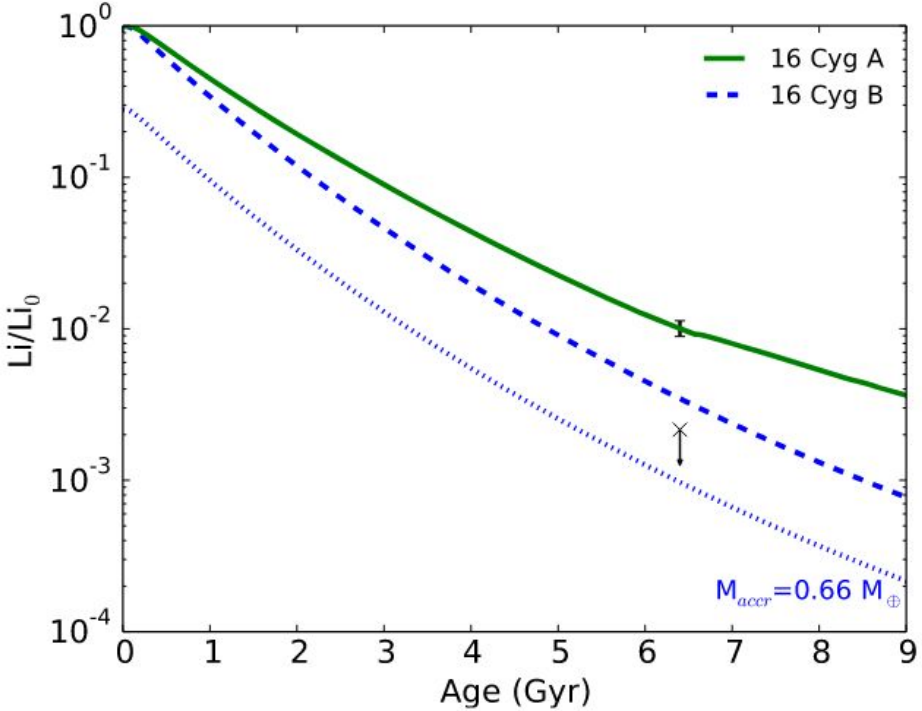

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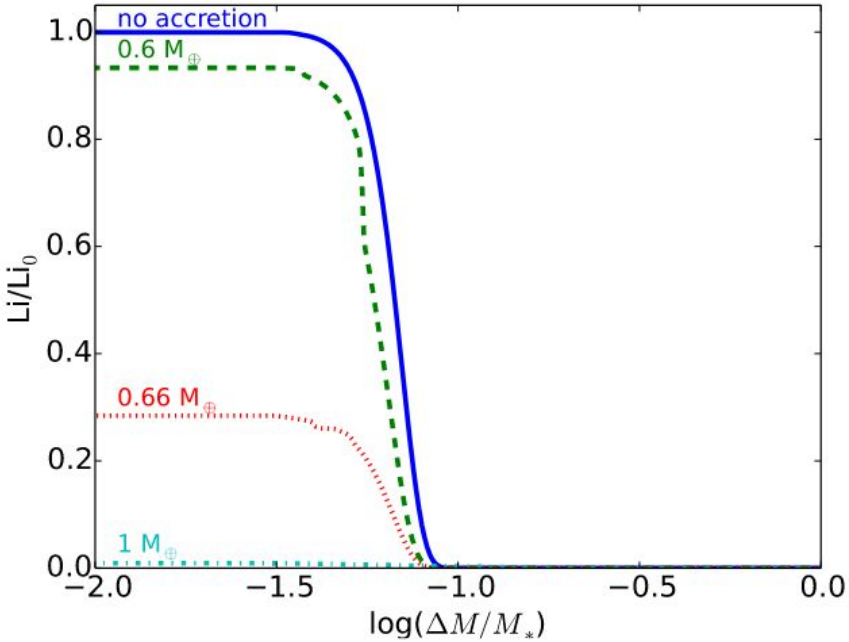

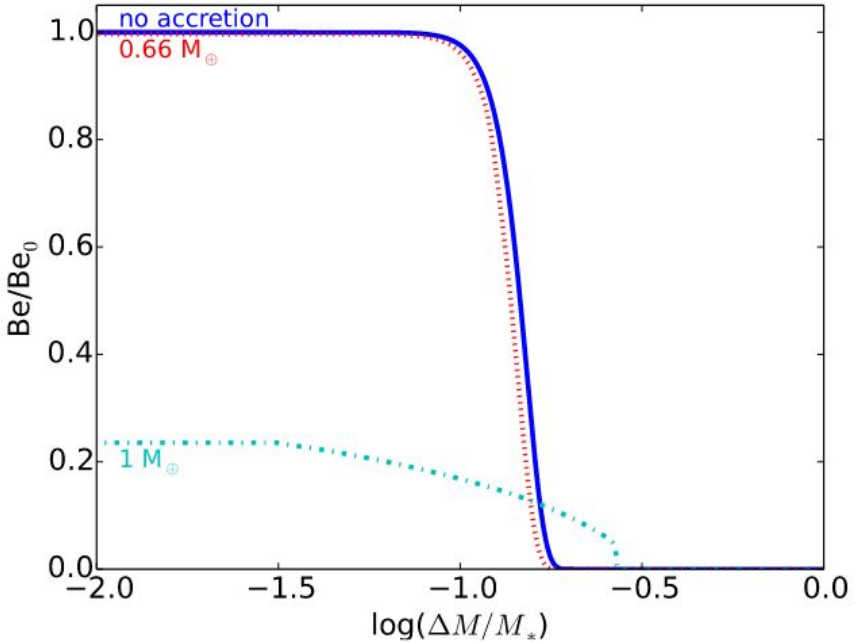

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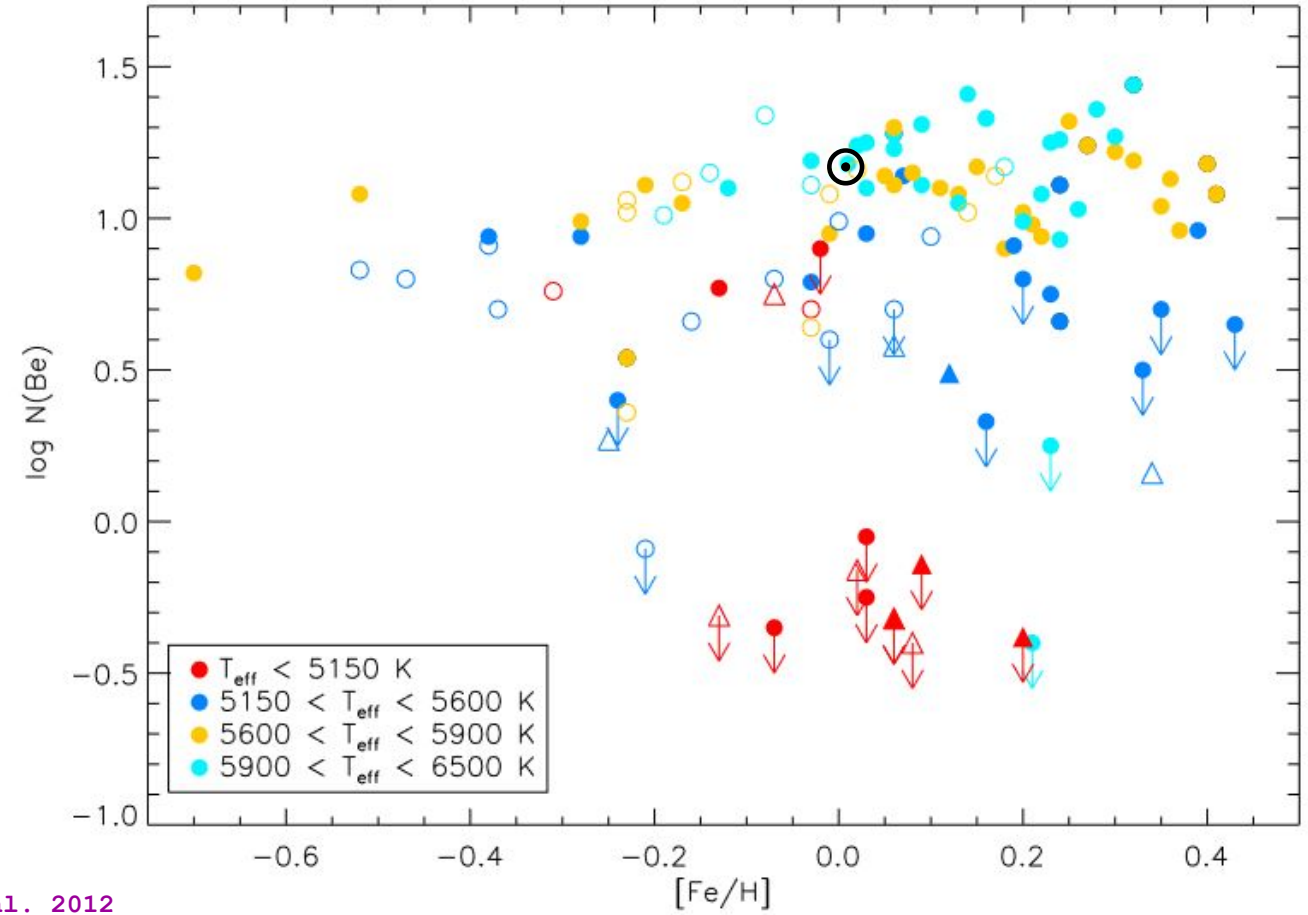

Delgado-Mena et al. 2012

Conclusions

➔ The **Sun** is **chemically similar to the thin disk solar-like stars** for the **heavy elements**

➔ **Possible distinction** between **stars hosting or not a planetary system** (formation/engulfment)

➔ **Possible connexion** between **lithium and the presence of planets**

➔ Important impact of the **transport of chemical/angular momentum** on **lithium surface abundances** …

➔ … also in the presence of **accretion/engulfment**

Is the Sun chemical peculiar?

➔ **Still an open question!** but depend on the definition of 'peculiar'