Exoplanets and their host stars:
Linking stellar properties with planetary formation

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Outline

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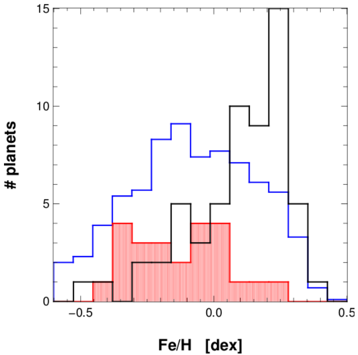
Frequency of giant planets: **Strong function of stellar [Fe/H]**

(González 1997, Santos et al. 2004, Fischer & Valenti 2005)



Black: giant planets, Red: low-mass planets (Mayor et al. 2011)

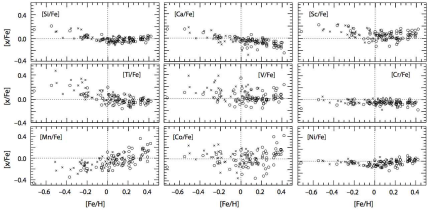
More complex than initially thought:

- **Also a function of mass:** P **(planet)** $\propto \mathbf{N}_{\mathrm{Fe}}^{1.2}\mathbf{M}_{\star}^{1.0}$ (Johnson et al. 2010)
- **Low-mass planets: not found around metal-rich stars** (e.g. Ghezzi et al. 2010, Mayor et al. 2011, Sousa et al. 2011, Bucchave et al. 2010)
- **Giant stars: contradictory results** (Maldonado et al. 2013, Mortier et al. 2013, Jofré et al. 2015, Reffert et al. 2015)

Usually interpreted in the framework of the core-accretion model

Importance of other elements

- **Pollution:** Enrichment of refractory elements
- **Accretion:** Overabundance of elements abundant in planetary material (e.g. ^{6}Li)



[X/H] versus [Fe/H] (From Bodaghee et al. 2003)

Some disputed claims

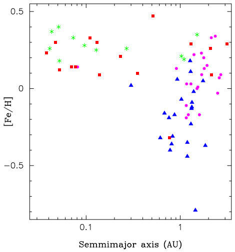
- **Higher lithium depletion**
- **Different <[X/Fe]>-T_C trends**

Large number of studies ⇒

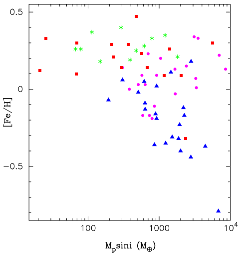
No clear global evidences

Planets around giant stars:

- **Lack of close-in planets**
- **Higher masses and eccentricities**
- **Decreasing trend [Fe/H] - planetary mass**



[Fe/H] vs. semimajor axis. (Maldonado et al. 2013)



[Fe/H] vs. planetary mass

Low-mass stars

Giant planets might be sparser (e.g Endl et al. 2006, Bonfils et al. 2013)

Other properties

- **Chromospheric activity, age, rotation: no differences with average field stars**
- **Galactic dynamics: inner disc origin?**

Correlation debris discs / low-mass planets

(Maldonado et al. 2012, Wyatt et al. 2012, Marshall et al. 2014)

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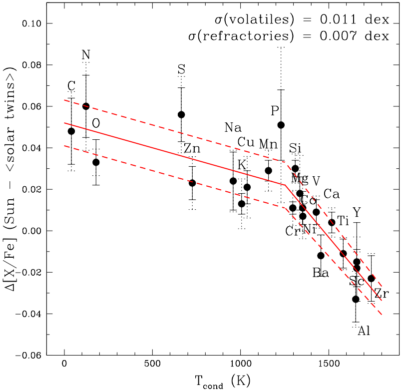
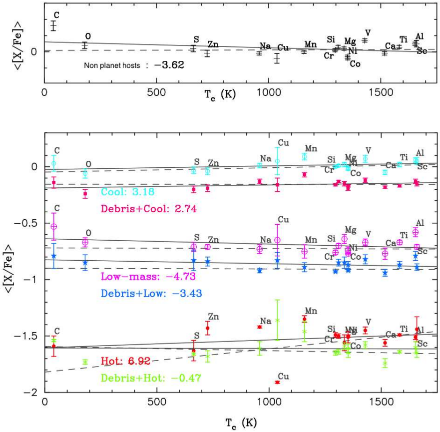
Is the Sun typical?

Meléndez et al. 2009: Deficit of refractories in the Sun with respect to other solar twins

Related to the formation of low-mass planets?



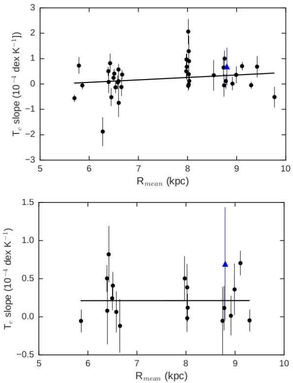
Different kind of planet hots (Maldonado et al. 2015)



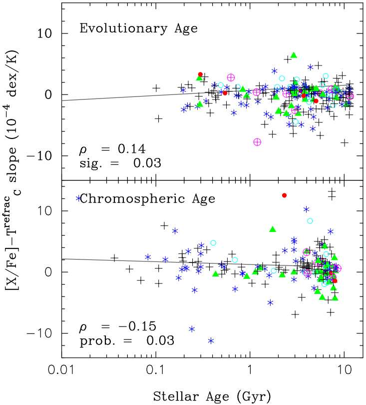
- **Differences between stars with cool and low-mass planets**

Abundance patterns may be affected by Galactic chemical evolution, age, and Galactic birth place effects

Correlations with [Fe/H], age, and R_{mean}



T_C slope vs. R_{mean} (Adibekyan et al. 2016)



T_C slope vs. age (Maldonado et al. 2015)

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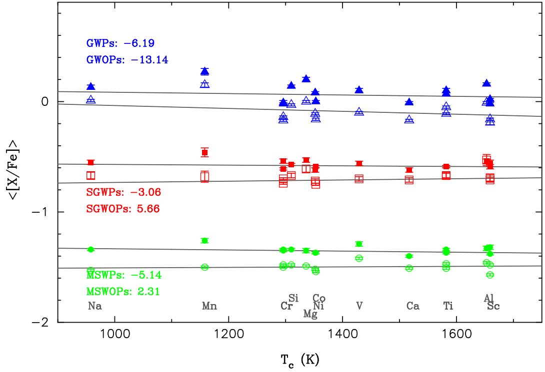
Evolved stars: Origin of chemical trends in planet hosts

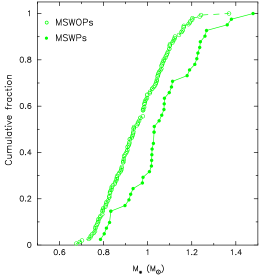


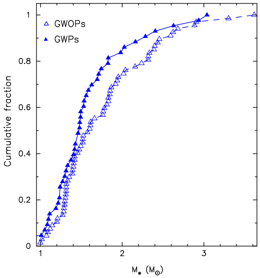
T_C trends in evolved stars (Maldonado & Villaver. 2016)

- **MS and Subgiants: planet hosts <0 slopes, comparison >0 slopes**
- **Giants: planet hosts and comparison <0 slopes**

Possible different trend planet/non-planet hosts. Only for MS and subgiant stars:

- **Correlations with** log *g*, **stellar mass, and age** (Even after correcting for GCE)
- **Less massive and older stars: Show more** + T_C^{ref}





Mass distributions (Maldonado & Villaver. 2016)

- **MS and subgiant nPHs:** Slightly smaller masses and older ages

- **Giants nPHs:** Slightly younger and massive than planet hosts

Haywood (2009): Possible inner disc origin of planet hosts
Radial mixing: secular process, older stars migrate further, come from a region with different abundances

- **MS non planet hosts:** older, less massive, more contaminated by stars from the outer disc, $\Rightarrow \Downarrow$ [Fe/H], $\Uparrow$ [X/Fe], $\Rightarrow + T_C^{ref}$
- **Giants:** giants with/without planets are younger and less contaminated by radial mixing

MS non-planet hosts less massive and older than MS with planets: **biases in exoplanet searches**

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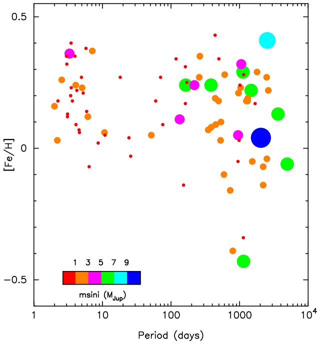
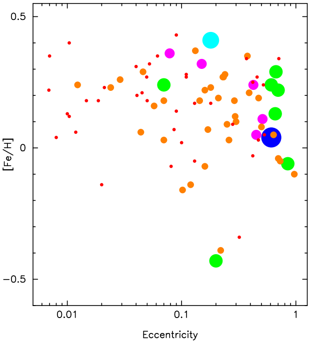
[Fe/H] - Period - Eccentricity

Hot Jupiters: Higher [Fe/H], $m_p \sin i \sim 1\ M_{Jup}$, $e < 0.1$

Cool Jupiters: Wide range of [Fe/H], and *e*, larger planetary masses



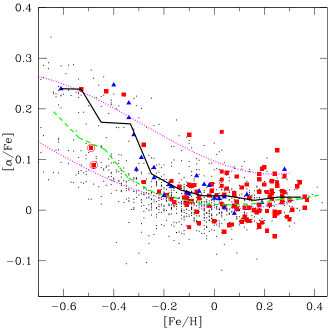


Maldonado, Villaver, & Eiroa, in prep.

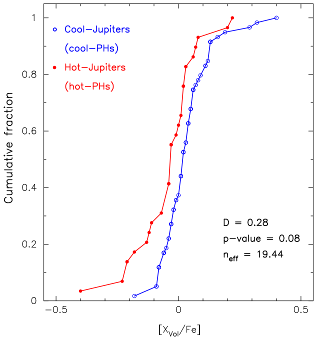
⇒ Different formation mechanisms?

Other chemical signatures

Metal-poor PHs show α enhancement: Mg, Si, Ti ... might play a role in planet formation.



Adibekyan et al., 2012



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Cool Jupiters: Large volatile abundances?

Outline

1. **Global properties of planet hosts:**
   - **Planet-metallicity correlation:** In agreement with core-accretion models
   - **Other chemical trends:** Controversial
   - **Evolved stars with planets:** Different properties from MS
2. **[X/Fe]-T_C trends in planet hosts:**
   - Correlations with [Fe/H], age, Galactic distance
   - **Evolved stars:** **Radial mixing**
3. **Planetary architecture**
   - **Hot Jupiters $\Uparrow$ stellar [Fe/H], $\Downarrow$ $m_p \sin i$, $\Downarrow$ e:** *in situ* formation?
   - **Cool Jupiters $\Uparrow$ α and volatile stellar abundances:** Role of other elements in planet formation

The opportunity of nIR spectrographs (e.g. GIARPS, Claudi et al. 2017):

- **Low-mass stars:** **e.g. HADES (Affer et al. 2016, Perger et al. 2017)**
- **Young stars with signatures of planet formation:** **e.g. GAPS2, On the rocks project (Eiroa et al. 2016)**