Host's stars and habitability

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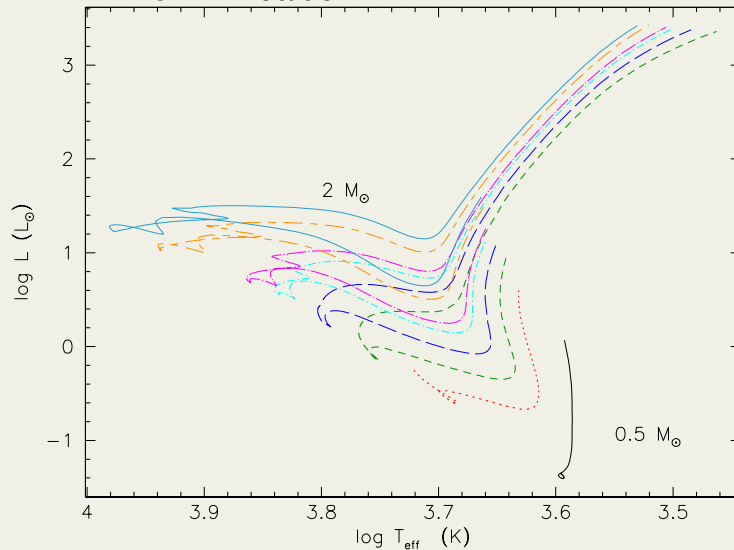
1) Introduction

- About **2000** exoplanets discovered within **different** configurations

- Thanks to **increase** of precision of modern techniques size and mass of detected planets have dramatically **decreased**

- **Earth like planets** => habitability?
  - **First** step : habitable zone (HZ) and continuously habitable zone (CHZ)

- We aim at:
  - highlighting the **impact** of stellar parameters on HZ and CHZ
  - add more **constraints** on HZ and CHZ location
  - link HZ location to stellar activity evolution

2) Reference grid of stellar models

STAREVOL
  - mass range 0.5 – 2 M$_\odot$
  - 4 metallicity values
  - impact of rotation-induced mixing
  - rotation

3) Model

- Habitable zone (Kopparapu et al. 2013,2014):

$$d = \left(\frac{L / L_\odot}{S_{eff}} \right)^{0.5} \qquad S_{eff} = \frac{F_{IR}}{F_{INC}}$$
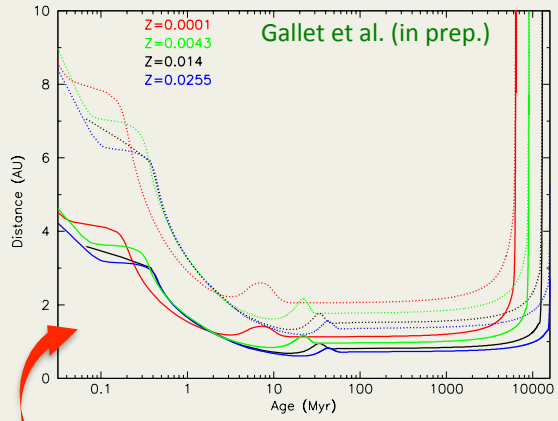
$$Seff = S_{eff\odot} + aT_* + bT_*^2 + cT_*^3 + dT_*^4$$

$$T_* = T_{eff} - 5780$$

- Stellar **structure** evolution grid: Amard et al. (in prep.)

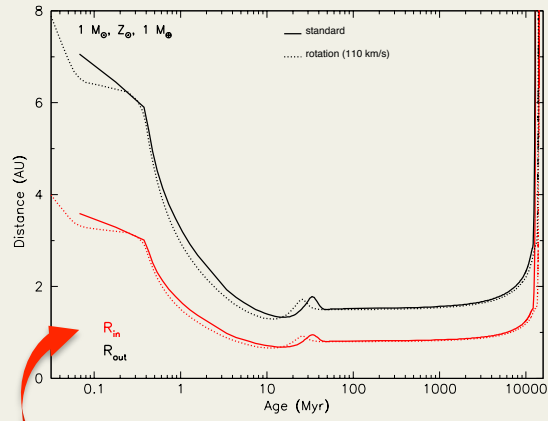Gallet et al. (in prep.)
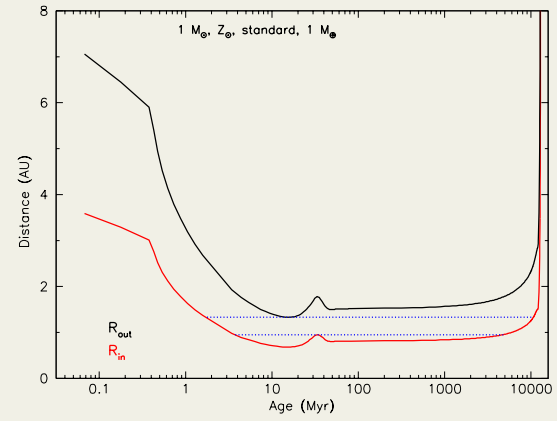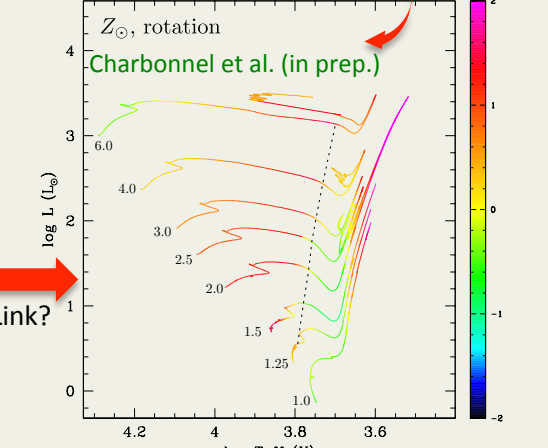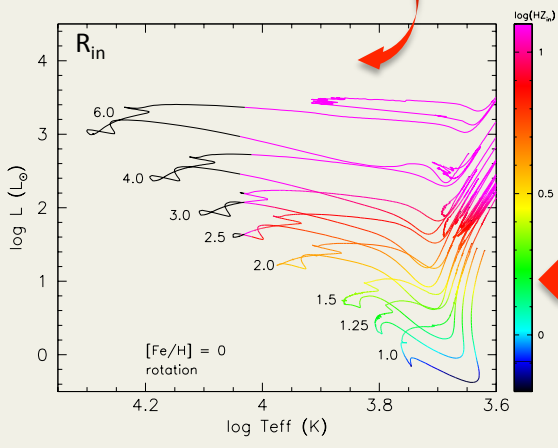
Metallicity and mass effect

Rotation effect and activity $Ro = \dfrac{P_{rot}}{\tau_c}$

Continuously Habitable zone

R_{in}

$Z_\odot$, rotation

Charbonnel et al. (in prep.)

Link?

Table 1. Size of the HZ as a function of stellar mass.

ΔHZ	0.5 $M_\odot$	1 $M_\odot$	1.5 $M_\odot$	2 $M_\odot$
ΔHZ$_{mean}$ (AU)	0.27	0.86	2.05	3.25
ΔHZ$_{min}$ (AU)	0.2	0.65	1.2	1.85
ΔHZ$_{max}$ (AU)	1.39	3.46	5.9	6.63

Table 2. Size of the CHZ as a function of stellar mass for solar metallicity.

Mass	HZ$_{in}$ (AU)	Start (Myr)	Time (Gyr)	HZ$_{out}$ (AU)	Start (Myr)	Time (Gyr)
0.5 $M_\odot$	0.22	79.5	19.35	0.41	10.80	19.41
1 $M_\odot$	0.95	3.74	4.77	1.33	1.76	10.67
1.5 $M_\odot$	2.34	0.917	1.87	2.53	0.721	2.19

Start (Myr) = starting age of the CHZ, Time (Gyr) = duration of the CHZ

✓ **Systematic** study of HZ and CHZ
- grid available
- online tool scheduled

✓ **Strong** effect of mass and metallicity
- limits
- shapes

✓ **Little** rotation effect on HZL and <u>none</u> on CHZL

✓ **HZL** <u>minimum</u> when stellar activity at its **lowest**
- Impact on planetary formation?

→ Need to include
- star-planet tidal interaction (dissipation processes)
- magnetic interaction/protection
- ...

<u>Contact</u>

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Amard et al. (in prep.)

Charbonnel et al. (in prep.)

Gallet et al. (in prep.)

Kopparapu, R. K., Ramirez, R., Kasting, J. F., et al. 2013, ApJ, 765, 131

Kopparapu, R. K., Ramirez, R. M., SchottelKotte, J., et al. 2014, ApJ, 787, L29