HIP 102152b

A low-mass planet candidate around an old solar twin

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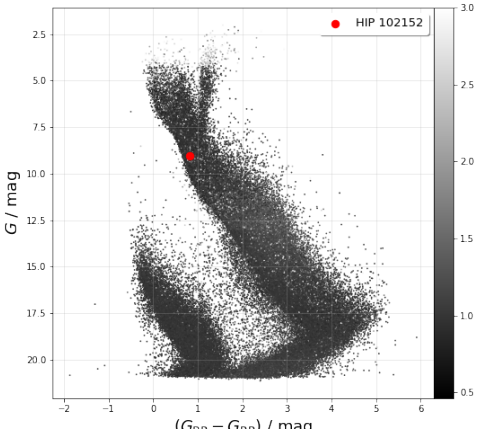
Host star:

• (nearby) **Solar-twin**
(Δ = 78.23 pc)
(M = 1.020 M$\odot$; R = 1.083 R$\odot$)
($T_{\rm eff}$ = 5718 K, [Fe/H] = -0.016, $\log g$ = 4.325);

• Placed near the end of MS (t = 8.2 Gyr), and Severely lithium depleted;

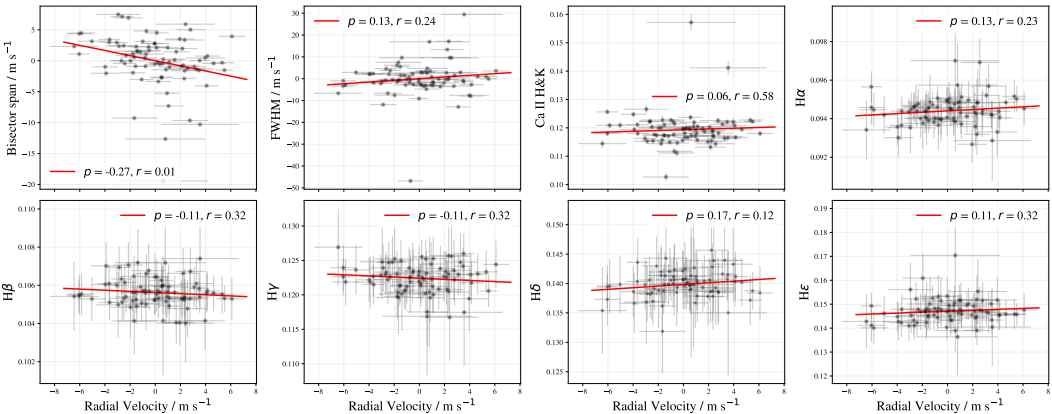
• Rotation period of 35.7 days (Lorenzo-Oliveira+2020).

• Identified as a **promising planet-hosting system** due to its low activity levels ($\log R'_{\rm HK} = -5.12$) but high VR RMS.

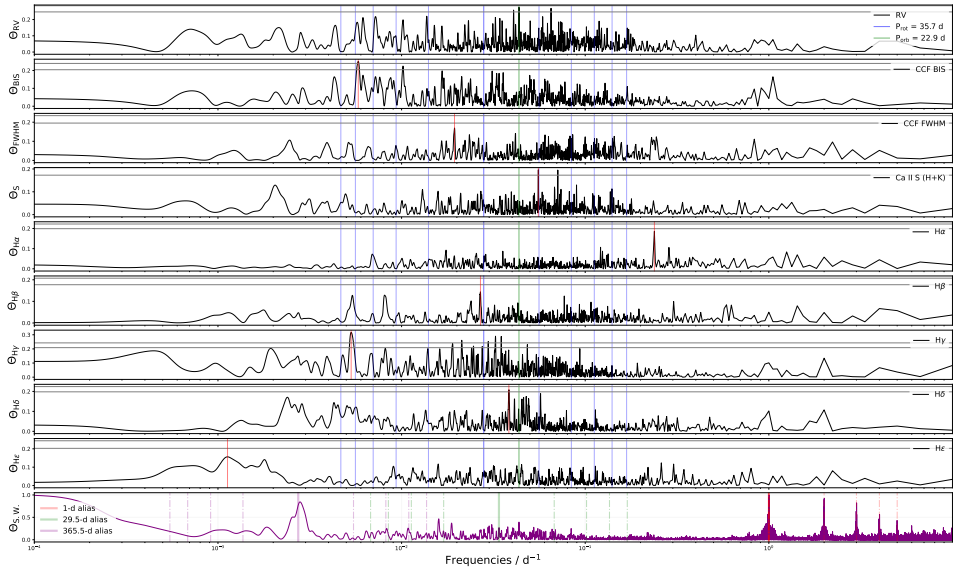


Data analysis:

- Observations with ESO/HARPS between Oct.–2011 and May–2019
- Activity indicators proxies: Bisector span, FWHM, Ca II H&K, and the Balmer lines.



- Generalised Lomb-Scargle (GLS)[1] $\longrightarrow$ **Initial period: $\sim$23 days**



[1] https://astrobase.readthedocs.io/

- **Joint Keplerian + Gaussian Process model**

$$\Sigma_{ij}(t_i, t_j) = \eta_1^2 \exp\left[-\frac{|t_i - t_j|}{2\eta_2^2} - \frac{2\sin^2\left(\frac{\pi|t_i - t_j|}{\eta_3}\right)}{\eta_4^2} \right] \tag{1}$$

where

$$\begin{aligned}
\eta_1 &= \text{Doppler amplitude of the signal} \\
\eta_2 &= \text{time-scale for growth and decay of active regions} \\
\eta_3 &= \text{recurrence time-scale for active regions} \sim \text{rotation period} \\
\eta_4 &= \text{Smoothing parameter } (0.1{-}0.5)
\end{aligned}$$

$$V_r = K\left[\cos(\nu + \omega) + e\cos(\omega)\right] \longrightarrow \text{RV equation} \tag{2}$$

$$\text{Kepler's eq.} \longrightarrow M = E - e\sin E; \quad \nu = 2\arctan\left(\sqrt{\frac{1+e}{1-e}}\tan\frac{E}{2}\right) \tag{3}$$

The total RV motion of a star:[2]

$$\mathcal{V}_r = \sum_{k}^{\mathrm{N_{pl}}} V_r + \gamma + \dot{\gamma}\,(t - t_0) - \ddot{\gamma}\,(t - t_0)^2 \tag{4}$$

[2]Fulton et al, (2018). *RadVel: The Radial Velocity Modeling Toolkit.*

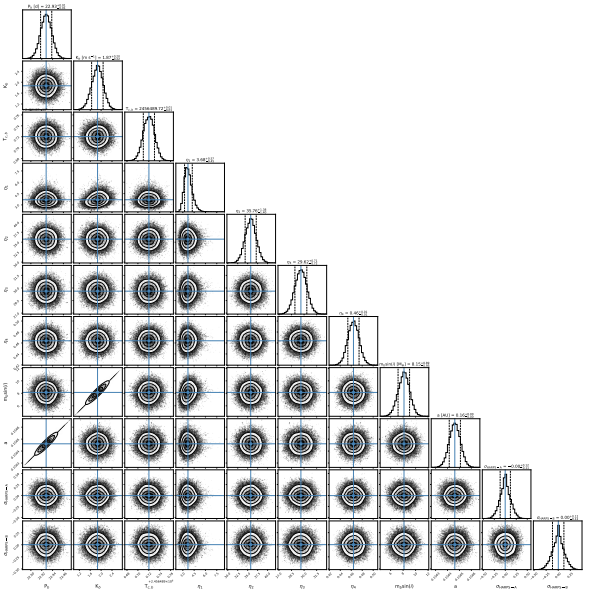
$$
\begin{aligned}
\pi(\mathcal{V}_r|\Theta) \quad &\propto \quad \mathcal{N}(P|22.9, 0.01) \times \mathcal{N}(K|2, 0.2) \times \mathcal{N}(t_0|x(\max y), 0.01) \\
&\times \quad \mathcal{J}(\eta_1|0.01, 100) \times \mathcal{N}(\eta_2|30, 0.7) \times \mathcal{N}(\eta_3|35.7, 1.4) \times \mathcal{N}(\eta_4|0.46, 0.01) \\
&\times \quad \mathcal{N}(\sigma_{H-B}|0, 0.1) \times \mathcal{N}(\sigma_{H-A}|0, 0.1) \\
&\times \quad \mathcal{F}(\dot{\gamma}| - \infty, \infty) \\
&\times \quad \mathcal{U}(\sqrt{e}\sin(\omega)| - 1, 1) \times \mathcal{U}(\sqrt{e}\sin(\omega)| - 1, 1)
\end{aligned}
$$

Four models comparison: Circular vs. eccentric, with and w/ RV slope

Circular without slope: $\Delta(\text{BIC/AIC}) = -13.4/-10.0$ over the second-ranked.

Markov sampling...

with 50 walkers, 1000 steps and 4 ensembles, plus requiring a maximum G-R statistic for chains of 1.01 and a burn-in of 1.01.



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Mini-Neptune ($m \sin i = 8 \pm 1$ M$\oplus$) on a circular orbit with $P = 22.9 \pm 0.01$–d, and no RV slope was observed due to acceleration from an outer massive companion.