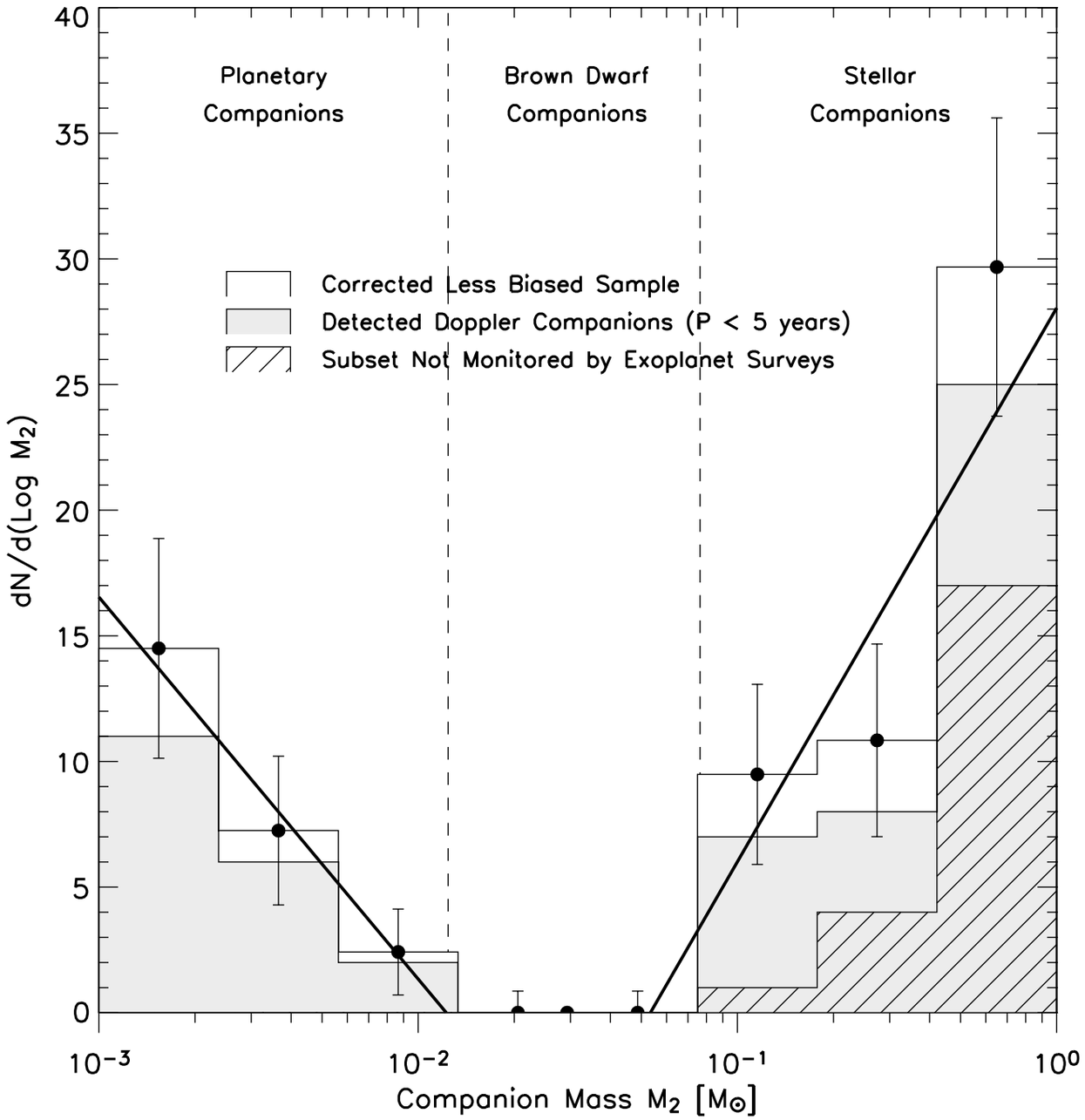
Can brown dwarfs survive on close orbits around convective stars?

Cilia Damiani[1] & Rodrigo Díaz[2]

[1] Institut d'astrophysique Spatiale, Orsay, France
[2] Geneva Observatory , Versoix, Switzerland

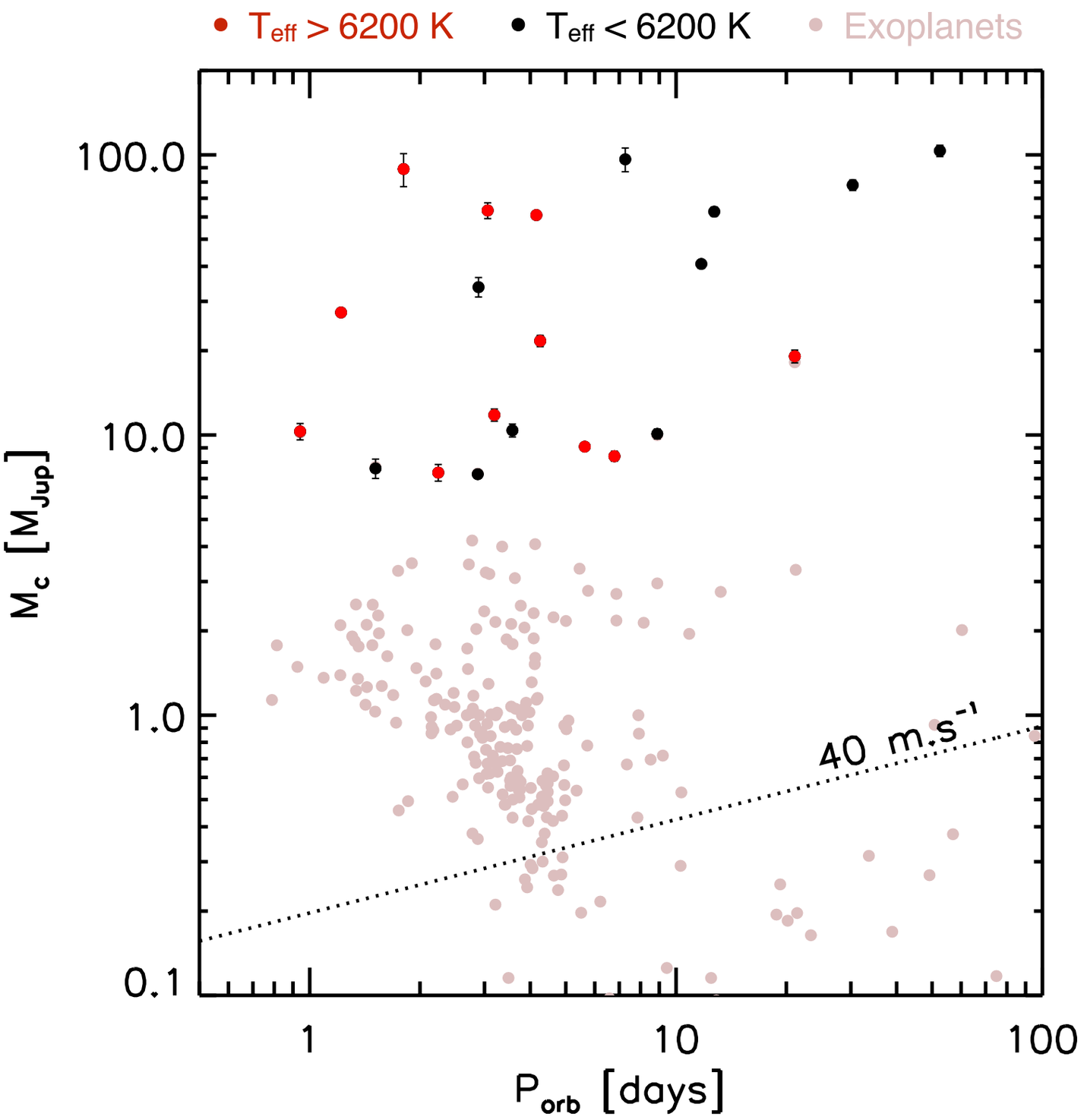
The Brown Dwarf Desert

Grether & Lineweaver 2006, ApJ, 640:1051

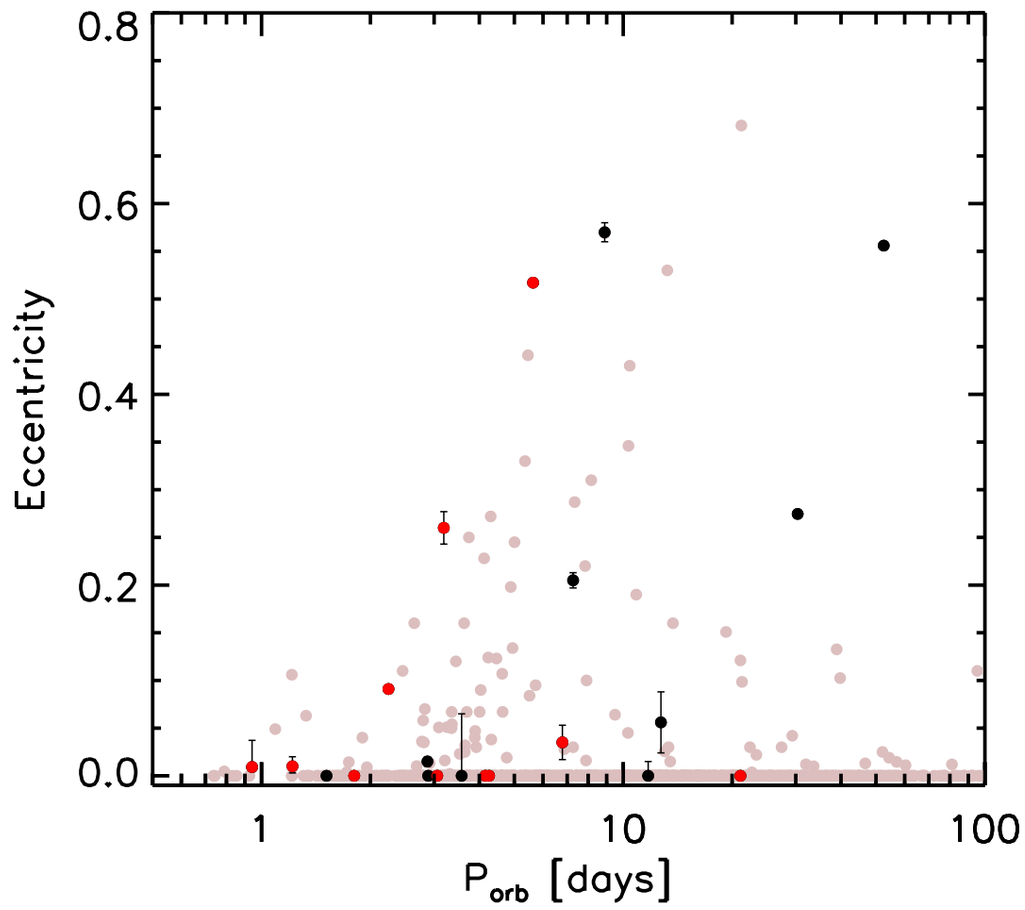


- See also: Murdoch, Hearnshow & Clark 1993; Marcy & Butler 2000; Sahlmann et al. 2011; Ma & Ge 2014
- Paucity of BD companions relative to planets within 3 AU around main-sequence FGKM stars

Transiting Brown Dwarfs



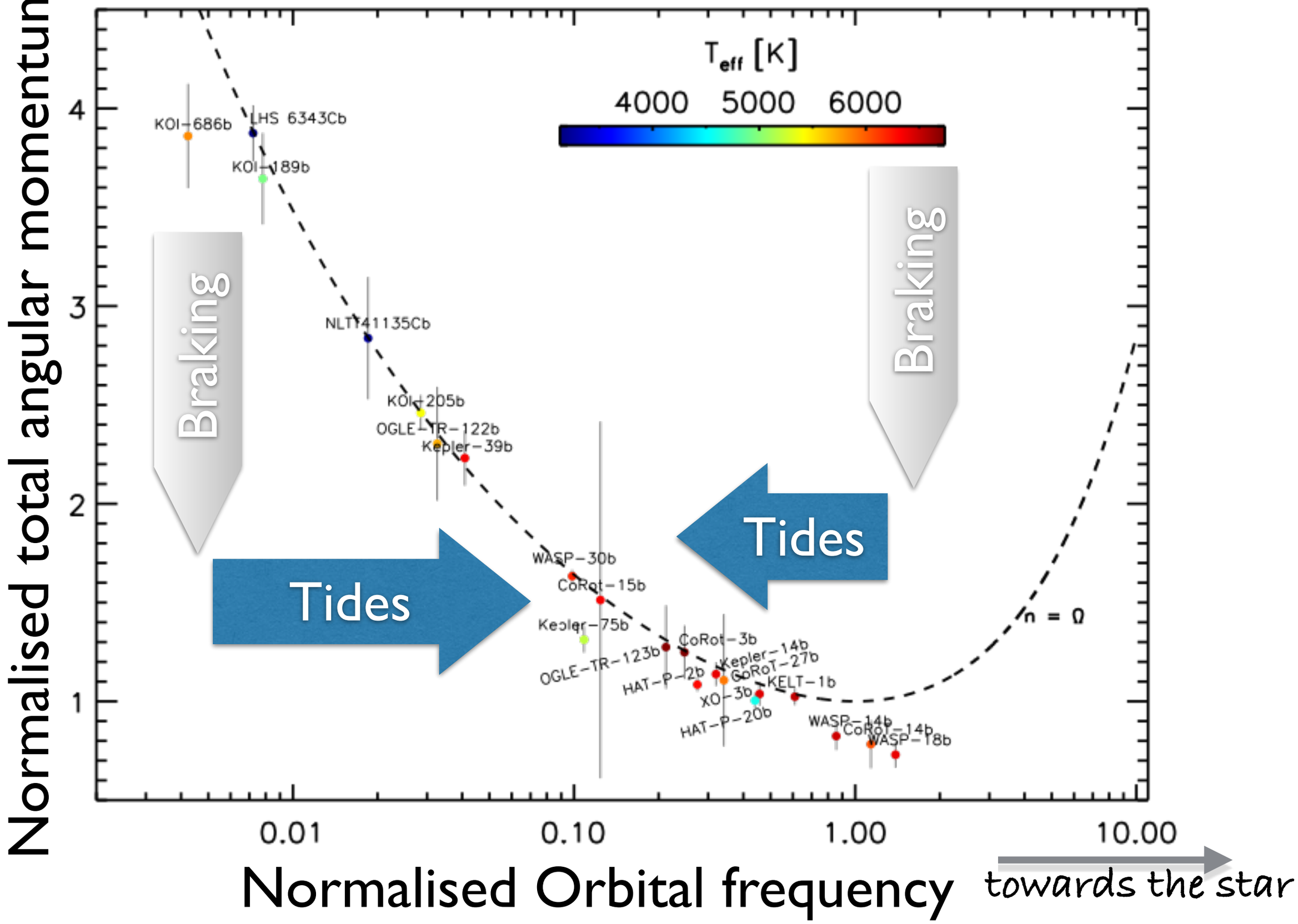
- 16 companions with M>10 M_{Jup}
- 10 of which orbit F-type stars
- Formation or evolution?



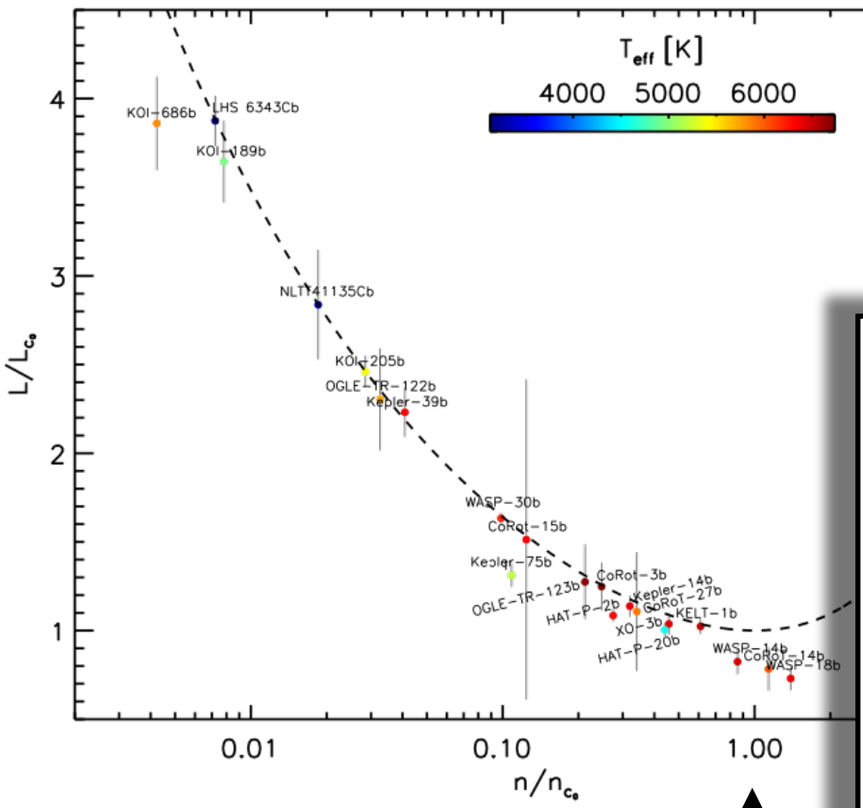
Transiting Brown Dwarfs

- Hypothesis from Bouchy et al 2011:
- The tides raised on the star threaten the survival of a close-in companion.
- Massive companion can escape engulfment if the total angular momentum of the system is above a critical value.
- Even in that case, magnetic braking in the central star will lead to a loss of angular momentum that will be transferred to the orbit of the companions through tides and lead to orbital decay.
- Early- and mid-F-type dwarfs are typically rapid rotators, independently of their age, a consequence of a small outer convective zone, and weak magnetic braking
- Thus close-in massive planets, brown dwarf or M-dwarf can survive when orbiting early or mid F-type dwarfs but be engulfed by G or late F-type dwarfs.

Damiani & Lanza 2015, A&A, 574, A39; Damiani & Díaz in prep.

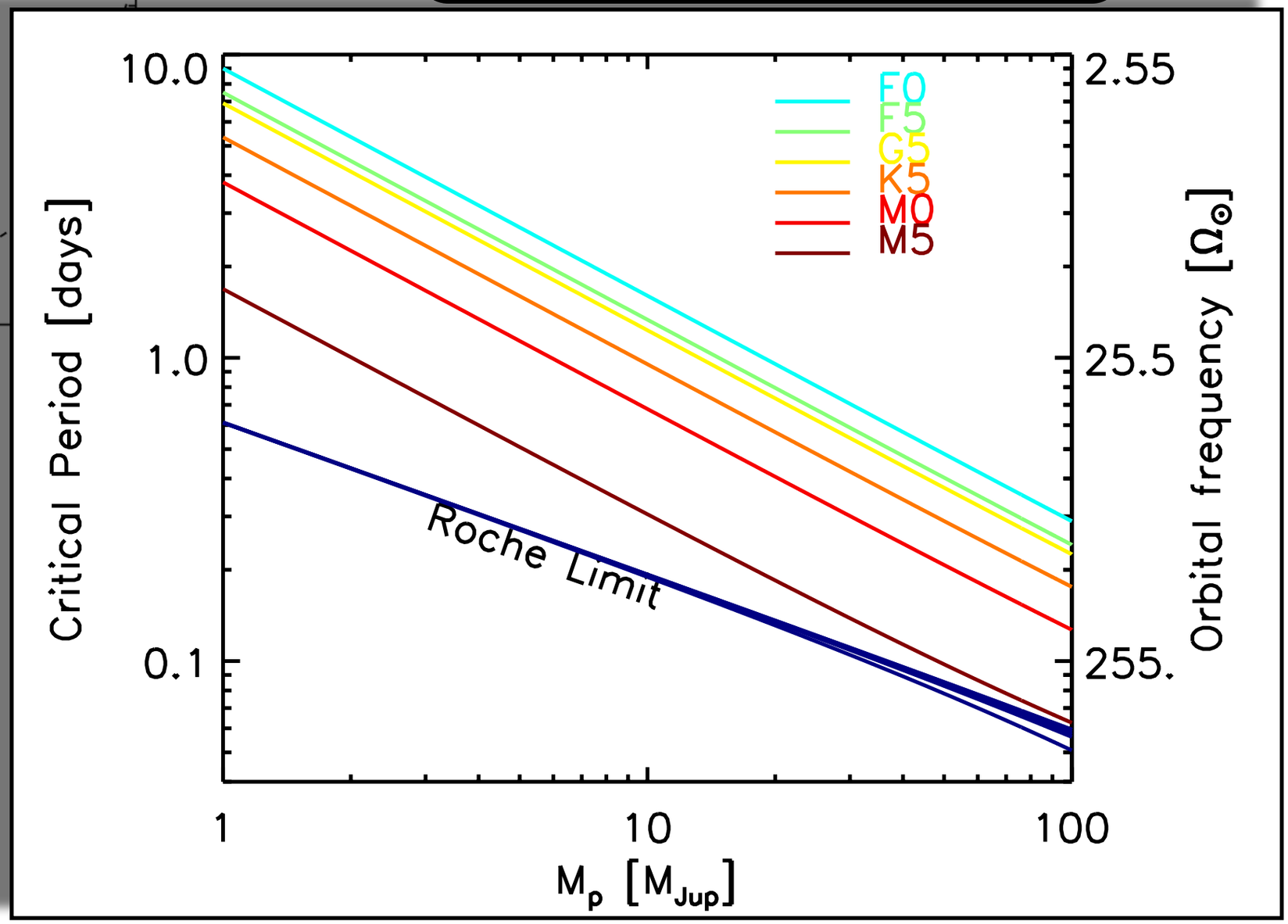


How close?



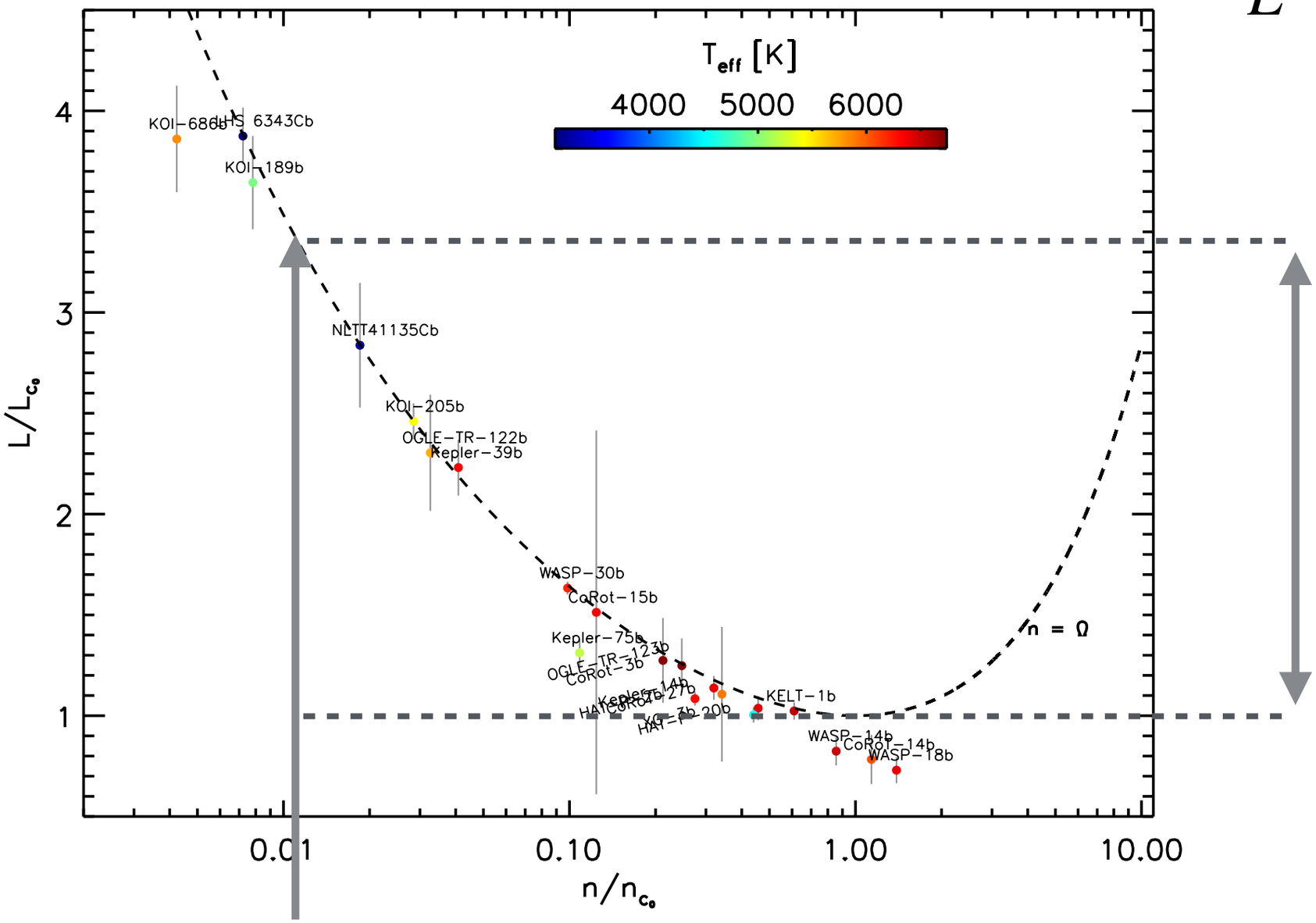
$$P_c \propto \left(\frac{M_\star^3 M_{\rm BD}^3}{M_\star + M_{\rm BD}}\right)^{-1/4} (I_\star + I_{\rm BD})^{3/4}$$

Closest stable orbit gets *closer* for decreasing stellar mass



How long?

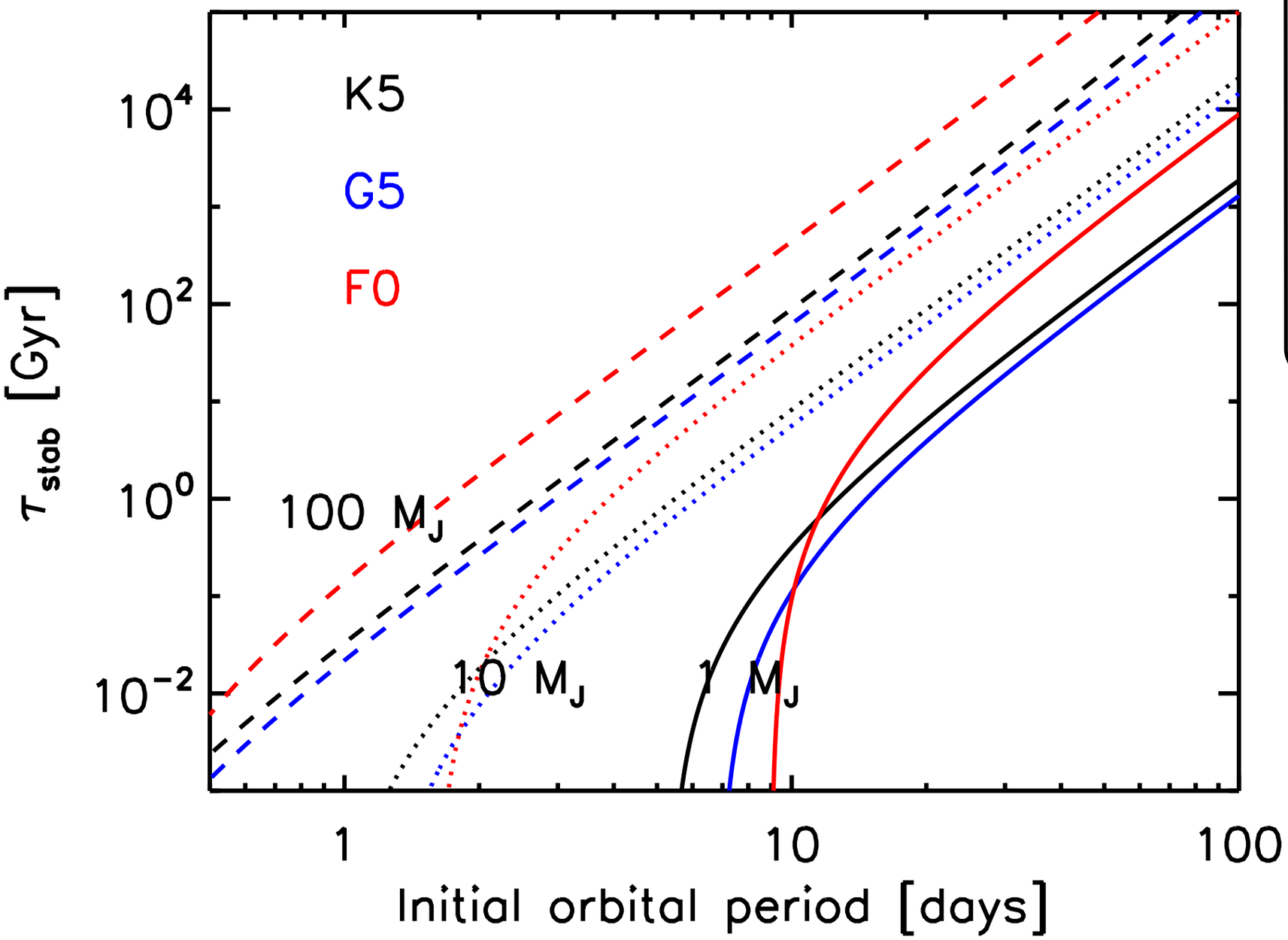
Conservative lower limit $\tau_{\rm sta} = \dfrac{\Delta L}{\dot{L}}$



Initial orbital period

How long?

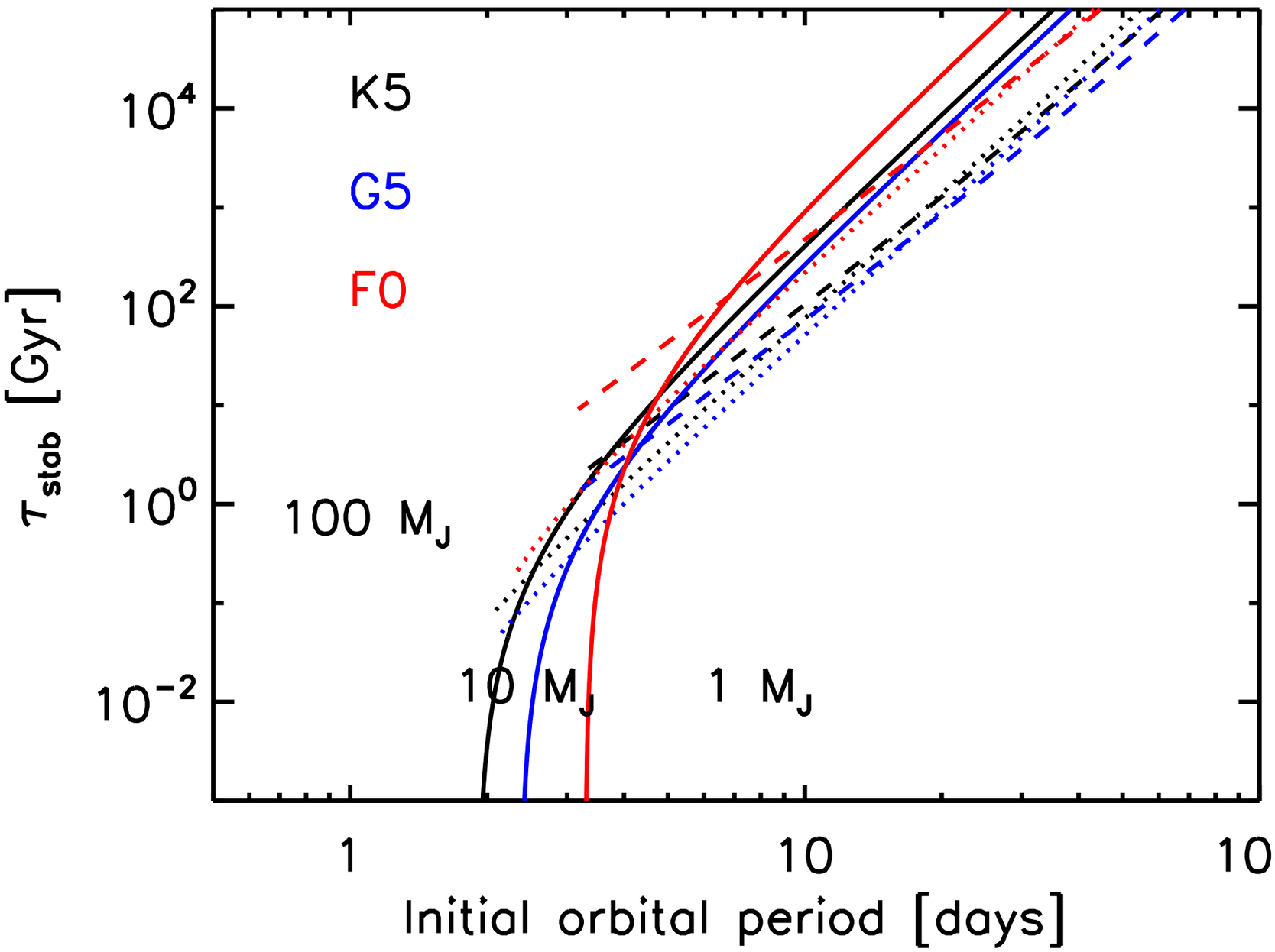
Lower limit



- Skumanich-type braking law
- reduced for F-type
- "instantaneous" tides

How long?

Reasonable lower limit



- Skumanich-type braking law
- reduced for F-type
- $Q'=10^6$ for G and K-type stars
- $Q'=10^7$ for F-type stars

➡ Stability less dependent on companion mass

Conclusions

- The dynamical evolution of objects on close-in orbits is driven by the resultant of the wind torque and the tidal torque
- Tidal dissipation and magnetic braking are not well known but

  ➡ The typical timescale for orbital decay should be long enough to allow BD on close-in orbits even around convective stars

  ➡ They could shape the distribution of orbital parameter in exoplanets (Dobbs-Dixon et al 2004, Dawson 2014, Damiani et al 2015)

- If transiting brown dwarfs are mainly observed around F-type stars, this must result from the formation processes and/or from selection bias.

Thank you!