Statistical Properties of Exoplanets

WHY?

- Compare to predicted outcomes of planet formation theories
- Assess prospects for future discoveries
- Place the Solar system in a larger context

Statistical Properties of Exoplanets

BEWARE!

- Small number statistics
- Selection effects
- Trials factor (look at enough variables, and you *will* find correlations)

The overall frequency of planets

From radial velocity surveys (nearby, mature FGK dwarfs)

- 1% have planets with $M > 0.5\ M_{jup}$, and $P < 10$ days
- 6% have planets with $M > 0.5\ M_{jup}$, and $P < 4$ years

The overall frequency of planets

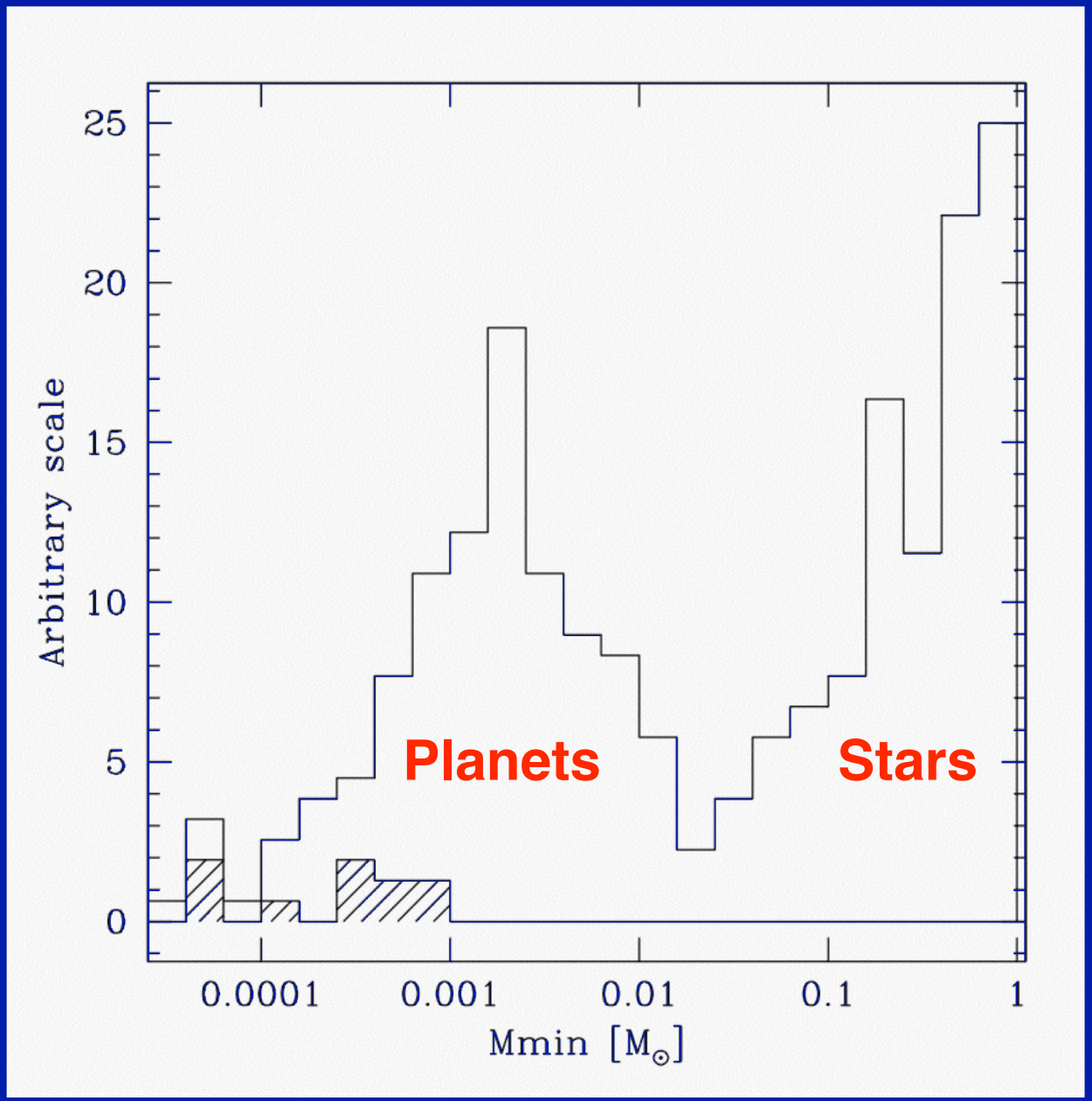
From microlensing surveys
(distant M stars)

- < 33% have planets with $M \sim M_{jup}$, and $1.5 < a < 4$ AU
  Gaudi et al. (2002)
- > 18% have planets with $M \sim M_{nep}$, and $1.5 < a < 4$ AU $(N = 2)$
  Gould et al. (2006)

The overall frequency of planets

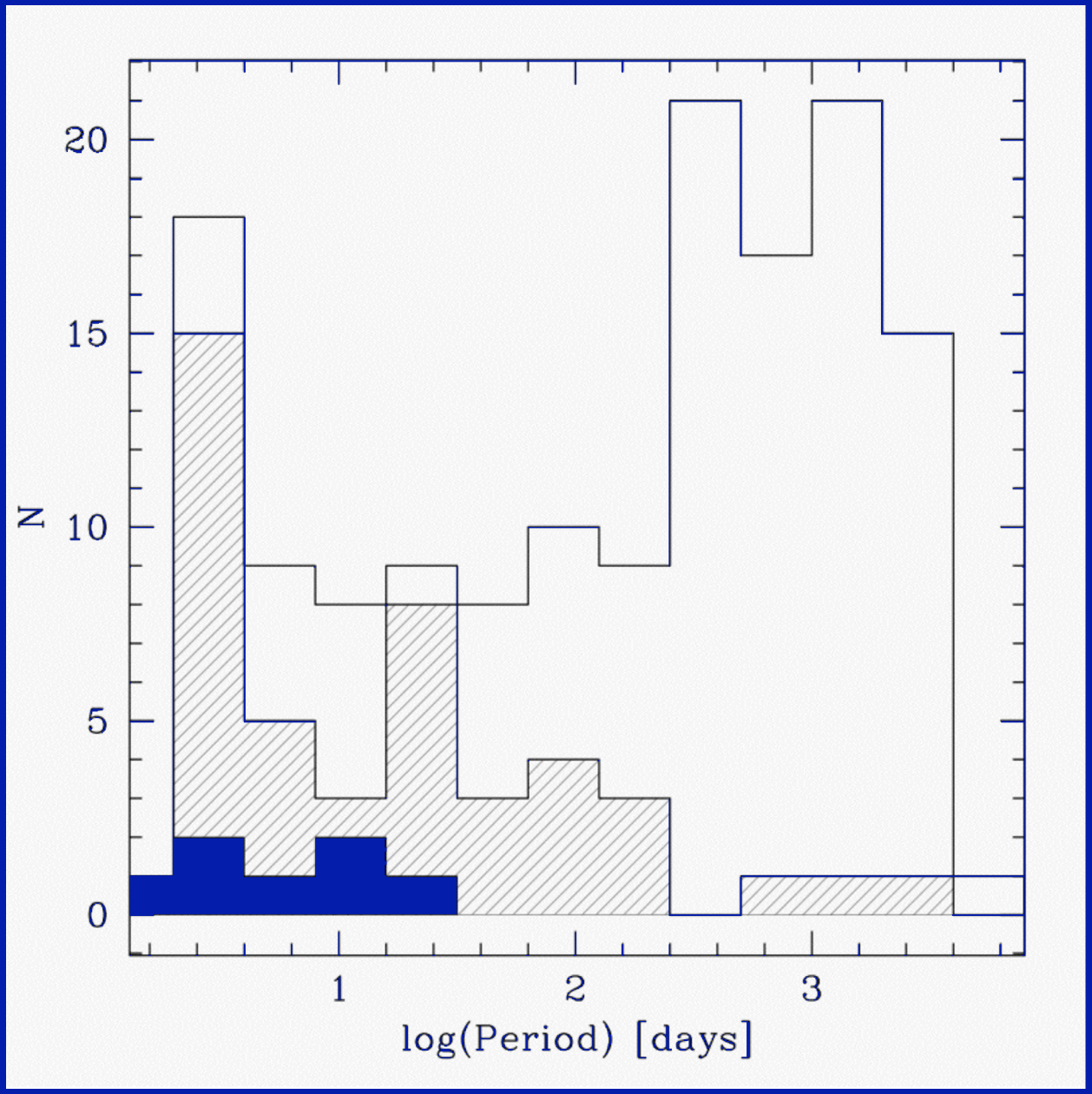
From transit surveys
(distant GK dwarfs)

- ~ 0.5% have planets with $R \sim R_{jup}$, and $2.5 < P < 6$ days — Gould et al. (2006)
- ~ 0.1% have planets with $R \sim R_{jup}$, and $P < 2.5$ days — Gaudi et al. (2005)



Planet masses

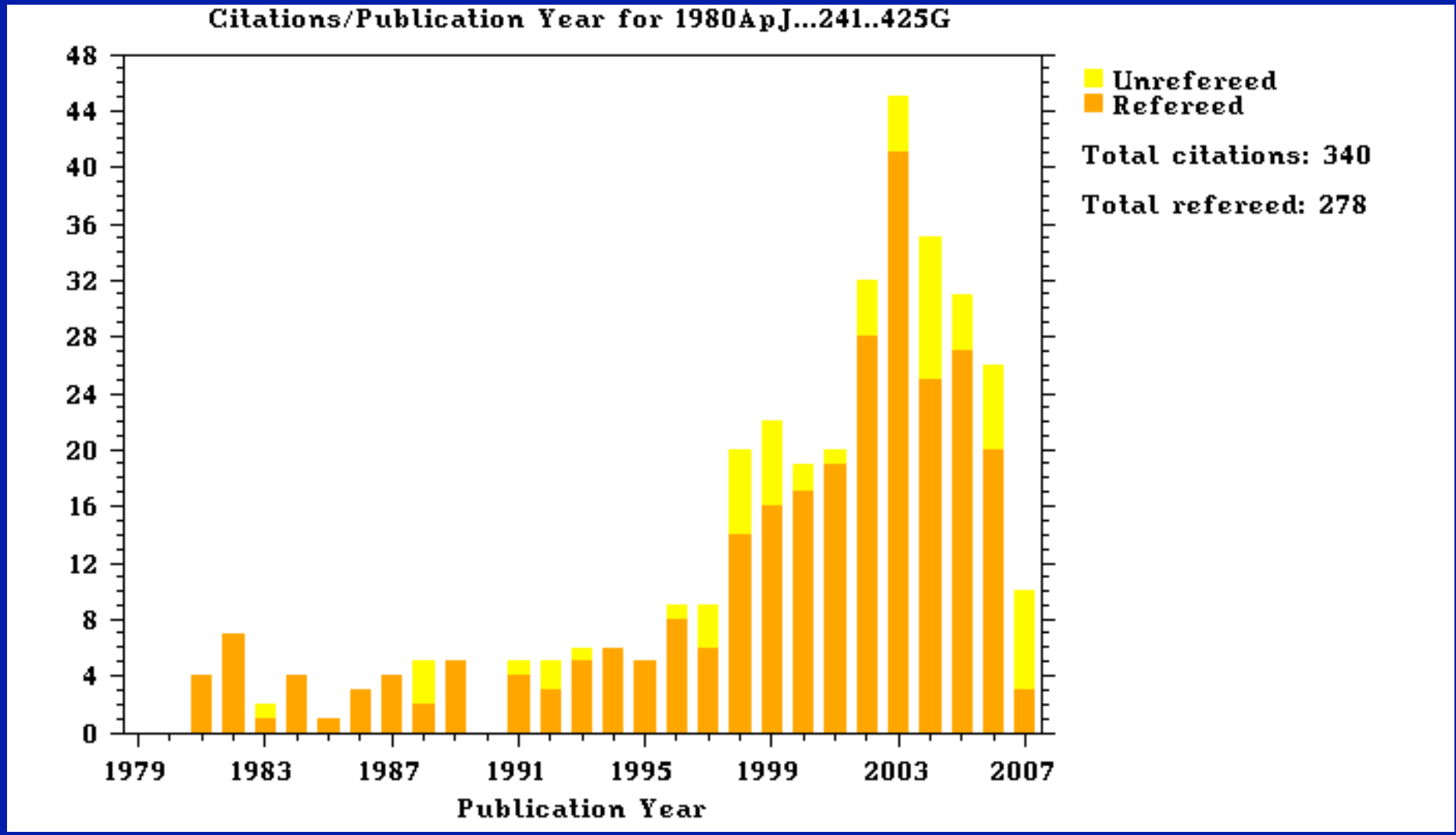
- Brown dwarf desert (20-60 M_{jup})
- $dN/dM \sim M^{-1}$
- Plentiful small planets?



Orbital periods

- "Pile-up" at $P \sim 3$ days
- Very few with $P < 3$ days
- Rising frequency with increasing P ?

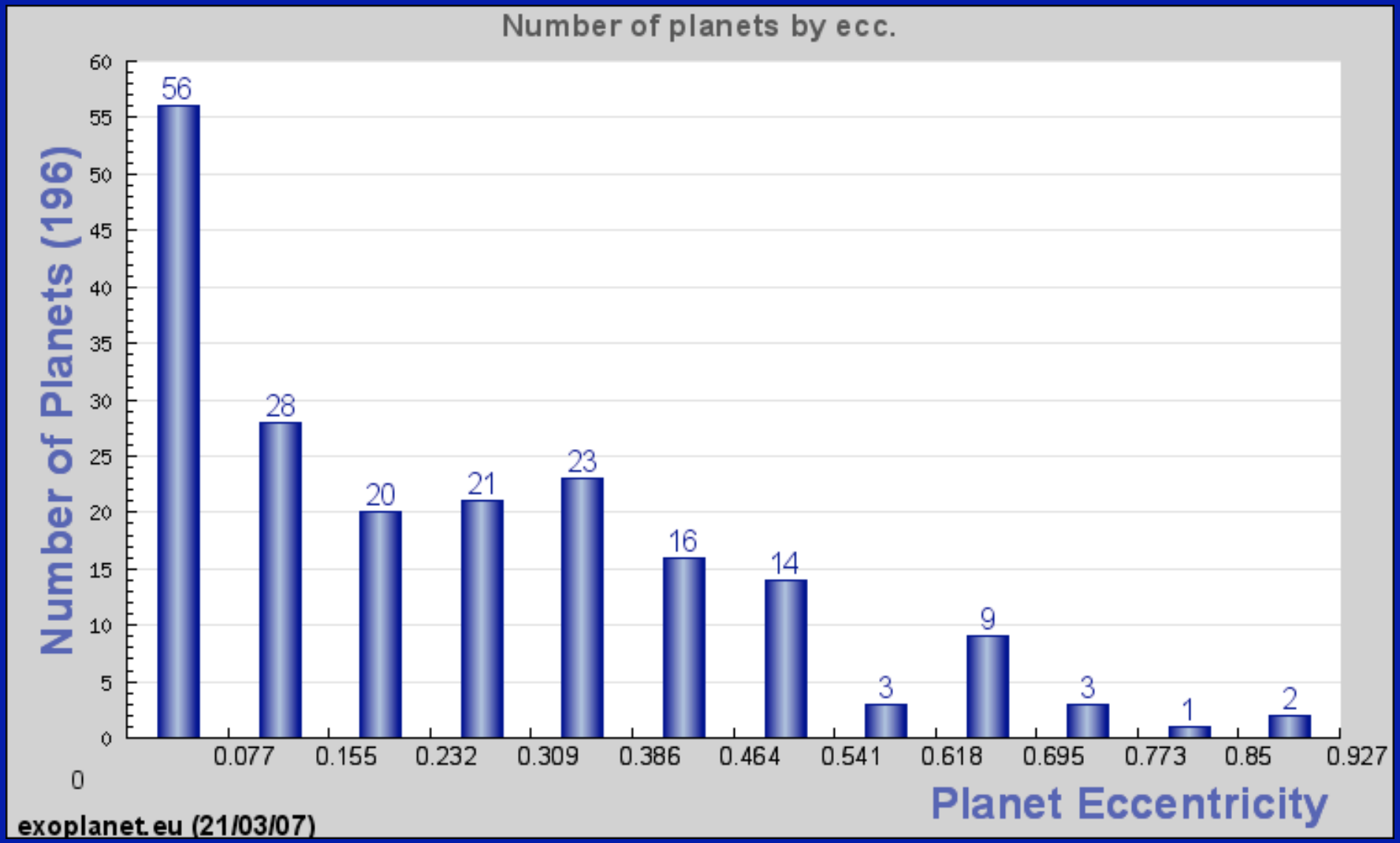
Goldreich & Tremaine (1980)

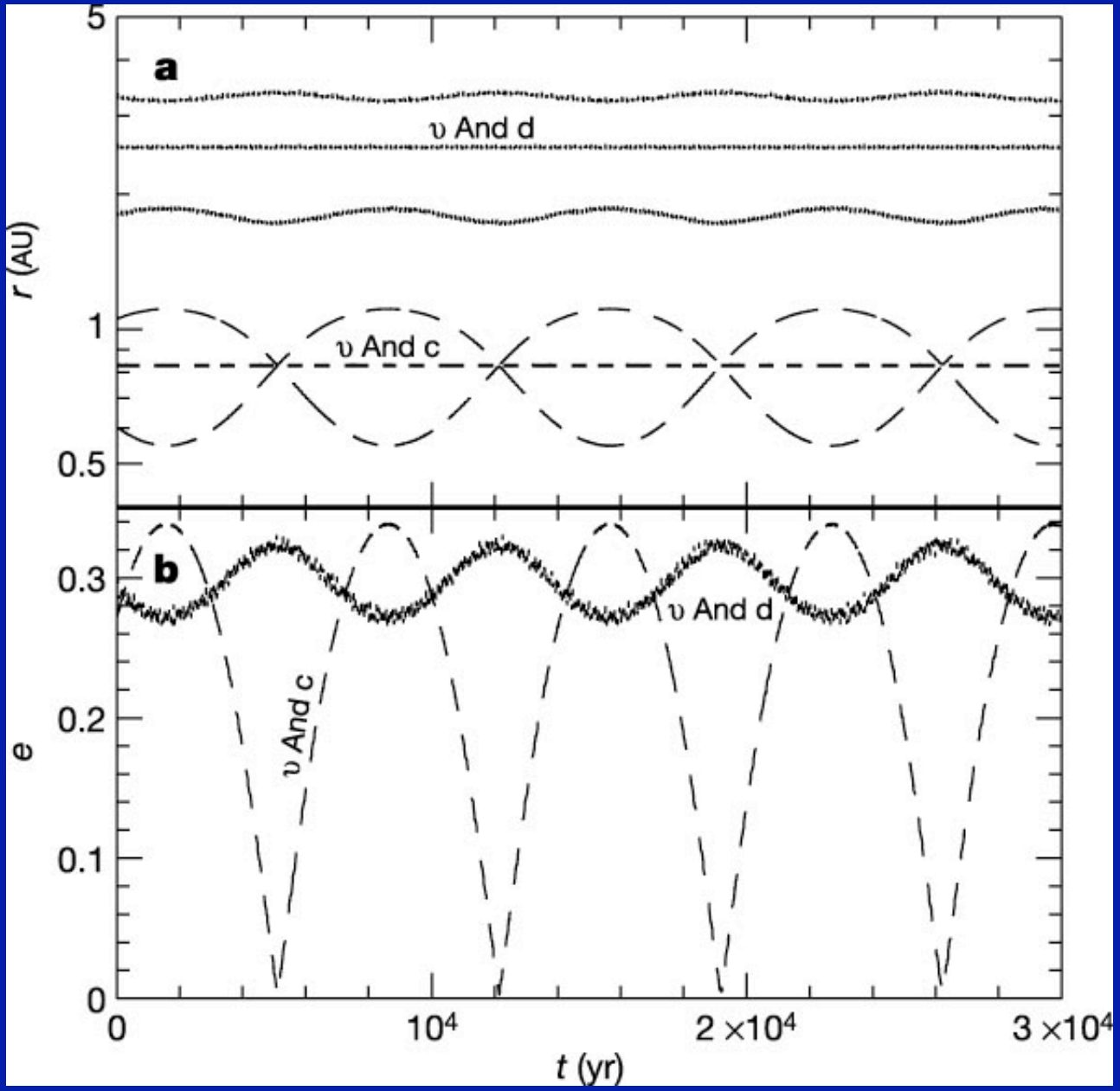


Planetary Migration

- Tidal interaction with protoplanetary disk
  - Torques from spiral-density waves (Type I)
  - Clear gap; viscous evolution of disk (Type II)
  - Timescale problem
  - Halting problem
- Tidal interaction with planetesimal disk
- Planet-planet scattering

Orbital eccentricities

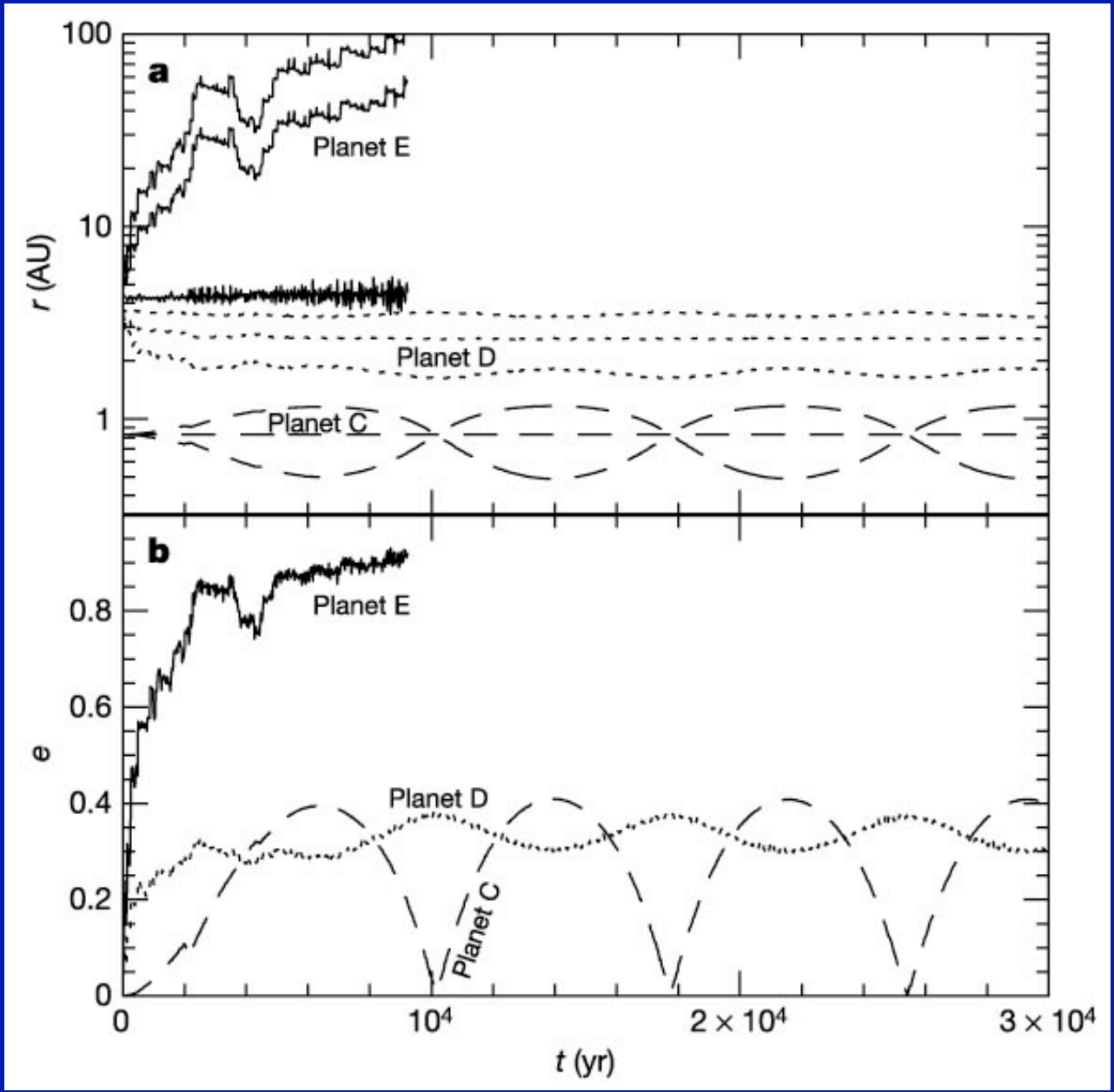




υ And

Evidence for planet-planet scattering

Ford, Lystad, & Rasio (2005)



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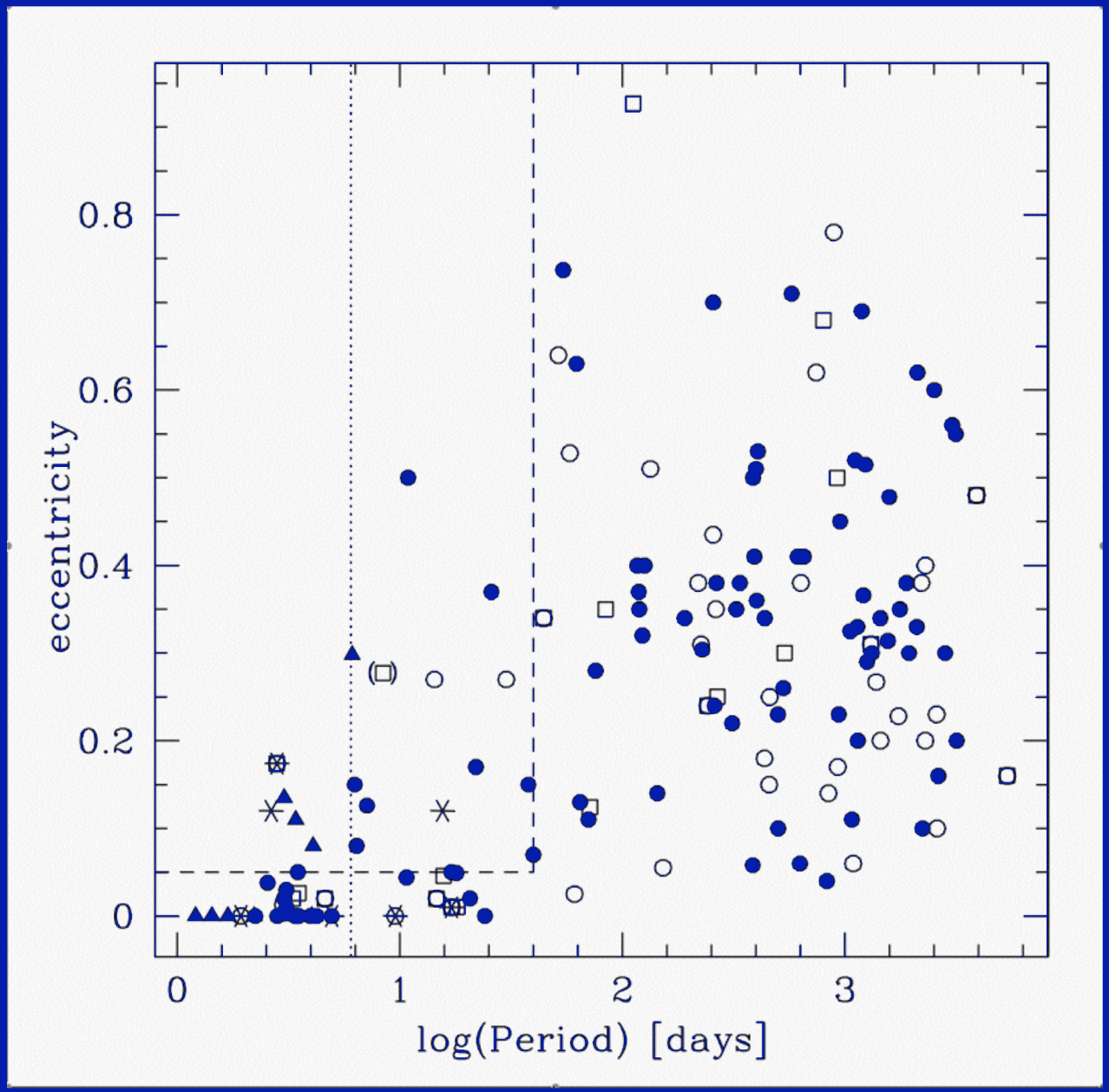
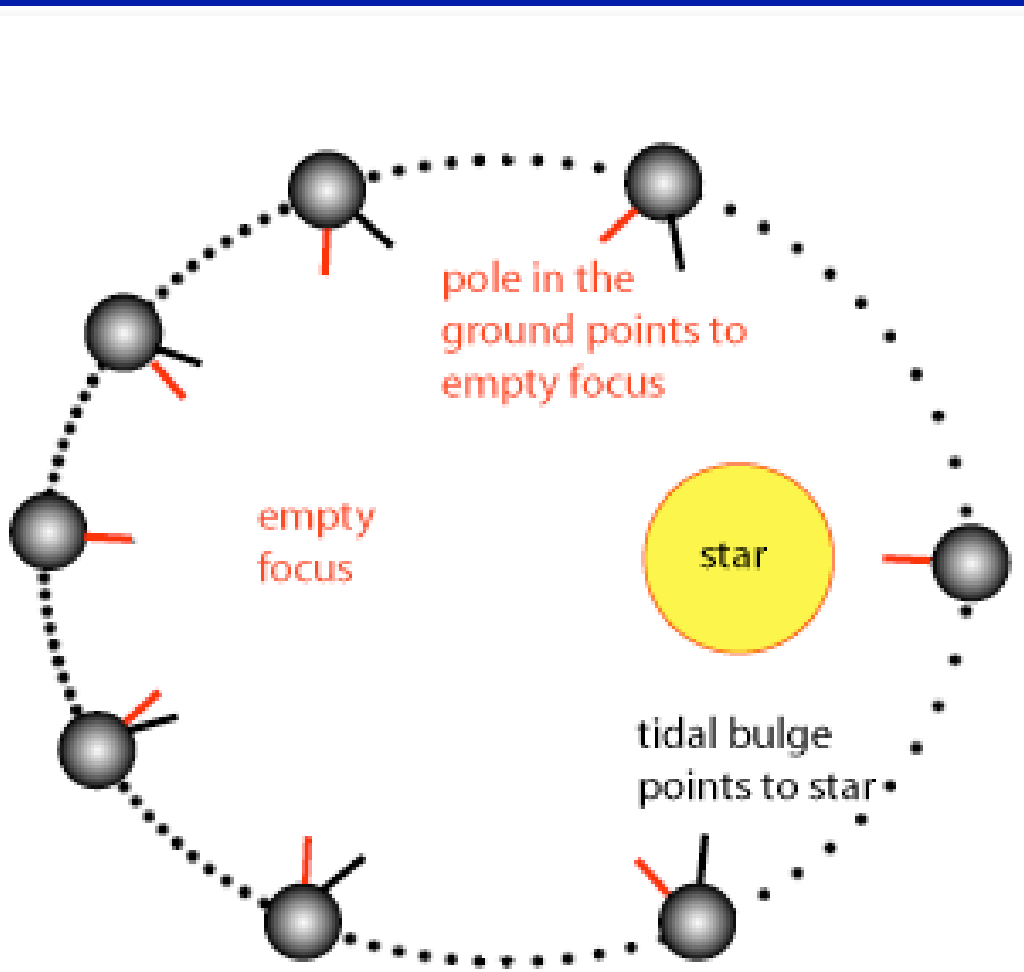
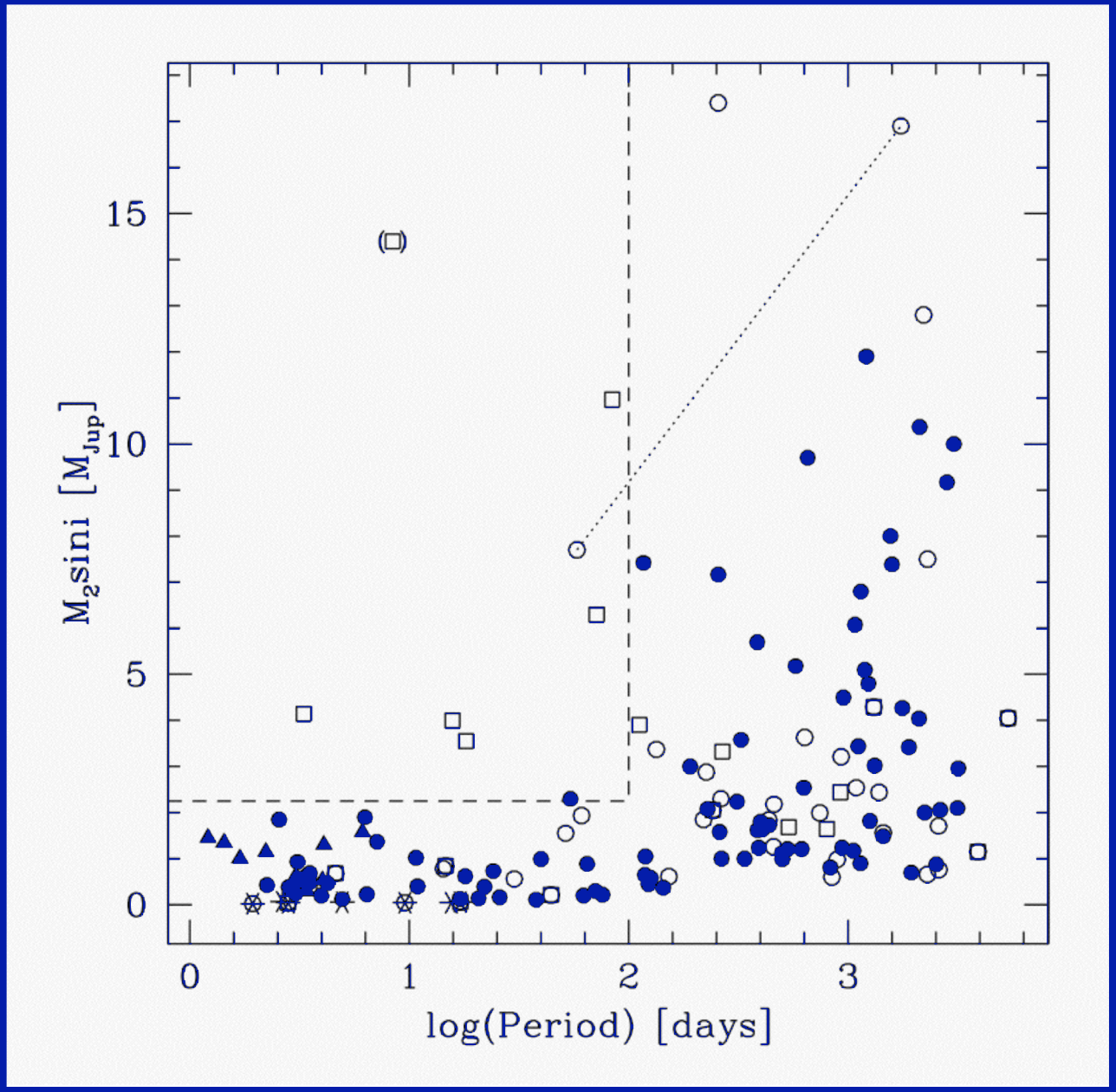


Period / eccentricity

Circular orbits for
P < 5 days

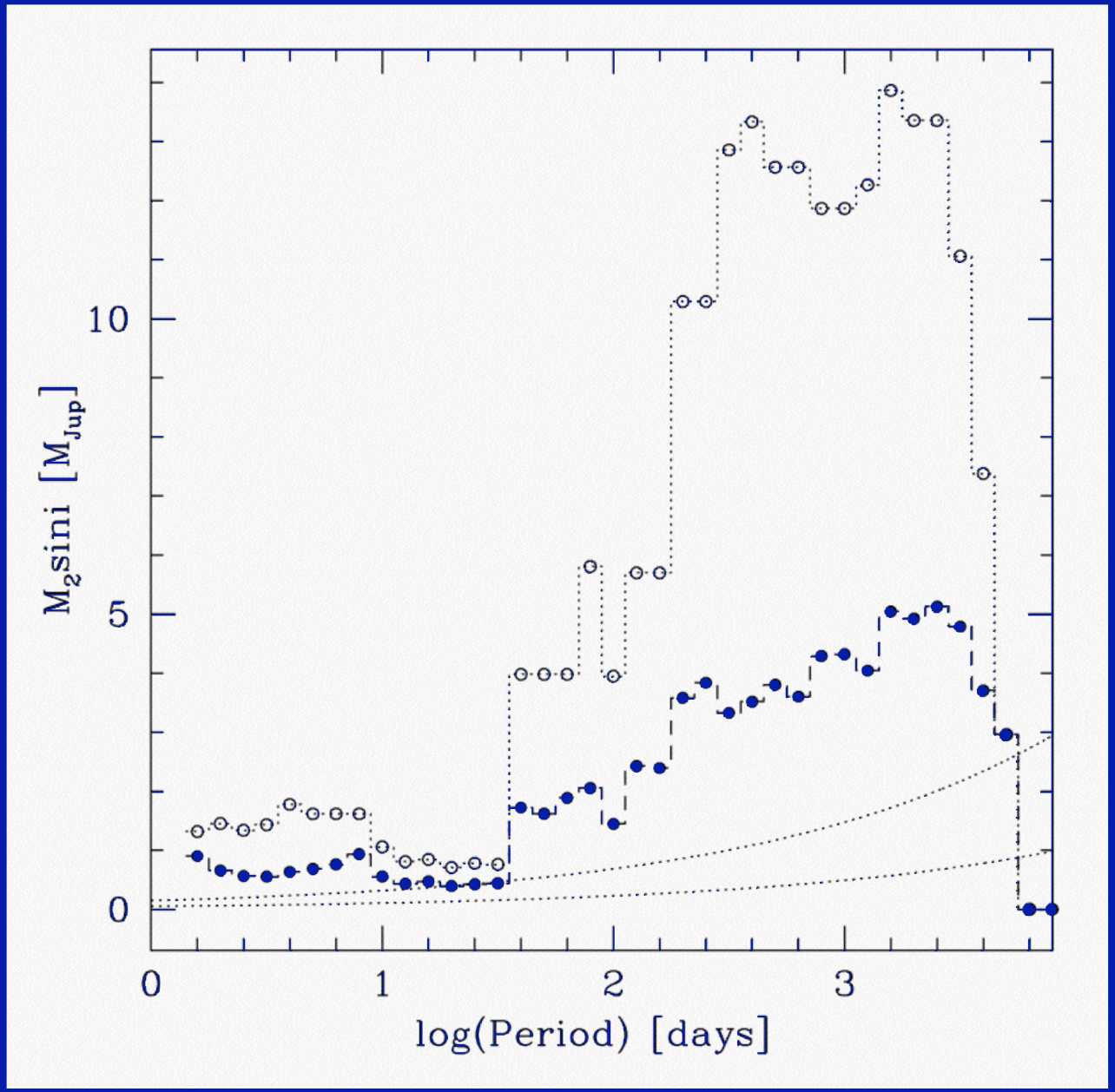
Tidal circularization





Period / mass

- Shorter-period planets have smaller masses
- Exceptions are all in multiple star systems



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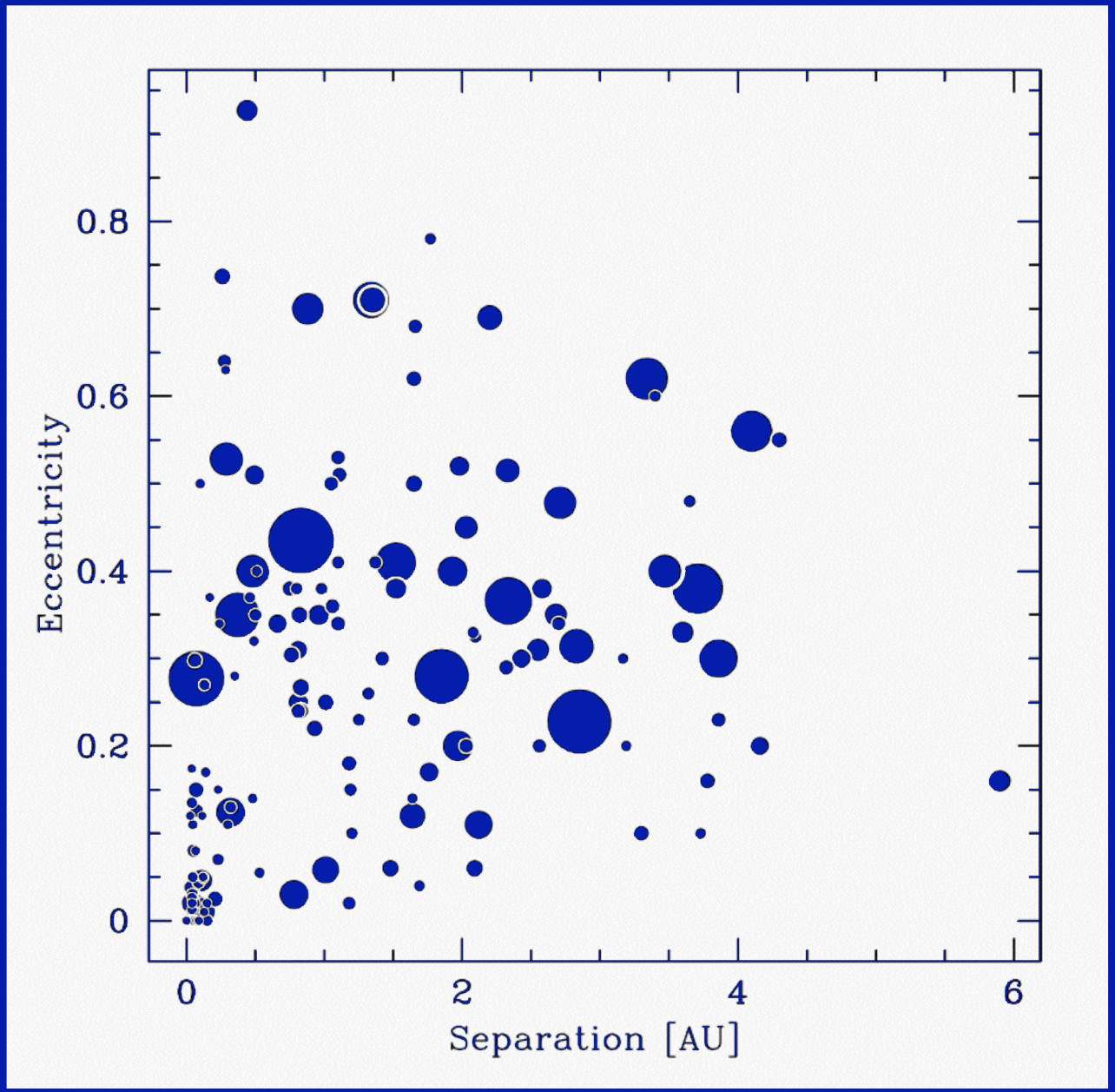
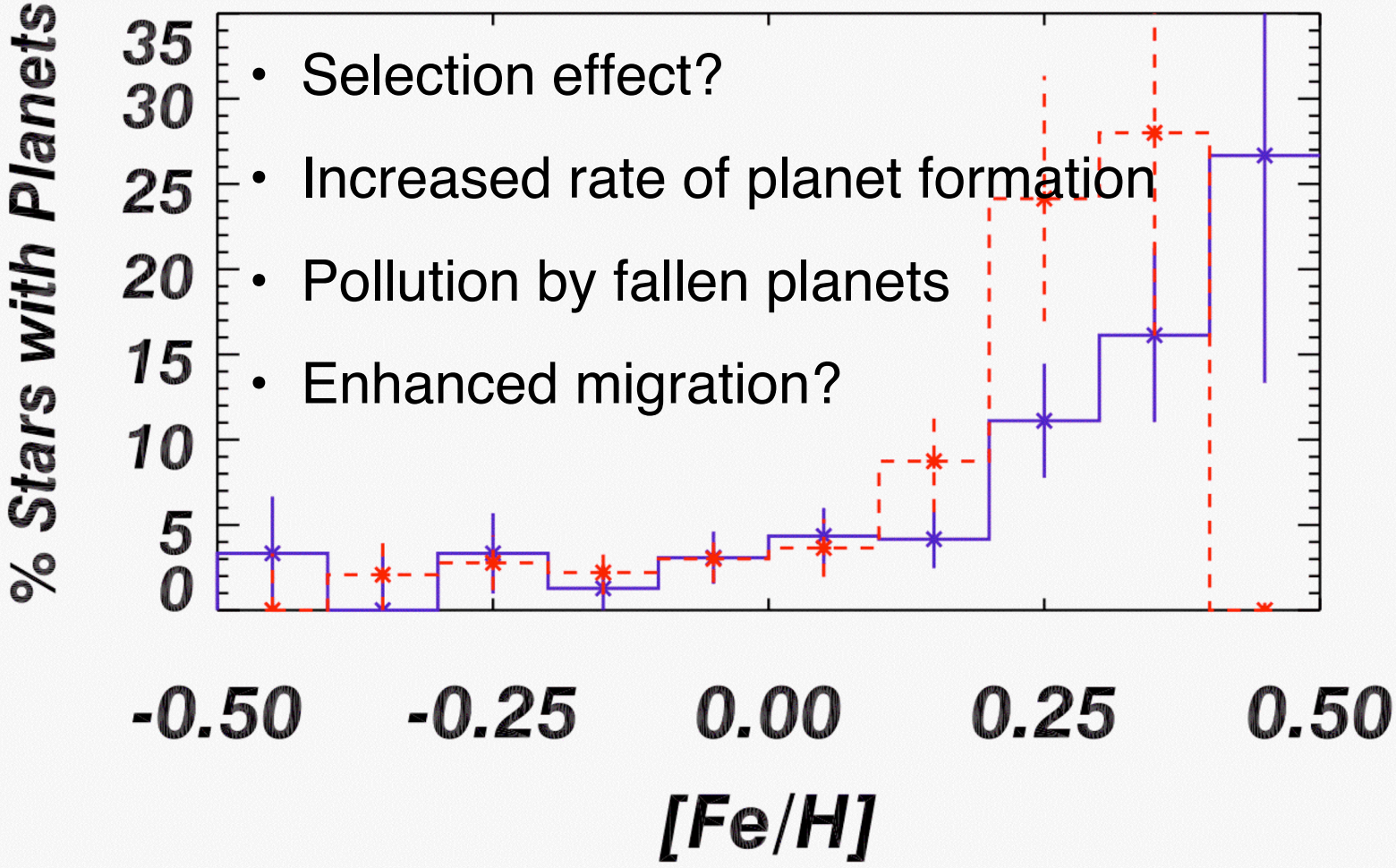


Period / mass / eccentricity

Stellar metallicity



Orbital period ratios