Open Clusters as Laboratories for Giant Planet Migration

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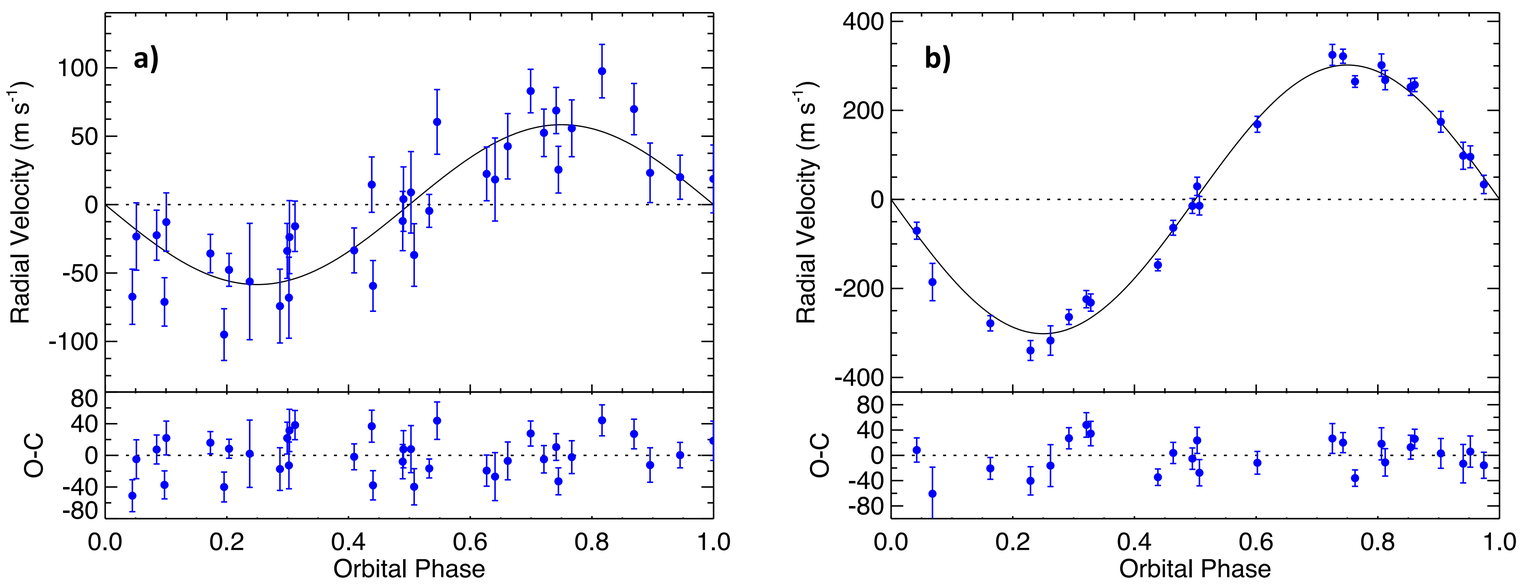
Based on our ongoing, precise radial-velocity survey of open clusters, we present here:

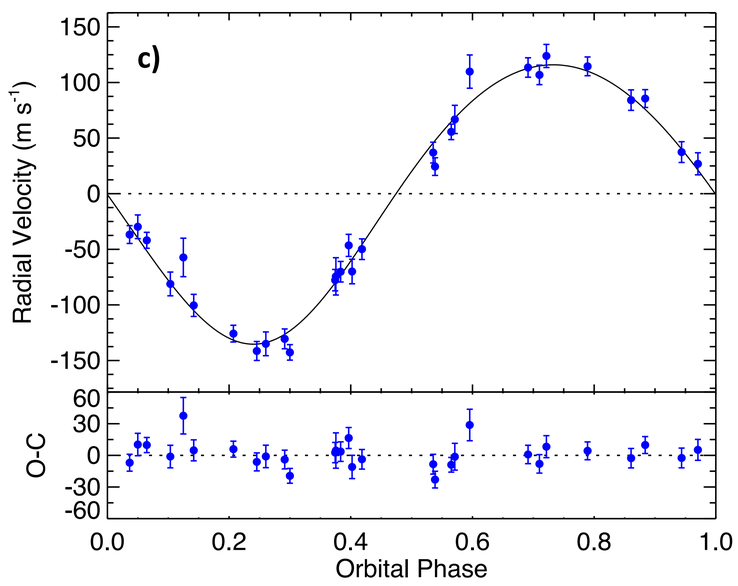
A. **The discovery of 2 hot Jupiters in Praesepe (578 Myr)**
B. **The discovery of an eccentric hot Jupiter in the Hyades (625 Myr)**
C. **Evidence for dynamical scattering during giant planet migration**

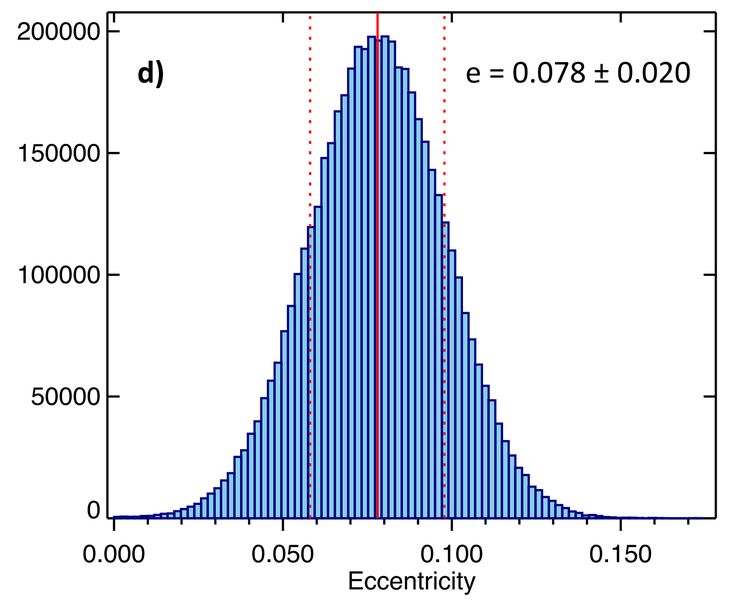
A. Two 'b's in the Beehive



Above: Orbital solutions (panels a and b) of the first two hot Jupiters discovered in an open cluster (Quinn et al. 2012). Although the systems are young (578 Myr), the orbital periods – 4.4 and 2.1 days – are short enough that tidal circularization should have already occurred, and the measured eccentricity is consistent with 0.

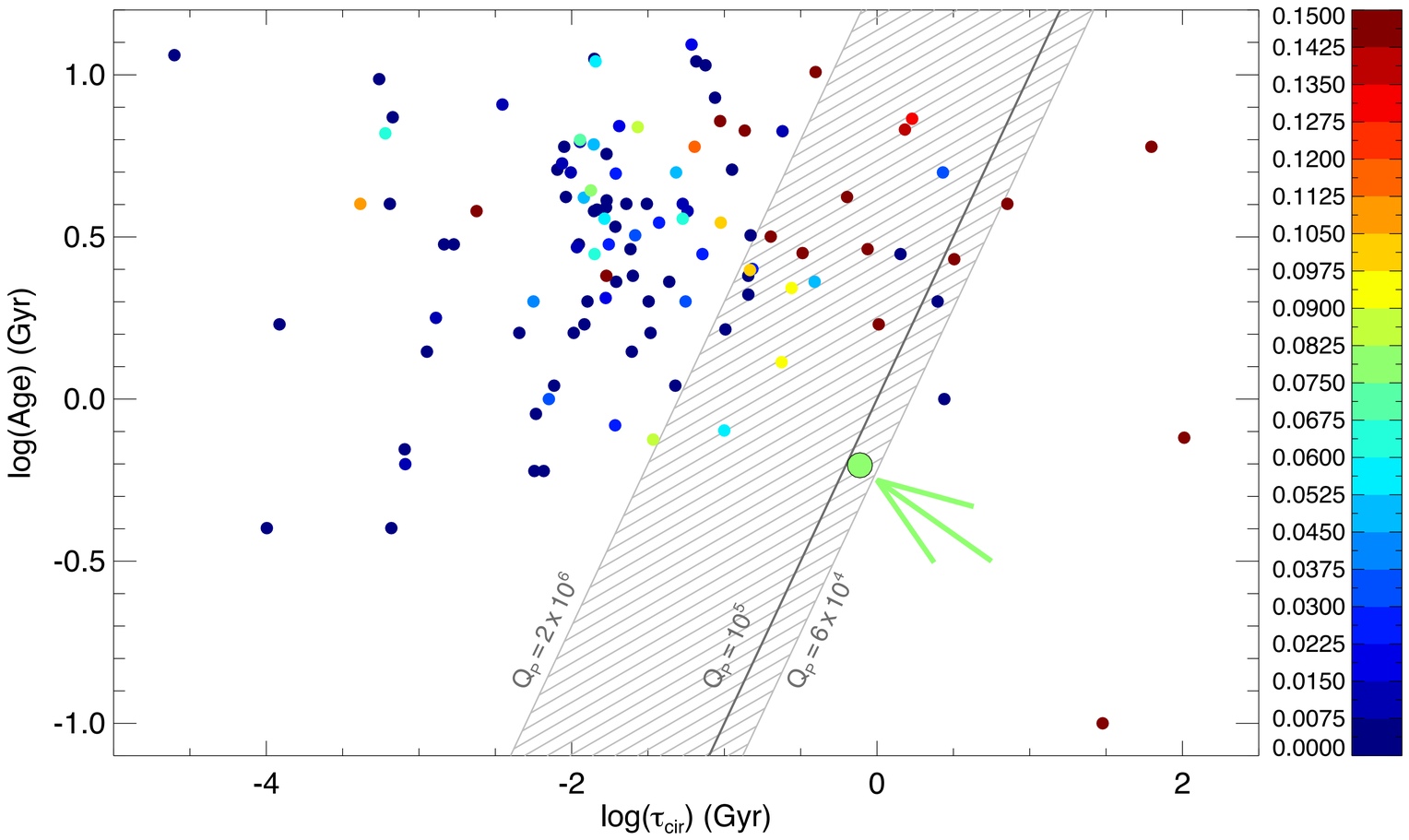
B. An Eccentric Hyades Planet





Above: Orbital solution (c) of our recently discovered hot Jupiter in the Hyades (Quinn et al., in prep). The eccentricity is non-zero, as seen in the posterior distribution of the Markov Chain Monte Carlo (d), which is not surprising given the longer orbital period (6.1 days) and youth of the system (625 Myr).

C. Observational Signature of Dynamical Scattering



Planet age versus circularization timescale for short period ($P < 10$ *d*) massive ($M > 0.3$ M_J) planets, assuming a tidal quality factor $Q_P = 10^5$ for all planets. Along the solid dark line, age = τ_{cir}; points to the left of the line are expected to have undergone circularization. We also plot a shaded region to show how this boundary shifts for the range of Q_P values consistent with observations of the Jupiter-Io interaction (see Yoder & Peale 1981). The data points are colored according to their eccentricities, and our Hyades planet is indicated by the green arrow. It appears very likely that its non-zero eccentricity is a remnant of its migration process, implying that dynamical scattering has played a role. Very few hot Jupiters have $\tau_{cir} > 1$ Gyr, so young planets offer an excellent opportunity to directly observe the dynamical effects of migration.

Notes:
Planet ages, stellar properties, and orbital parameters were obtained from The Extrasolar Planets Encyclopaedia (www.exoplanet.eu)

Radii of non-transiting planets were estimated from the mass-radius relations of Weiss et al. (2013): $\frac{R_P}{R_E} \approx 2.45 \left(\frac{M_P}{M_E}\right)^{-0.039} \left(\frac{F}{\mathrm{erg\ s^{-1}\ cm^{-2}}}\right)^{0.094}$

Circularization timescale was calculated according to Adams & Laughlin (2006), eq. (3): $\tau_{cir} \approx 1.6\ \mathrm{Gyr} \left(\frac{Q_P}{10^6}\right)\left(\frac{M_P}{M_J}\right)\left(\frac{M_*}{M_\odot}\right)^{-1.5}\left(\frac{R_P}{R_J}\right)^{-5}\left(\frac{a}{0.05\ \mathrm{AU}}\right)^{6.5}$

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