## Detection and Dynamics of Exoplanets (DDE): Interplay between theory and observations



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## Identifying hot Jupiters that arrived via disk migration

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Two leading hypotheses of hot Jupiter formation are disk migration, where a Jupiter in the outer part of the disk and migrates inward due to gas drag, and high eccentricity migration (HEM), where a Jupiter is excited to an eccentric orbit by its stellar or planetary companion and subsequently circularizes close to the pericenter distance due to tidal dissipation in the planet. Measurement of stellar obliquity, a byproduct of the eccentricity excitation, has been a common method of testing the two hypotheses, but while a high obliquity suggests HEM, low obliquity does not necessarily suggest disk migration. This is because obliquity could damp due to tidal dissipation in the star, and hot Jupiters that arrived via HEM could very well have aligned orbits as well. In this study, we therefore attempt to identify hot Jupiters that may have arrived by disk migration by calculating tcirc, the circularization timescale of about 400 hot Jupiters with measured masses and radii. For systems where  $\tau circ > \tau age$  (estimated age of the system) but the eccentricity e = 0, HEM would not be able to complete in time, suggesting disk migration. Tidal quality factor used to calculate tcirc was determined as the value that maximizes the difference between the eccentricity distributions of the two samples with  $\tau$ circ >  $\tau$  age and  $\tau$  circ <  $\tau$  age. Tidal quality factor obtained are consistent with the values for Jupiter in the solar system estimated from the interactions with the satellites. As a result, we identified dozens of hot Jupiters ( $\tau circ > \tau age, e = 0$ ) that are suggestive of disk migration. While the list includes many of the hot Jupiters with known inner companions (also hinting disk migration), it does not include ones on significantly inclined orbits. This is consistent with disk migration being a more quiescent migration mechanism than HEM. We also report that the accuracy of the estimation of the tidal quality faactor (p-value of the difference in the eccentricity distribution) deteriorated significantly when hot Jupiter for which e was assumed to be zero (but not measured) were included. This suggests that many of these hot Jupiter have significant eccentricities.

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