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Architecture of resonant systems of sub-Neptunes: constraints from transit timing variations

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Resonances are a natural outcome of the migration of exoplanets. Consequently, they appear to be a crucial step in the formation of close-in sub-Neptunes. These exoplanets, with radii ranging from 1 to 4 Earth radii and orbital periods of less than 100 days, have been shown to exist around 30 to 50% of sun-like stars, based on early results from the HARPS spectrograph and the Kepler spacecraft.

A leading model for the formation of this population is called "breaking the chains." In this model, close-in systems of sub-Neptunes form in resonant chains due to the migration of planets in protoplanetary disks. After the disk dissipates, most resonant chains become dynamically unstable. The chains that survive then evolve through tidal forces over timescales of billions of years. Although resonant configurations represent only a few percent of transiting systems, they are crucial to understanding the formation and evolution of about half of planetary systems. The intricate details of the architecture of resonant exoplanets encode their history. We can access these architectures by observing the effect of planet-planet gravitational interactions on the timing of planetary transits, known as the transit timing variation (TTV) method.

However, TTVs present challenges: for shallow transits, the use of non-adapted methods can lead to non-detection of planets or erroneous TTV measurements, which in turn biases the estimated masses. For some configurations, the mass can be affected by a degeneracy between the recovered mass and eccentricity. Additionally, non-transiting planets can also affect the observed TTVs. During this talk, I will discuss the TTV-related challenges and the state-of-the-art methods to alleviate them. I will then describe how these issues potentially impacted major statistical results of the 2010s, notably the apparent paucity of exoplanetary systems within resonances, and the apparent low density of TTV-characterized planets.

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