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# Relaxation of resonant two-planet systems and their TTVs

Rosemary Mardling (1,2)
(1) School of Physics and Astronomy, Monash University, (2) Astronomy Department, University of Geneva
(rosemary.mardling@monash.edu)

## Abstract

Many two-planet systems reside near or inside first-order resonances. These are normally the product of planet-disk interactions during the time of formation, with eccentricity damping and migration resulting in a relaxed system with fewer degrees of freedom than for an arbitrary two-planet system. We will present a simple formulation describing such systems which is valid inside, across and outside the resonance. We will show that all such systems are governed by a single two-parameter ordinary integro-differential equation, and that all system information (variation of eccentricities, orbital frequencies, resonance angles, apsidal orientations, transit timing variations or TTVs) can be derived from its solution. The expression for the TTVs can be easily inverted to solve for the planet masses (and other system parameters) when both planets transit; if no valid inversion is possible (given sufficient signal to noise for the TTVs), it is possible to infer the existence of non-transiting planets, the signature of which will be imprinted on the signal.