Astrophysics > Earth and Planetary Astrophysics

Tidal evolution of hierarchical and inclined systems

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We investigate the dynamical evolution of hierarchical three-body systems under the effect of tides, when the ratio of the orbital semi-major axes is small and the mutual inclination is relatively large (greater than 20 degrees). Using the quadrupolar non-restricted approximation for the gravitational interactions and the viscous linear model for tides, we derive the averaged equations of motion in a vectorial formalism which is suitable to model the long-term evolution of a large variety of exoplanetary systems in very eccentric and inclined orbits. In particular, it can be used to derive constraints for stellar spin-orbit misalignment, capture in Cassini states, tidal-Kozai migration, or damping of the mutual inclination. Because our model is valid for the non-restricted problem, it can be used to study systems of identical mass or for the outer restricted problem, such as the evolution of a planet around a binary of stars. Here, we apply our model to three distinct situations: 1) the HD80606 planetary system, for which we obtain the probability density function distribution for the misalignment angle, with two pronounced peaks of higher probability around 53 and 109 degrees; 2) the HD98800 binary system, for which we show that initial prograde orbits inside the observed disc may become retrograde and vice-versa, only because of tidal migration within the binary stars; 3) the HD11964 planetary system, for which we show that tidal dissipation combined with gravitational perturbations may lead to a decrease in the mutual inclination, and a fast circularization of the inner orbit.

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