Conference in Numerical Analysis 2014 (NumAn 2014)
September 2-5, 2014
Chania,Greece

Continuation and stability deduction of resonant periodic orbits in three dimensional systems

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Abstract

The general three body problem (GTBP) through the implementation of periodic orbits computed in a suitable rotating frame of reference can be used in order to describe the dynamics of planets locked in a mean motion resonance. The families of periodic orbits, either planar or spatial, derived by specific continuation processes can, also, constitute paths that can drive the planetary migration.

In Hamiltonian systems, it is known that in phase space the stable periodic orbits are surrounded by invariant tori, while in the neighbourhood of unstable periodic orbits chaotic regions exist. It has been shown numerically that in the vicinity of stable periodic orbits, where the motion is regular and bounded, exoplanetary systems can survive, whereas in case they are found near unstable ones, they will eventually destabilize and the planets may collide or even escape. The significance of periodic orbits is therefore taken for granted and the accuracy of their computation is apparently crucial.

We herein present applications of our numerical methods to compute resonant periodic orbits, exploit analytic continuation and elaborate on matters of both horizontal and vertical stability. Particularly, we consider the spatial GTBP and study the dynamics of planetary systems consisting of a Star and two inclined Planets, which evolve into mean motion resonance. We attempt a comparative study between three methods used for the deduction of the stability of a periodic orbit: the computation of eigenvalues, stability indices and Fast Lyapunov Indicator. Finally, we construct maps of dynamical stability in the vicinity of periodic orbits, in order to identify the extent of stable regions in phase space.

Key words: periodic orbits, horizontal and vertical stability, mean motion resonance