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MODELLING COORBITAL MOTION IN CURVILINEAR COORDINATES

Abstract

Even within the simplifiying assumption of circular restricted three body problem (CRTBP) coorbital motion exhibits an extraordinarily rich dynamical behaviour. The three main classes of relative orbital motion, namely the tadpole, horseshoe and quasi-satellite state can be difficult to model and predict analytically, especially in the region near to the second primary [Brasser et al., Icarus 2004]. In addition, hybrid combinations and transitions between the main coorbital states are common and even more difficult to predict. The complex transition mechanism, in particular, has been shown to occur at relatively high values of the eccentricity and/or inclination of the secondary [Namouni 1999].

The literature dealing with coorbital motion is enormous and ranges from purely numerical studies (from the early work by Wiegert et al. [AJ 2000], to the very recent work of Morais and Namouni [CMDA2016]) to complex mathematical methods developed mainly on the Hamiltonian formalism, averaging methods and perturbation theory (see [Robutel et al. Comp. Appl. Math 2015]). In general, one important aspects characterizing several works in the literature is the importance of the formulation employed and the effort to deal with singularities near interesting regions of the coorbital dynamics (see for instance [Nesvorny et al. CMDA 2002]).

Recently, one of these authors obtained an accurate description of relative motion with respect to a circular orbit using curvilinear coordinartes [Bombardelli et al. CMDA 2016]. The solution, valid for large eccentricities (up to 0.4-0.45) and inclinations (up to 30-40 deg), is here generalized to the CRTBP by adding the perturbing effect of the second primary, which is used at the same time as the reference for the definition of the curvilinear coordinates. The full non-linear equations of motions are derived in curvilinear coordinates together with all relevant relations (Jacoby Constant, disturbing potential, etc.). Next a perturbation approach is employed to model the CRTBP drift motion starting from a Keplerian relative motion solution, providing new analytical relations describing the amplitude and drift rate of the horseshoe helicoidal motion with good accuracy sufficiently far from the second primary. Finally, the new formulation is applied to the description of quasi-satellite orbits, which in spite of the impossibility of deriving a sufficiently accurate analytical solution can still be used to predict important qualitative aspects of the motion.