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HIGHER ORDER ANALYTICAL SOLUTION TO THE DISTANT RETROGRADE ORBITS PROBLEM

Abstract

Current interest in the study of distant retrograde orbits (DRO) is motivated by new proposed space missions, as the Deimos and Phobos Interior Explorer proposal to ESA's Cosmic Vision Program, or NASA's Asteroid Redirect Mission.

Proposed solutions to the DRO problem commonly rely on the numerical computation of periodic and quasi-periodic orbits. Analytical approximations to the DRO problem are also possible, yet, in view of the essential dependence of the solution on special functions, they are commonly constrained to low order approximations which are useful only in the qualitative descriptions of the co-orbital dynamics.

To improve the accuracy of the analytical solution, we approach the DRO problem from the point of view of Hamiltonian perturbation methods. Focusing on the approximation to the dynamics provided by the Hill problem, we compute an exact, explicit, low order solution in epicyclic variables that has the advantage with respect to previous alternatives in the literature of being free from special functions. Because of that, the new analytical solution provides deeper insight on the dynamics and speeds evaluation.

The computation of higher orders of the perturbation approach extend the range of applicability of the analytical solution. Unfortunately, the advantages of getting an exact solution in trigonometric functions are inevitably lost. Indeed, while the flow can still be solved by quadrature, the higher order solution relies on the use of special functions. Besides, the performance of the perturbation solution is further degraded since it is achieved in an implicit way. However, these inconveniences are overcome by the use of Lindstedt series, which allow the computation of an explicit approximation to the higher order solution that only relies on trigonometric function.

Numerical explorations show that the low order solution is useful in the computation of periodic or quasi-periodic orbits which are the typical DROs. For its part, the higher order solution can account for higher amplitude librations of the orbit, which may cause close encounters between the satellite and its co-orbital companion.