On the uncertainty of the minimal distance between two confocal Keplerian orbits

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Abstract

The knowledge of the local minimum points of the distance d between two points on two confocal Keplerian orbits is a useful tool to study the possibility of close approaches or collisions between two celestial bodies.

In [1], [2] an algorithm for the computation of all the critical points of d^2 is proposed using methods from the algebraic elimination theory; an estimate of the maximal number of critical points is also given. Numerical experiments have shown that there are configurations with a surprisingly high number of critical points: 12 in the general case and 10 if one orbit is circular.

In the applications to Astronomy an orbit of a celestial body is computed starting from its observations on the celestial sphere, which are affected by errors, and these errors produce an uncertainty in the nominal orbit obtained by the standard orbit determination methods. The uncertainty of the orbit distance can be computed from the uncertainty of the two orbits, but the possibility of orbit crossings produces a singularity in this computation. We present a recent work concerning a regularization of the minimal distance maps, giving the local minima of d^2 for different two-orbit configurations, that allows to solve these problems.

References

[1] G.F. Gronchi. On the stationary points of the squared distance between two ellipses with a common focus. *SIAM J.Sci.Comp.*, 24(1):61–80, 2002

[2] G.F. Gronchi. An algebraic method to compute the critical points of the distance function between two Keplerian orbits. *Celestial Mech.*, 93(1):297–332, 2005