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An analytical treatment of the swing-by problem

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Abstract.

In the framework of the extension of Öpik's theory of close encounters developed in the last decades, we make a fully analytical, quantitative treatment of the motion of a small body encountering a massive perturber on a circular orbit (Valsecchi et al. 2015a,b).

We derive explicit expressions for the initial values of the angular elements of a small body orbit, of given semimajor axis a, eccentricity e, and inclination i, that are needed in order to obtain a post-encounter orbit with prescribed values of semimajor axis a', eccentricity e', and inclination i'.

We discuss the geometrical aspects of the algorithm, and give two examples of application; the first one deals with the geometry of the 2029 Earth encounter of Apophis, while the second illustrates a sequence of close encounters with Callisto of the JUICE probe, aimed at changing the inclination of the spacecraft orbit.

In planning complex space missions involving multiple encounters with planets or satellites, the algorithm described here could provide a reliable initial guess to start the computationally intensive optimization process.

References

Valsecchi, G. B., Alessi, E. M., & Rossi, A. 2015a, Celest. Mech. Dyn. Astr., 123, 151
Valsecchi, G. B., Alessi, E. M., & Rossi, A. 2015b, Celest. Mech. Dyn. Astr., 123, 167