IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IPB)

Author: Mr. Nicolo' Stronati
Cranfield University, United Kingdom

METHODS FOR DYNAMIC STUDIES OF CLOSE ENCOUNTERS AND APPLICATION TO REAL CASES

Abstract

Two bodies orbiting about the same primary can get, in their independent trajectories, close enough to start being mutually influenced by their gravitational fields. This interaction, namely a close encounter, consists in an exchange of energy from a massive body to a smaller one, that can modify the original trajectories to an extent depending on various factors. Close encounters happen in nature when small solar system objects, such as asteroids, have a fly-by with planets or much more massive asteroids. Also, in mission design analysis, spacecraft can be put in trajectories that have encounters with bigger bodies, with the aim of exploiting their gravitational fields to increase or decrease the energy of the spacecraft without fuel expense.

In this context, the fly-by problem consists in finding the orbital parameters of the small object after the encounter, or, in the case of the mission design, the trajectory before the encounter and/or the perturbing body to be exploited to get to the final design orbit. For this purpose, several theories have been developed to cope with the dynamics of a close approach and to describe the outcomes. Some models, such as the 2-body scattering theory or the Öpik's theory, rely on the assumptions of the patched-conics approximation, and describe the encounter as a simplified 2-body hyperbole of the smaller body about the more massive one, and can fully describe the outcomes of a fly-by with geometrical formulas. Other theories include in the study, for a better completeness of the dynamic framework, also the presence of the primary. The Hill's problem is one of the examples of the theories that deal with close encounters as if they were 3-body problems. Most of the existent theories rely, however, on assumptions that, although simplify the mathematical expressions, can make the theories fail in front of some particular real cases.

The main theories describing close encounters are applied and discussed, with care on their assumptions and ranges of application, for their ability to model real cases of close approaches among asteroids, of which all the orbital data are known. In particular, the inability of some of the models to describe encounters characterised by slow relative velocities or large miss distance is proved.