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ON THE BOUNDED DYNAMICS OF A PROBE FLYING AROUND A COMET

Abstract

The recent success of the Rosetta mission has increased the interest of researchers on the missions involving deep space bodies in highly elliptic heliocentric orbits. The attention is often focused on the optimal transfer for reaching the desired orbit, with several flybys around massive planets.

Less attention is instead dedicated to the final phases, when the probe performs the rendezvous with the comet (or, quite similarly, with an asteroid). Usually an assumption is made that the residual gravity of the celestial body is negligible (possibly considered as a perturbation). However, as the distance decreases, the effect of the gravitational attraction of the comet becomes more and more remarkable, and it starts playing a major role.

This paper studies the final phases of the probe's journey, when a unique dynamical transition takes place, from a two-body problem (probe-plus-Sun) to another two body problem (probe-plus-comet) passing through an elliptic three body problem. The original approach of this paper is to model the relative dynamics of the probe with respect to the comet as a formation-flying problem. In fact, with the proposed approach a single dynamical model is sufficient to describe all the different environmental conditions that the probe will experience.

Taking advantage of the developed model, this paper investigates the natural behavior (uncontrolled dynamics) of the formation in order to search for bounded relative trajectories of the probe around the comet. The periodic solution of the well-known Tschauner-Hempel equations is valid when the distance between the bodies is large, while probe's dynamics resembles a classical two-body motion with the comet as central attractive body when the distance is very small. Less is known about transition phase between these two scenarios, which will be therefore the main focus of the dynamic investigation.

This will allow to gain an insight into the nonlinear relative dynamics of the bodies, which is used to inform the design of the probe guidance and control. In particular, the identification of useful natural trajectories could allow a large saving in the control cost. The probe mission will be designed as a sequence of coasting arcs belonging to bounded relative orbits, thus resulting in a reduced control effort.