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EFFECTS OF THE ATMOSPHERIC DRAG IN CLOSE APPROACHES FOR A CLOUD OF PARTICLES

Abstract

The goal of this research is to study close approaches between a planet, which is assumed to have an atmosphere and a cloud of particles. The complete system is formed by two main bodies (the Sun and the planet) that are assumed to stay in circular orbits around their center of mass. The cloud of particles is moving under their gravitational attraction, when it makes a close approach with the planet in such a position that it passes inside the atmosphere of the planet. The motion is assumed to be planar for all the particles and the dynamics is given by the well-known planar restricted circular three-body problem plus atmospheric drag. The equations of motion are regularized (using Lamaître's regularization), so we can avoid the numerical problems that come from the close approach with the planet. To solve this problem, for each single particle, we integrate numerically the equations of motion forward and backward in time, until the spacecraft is at a distance that we can consider far enough from the planet, such that we can neglect the planet's effect and consider the system formed by the Sun and the spacecraft as a two-body system. At these two points we can use the two-body celestial mechanics to compute energy, angular momentum and the Jacobian constant before and after the close approach. So, this problem is similar to the standard Swing-By maneuver. A spacecraft comes from a long distance, passes close to a planet and then leaves it again. The planet is supposed to be in a circular orbit around a central body and any type of orbit is assumed for the spacecraft (elliptic, circular or hyperbolic). At the points A and B (where the spacecraft can be assumed to be far enough from the planet), the system can be modeled as a two-body problem (the spacecraft and the central body). The difference from the standard maneuver is that the planet is assumed to have an atmosphere and it generates a drag force in the spacecraft. Then, this study is generalized for a cloud of particles. The main objective is to understand the change of the orbit of this cloud of particles after the close approach with the planet. It is assumed that all the particles that belong to the cloud have semi-major axis a da and eccentricity e de before the close approach with the planet.