Formation Flying in Space-Borne Artificial Magnetic Dipole Field

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Abstract

In this paper we consider a new dynamical scenario in which a constantly charged spacecraft (follower) moves near a leader spacecraft that follows a circular Keplerian orbit around the Earth, and generates a rotating artificial magnetic dipole. The mass of the follower is assumed to be negligible compared with the one of the leader, which is suposed to be in a high-Earth orbit (such as GEO), so the Lorentz force on the follower due to the geomagnetic field is ignored. With these assumptions, the leader's motion is not perturbed by the follower which moves only under the influence of the Earth's gravitational force and the Lorentz force.

The magnetic dipole is supposed to be produced by three concentric and orthogonal superconducting wires, in such a way that it can point in any direction. In this study we consider three different orientations of the dipole of the leader, radial, tangential and normal, according to its relative position in the orbital plane. We will focus on the dynamics of the system and its possible use for formation flying. For this purpose we study the critical points of the system and their stability, according to the parameters of the model, among which we will give spacial attention to the physical parameter β, which is defined as the ratio of the leader's mean motion around the Earth to the dipole's rotating rate. Furthermore, the different families of periodic orbits around each equilibrium point are computed. By selecting suitable periodic orbits, a four-satellite formation flying configuration is briefly explored, in which four satellites are placed at the periodic orbits around four symmetric equilibrium points of the system.

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