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INVESTIGATING POTENTIAL APPLICATIONS OF LORENTZ FORCE FOR SPACECRAFT FORMATION FLYING WITH REDUCED FUEL CONSUMPTION

Abstract

A spacecraft orbiting the Earth tends to accumulate charges on its surface whenever there is an interaction with the space plasma. Such a charged spacecraft experiences a perturbative force, called the Lorentz force, due to the Earth's magnetic field. Numerous studies have been conducted on the effect of the perturbative Lorentz force on the orbit of the spacecraft. Apart from the natural perturbative Lorentz force, artificial Lorentz force can also be generated through various methods. The utilization of such artificially generated force for spacecraft attitude control and formation flying has also been an active area of research. This work considers the problem of satellite formation flying and explores the possibility of utilizing the Lorentz force for achieving mission objectives with reduced fuel requirement. Lower fuel requirement can lead to either an increase in the spacecraft's lifetime or more payload capacity, resulting in a reduction in the mission cost with increased science output.

Formation in a leader-follower framework is considered here. A Hill reference frame located at the center of mass of the leader is used to formulate the relative equations of motion of the follower. Effects of the two types of Lorentz force, viz. Lorentz force induced by the geomagnetic field and that generated artificially, on the two spacecrafts are studied. These forces are expressed as components along the Hill frame axes. Circular and elliptical reference orbits are considered and Hill-Clohessy- Wilshire equations and Tschauner-Hempel equations, respectively, are used to study the relative motion of the spacecrafts under the action of these forces.

Various methods of generating Lorentz force on the two spacecrafts are investigated with an aim to develop control methodologies for their efficient utilization in spacecraft formation flying, which results in reduced fuel requirement while at the same time offering flexibility regarding mission objectives.