

Study of Interspacecraft Coulomb Forces and Implications for Formation Flying

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Abstract

In the course of exploiting spacecraft formations for use in separated interferometry (or other missions), it is possible that the separation distance between vehicles will be on the order of 10m. The effects of spacecraft charging on the dynamics of very closely spaced formations are investigated. For certain high-Earth orbits, the ambient plasma conditions will conspire to produce significant spacecraft charging in an environment with a plasma Debye length of more than 100 m. For such conditions, it is shown that the potential exists to develop disruptive interspacecraft Coulomb forces and torques, with magnitude comparable to candidate formation-keeping thrusters over distances of tens of meters. Because of the unexpectedly large interaction forces, the concept of purposely charging spacecraft to affect formation-keeping Coulomb forces is also explored. Analytic methods are developed that show the existence of static equilibrium formations in Earth orbit using only inter-vehicle coulomb forces for one-, two-, and three-dimensional formations. Such Coulomb formations would be free of the risk of plume contamination due to thrusters firing in close proximity. Figures of merit for the proposed Coulomb control system are calculated in a manner analogous to traditional propulsion systems, and it is shown that required forces can be created with milliwatts of power, can be controlled on a millisecond timescale, and imply specific impulses that can be as high as 10¹³ seconds.