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CHARGED-SPACECRAFT FORMATION: MANIFOLDS, DEPLOYMENT AND RECONFIGURATION

Abstract

Spacecraft formation maintenance and reconfiguration play an important role in some space mission, such as high accurate earth observation and astronomy. Coulomb thrust is superior to the traditional conventional chemical and electronic thrust in the proximate-formation control due to its fast throttling, nearly propellantless features and no thruster plume impingement. In this paper, we introduce a novel configuration of Coulomb formation, and use its complicated dynamic properties to design, maintain and reconstruct formation trajectories. In the Coulomb formation, chief spacecraft has eight active controllable charged spheres to control deputies and the deputies are assumed as spheres. This dynamical system can be described as a Hamiltonian and numerous equilibrium points are derived. Then invariant manifold theory is employed to design the transfer trajectory between different Coulomb formation with the supplement of inertial chemical thrust. Based on the analysis of the manifolds of these equilibrium points, we develop a general algorithm for patching these invariant manifolds, which provide nearly continuous and low-energy transfers from a formation configuration to another. Finally, possibly discontinuous patching manifolds are matched by inertial trust, and Particle Swarm Optimization method is used to obtain the transfer trajectory with the lowest energy consumption. Simulation results demonstrate that the phase space structure of Coulombs formation is so complicated that there exist a number of paths along manifolds for transfers between different formations. For most proximate formation (less than 100 meters), only few fuels (total V 5 m/s) are needed to reconstruct flying formation. Besides, deputies also can be deployed from the chief or took back to it, applying a hybrid control strategy with Coulomb and chemical trust.