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LABORATORY EXPERIMENT OF THE FORCE GENERATED FROM INTERACTION BETWEEN MAGNETIC TORQUERS AND THE LOW EARTH ORBIT PLASMA

Abstract

In this study, we conduct an experiment to examine the practicality of a new orbit change method, using the force generated from the interaction between magnetic torquers (MTQ) and the low earth orbit (LEO) plasma. The number of small satellites launched has been increasing due to advantages such as low cost and short-term development. Taking advantage of these characteristics, formation flight by multiple small satellites has been proposed. By using formation flight, missions that are difficult to realize with a single spacecraft can be realized, and the use of space is expected to expand. In order to achieve such a mission, relative position control between multiple satellites is necessary, so orbit controllers such as a thruster is indispensable. However, since small satellites have strict restrictions on their mass and volume, it is important, how they can mount orbit controllers without consuming space. Therefore, orbit control using the force generated from the interaction between the MTQ, which is often mounted on small satellites for attitude control, and plasma in low earth orbit has been proposed. The MTQ magnetic field bends the orbits of ions and electrons by the Lorentz force, and the difference in curvature induces a local electric field. Ions are bounced off the induced electric field and force is generated by exchanging momentum. This method, unlike aerodynamics, produces a force in the lift direction due to the angle of attack of the magnetic torquer with respect to the plasma flow. Furthermore, the smaller the satellite, the more effective the force. Using this method, it is possible to change the orbit without the need for additional components. This method using the MTQ has been examined by simulation. However, since it is a complicated physical phenomenon, the validity with the actual phenomenon has not been evaluated, and sufficient confirmation has not been obtained up to the deployment to satellites. In this study, we simulate the LEO plasma environment using a vacuum chamber and a hall thruster, and conduct a demonstration experiment on mutual interference between the MTQ and LEO plasma. By analyzing changes in plasma behavior and measuring the generated force, we elucidate the phenomenon and evaluate the force characteristics. This makes it possible to demonstrate the practicality of the proposed method.