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LABORATORY DEMONSTRATION OF SPACE DEBRIS REMOVAL BY A BI-DIRECTIONAL HELICON PLASMA THRUSTER

Abstract

Space debris removal is one of the crucial space challenges for space development. To decelerate and transfer debris to the Earth's atmosphere, momentum has to be imparted to the debris. When exhausting momentum from the satellite and imparting it to the debris, the thrust obviously propels the satellite to the opposite direction to the debris. To maintain and control the distance between the satellite and the debris, additional momentum has to be exhausted from the satellite to cancel out or calibrate the thrust. Here a helicon plasma thruster having two open source exits and a magnetic nozzle is operated in a laboratory experiment to demonstrate space debris removal.

The thruster consists of a glass source tube, a double-turn rf antenna, and two solenoids. The two solenoids situated upstream and downstream of the rf antenna provide a static magnetic field, where two magnetic nozzles are formed upstream and downstream of the plasma source. The magnetic field configuration can be modified by adjusting the solenoid currents of each of the two solenoids. The whole thruster structure is attached to a pendulum thrust balance and the balance displacement induced by the plasma is measured by a laser sensor. A pendulum target acting as the debris is located downstream of the thruster so that both the thrust imparted to the thruster (spacecraft) and the force exerted on the target (debris) are simultaneously measured.

These measurements demonstrate that the two forces can be controlled by adjusting the plasma momentum components respectively exhausted from the upstream and downstream open source exits, be adjusting the magnetic field structure. Hence the thrust for propelling the spacecraft and the momentum exerted to the debris can be simply controlled by varying the solenoid current only, i.e., the operation modes for propelling the spacecraft and removing the debris can be switched via the magnetic field configuration.