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THREE-DIMENSIONAL MHD ANALYSIS OF MAGNETIC PLASMA DRAG WITH COILS PLACED ON THREE AXES

Abstract

Plasma drag is generated by the interference between the plasma existing in the space and magnetic field of a coil mounted on spacecraft. Various applications of systems that obtain drag using the plasma drag are being studied, from large magnetic sails to deorbit mechanism of small satellites. Regarding to a large magnetic sail, it has been confirmed by several previous studies that the magnetosphere can be expanded by arranging multiple coils. Additionally, it is possible to place coils on three axes by using the deployable structure technology. However, the investigation of the plasma drag generated by the coils placed on three axes has never been conducted. Regarding to a small satellite, since it is premised on using a magnetic torquer for attitude control, the satellite has coils on three axes in the first place, but it has not been verified when multiple coils are driven at the same time. Therefore, in this study, the plasma drag when driving coils on three axes was analyzed by 3-D MHD. The conditions of our analysis are under a solar wind plasma environment of 1 AU, and a parametric study was conducted. The parameters are the combination of the directions of the magnetic axes and the attitude of the entire spacecraft. As a result, when the same current is passed through each single coil, the drag by driving all three coils is greater than by driving a single coil, but the drag by driving all three coils is smaller than the single coil with three-times current. This result indicates that it is better to concentrate the current to drive only a single coil to acquire larger drag, but when using a system, the coils of which have fixed rated current and are already arranged on three axes such as the magnetic torquers on a small satellite, an efficient coil driving scheme should be considered. It was also clarified from the analysis that the combination of magnetic axes and the attitude greatly affect the drag. The reason is considered to be the effects of intension and cancellation of the magnetic fields created by each coil, and the difference of the shape of the magnetotail behind the coils. It can be expected that the results of this research is applied to efficient operation of spacecraft with coils on three axes by controlling the drive of the coils according to the attitude.