DC electric field measurement by the probe system in space plasma: Evaluation of the accuracy

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Electric field in the space plasma is one of key parameters for the space plasma studies, such as the detection of global plasma convection and the phenomena of the break down of the MHD approximations. There are two systems to measure this value, Probe system using the difference of the electric potential between two probes extended from the spacecraft, and Beam system using electron cyclotron motion. The former is more stable and can always operate. However, this method is not reliable yet because of the lack of quantitative model and the verification on the ground. The lack of highly accurate electric field data is one of the obstacles for the space plasma studies, especially in the phenomena related to the break don of the MHD approximations.

The potential of the conductive body in the thin space plasmas is controlled by the outflow of photoelectrons and the inflow of the surrounding electrons. In the magnetosphere, the former is major. Such environment is not generated in the ground-based laboratory, so the ability of the probe system was not confirmed before the extension in the real space plasma after the launch. We do not have the established models of the behavior of the probe system, including the affection from the potential of the spacecraft body, extremely thin space plasma in which the Debye length is much larger than the probe system, etc.

The following investigations are required for defeating these situations and establishing the quantitative model and evaluation method of the probe system before and after the launch:

1) The quantitative modeling of the probe characteristics in the space plasma: The plasma physics around the probe controlled by photo- and surrounding electrons should be quantitatively evaluated in the model based on the data from laboratory experiments and spacecraft observations. 2) Re-investigation of the electric field measurement by the spacecraft (GEOTAIL): Based on the comparison with the quantitative models derived in 1), the variation of the non-stable terms such as offset and effective length should be evaluated and corrected.

3) Numerical modeling of the probe system: For the quantitative design of the probe system, the numerical models based on plasma simulations are required. Numerical system should be established for the pre-launch studies.

From these studies, we will realize the progress of the reliability of electric field data obtained by the past spacecraft and the rational and quantitative design methods of the probe system for the electric field measurement in thin space plasma with accuracy less than sub mV/m.

We have two probe systems, GEOTAIL-type (with thin wire and spherical probe) and CLUSTER-type (with thin wire, guard electrode, and spherical probe). We now investigate the both systems for the ESA-ISAS collaborating Mercury exploration mission BepiColombo. And the next generation multi-spacecraft magnetospheric mission SCOPE also requires the high accuracy of the electric field measurements in 3-axis.

We will report the intermediate results of these studies.