Development of a low energy electron spectrometer for SCOPE

Yuu Tominaga[1]; Yoshifumi Saito[2]; Shoichiro Yokota[2]
[1] Dept. of Earth and Planetary Science, The Univ. of Tokyo; [2] ISAS

We are newly developing an electrostatic analyzer which measures low energy electrons for the future satellite mission SCOPE (cross Scale COupling in the Plasma universE).

The main purpose of the SCOPE mission is to understand the cross scale coupling between macroscopic MHD scale phenomena and microscopic ion and electron scale phenomena. In order to understand the dynamics of plasma in such small scales, we need to observe the plasma with an analyzer which has high time resolutions. In the Earth's magnetosphere, typical timescale of plasma cyclotron frequency is ˜10 sec (ions) and ˜10 msec (electrons). Previous low energy particle experiments had time resolution utmost ˜10 sec, so they could measure ion-scale phenomena and could not measure electron-scale phenomena. Since the low energy particle experiment of the SCOPE mission will go further to conduct electron-scale observations, an analyzer which has a very high time resolution (˜10 msec) is necessary for the experiment.

So far, we decided a design of the analyzer. We made a numerical model of the analyzer, and numerically calculated its characteristics. The design satisfies the size restrictions of the satellite, so the analyzer is small enough to be set on the satellite. The analyzer has three nested spherical/toroidal deflectors, which enables us to measure two different energies simultaneously and shorten the time resolution of the experiment. In order to obtain three dimensional velocity distribution functions of electrons from the experiment, the analyzer must have 4-pi steradian field of view. We will install 8 sets of the analyzers (16 analyzers) on the satellite. Using all these analyzers we will secure 4-pi str fov at the same time, which enables us to make the sampling time of the experiment much shorter than those of previous experiments. In the experiment, we plan to measure electrons from 10 eV to 22.5 keV with 32 steps. Given that the sampling time of the experiment is 0.5 msec, it takes about 8 msec to measure the whole energy range, then the time resolution of the experiment is 8 msec which is short enough to measure electron-scale phenomena. The energy and angular resolution of the inner analyzer is 0.23 and 16 degrees, respectively, and that of the outer analyzer is 0.17 and 11.5 degrees, respectively. To measure enough electrons within the sampling time, the analyzer is designed to have geometrical factors (sensitivities) of 7.5e-3 (inner analyzer) and 1.0e-2 (outer analyzer) cm^{-2} str^{-1}, respectively.

However, it is not apparent that these characteristics of the analyzer is really appropriate for the experiment. And there are some operational problems which we have to consider and resolve. In this study, we ...

1.confirm that the analyzer we designed has characteristics appropriate for the experiment and it can measure the 3 dimensional distribution functions of electrons and velocity moments of those.

2.estimate how the non-uniformity of the analyzer's efficiency affects the calculation of the velocity moments.

3.estimate how spin motion of the satellite affect the calculation of the velocity moments.

Assuming Maxwellian electron distribution function with known density, bulk velocity, and temperature, we calculated the counts that the analyzer will measure taking into account the characteristic of the analyzer. Using these counts, we calculated the distribution function and velocity moments, and compared the results with the assumed density, bulk velocity and temperature to see the precision of the experiment. From these calculations we found that ...

1.the characteristics of the analyzer are good enough to measure the velocity moments of electrons within a precision of several percent.

2.the non-uniformity of the efficiency of the analyzers will severely affect the calculations of bulk velocity of electrons.

3.we should have some observation modes which depends on the observation area.