Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PCG008-09 Room:202 Time:May 26 11:30-11:45

Development of a low energy electron spectrometer for SCOPE

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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 spatial scale phenomena. In order to understand the dynamics of plasmas in such small scales, we need to observe the plasma with an analyzer which has high time resolutions. In order to conduct electron spatial scale observations, we have to develop a Fast Electron Spectrum Analyzer (FESA) which has a very high time resolution ($<$10 msec).

Observations using multiple analyzers which have three nested deflectors are the secrets to achieve 8 msec time resolution. We will set 8 FESAs on the SCOPE satellite, which enables us to secure 4 pi str FOV at the same time. FESA has three nested spherical/toroidal deflectors, which enables us to measure electrons of two different energies simultaneously and make the time resolution higher.

In this study, we designed the second testmodel of FESA (TM2) . The sensitivity (g-factor) of TM2 is designed so that the same amount of counts within 0.5 msec as GEOTAIL LEP-EAe should be obtained. TM2 should also have an energy resolution that is appropriate for measuring electrons from 10 eV to 22.5 keV with 32 steps, and have an angular resolution that is appropriate for secure 45 deg. FOV along the spin direction of the satellite. We built a numerical model of TM2, and calculated the characteristics of it using numerical simulation. From the calculation, we found that TM2 has g-factor of 6.37e-^{3} [cm^{2} str eV/eV /22.5deg.] (Spherical part, Inside) and 9.12e^{-3} [cm^{2} str eV/eV /22.5deg.] (Toroidal part, Outside), energy resolution of 25.4% (Inside) and 18.6% (Outside) [Full Width at the Half Maximum : FWHM], and angular resolution of 14 deg.(Inside) and 9 deg.(Outside) [FWHM].

We built numerical models of electron velocity distribution function, and using these models we calculated the counts that TM2 will obtain in plasma sheet, lobe, and solar wind regions. From the calculation, we found that 20 msec sampling time is appropriate for observations in solar wind regions, and 50 msec is appropriate for observations in lobe regions. The sampling time of the observation in plasma sheet regions should be 0.5 msec. However, we found that statistical error of obtained counts within the sampling time severely affects the observation. So careful analysis of the obtained counts is necessary for more precise observations in this region.

We estimated counts that will be obtained in the magnetotail reconnection region using the result of a three-dimensional full kinetic simulation. From these estimated counts, we calculated the velocity distribution function, and found out how precisely these calculated distribution function shows thermal anisotropy of this region. We found that distribution function obtained within 8 msec can show these anisotropies to some extent, and we could calculate the velocity moments of this region using the function.

It is not simple to obtain a flux from one direction using data from multiple analyzers. That is because Field of views (FOVs) of these analyzers rotate as the satellite spins. Therefore it is not simple to draw Energy-Time (E-T) spectrogram from the observation. In this study, we suggested a method to make E-T spectrogram from the counts obtained by FESA. Using the method, we drew E-T spectrum from the estimated counts, and verified the validity of the method. In order to estimate the accuracy of calculated differential energy flux, we also drew E-T spectrogram from estimated counts obtained by the dummy satellite that does not spin during the observation. Comparing these two E-T spectrograms, we found out how precisely we can calculate the differential energy flux with the proposed method.