Innovative design of double-shell type energy analyzer for simultaneous electron and ion measurements in space

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It is well known that the terrestrial and planetary magnetospheres and the interplanetary space are filled with charged particles such as electrons and ions, which are so-called the space plasma, and in-situ observations of the space plasmas have been conducted by using satellites carrying particle instruments, such as the top-hat type electrostatic energy analyzer. Essentially, obtaining three-dimensional velocity distributions of the space plasmas or energy-pitch angle distributions help us understand the dynamics of the space plasmas. Because the top-hat type analyzer is cylindrically symmetric and has a 2π-radian planar field of view, it can independently measure the wide angular and energy distributions of incident particles. Also, three-dimensional velocity or energy-pitch angle distributions can be obtained by utilizing the satellite spin motion.
The top-hat type electrostatic energy analyzers can measure the ions when a negative potential is applied to the inner electrode and the electrons by a positive potential with the outer electrode grounded. Therefore, in the prevailing design of the top-hat type analyzer, the sensor heads separate for the ion and electron observations, respectively. Because of the recent miniaturization of the satellites, the weight and space of the instruments mounted on the small and micro satellites are getting severely restricted. However, if two sensors for electron and ion observations are combined into one sensor head, it is possible to save both weight and space on the small and micro satellites. Therefore, we have been developing double-shell type energy analyzer which can simultaneously measure the ions and the electrons with one sensor head.
We designed the shapes of the collimator and the double-layered dome-shaped electrodes so that the electrons and the ions with appropriate energies pass through the inner gap and the outer gap by applying a negative potential to the central electrode with the inner and outer electrodes grounded, respectively. We made the numerical simulations using SIMION which is a charged particle simulator program and investigated the performance and characteristics as the electrostatic analyzer. Consequently, we confirmed that the electrons and the ions can be analyzed with one sensor head by only applying negative high voltage to the electrodes. So far, we consider the detection unit using Time-Of-Flight velocity spectrometer for the discrimination of the ion species as the part where the ions are detected, and an assembly of micro channel plates is expected for the electron detection. The design of TOF-type mass analysis unit as ion mass analysis unit is one of subjects for future work.

