Development of an ion beam line for calibration of the suprathermal ion mass spectrometer (STIMS)

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Ion escape processes are critical issues to unravel atmospheric evolutions of non-magnetized planets (e.g., Venus and Mars). Many studies about the ion escape have been conducted by both observational and theoretical methods. There is, however, a problem that qualities of in-situ observations have not been sufficient to identify the detailed suprathermal plasma dynamics around the non-magnetized planetary ionospheres.

A suprathermal ion mass spectrometer (STIMS) has been designed for future in-situ observations of suprathermal ion three dimensional velocity distributions around the planets' atmospheres. The STIMS consists of energy analysis and velocity (mass) analysis sections. A field of view of the STIMS is 4 pi sr a half spin of spin-stabilized spacecraft. A target energy range of the STIMS is from 0.1 to 300 eV, which corresponds to suprathermal energies, and its mass range is from 1 to 50 amu. The energy analysis is conducted by a top-hat type electrostatic analyzer. The velocity analysis section consists of gated type and linear-electric-field type Time-Of-Flight (TOF) analyzers. At the gated type TOF analyzer, an electrostatic gate can control the TOF window of incident ions with high accuracy. In the following linear-electric-field type TOF analyzer, high accuracy mass-per-charge determination independent of energies of the incident ions is carried out. In the STIMS, a conversion surface is applied as an emitter of secondary electrons. The secondary electrons emitted by collisions of incident ions with the conversion surface, are detected as start/stop signals by micro channel plate assemblies. Accuracy of linear-electric-field type TOF of the STIMS depends on characteristics of reflected ions on the conversion surface. For instance, following characteristics affect the TOF accuracy: (a) angular distributions, (b) rate of charge exchanges occurrence, (c) rate of dissociation occurrence, (d) energy distributions of the reflected ions at the conversion surface. For a clarification of the TOF accuracy, therefore, it is necessary to investigate the ion reflection characteristics at the conversion surface.

Our group has been constructing an ion beam line and calibration facility for the STIMS analyzers that are under development. In the case of the STIMS calibration, the following parameters are required:(i) energy range from 10 eV/q to 5 keV/q, (ii) mass range from 1 to 44 amu, (iii) beam intensity controlled from 10^3 to 10^6 #/cm^2. It is planed that the facility consists of six parts: (1) ion source, (2) electro-magnetic ion mass spectrometer, (3) beam expander, (4) main acceleration, (5) vacuum chamber, (6) multi-axial turntable.

In this presentation, we will introduce design concepts of the STIMS and the calibration facility, and will discuss their specifications.