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Detailed design and performances on radio frequency mass spectrometer for development of Atmospheric Neutral Analyzer

Ayuko Hayashi[1*], Manabu Shimoyama[1], Keisuke Ishiguro[1], Masafumi Hirahara[1]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University

Neutral Mass Spectrometer (NMS) has been onboard several satellites and sounding rockets to observe neutral upper atmosphere of the Earth and other planets. However physical processes of neutral atmosphere are not fully understood because of limitations of observation time and NMS capabilities to observe neutral particle motion such as wind or temperature. Since in almost NMSs quadrupole mass spectrometer was applied to analyze particle species, it is difficult to obtain information on detailed velocity distributions for specific species. Neutral particles interact with plasma through collisions with ions in the upper atmosphere. Behavior of neutral particle motion thus varies by conditions in the ionosphere or the magnetosphere. In order to understand physical processes of neutral atmosphere response to the ionosphere and magnetosphere variation, it is necessary to achieve velocity distribution function for each atmosphere species.

We are developing new NMS which is called Atmospheric Neutral Analyzer (ANA). In ANA, radio frequency (RF) electric field is applied for mass analysis. After ionization of incident neutral particles, the particles are uniformed in a certain energy perpendicular to the entrance slit plane and then the particles through RF fields in three times. While passing through RF sections, the velocity perpendicular to the entrance slit plane is accelerated or decelerated by RF fields, and only particles with specific mass which have the resonant velocity can gain maximum energy in comparison with other particles. The particles which gained maximum energy can pass through the retarding potential analyzer (RPA) which is placed after the exit of the RF section to detection section. Counts and locations of the accelerated particles are detected by combination of MCP with fluorescent plate and CCD as a 2D image. The image represents 2D velocity distribution parallel to the plane of entrance slit and winds and temperatures are derived.

The detection efficiency and mass resolution of ANA depends on the potential on RPA and characteristics of energy gain. We improve mass resolution and detection efficiency by optimizing the geometry of RF analyzer. We will show performances of the RF analyzer estimated from numerical simulation.

Keywords: Upper atmosphere, In-situ observation, Neutral particle, Radio frequency, Ion mass analyzer