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Initial performance verification of Atmospheric Neutral Analyzer for in-situ observations of planetary atmospheres

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The dynamics in the neutral upper atmosphere of the Earth and the other planets affect the environment of their ionospheres and the thermospheres. In-situ observations of the neutral atmospheres utilizing spacecraft are needed for understanding atmospheric circulations, heating, and dissipation. Neutral Mass Spectrometers for the terrestrial and planetary explorations have not had a capability to directly observe two-dimensional particle velocity distributions in the past. Therefore, detailed information on the interaction of the upper atmosphere with the solar wind and the dynamics of neutral particles have not been obtained so far.

We are newly developing a Bennett-type radio-frequency mass spectrometer, which is called Atmospheric Neutral Analyzer (ANA). The ANA is capable of observing 2-D velocity distributions, from which density, wind velocity and temperature are derived, for each component of neutral species. The ANA consists mainly of five sections: an entrance slit, an ionization section utilizing electron gun, a pre-acceleration section, a Radio Frequency (RF) stage for mass spectrometry, and a detection section which obtains 2-D velocity distributions in combination of MCP with 2-D position-sensitive device. We now concentrate on the development of the whole ion mass spectrometer after the ionization section.

In addition to the numerical design of the structure and the performance of the mass spectrometer by using SIMION 8.1, we newly had experiments to investigate the characteristics of the engineering model of the ANA except for the ionization section. We, here, used the suprathermal ion beamline of Ar^+ and $N_2{}^+$. For the calibration, we set the ANA in a vacuum chamber, and irradiated the ions with energies of several to a few tens of eV, in order to investigate its response. Because the spacecraft velocity is assumed to be 8 km/s, the energy of the irradiated ions must correspond to it. The energies of the Ar^+ and $N_2{}^+$ of 8 km/s are 13.3 and 9.3 eV/charge, respectively. We irradiated the Ar^+ and $N_2{}^+$ beams of 8 km/s, but the beam ions were not detected in the detection section. Instead, particles whose energies were approximately 17 eV (Ar^+) and 13 eV ($N_2{}^+$) were detected when the voltages of the ANA electrodes were of reference values for the 8 km/s cases of each species. We are now considering the possibility of fabrication errors in ANA. Besides, the irradiated Ar^+ whose energy was 17 eV was not detected when the parameter of the ANA electrodes were of reference values for the 13 eV cases of the $N_2{}^+$. And vice versa.

In the presentation, we will show the overall design of the ANA regarding the mass spectrometry and the characteristics investigated by the simulation and the beamline experiments.

Keywords: Planetary atmosphere, In-situ observation, Neutral mass spectrometer, Equipment development