Design of an ion mass/isotope spectrometer for observation around planets and moons

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In situ low-energy ion measurement in terrestrial or planetary plasma environment has been done with a variety of ion analyzers onboard spacecraft. Detailed studies of plasma characteristics demand measurement of a three-dimensional distribution function with adequate energy and angular resolution, a wide energy range, full coverage of space, and a high sampling rate. When measuring a variety of ions originating from planetary atmospheres, we need to be able to measure the ion composition with high mass resolution. Therefore, mass analyses as well as energy analyses are important for the planetary plasma and atmosphere physics. For three-dimensional energy analysis of low-energy charged particles, the top-hat electrostatic method using spherical deflectors or toroidal deflectors1 has usually been applied because of its large geometric factor and uniform angular response while requiring relatively few resources. On the other hand, composition measurement of space plasmas, especially near the Earth, Mars, Venus, other planets, the Moon, and asteroids is of great interest. Time-of-flight (TOF) analysis for space use had been applied and further developed mainly for observing highly energetic particles. The development of TOF techniques using thin carbon foil, whose secondary electrons generate start signals, made it possible to measure lower-energy ions, when necessary, in combination with the post-acceleration voltages which accelerate incident ions to energy high enough for the ions to pass through carbon foil. Moreover, a TOF technique with a specific electric field, called a linear electric field (LEF), was developed and has been used for measuring space plasmas around the Moon and planets.

We developed an LEF-TOF ion mass analyzer, MAP-PACE-IMA, for Kaguya, with a mass resolution of M/dMˇ20, which has measured ions originating from the lunar exosphere and surface. In addition, MPPE-MSA of M/dMˇ40 has been prepared for the BepiColombo mission, which will observe the plasma environment around the Mercury. We have recently started developing a next-generation mass analyzer of M/dMˇ100 for the isotope analysis of planetary particles, employing nearly the same technique as that for Kaguya and BepiColombo. We present the outline and design results of the mass analyzer.