論文内容の要旨

Study of measurement techniques for thermal and suprathermal electrons in the lower ionosphere

(下部電離圏の熱的･超熱的電子の測定法に関する研究)

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Processes of energy transfer from suprathermal to thermal electrons have been poorly understood mainly due to a lack of observations, though they significantly affect the thermal structure of the lower ionosphere and play an important role in the energy budget. In this thesis, the measurement techniques for thermal and suprathermal electrons in the lower ionosphere are investigated from two aspects: 1) Theoretical and experimental study of inherent but unresolved problem in Langmuir probe measurements on a sounding rocket, and 2) a new development of suprathermal plasma analyzer.

Langmuir probe has been used for a long time to measure electron temperature and density, which are the most fundamental parameters in the ionosphere, and are still considered as a primary and indispensable technique for the ionospheric sounding. There have been remained several problems in the Langmuir probe measurement, and some are known to cause a serious impact on accuracy particularly when the probe is installed on a sounding rocket. In the present study, one of the most outstanding problems is discussed by conducting laboratory experiments. An effect of a finite electrode area ratio of a probe to a rocket surface on the measurement is considered in

detail. When the surface area ratio is not large, non-zero impedance of the rocket sheath causes a decrease of the probe current and as a result the current-voltage (I-V) characteristics are distorted. The impedance of rocket sheath is estimated from the sweep frequency dependence of I-V characteristics to investigate how an effect of the rocket sheath can be overcome in the Langmuir probe measurement. A definite idea to minimize the effect is indicated, and thereby a good estimation is possible even when the surface area ratio is relatively small.

A completely new development of instrument based on the original concept to measure an energy distribution of thermal to suprathermal electrons (< 5 eV) is made in the present study. The innovative combination of a second harmonic method and a channel electron multiplier (CEM) makes it possible to measure an energy distribution of both thermal and suprathermal electrons with high energy resolution. Outstanding points of this instrument are: 1) accurate calibration of electron energy within the order of 0.01 eV, and 2) the energy resolution smaller than 0.15 eV. For a safe operation of CEM in the lower ionosphere, a differential pumping system is absolutely necessary. An adoption of a liquid nitrogen sorption pump and a non-evaporable getter pump is discussed.

We have also carried out a laboratory simulation in order to investigate the energetics of lower ionosphere as well as to confirm ability of the developed instrument. Several specific structures in the energy distribution are found to exist at a certain energy range and identified as the products of inelastic collisions of electrons with neutral particles.

Accurate measurements of thermal and suprathermal electrons make a huge contribution to the understanding about energetics of lower ionosphere.