Development of suprathermal plasma analyzer (SPA) for ionospheric sounding

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Processes of energy transfer from suprathermal to thermal electrons have been poorly understood mainly because of a lack of observations, though they significantly affect the thermal structure of the lower ionosphere and play an important role in the energy budget. We have developed an instrument to measure the electron energy distribution in the thermal and suprathermal energy range ($<$5 eV) for the sounding rocket. The innovative combination of Druyvesteyn method and a channel electron multiplier (CEM) enables us to measure an energy distribution of suprathermal electrons, whose flux is much smaller than thermal 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) energy resolution smaller than 0.15 eV. For a safe operation of a CEM in the lower ionosphere, this instrument is equipped with a differential pumping system. We have also carried out a laboratory simulation in order to investigate the energetics of the lower ionosphere as well as to confirm the ability of the developed instrument. Several specific structures in the energy distribution are found to exist at a certain energy range, and some are identified as the product of inelastic collisions of electrons with neutral particles. The electron energy distribution obtained by the past sounding rocket experiment in the lower ionosphere shows the structure extremely similar to that of the present experiment. This consistency indicates the existence of energy transfer from neutral particles to thermal electrons through inelastic collisions in the lower ionosphere. The result of the laboratory experiment also demonstrates the instrument capability to observe such an energy transfer.