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High time resolution low energy electron spectrometer LEP-ESA on Norwegian sounding rocket ICI-4

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Strong coherent HF radar backscatter is a well-known characteristic of the polar cusp ionosphere. The echoing targets for the coherent HF radars are decametre scale electron density structures. The main purpose of ICI (Investigation of Cusp Irregularities) project is to understand the generation mechanism of this decametre scale electron density irregularities. Although the generation mechanism of the backscatter targets has not yet been agreed, the gradient drift instability (GDI) has been regarded as the dominant mode for driving the plasma instability in the F-region auroral ionosphere under conditions when the plasma flow has a component in the direction of a density gradient.

In order to understand the role of the precipitating electrons on the plasma irregularity generation, we have developed a high time resolution low energy electron spectrometer LEP-ESA for ICI-2 and ICI-3 sounding rockets. ICI-2 was successfully launched from NyAlesund, Svalbard into a sequence of Poleward Moving Forms (PMAFs) separating from the cusp proper on 5 December 2008. ICI-2 had a direct encounter with HF cusp backscatter in the vicinity of an inverted-V structure and elevated electron density near the poleward boundary of the cusp flow channel. ICI-2 succeeded in obtaining absolute electron density measurements of decametre scale plasma structures for the first time. ICI-3 was launched on 3 December 2011 and its trajectory successfully intersected an RFE (Reverse Flow Event). By analysing ICI-3 data, the effect of the two-step Kelvin Helmholtz Instability - Gradient Drift mechanism will be resolved. Following the successful flight of ICI-2 and ICI-3, ICI-4 will be launched in November 2013 so that the trajectory should intersect a Flow Channel Event.

Low energy electron spectrometer LEP on ICI-2, ICI-3, and ICI-4 consists of sensor head LEP-ESA (Electron Spectrum Analyzer), deployment mechanism, and electronics box LEP-E. LEP-ESA measures the electron distribution function in the energy range between 10eV and 10keV. LEP-ESA is a top-hat type electrostatic analyzer with a pair of disks that works as a collimator at the entrance and toroidal electrodes inside. The inner toroidal electrode is supplied with high voltage swept between 0V and +3kV. The electrons coming through the collimator are attracted down toward the inner electrode. Only the electrons with specific energy range can further travel down to the exit of the electrodes. The electrons passing through the deflector plates enter to Micro-Channel Plate (MCP) and are intensified to detectable charge pulses. The intensified charge pulses are received by annular discrete anodes that are divided into 16 parts. The positions where the charge pulses are detected correspond to the incident polar directions of the electrons/ions.

Although LEP on ICI-2 and ICI-3 succeeded in obtaining the high time resolution electron energy spectra in the plasma irregularity region, it does not necessarily mean that the flight performance of LEP on ICI-2 and ICI-3 was perfect. We used triangular voltage waveform for the energy sweep. Our original plan was to obtain 11msec high time resolution data using 16 rising / falling energy steps. However, there existed difference between the rising 16 steps data and falling 16steps data except when the electron energy distribution was broad. This may be caused by the slow temporal response of the stepper high voltage power supply that was connected to the analyzer sphere. We are going to modify the previous high voltage power supply used for ICI-2 and ICI-3 LEP in order to realize the 11msec time resolution measurements of the low energy electrons by ICI-4 LEP.

ICI-4 is the first mission included in the 10-year plan for Japan-Norway sounding rocket experiment program whose main goal is to achieve collective understanding of the microphysics and its role (scale coupling) in the global to meso scale phenomena in the polar ionosphere.

Keywords: sounding rocket, charged particle, detector, ASIC, MCP anode, cusp