

An auroral particle detector using avalanche photodiodes onboard the rocket S-310-35

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The sounding rocket S-310-35 is planned to be launched from the Andoya Rocket Range, Norway, in December 2004 to study the ionospheric dynamics associated with the auroral precipitation. Energy and pitch angle distributions of electrons over an energy range of 3 to 50 keV will be measured with a new instrument based on Avalanche Photodiode (APD).

APD is a promising device for measuring and counting low energy electrons individually. It is a kind of p-n junction semiconductor with an internal gain due to the avalanche amplification of electrons and holes in the strong electric field within its depletion region, which is usually applied for photoelectronic devices. We have studied on the device in anticipation of the application to measurements of electrons in space and actually measured energetic electrons in our experiments. The response of the device (Type Z7966-20, Hamamatsu Photonix co., ltd.) to electrons was quite linear for 8-20keV with significant peaks (~1keV in FWHM) in their output pulse height distribution and it was confirmed to be able to count 4keV electrons at the minimum. Most importantly, the detection efficiency of APD is thought to be pretty good for electrons of several to several tens of keV, reaching 80% at 10keV in numerical calculations. This energy range is very important to be measured due to a lack of reliable measurement caused by technical problems of devices surrounding detection efficiency and noise reduction in the past.

The new instrument consists of four APDs in line. Incident electrons are collimated and each of their energies is dispersed by a homogenous magnetic field in front of APDs in order to discriminate UV or light pulses from signals of electrons. The time resolution is as high as 10msec because APD is able to differentiate the individual energy of electrons by itself and needs no energy-sweeping time as conventional low energy particle detectors. Nevertheless, 1sec will be needed to obtain an electron distribution function for all pitch angles in synchronization with the rocket spin. This experiment is meaningful not only because it is the first challenge of APD as a particle detector onboard a rocket, but also there are many precipitating electrons of an appropriate energy range for the device in the target region. All measurements are going to be performed at the altitude of 90-150km, plunging into defused aurorae. The energy spectrum of precipitating electrons in defused aurorae, as is well known, is very akin to that in the plasma sheet, which is often a Maxwellian distribution with the energy of several keV. We will be able to predict the site of the acceleration region from the in-situ information on the pitch angle. There have been two problems that are peculiar to APDs. They are the output dependence on temperature and the radiation hardness. Although each will not become a serious problem in such a brief observation as a rocket experiment, this may also become a good chance to estimate the effect.