Z237-003 **Room: 101A** **Time: May 16 15:56-16:08**

Nano-satellite mission for imaging of sprites/lightning and detection of terrestrial gamma ray flashes

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URL:http://pat.geophys.tohoku.ac.jp/indexj.html

Sprites are large transient optical phenomena in the middle atmosphere associated with lightning discharges in thunderstorms and have been studied with great intensity in the last dozen years. However, horizontal structures of sprites have been investigated only several times by ground-based triangulations and little is known with any certainty. On the other hand, lightning discharges can also generate runaway electrons which are thought most likely to produce gamma rays from Earth, called terrestrial gamma ray flashes (TGFs). Simultaneous space measurements of lightning discharge and TGFs are important to understand the relationship between them, which need nadir observations but have not been carried out until now. Nadia observations of sprites also provide us details of horizontal structure and distribution of sprites.

A Nano-satellite for investigation of horizontal structures of sprites and the relationship between lightning discharges and TGFs has been mainly developed by Tohoku University group. The science instruments and the satellite bus are developed in Graduate School of Science and in Graduate School of Engineering, respectively. The total weight of the satellite would be about 10 kg, including 2 - 3 kg mission payload. There are three kinds of science instruments on board the satellite. The first is two CMOS imagers with a wide field of view (about 40 deg), which pointed at nadir to take images of the horizontal structure of lightning and sprites. Nadir observations of lightning and sprites have to be performed at two wavelength ranges: one in the visible and near-infrared and the other around 762 nm. The latter wavelength range includes one of the most intense emission bands of sprites and the oxygen absorption bands. The light emission from sprites occurring in the upper atmosphere are then differentiated from the emissions from lightning, occurring more deeply in the atmosphere and then absorbed. We therefore equip either CMOS imager with a band-pass filter at 762 nm. The second instrument is a CCD imager equipped fish-eye lens (FOV is about 140 deg) and a gamma counter. The gamma counter can detect TGFs (30 - 130 keV) and operates simultaneously with the CCD imager which takes images of lightning discharges inducing TGFs. The last instrument is a CMOS camera which plays as a star tracker. All observations are performed during nighttime.

We chose to use the passive stabilization of a gravity gradient boom because it is cheaper, less complex and less weighty than other methods. We presently consider beryllium copper alloys as material of the boom due to their stiffness, light weight, and their dimensional stability over a wide temperature range. Solar cells charge a battery bank during sun hours and generate 10 W of power at maximum. An S-band communication system for telemetry and downlink, and UHF system for uplink are installed. A 500 - 800 km altitude of sun-synchronous polar orbit is assumed taking into account the high possibility of piggy-back launch opportunity. This satellite will be launched in 2008 or early 2009.