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Auroral camera required in the future small satellite missions exploring the magnetosphere-ionosphere coupling processes

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We propose the conceptual design of auroral camera required for future small-scale satellite mission to be launched for understanding the magnetosphere-ionosphere coupling system and fine-scale aurora. Reimei satellite showed that the simultaneous image-particle data are useful to investigate the fine-scale auroral dynamics, such as small-scale discrete aurora and time-varying pulsating aurora. However, Reimei does not carry the wave and field detectors, and therefore it is hardly measure the field aligned current, which is essential to understand the coupling process. Thus, the fundamental issues, such as the coupling process (time and spatial variation) via dispersive Alfven wave, radio wave emission from the auroral acceleration region, the relationship between large-scale auroral dynamics (like substorms) and small-scale aurora, etc., are still not understood.

We are now discussing on the possibilities for future small- and micro-scale satellites to understand the small-scale aurora and the coupling system between magnetosphere and ionosphere. In this talk, we focus on the scientific targets to be solved by the future satellite missions, and also show the conceptual design of auroral camera. These will be launched into a polar orbit at low-earth-orbit (LEO) or at mid-altitudes up to a few thousands km. We consider that the following specifications are required to this auroral camera. (1) Imaging optics is preferred. (2) At apogee, the field-of-view mapped on the ionosphere is wider than 400 x 400 km, which is about 6 times greater than that of Reimei. (3) Spatial resolution is better than 1 km/pixel to obtain fine-scale aurora. (4) Time resolution is higher than 1 frame/sec to obtain time variation of aurora. (3) It is preferred that the camera measures auroral emission in the nightside hemisphere under sunlit conditions.

To satisfy the requirements, we carried out the conceptual design of auroral camera as follows, assuming that the satellite is three axis stabilized and its apogee is 3000 km. The target is auroral N2 1P emission at 670 nm and/or O2 A-band emission at 762 nm. The objective lens is f=100mm (F1.5), and the preferred detector is 1k x 1k EMCCD of which pixel size is 13 x 13 um. Then, the field-of-view is 7.6 deg, which enable us to cover 400 x 400 km and 200 x 200 km with spatial resolution of 2 km/bin and 1km/bin (assuming 5-pix binning) viewed from altitudes of 3000 km and 1500 km, respectively. In the case of 10 frame/sec sampling and the EM gain 50, we obtain the S/N of 50 for 1kR auroral intensity and the data rate is 4.5 Mbps (assuming lossless data compression rate of 0.7). We also discuss the requirement for auroral camera measurement under sunlit conditions using a dipole or IRGF magnetic field model. We find that the satellite exists in the shadow of the Earth at altitude of 3000 km only in the limited period in the winter hemisphere in addition to that the magnetic pole tilts toward the anti-sunward direction. Thus, we suppose that we should take auroral image under the sunlit conditions using a baffle prior to the objective lens to reduce the strong scatter light.