# Auroral imaging at visible and far-ultra-violet wavelengths for the future polar orbiting satellite mission FACTORS

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We report the science objectives, feasible design of instruments, and current status of the future polar orbiting satellite mission FACTORS, mainly focusing on the auroral imaging. FACTORS stands for Frontiers of Formation, Acceleration, Coupling, and Transport Mechanisms Observed by the Outer Space Research System, which is going to be proposed as a next-generation multi-satellite formation flight mission. Major scientific targets are: 1) energy transport in the magnetosphere-ionosphere (MI) coupling system and their relationship to small-scale auroral phenomena, 2) particle transport in the MI system by ion outflow, and 3) neutral-ion coupling in the auroral thermosphere. Observation of small-scale plasma parameters and simultaneous auroral imaging data obtained with multi-satellite measurements in the altitude range from ~300 km to 4000 km enable us to understand dynamical spatial and time variations in the MI coupling system, such as an Alfvenic wave acceleration and small-scale discrete aurora. Field-aligned current, particle distribution function, and Poynting flux obtained with FACTORS are the key parameters to reveal small-scale aurora.

We are making the design and development of visible and far-ultra-violet (FUV) imagers for this mission. To observe dynamical morphology of small-scale aurora, both visible and FUV images are required to have high-spatial and high-time resolution capability. Therefore, we set the instrumental requirement for visible imager to measure small-scale faint aurora with a spatial resolution of ~1km x 1km at apogee (~4000km altitude), a time resolution of ~10 frame/sec and sufficient sensitivity for auroral intensity of ~1 kR. Target auroral emission should be permitted lines, and $N_2^+$ 1NG (391 or 428nm) or $N_2$ 1PG (670nm) are candidates. We have established high-spatial and high-time resolution auroral imaging measurement with Reimei/MAC, and the similar objective lens (F/1.6, f =50 mm) made of fused silica, which has radiation hard capability, can be used. For the visible detector, we are discussing CCD or space-qualified sCMOS which has low-noise and radiation-hard performances.

Concerning the FUV imager, it was originally designed to measure a wide area (a few thousand km range) to monitor medium scale auroral phenomena, such as westward travelling surge and omega band. However, from recent discussion, the satellite will not be in the noon-midnight meridian sun-synchronous orbit, but in an orbit with a lower inclination angle. In this case, the period of satellite sunlit conditions increases where the visible camera cannot operate due to the scattering of sunlight and earth's dayside reflection. On the other hand, the intensity of sunlight is relatively lower in the FUV range, and we can obtain auroral FUV images during sunlit conditions. Thus, the FUV imager now plays a more important role to achieve the scientific objectives of FACTORS. Here, we require the high-time and high-spatial resolution capabilities with a few km x a few km, several frame/sec, and sufficient sensitivity for auroral emission at ~1 kR. We examined the FUV detector and objective system so far. Recent progress in FUV detector technology enables us to use a space-qualified FUV 2D array detector without high-voltage image intensifier. We investigated the performance of CCD and sCMOS detectors for the FUV imager. We set the field-of-view (FOV) of the FUV imager to be ~10 deg x 10 deg. According to this relatively narrow

 

FOV requirement, and thanks to the latest lens polishing technology, we designed the objective system made of $CaF_2$ aspherical lenses with a F-number of 2.5 and focal length of 50 mm. The candidate auroral emission is OI 135.6 nm, and/or $N_2$ LBH band (140-180 nm), and the wavelength is selected by a space-qualified FUV bandpass interference filter. We present estimations of counts detected by the preliminary designed FUV imager.

Keywords: aurora, airglow, imager

 