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Proto model development of the lightning and airglow camera onboard Planet-C

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Since thick clouds cover the entire Venus, it is likely that Venus has lightning activity. Although various optical and electromagnetic wave observations of evidence on Venus lightning activity have been carried out, almost over a quarter of a century the evidence on lightning activity is still controversial. In the upper atmosphere, subsolar-to-antisolar circulation has been found; however, global distributions of airglow in the upper atmosphere and their spatio-temporal variations are still open questions.

The Japanese Venus mission Planet-C project started in 2001 for understanding the meteorology and climate of the Venus atmosphere. We are developing the proto model (PM) of the lightning and airglow camera (LAC) onboard the Planet-C spacecraft for obtaining clear evidence on Venus lightning activity and for two-dimensional mapping of Venus airglows in the nightside disk.

In order to complete the PM design of the LAC, we have evaluated the optical and data acquisition performances both theoretically and experimentally. We have determined the sensitivity requirement that the LAC can detect lightning emissions with the same intensity as typical terrestrial lightning flashes from an altitude of 5 Rv even if they occur under the cloud layer. We have also determined the requirement that the LAC can detect airglow with an intensity of 100 R (Rayleigh) as satisfying signal-to-noise ratio (SNR) more than 10. We have selected the atomic oxygen line at 777.4 nm for lightning flash measurement, and the molecular oxygen Herzberg II 0-10 band in 551.0 - 552.5 nm, the atomic oxygen green line at 557.7 nm and the red lines at 630.0 nm for nightglow emission measurement. A multi-anode silicon avalanche photodiode (APD) is adopted as a detector. To reduce the weight of LAC as much as possible, a complex of rectangular interference filters is placed just on the APD detector. An image-side telecentric system is adopted as the optics of LAC, which enables us to reduce the central wavelength shift of the interference filters. A solar blocking filter (SBF), which transmits only the wavelength ranges for measurement, is placed at the front of objective lens so as to reduce the damages on APD and/or ABPF by incident sunlight and thermal radiation during orbital operation. Two observation modes are prepared: a pre-trigger sampling mode is adopted for lightning measurement, while a numerical integration mode is adopted for nightglow measurement. Finally, the LAC composed of the sensor (LAC-S) and the electronics (LAC-E) has been developed as a very small size (LAC-S: 158 x 120 x 121 mm; LAC-E: 150 x 135 x 35 mm) and extremely light (1.6 kg) instrument. This high-performance instrument would be applied to various future satellite missions.