Ground-based Observation of planetary lightning flashes by using Photomultiplier tube

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The lightning flashes observation is useful as a way to understand the atmospheric large structure and the chemical reaction constituting the atmosphere. The lightning flashes have been observed in the Earth and Jupiter. It is suggested that there is a relationship between the zonal jet and the cumulonimbus with lightning in Jupiter (Gierasch et al.,2000, Ingersol et al., 2000). It is difficult to know the vertical convection covered by the dense clouds by using multi-wavelength observation. However, the lightning flashes observation can use for monitoring the atmosphere dynamics like the vertical convection covered by dense clouds. And one hypothesis suggests that some components of the Jovian atmosphere are created by lightning flashes. It is important to know the lightning to understand the formation mechanism of the atmosphere. In Venus, it is considered that there are lightning generated by the charge separation by the ice particle like the Earth or cloud particles of sulfuric acid. The existence of Venusian lightning is controversial for over 20 years. In the previous study, there are radio wave observations and optical observations by CCD. There is no robust evidence of existence the lightning because it is difficult to distinguish between the lightning signal and the electrical noise or other plasma waves, the observation area is limited, and the CCD's sensitivity is not enough for lightning flashes. If we can confirm the existence of Venusian lightning like the Jovian, it leads to an understanding of the Venusian atmosphere dynamics and atmospheric components.

Our study’s purpose is to reveal the relationship between lightning and atmospheric dynamics. For this purpose, we develop the instrument to equip for the Pirka telescope. By using it, we observe Venus more than tens of hours to obtain the lightning’s light curve, occurrence frequency, and distribution. We reveal the relationship between lightning and atmosphere dynamics by comparing the lightning data and wind velocity and cloud distribution.

The Planetary Lightning Detector (PLD) we developed is designed for Venusian and Jovian lightning flashes' observation. From the previous study, the dominant wavelength of the lightning flashes could be 777 nm in Venus (Borucki et al.,1996). PLD equips narrowband filter (FWHM = 1nm) of 777 nm. PLD observes the light by using a Photomultiplier tube. The minimum exposure time is 50 microseconds. The maximum time resolution is about $2x10^4$ points/s. PLD’s FOV can be changed to 5”, 10”, 30”, 60” pinhole and 2”x11” slit by using field stops. Slit and Pinhole are used for Venus’s night-side observation. To obtain the lightning’s light curve, we operate the bandpass filter to remove noise and large time scale variation by the atmosphere. And then, we search the large count value over 3-sigma. We have observed Venus by using PLD. For Venus’s data, we have obtained a few events whose count value is over the 3-sigma. These energies are estimated. The energy is about 10^9 to 10^{10} J. However, the light curves are too short less than 2 milliseconds and similar to the cosmic ray’s light curves obtained on different days. From this result, it’s considered we only observed the cosmic ray in this observation time. The observation time is not enough to reveal the lightning occurrence frequency for Venus. In the future, we increase the total observation time by using shorter exposure time.

In this presentation, we introduce the PLD and discuss the result observed from Jan 2020. And we report the plan of the cooperative observation with LAC (Lightning and Airglow Camera) onboard the AKATSUKI.

Keywords: Venus, Lightning, Ground-based telescope, Photomultiplier tube, LAC

