Local time dependence of limb darkening seen in the thermal infrared Venus disk

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Brightness temperature of the Venus disk obtained by Longwave Infrared Camera (LIR) onboard Akatuski shows clear limb darkening in the low and middle latitudes. Limb darkening is an apparent temperature decrease from the center to the limb of the Venus disk. It is caused by thermal and radiative characteristics that the sensing altitude of LIR increases as an emission angle, which is a zenith angle of direction of emission from the Venus atmosphere to the sensor, increases and that the atmospheric temperature monotonically decreases with altitude. In higher latitudes limb brightening is observed, because an inversion layer exists at the cloud-top altitudes in higher latitudes. In other word a profile of the limb darkening reflects vertical distributions of atmospheric temperature and optical thickness of cloud particles. Taylor et al. [1980] presented local time dependence of limb darkening using brightness temperature data obtained by the Pioneer Venus orbiter, but did not mention its physical mechanism. In this study brightness temperature distributions obtained by LIR when Akatsuki was in the altitude range from 60,000 to 100,000 km during the period from October 19, 2016 to July 17, 2018 were analyzed to investigate temperature and cloud particle property at the cloud-tops. Each brightness temperature image with 328 x 248 pixels was divided into 3280 x 2480 sub-pixels, and 32 successive images were accumulated after precise adjustment of the Venus disk position to improve S/N. Brightness temperature profiles as a function of the emission angle were derived for 24 local time zones and 9 zonal belts with a latitudinal width of 10˚ within ±45˚. A degree of limb darkening and a brightness temperature at the disk center were determined by least-square function fitting. As a result, the degree of limb darkening shows a clear semi-diurnal variation, and is the strongest at 11h and 22h and the weakest at 7h and 18h in local time. The amplitude of semi-diurnal variation peaks at the equator, whereas its phase seems constant in all latitudes. The temperature at the disk center also shows a semi-diurnal variation with a phase shift of approximately two hours earlier than the phase of the degree of limb darkening and a slight diurnal variation in higher latitudes. These semi-diurnal and diurnal components observed by LIR are consistent with the past observation of thermal tides in the Venus atmosphere by VENERA 15 [Zasova et al., 2007]. The physical mechanism of the semi-diurnal and diurnal thermal tide components seen in the degree of limb darkening and cloud-top temperature will be discussed.

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