Day-night asymmetry of center-to-limb curves and streaky patterns seen in Venus mid-infrared images

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The middle atmosphere (60-100 km altitudes) of Venus plays an important role in determining its own environment. Venus is completely shrouded by a curtain of dense clouds (50-70 km) with total optical thickness of 20-40 at visible wavelengths. The upper sulfuric acid (H_2SO_4) clouds reflect ˜76% of the incident solar radiation back to space (Crisp and Titov, 1997). More than 70% of the solar energy absorbed by Venus is deposited at altitudes higher than 64 km mainly due to absorption of unknown UV absorbers mixed in the upper cloud (Tomasko et al., 1980, 1985). This horizontally and vertically unusual heating in the cloud layer excites the thermal tides, which are the key process to understand the atmospheric super-rotation. In order to elucidate this mysterious atmospheric phenomenon, it is fundamental to investigate horizontal and vertical thermal structure in the middle atmosphere.

We conducted Venus observations at three mid-infrared wavelengths (8.59, 11.24, and 12.81 micron) with the Cooled Mid-Infrared Camera and Spectrometer (COMICS), mounted on the 8.2-m Subaru Telescope, during the period of 25-29 October 2007 (UT). Thermal radiations at these wavelengths (brightness temperature: 230-240 K) are most sensitive to altitudes of ˜70 km. The angular diameter of Venus and the solar phase angle (Earth-Venus-Sun angle) at the observation period were ˜25 arc-seconds and ˜90 degrees (i.e., both the dayside and nightside hemispheres were observed), respectively. The spatial resolution of the observed images, which was determined by seeing size, was ˜500 km for the sub-observer point. This was the first time that such high spatial resolution full-disk images had been obtained at mid-infrared wavelengths (Mitsuyama et al., 2008).

From these observations, we obtained three important findings. First, the brightness temperatures at cloud top altitudes (˜70 km) in north polar regions were synchronized with those in south polar regions at least in the three observation nights (26, 28, 29 October 2007). Such atmospheric synchronization has not been reported because previous mid-IR ground-based observations (Apt and Goody, 1979; Orton et al., 1991) had lower spatial resolution while spacecraft observations (Taylor et al., 1980) were conducted from polar orbits. Second, the center-to-limb curves (dayside and nightside) have different characteristics in the equatorial region for all observation nights. The day-night asymmetric features, which have been detected by the above observations, would result from the difference of vertical cloud structure and/or thermal structure in between dayside and nightside. Finally, there were some streaky patterns in the Venus images at 8.59 micron after high-pass filtering. These patterns, amplitudes of which were ˜0.5 K, varied from day to day. It is worth noting that streaky patterns obtained on 28 October 2007 were similar to a well-known horizontal Y-shape structure seen in UV. The above three findings are commonly seen at the other wavelengths.

In this talk, we will present what kind of atmospheric parameters are responsible for the anomalous features of planetary scale center-to-limb curves and for the amplitudes of small scale streaky patterns through radiative transfer calculations.