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The vertical density profile of the mesosphere of Venus by independent measurements from SPICAV/SOIR and aureole photometry

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Abstract

The mesosphere of Venus, above the optically thick cloud deck, remains poorly known and shows an important variability as a function of position and time as revealed by Venus Express (VEx) data (SPICAV/SOIR experiment). For the first time, we validate the SOIR vertical density profile by reproducing the accurate photometry of the aureole of Venus obtained by the HMI instrument onboard SDO, during the solar transit of Venus on June 5-6, 2012. The aureole is produced by sunlight refraction in the mesosphere, and is highly sensitive to the details of the vertical density variations. For this task, we use the data that SOIR has captured from the Venus Express orbiter at the time Venus transited the Sun. The photometry of the aureole at the same latitude is then fitted by a multi-layer model adopting the vertical profile of SOIR. We find that our fit is sensitive to the variations of the CO_2 mixing ratio, the altitude of the opaque layer at visible wavelengths, and the scale height of the aerosols above them. In particular, we determine the last two parameters. As the inversion method has been validated, we will invert the photometric light curve at all other latitudes observed on the evening limb.

1. Introduction

The transit of Venus in June 2012 provided a unique case study of the Venus' atmosphere transiting in front of the Sun, while at the same time ESA's Venus Express orbiter observed the evening terminator at solar ingress and solar egress. Close to ingress and egress phases, we have shown that the aureole photometry reflects the local density scale height and the altitude of the refracting layer [1].

2. SDO Observations

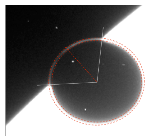

Figure 1 : Ring photometry performed on NASA's Solar Dynamics Observatory of the LWS program. The HMI instrument (Helioseismic Magnetic Imager) observes the full solar disk at 6173 Å with a 1 arc-sec resolution and was used to image the aureole on June 5-6, 2012.

3. SPICAV/SOIR Observations

SOIR [2] performs solar occultation observations of the Venus atmosphere from the VEX spacecraft, which is in a polar orbit with its periapsis located above the North Pole. The vertical size of the instantaneously scanned atmosphere at the limb tangent point varies from a few hundreds of meters for the Northern measurements to tens of kilometers for the Southern measurements. The altitude range probed by SOIR, i.e., where measurements are scientifically mean- ingful, varies from 70 km up to 170 km. The lower boundary corresponds to total absorption of sunlight by Venus' clouds, and the upper boundary to the detection of the strongest CO_2 band in the selected SOIR wave number range. The continuum of absorption in the SOIR spectra is primarily shaped by the extinction caused by the aerosol particles present in the upper haze (between ~70 and 100 km) of the Venus mesosphere.

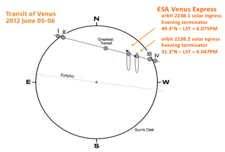

Figure 2 : Geometry of the VEx/SOIR vertical temperature profiles obtained during orbit 2238 at terminator during solar ingress (49.3N - LST = 6.075PM) and egress (31.3N - LST = 6.047PM) as seen from the orbiter. Solar occultations take place at 6:00a and 6:00p local time on Venus, at the same local time probed by the transit aureole.

4. Model

A new ray-tracing transmission-refraction model has been developed to fit the transit data based on a stellar occultation point-source geometry. The main problem in the case of Venus was the limb surface of the Sun, the star representing an extended light source through the upper mesosphere. So, the model is based on an occultation code [3, 4] modified to take into account the extended source and inverse with a MCMC Markov Chain Monte Carlo algorithm to find the best parameters for the altitude of the opaque aerosol layer in tangent geometry at visible wavelengths, and the scale height of the refracting atmosphere layers above.

Fig.3 indicated that simultaneous SOIR data obtained at evening terminator at 49.3°N on June 6, 2012, when inserted in the model without modification, the fit produced is in good agreement with the photometry extracted for the SDO imaging at 617.3 nm.

5. Conclusion

SDO/HMI measurements are in agreement with the VEx/SOIR temperatures obtained during orbit 2238 at evening terminator during solar ingress (49.3°N - LST = 6.075PM) and solar egress (31.3°N - LST = 6.047PM) captured from the Venus Express orbiter at the time Venus transited the Sun. As the inversion method has been validated, we will invert the photometric light curve at all other latitudes observed on the evening limb

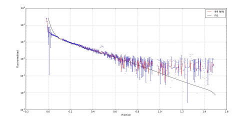

Figure 3 : Representation of the refraction aureole flux in in the SDO imaging at 617.3 nm selected at the latitude of simultaneous VEx/SOIR vertical temperature profiles obtained during orbit 2238 at 49.3N. Maximum intensity for the aureole is obtained near second contact (fraction = 0.0). The red curve with the blue error bars is the measured flux. The black curve is the model of aureole intensity obtained with the VEx/SOIR data.

Acknowledgements

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