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Transition from Zonal Wind to Subsolar-to-Antisolar Flow on Venus

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Abstract

We observed Venus on 19–23 Aug 2010 (UT) using a systematic sampling scheme to investigate equatorial wind velocities in the upper troposphere/lower thermosphere region above the cloud tops. Spectra were acquired at high resolving power ($\lambda/\Delta\lambda=2.5\times10^7$) to determine line of sight velocity to the pressure-broadened CO_2 absorption feature in the 10.6 µm lasing band *vs.* the thermal Doppler-broadened non-LTE core emission formed in the lower thermosphere. The altitude differential between the CO_2 spectral features enables an investigation of the transition from predominantly zonal wind flow in the troposphere to predominantly subsolar-to-antisolar flow in the thermosphere.

1. Science Background

We investigate dynamics in the region above Venus' cloud tops, using extremely high resolution spectroscopic observations to distinguish the differences in line-of-sight velocity of spectral features measured simultaneously. The dominant features that appear in the measured spectra are the pressure-broadened absorption of normal-isotope carbon dioxide in contrast against thermal emission from the underlying cloud layer, and the strong core emission feature of non-thermally excited carbon dioxide that forms in the lower mesosphere. We also sought weak transitions due to singly-substituted ^{18}O and ^{17}O isotopologues of CO_2 that appear within the same spectral interval as the primarily-targeted transitions. The principal CO_2 absorption feature probes the region of declining temperature above the cloud tops, the upper troposphere. The non-LTE emission feature forms in the lower thermosphere; although this is an altitude range of increasing temperature with altitude, the slope of the thermal profile is irrelevant to the non-thermal excitation of the emission [1] [2]. The differential altitude at which the features form enables probing the shear between the features, which roughly coincides with the transition from stable zonal superrotation in the troposphere to subsolar-to-antisolar flow in the thermosphere. The very weak isotopologue features form deepest in the region above the cloud tops, where the number density is greatest.

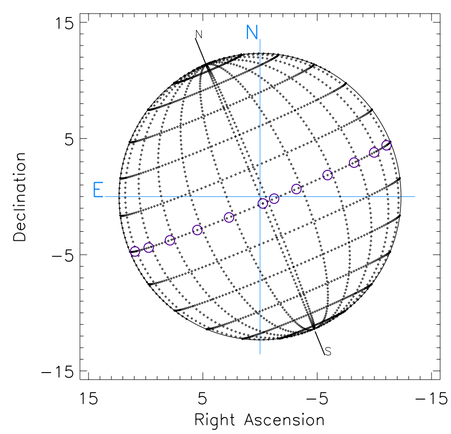

Figure 1: Targeted positions on Venus, insolation from right (West), terminator indicated just West of central meridian.

2. Observations

Venus was observed on 19–23 August 2010 UT, as an evening target, from the NASA Infrared Telescope Facility on Mauna Kea, Hawaii. Observations were conducted using the NASA Goddard Space Flight Center Heterodyne Instrument for Planetary Winds and Composition (HIPWAC). The IR heterodyne technique, implemented in a predecessor instrument from GSFC, was used to discover the natural lasing properties of the Venus upper atmosphere [2]. More recently, spectroscopic observations using a similar instrument from the University of Cologne have been used to investigate the wind velocities in the Venus upper atmosphere and have shown significant evidence for variability [3]. This work expands upon those efforts.

Carbon dioxide spectral features were observed in Venus in the vicinity of the 952.8808 cm^{-1} (10.494 μm) rest-frequency transition of the 10.6 μm lasing band of normal-isotope CO_2, at a resolving power of 2.5×10^7, using an Acousto-Optic Spectrometer (AOS) spectrum analyzer and a CO_2 laser local oscillator frequency reference. Orbital radial velocity Doppler-shifted the lines in Venus ~1300 MHz from the corresponding frequency at rest. Observed positions were distributed about the central meridian at ±15° intervals in longitude. The non-LTE emission is solar-pumped and appears only on the daylight side of Venus. The tangential velocity of the subsolar-to-antisolar flow, sensed with the non-LTE line, is maximum at the terminator (approximately central meridian). The maximum line-of-sight projection thus is found interior to the apparent disc. The tangential velocity of the zonal flow is approximately uniform and thus reaches its maximum line-of-sight projection at the limb. The Doppler shift between the observable features and the differing angular dependence of the contributing wind phenomena thus provide independent mechanisms to distinguish the contributing dynamical processes at the altitude of each observed spectral feature.

References

[1] López-Valverde, M. A., P. Drossart, R. Carlson, R. Mehlman, and M. Roos-Serote (2007). Non-LTE infrared observations at Venus: From NIMS/Galileo to VIRTIS/Venus Express. *Planet. & Space Sci.* **55**, 1757–1771, doi: 10.1016/j.pss.2007.01.008.

[2] Deming, D., and M. J. Mumma (1983). Modeling of the 10-micron natural laser emission from the mesospheres of Mars and Venus. *Icarus* **55**, 356–368.

[3] Sornig, M., T. Livengood, G. Sonnabend, P. Kroetz, D. Stupar, T. Kostiuk, and R. Schieder (2008). Venus upper atmosphere winds from heterodyne spectroscopy of CO_2 at 10 µm wavelength. *Planet. & Space Sci.* **56**, 1399–1406, doi: 1310.1016/j.pss.2008.1305.1006.