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Observations of Venus Night-Side by CO_2 Absorption Features in the Mid-Infrared

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Abstract

Ground-based, mid-infrared observations of pressure broadened CO_2 absorption features around 10 μm, in an altitude region from 65 km to 100 km of the Venusian night side atmosphere will be presented. Spatial variety of the line shape along different longitudes and latitudes are under investigation, in order to determine and validate vertical temperature profiles and to retain information about the dynamical properties of the upper atmosphere. The data were acquired using the two existing infrared heterodyne spectrometers THIS (Tuneable Heterodyne Infrared Spectrometer) [5] and HIPWAC (Heterodyne Instrument for Planetary Winds And Composition).

1. Introduction

In recent years, more emphasis was given to the investigation of the Venusian atmosphere, due to various spacecraft missions such as ESA's VenusExpress (VEX). Ground-based observations of the climatology on Venus can provide corresponding and supporting measurements and are crucial to understand the dynamical behavior especially in the upper atmosphere above the cloud top.

Investigations of the dark side of the planet showed an inversion of the temperature at around 59 km altitude [6]. This temperature inversion provokes absorption features of CO_2 even in high altitude regions. Heterodyne spectroscopy in the infrared range of the electromagnetic spectrum offers the advantage to resolve single molecular ro-vibrational transitions. This way, a close investigation of the line profile is possible in order to determine dynamics and temperatures of the atmospheric layer. The diffraction limited field-of-view at 10 μm yields a good spatial resolution and is by orders of magnitudes smaller than the apparent diameter of Venus.

Infrared heterodyne spectroscopy probes the Venusian atmosphere between 65 km and 100 km by measuring those pressure-broadened CO_2 lines. A first heterodyne observation of the CO_2 R(8) transition feature on the Venus night side was performed by *Deming et al.* in 1980 [2].

This very special transition region, where the dominating dynamical mechanism changes from the retrograde zonal superrotation (RSZ) into a solar induced sub-solar to anti-solar flow, is thought of to be most interesting to acquire better knowledge of the properties of Venus atmosphere. In addition, a lack of high spatially resolved, direct wind measurements in this altitude region enforces the necessity of continuous observations in the infrared.

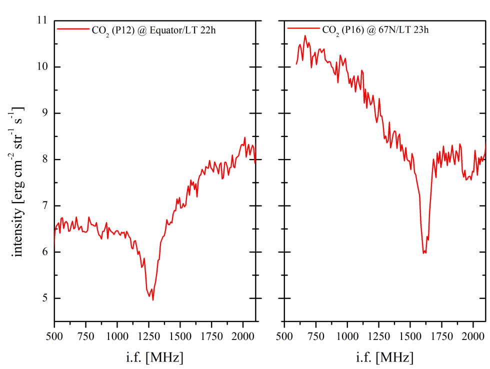

Figure 1: *Comparison of the CO_2 P(12) (left graph) and P(16) (right graph) line on Venus night side. The P(12) line was measured on the Equator at a local time of 22h. The (P16) was measured at 67N and a local time of around 23h. The P(16) line shows a much sharper absoprtion peak, whereas the the P(12) line seems to be saturated.*

2. Observations

Observations of the P(12) and P(16) CO_2 absorption lines on Venus night side were carried out during two observing runs in March (RI) and April (RII) 2009 and one in March 2012 (RIII) at NSO's McMath-Pierce Solar Telescope on Kitt Peak, AZ using the spectrometer THIS. Most recently, measurements with HIPWAC have been performed at NASA's Infrared Telescope Facility on Mauna Kea, HI (RIV). During the runs (RI), (RII) and (RIV) Venus was close to inferior conjunction ($\approx 0\%$ illumination) whereas it just past greatest eastern elongation during (RIII) ($\approx 50\%$ illumination). Various spectra were taken over the whole planetary disc in order to provide a good longitudinal and latitudinal coverage.

3. Results

Variations of the CO_2 absorption line shape has been observed (see Fig.1). An overview over the measured spectra will be presented in terms of latitude and Venusian local time.

The contributions to the overall spectrum from atmospheric levels of different pressure correspond to the temperatures in these layers. Therefore a careful analysis of the lineshape by using a radiative transfer model [3] yields information on the temperature profile of the atmosphere. First results of the variation of the vertical temperature profiles will be shown.

4. Outlook

The main perspective will be to finally analyze the line shapes in a way direct wind measurements in dependence of the altitude can be provided. Besides a reference analysis of calculated absorption lines to measured spectra will be performed, taking various vertical temperature profiles such as VeRa [6], VIRTIS [1] and PVO [4] into account.

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