EPSC Abstracts,
Vol. 4, EPSC2009-439, 2009
European Planetary Science Congress,
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Observations of non-LTE 10 µm emission in the Mesosphere of Venus and Comparisons to Models

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Introduction

Heterodyne spectroscopy of CO_2 at mid-infrared wavelengths is a powerful tool to study various physical properties like winds, temperatures or abundances in the mesospheres of the terrestrial planets. On Mars as well as on Venus non-local thermodynamic equilibrium (non-LTE) emission of CO_2 can be observed. Modeling the process leading to the non-LTE emission [1,2] is still limited, thus limiting the development of accurate complete models of the atmospheres of Mars and Venus.

Temperature Measurements

We will present temperature measurements from 2007 together with corresponding model predictions and new observations taken shortly before and after inferior conjunction of Venus in March/April 2009, probing the symmetry of non-LTE emission from the morning and evening terminators. Observations on Venus were done in 2007 with HIPWAC, the Heterodyne Instrument for Planetary Winds and Composition [3] and the Cologne Tuneable Heterodyne Infrared Spectrometer (THIS) [4]. Kinetic temperatures can be calculated from the width of the fully resolved lines (see Fig. 1+2) and are compared to the model predictions. The rotational temperatures can be extracted from the distribution of line intensities of different rotational transitions in the 10 µm CO_2 bands.

The altitude of the emitting region is determined by the ratio of collision induced to the probability of spontaneous emission for the excited CO_2 molecules and was found to be around 110 km for Venus, (see Fig. 3) [2,3,6]. Temperatures were retrieved on Venus at the equator and mid-latitudes on both hemispheres and close to the South vortex with an accuracy of better than 5 K. Rotational temperatures were derived from the intensity distribution of the detected CO_2 lines and the observed values suggest an unexpected North-South asymmetry at the mid-latitudes. Retrieved rotational temperatures (180-240 K) deviate from the observed kinetic temperatures at some positions. Kinetic temperatures reach values of ~220 K at the equator and the mid latitudes. This value is higher than the VIRA model predicts, but consistent with earlier observations and suggest that a warm layer in the atmosphere around 100 km altitude that was recently reported for the night side of Venus is also present on the day side.

Observations and Models

Differences between rotational, kinetic, and vibrational temperatures can provide important clues for understanding and modeling the non-LTE emission phenomenon, the Venusian thermal structure and possible temporal and spatial variability.

Comparisons of non-LTE modelling and heterodyne observations started with Mars and has been extended to Venus. First tests are promising and the model reproduces the observed data without any special tuning (see Fig. 4). The new set of observations (spring '09) will provide more complimentary altitude profile information from night-side absorption measurements and will probe the model for the emission at different solar zenith and emission angles as before.

It also could be possible to determine the density of the CO_2 molecules in the emission layer by carefully identifying the absolute intensity of the non-LTE emission.

References

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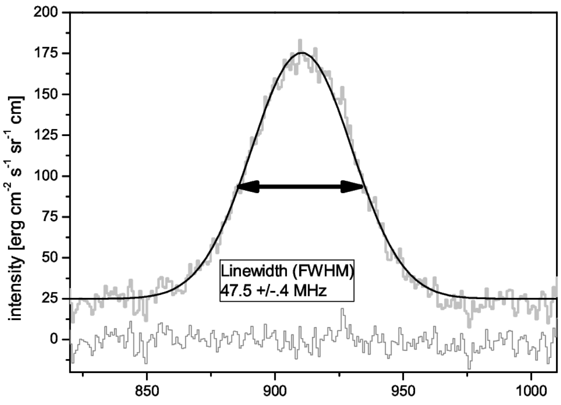

Fig. 1: Resolved line profiles yield the kinetic temperature.

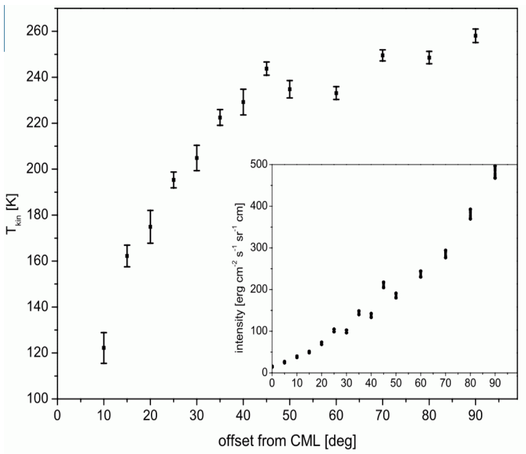

Fig. 2: Plot of the temperatures retrieved of the P 12 line at various offsets from the centre meridian line along the equator. The inset shows the corresponding intensities.

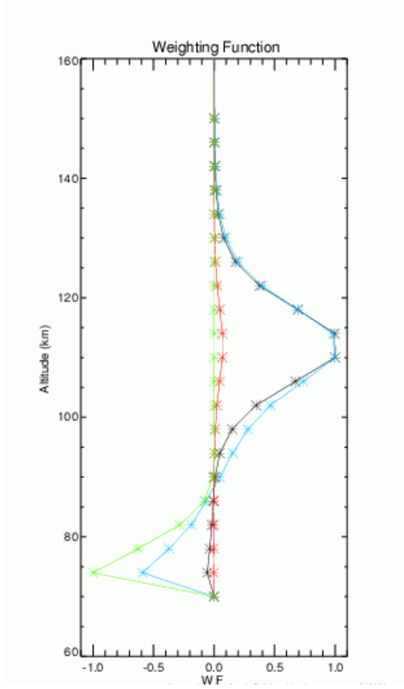

Fig. 3: Weighting function of different isotopes to the nLTE emission indicating the altitude of the emission.

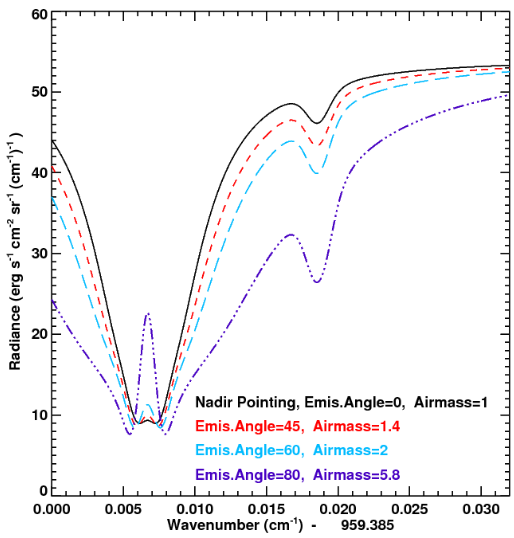

Fig. 4: Model dependence on the emission angle: observations require high spatial resolution and good pointing .