Investigation of CO_2 Absorption Features on Venus

Ground-based Observations in the Mid-infrared

Tobias Stangier (1,2), Manuela Sornig (1,2), Guido Sonnabend (1) and Dusan Stupar (1)
(1) University of Cologne, KOSMA, Cologne, Germany (stangier@ph1.uni-koeln.de)
(2) Rheinisches Institut für Umweltforschung, Abteilung Planetenforschung, Cologne, Germany

Heterodyne Priciple:

THIS (Tuneable Heterodyne Infrared Spectrometer)[1]

iCHIPS (infrared Compact Heterodyne Instrument for Planetary Science)

- Superimposing Signal + Local Oscillator (LO)
  - → all spectroscopic information preserved
- Ultra High Resolution (R > 10^7)
  - → fully resolved lines
  - → sensible for dynamics down to m/s
- Local Oscillator: Distributed Feedback-QC Laser (DFB-QCL)
- Mixer: Mercury-Cadmium-Telluride
- Analysis: Accousto-Optical-Spectrometer

Applications:

→ Analysis and monitoring of trace gases in atmospheres of planets and moons

→ Dynamics in planetary atmospheres

Experimental setup of iCHIPS:

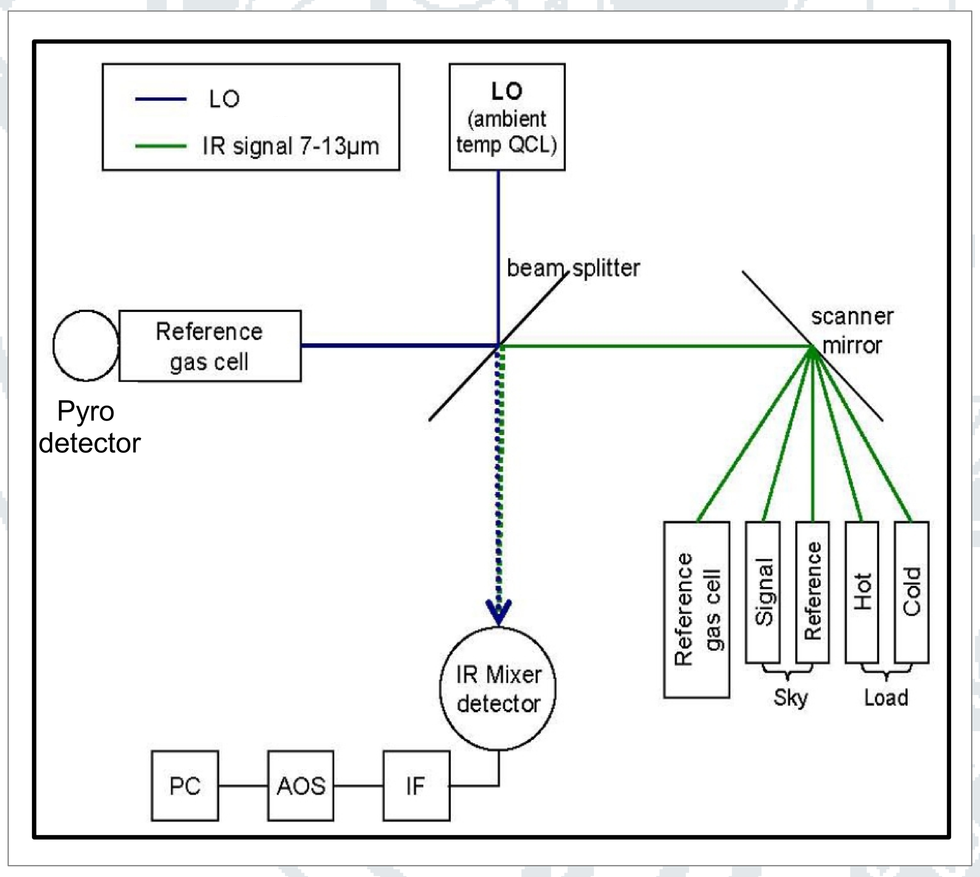

Fig.1: Schematic view of the spectrometer setup (QC laser path: blue; different signal paths: green)

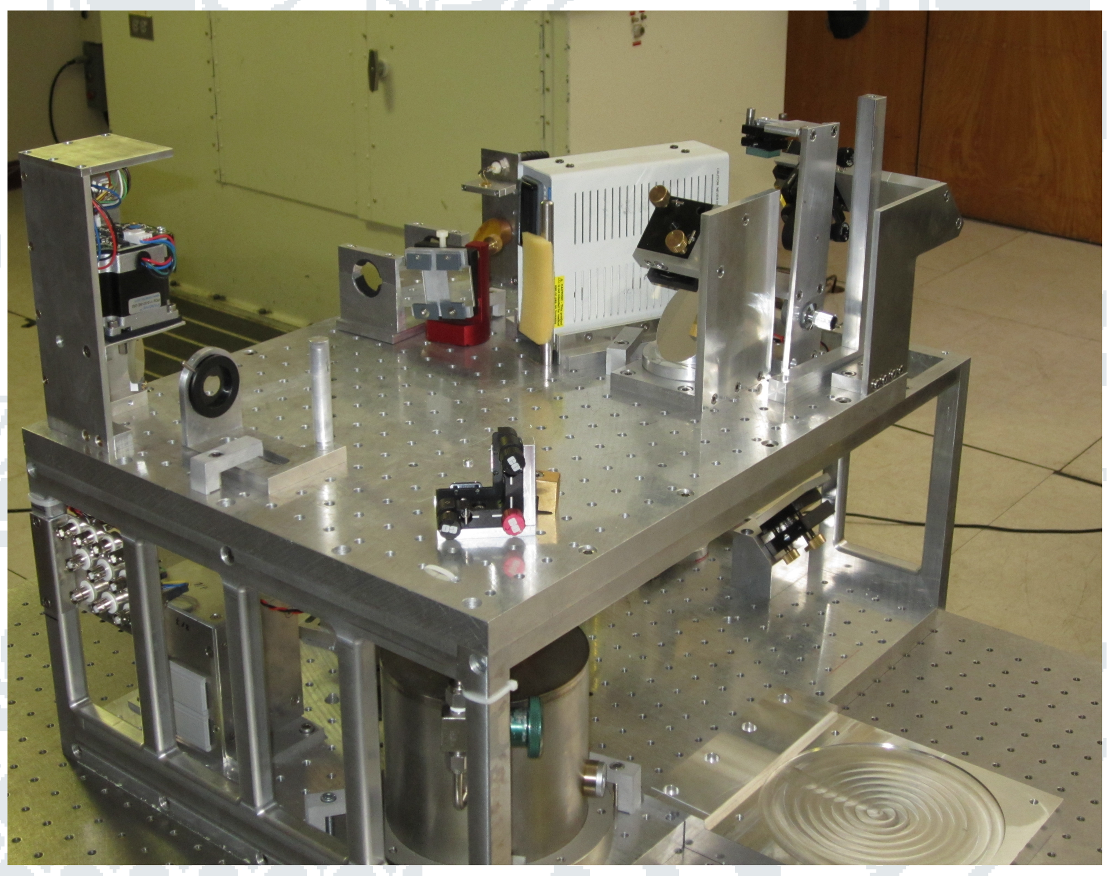

Fig.2: The heterodyne spectrometer **iCHIPS** applied at the East Auxiliary of the McMath-Pierce Solar telescope on Kitt Peak, Az

Absorption Features of CO_2 on Venus:

- pressure broadend CO_2 absorption features
  - → origin between 60 km and 100 km
  - → induced by thermal emission from the cloud level and above
- non LTE emission peak superimposed to a broad absorption baseline
  - → LTE contribution of CO_2 feature was fitted with the full radiative transfer code CODAT[3]
    - different temperature profiles, corresponding in time and location to the measurement, were used
    - quality of fit varies (see Fig.3 and 4)

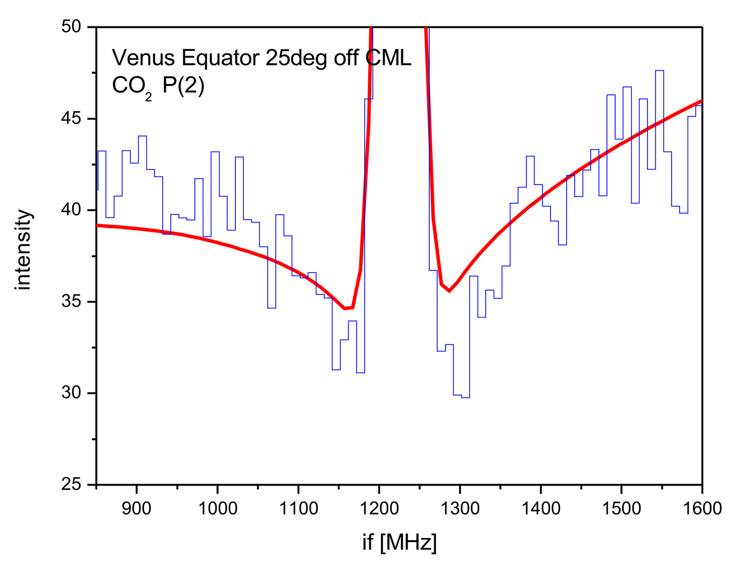

Fig.3: Measured absorption line of CO_2 superimposed to non-LTE emission core (blue) and best fit (red) using VIRA temperature profiles. Fit seems to be asymetrical and does not match the wings of the absorption line

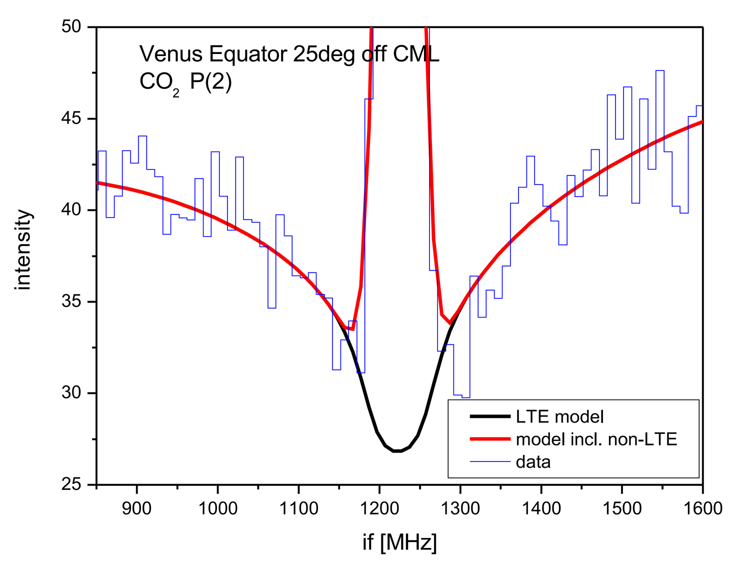

Fig.4: Measured absorption line of CO_2 superimposed to non-LTE emission core (blue) and best fit (red) using temperature profiles derived from VEX Radio Science Experiment VeRa[2]. Fit matches the wings of the absorption line.

- vertical temperature profiles VIRA[4] and VEX RadioScience[2] displayed in Fig.5
- corresponding profiles to observing geometry at Venus equator and 25°W of central meridian line (CML)
- VEX RadioScience profile shows inversion and isothermal part around 40 to 120mbar

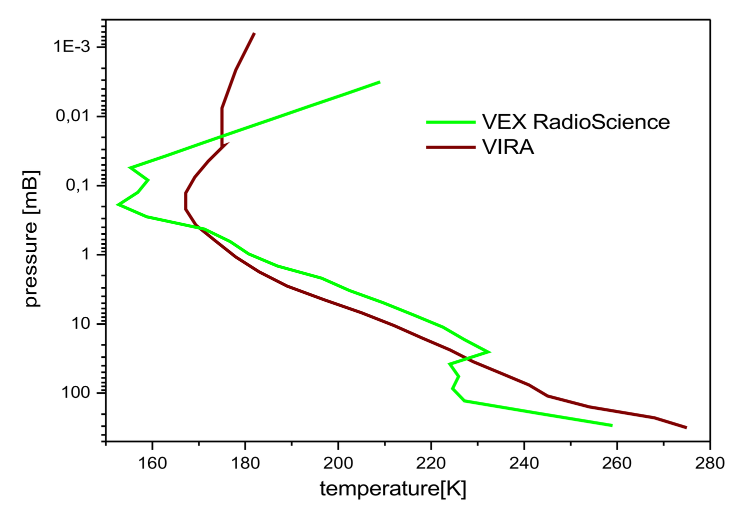

Fig.5: vertical temperature profile of the Venusian atmosphere of the Venus International Reference Atmosphere VIRA [4] and measured contribution of the VenusExpress RadioScience Experiment [2]

Distribution on Planetary Disc:

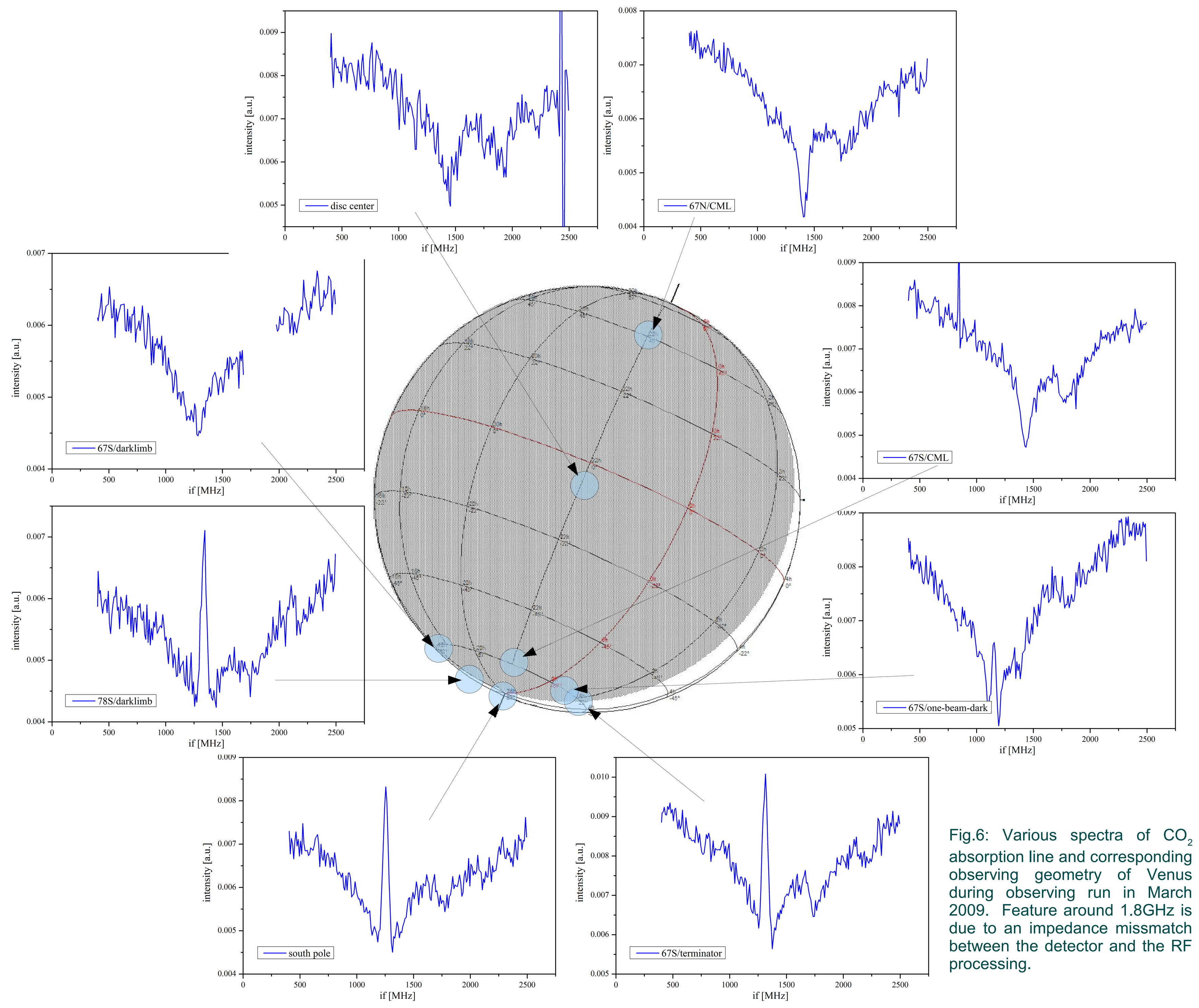

Fig.6: Various spectra of CO_2 absorption line and corresponding observing geometry of Venus during observing run in March 2009. Feature around 1.8GHz is due to an impedance missmatch between the detector and the RF processing.

- Variation of investigated spectrum
- Observations performed in March 2009
- CO_2 P12 transition @ 951.1923 cm^{-1}
- strong absorption features on night-side
- on sun-lid crescent non-LTE emission occurs

Outlook and Observational Goal:

- investigation of spatial and temporal variations
  - → determination of longitudinal and latitudinal profiles
  - → dependence between local time and absorption depth
- column density of molecule can be derived from the absorption depth

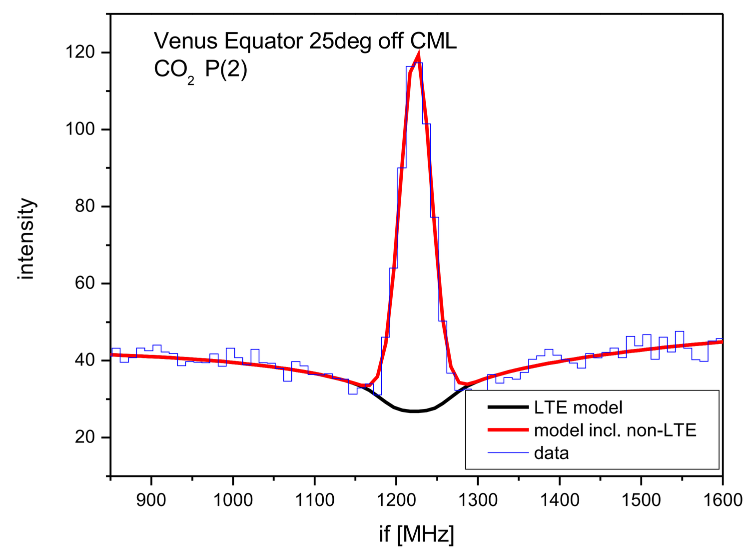

Fig.7: observed non-LTE emission feature superimposed to broad absorption line on Venus day-side and best fit. Observations performed in 2007 at the McMath-Pierce Solar Telescope on Kitt Peak, AZ

- reference analysis for existing temperature profiles
  - → comparison of quality factor variation of the single fits
  - various profiles under investigation i.e. VIRA[4], VeRa[2], VIRTIS[5]

References:

[1] Sonnabend, G., Sornig, M., Krötz, P., Stupar, D., Schieder, R.:Ultra high spectral resolution observations of planetary atmospheres using the Cologne tuneable heterodyne infrared spectrometer. *J. of Quantative Spectr.& Rad. Transfer*, Vol.109, pp.1016 (2008)

[2] Tellmann, S., Pätzold, M., Häusler, B., Bird, M.K., Tyler, G.L.: Structure of the Venus neutral atmosphere as observed by the Radio Science experiment VeRa on Venus Express. *J. Geophys. Res.*, Vol.114, pp.19 (2009)

[3] Hewagama, T., Goldstein, J., Livengood, T.A., Buhl, D., Espenak, F., Fast, K., Kostiuk, T., Schmülling, F.: Beam integrated high-resolution infrared spectra: Accurate modeling of thermal emission from extended clear atmospheres. *J. of Quantative Spectr.& Rad. Transfer*, Vol.109, pp.1081 (2008)

[4] Seiff, A., et al.: Measurements of Thermal Structure and Thermal Contrasts in the Atmosphere of Venus and Related Dynamical Observations: Results From the Four Pioneer Venus Probes. *J. Geophys. Res.*, Vol.85, pp.7903 (1980)

[5] Bertaux, J., et al.: A warm layer in Venus' cryosphere and high-altitude measurements of HF, HCl, H2O and HDO. *Nature* Vol.450, pp.646 (2007)