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# Heterodyne Spectroscopy of Methane on Mars at 7.8 $\mu$m wavelength

**D. Stupar**, T. Stangier, G. Sonnabend, M. Sornig and P. Krötz
University of Cologne, Germany (stupar@ph1.uni-koeln.de / Fax: +49-221-470-5162)

## Abstract

We present observations of Methane ($CH_4$) on Mars. Data was gathered using ground based ultra-high resolution spectroscopic observations of $CH_4$ absorption features around 7.8 $\mu$m wavelength. Observations were carried out during 26th April till 8th May 2010 using the Cologne Tuneable Heterodyne Infrared Spectrometer (THIS) at the Mc-Math-Pierce Solar Telescope on Kitt Peak, Arizona.

## 1. Introduction

The detection of Methane in the Martian atmosphere has been claimed by various groups since 2003 [1, 2] but only recently its presence has been undoubtedly established by Mumma et al. [3] who found strong variation of methane with season, latitude and longitude at a mixing ratio of up to 40 ppb in late Northern summer. One significant flaw which is pointed out is the absence of a confirmation of its presence in a second wavelength range. So far, all ground based detections were reported at 3.3 $\mu$m.

Ultra-high resolution spectroscopy at infrared wavelength has proven to be a powerful tool to study planetary atmospheres as many physical parameters of such atmospheres such as composition [5]. A spectral resolution of better than $10^6$ allows one to fully resolve profiles of single molecular features. This is a strong advantage as the analysis of low resolution data in general requires more information about the state of the studied atmospheres which has to be provided from additional observations or models. High-resolution heterodyne spectroscopy at the strong methane band at 7.8 $\mu$m can lead to new insights to the vertical mixing ratio profile and can provide further independent prove of the existence and more detailed data on the abundance and distribution of methane in the atmosphere of Mars, helping to determine the location of the methane source either on or under the surface or within the atmosphere itself.
Another advantage of the 7.8 $\mu$m over the 3 $\mu$m wavelength regime is the data analysis. At 3 $\mu$m you have to take account of the reflected sunlight with all its solar lines and the double pass through the Martian atmosphere before the information can be retrieved from the recorded spectra. Whereas the measured spectra at 7.8 $\mu$m consists only of an absorption feature originating from the atmosphere of Mars and its surface radiation.

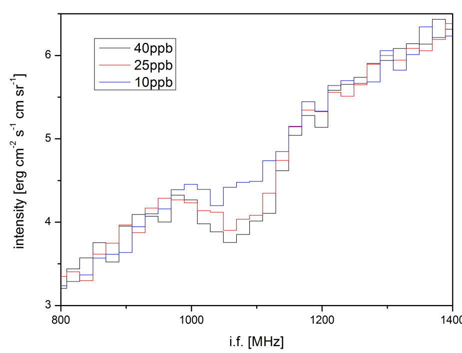


Figure 1: Simulated spectrum of methane calculated using a full radiative transfer model. Spectra are calculated for three different volume mixing ratios of methane of 10, 25 and 40 ppbV. The simulated noise represents one hour of integration time at the instrument's sensitivity at 7.8 $\mu$m which was established during a test observation in 2008.

### 1.1. Instrumentation

A spectral resolution of better than $10^6$ at infrared wavelength can only be achieved by heterodyne techniques. THIS (Tuneable Heterodyne Infrared Spectrometer)[4], one of the only two instruments worldwide are using this method for astronomical observations, was designed and build by our group at University of Cologne. THIS is the only astronomical receiver making use of newly developed tuneable quantum-cascade lasers (QCLs) as local oscillators (LOs), which offers the possibility to observe methane at 7.8 $\mu$m.

## 2. Observation

We acquired two weeks observing time in the end of April 2010 (Martian season of Northern summer (Ls=80) at the McMath-Pierce telescope in Arizona. Northern summer is a season which has not been observed from the ground before but if methane is released from subsurface reservoirs as most observers believe a strong increase in the methane mixing ratio can be expected starting in Spring (Ls=0) and continuing throughout the summer.
The diameter of the apparent disk of Mars was around 7 arcsec. At a diffraction limited resolution of the telescope of 1.3 arcsec at 7.8 $\mu$m we were able to resolve the planetary disk and study several regions of Mars.
At the conference we are going to present analyzed data from this run.

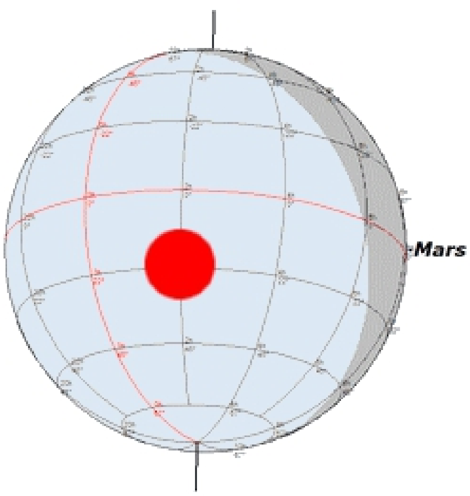


Figure 2: The observing geometry for the April 2010 run at McMath-Pierce telescope. The diameter of the apparent disk of Mars was around 7 arcsec. The size of the red circle represents the actual telescope FOV relative to the size of Mars.

## References


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