We present an atmospheric study of methane (CH\textsubscript{4}) on Mars. Data were gathered using ground based ultra-high resolution spectroscopic measurements of CH\textsubscript{4} absorption features around 7.8 \textmu m wavelength. Observations were carried out from 26th April to 8th May 2010 using the Cologne Tuneable Heterodyne Infrared Spectrometer (THIS) at the McMath-Pierce Solar Telescope on Kitt Peak, Arizona.

**Instrumentation**

High resolution spectroscopy at infrared wavelength has proven to be a powerful tool to study planetary atmospheres as many physical parameters such as composition [11, 12]. A spectral resolution of better than 10\textsuperscript{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. Heterodyning means the superimposition of the radiation to be analyzed with a reference radiation. The latter is the so called local oscillator (LO). THIS (Tunable Heterodyne Infrared Spectrometer) [13] is one of only two IR heterodyne instruments worldwide accomplishing astronomical observations. It was designed and developed by our group at University of Cologne using tuneable quantum-cascade lasers (QCLs) as LO’s, which offers the unique possibility to observe methane at 7.8 \textmu m.

High-resolution heterodyne spectroscopy at the strong methane band at 7.8 \textmu 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. The methane features are comparable in strength to the lines that fall into the usually used 3 μm window. However, at the longer wavelength reflected sunlight does not contribute significantly to the observed spectra thus analysis and interpretation of the acquired data is much easier. Our calculations (see Fig.1) show that this is capable of detecting volume mixing ratios of methane down to 10 ppbV. The simulated noise represents four hours of integration time at the instrument’s sensitivity at 7.8 μm which was established during a test observation in 2008.

**Observation**

Observations of methane from the ground require careful selection of wavelength ranges and observing dates. Only few days timed around the maximum Earth-Mars Doppler shift are suitable to separate the Martian lines sufficiently from their telluric counterparts. Even then, the maximum expected transmission through the telluric atmosphere is 20% at 2 km altitude justifying the need for two weeks of continuous observations. On account of this we acquired 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 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 μm we were able to resolve the planetary disk and study a specific region of Mars (see Fig.2.3).

**Conclusion**

Fig.4 presents the measured heterodyne spectrum. Due to unfavorable weather (80% of the observing time was lost) and technical problems the signal to noise ratio is worse than expected. For that reason only an upper limit of ~100 ppbV for the methane mixing ratio in the observed area (see Fig.3) can be deduced. Another interesting fact is, that we received less signal from Mars. An explanation of this could be, that the maximum transmission through the telluric atmosphere...
is less than the expected 20% at around 7.8 μm. Consequently we have to adopt our atmospheric model for future observations. At the conference we are going to present the analyzed data from this run and show an outlook.

References


