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High Spectral and Spatial Resolution Observation of Upper Atmospheres by IR Heterodyne Spectroscopy

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High resolution spectroscopy is a versatile tool to study planetary atmospheres. In the mid infrared wavelength regime the highest possible spectral resolution is provided by applying heterodyne techniques. At spectral resolution of more than 10^5 observations of fully resolved molecular features are possible allowing retrieval of many physical parameters from single lines. Due to the fact that many of the observed species are abundant also in the Earth's atmosphere, high resolution measurements allow to peak through the telluric features and lead to less ambiguity than low resolution data. In addition the high spatial resolution on the planetary disk intrinsic to infrared wavelengths compared to sub-mm observations enables unique ground-based studies of planetary atmospheres like Mars and Venus. A short description of the Cologne Tuneable Heterodyne Infrared Spectrometer - THIS and its specific application to the atmospheres of the terrestrial planets will be presented.

The Cologne Tunable Heterodyne Infrared Spectrometer - THIS [Sonnabend2008a] is one of worldwide two IR heterodyne systems presently used for astronomical studies. The accessible wavelength range is between 7 and 13 μ constrained by the laser technology employed in the local oscillator and available detector/mixers. Currently, tuneable Quantum Cascade Lasers are used as local oscillator and the detector is a Mercury-Cadmium-Telluride Photo Diode providing a bandwidth of $\sim$3000 MHz (3 dB cutoff). The spectral resolution is better than 3×10^7 which is not feasible with any direct detection method. The instrument consist of two parts: the optical receiver contains all the optical components and is housed in (80 x 60 x 45) cm^3 aluminum cube with a weight of approx. 80 kg. It can be attached to various telescopes (Coude, Nasmyth, Cassegrain) with different F-numbers between 10-60. The second part contains all the electronical equipment including the brick-end spectrometer an Acousto-Optical Spectrometer (AOS) and equipment for data acquisition.

In the atmospheres of Mars and Venus non-LTE processes lead to an enhanced mesospheric emission from CO_2 molecules in the 10 μm band. These very narrow emission features can be used to detect Doppler-shifts induced by winds with an accuracy down to 10 m/s [Sonnabend2006, Sornig2008]. Due to the small line width of the emission features ($\sim$25 MHz FWHM) a high spectral resolution of $\nu/\Delta\nu \sim 10^6$ is required. In addition to winds, temperatures can be extracted from the measured linewidths [Sonnabend2008b].

References

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