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THIS – Tuneable Heterodyne Infrared Spectrometer for high resolution infrared remote sensing

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A new infrared heterodyne instrument has been developed which uses tuneable quantum cascade lasers (QCL) as local oscillator (LO). The operating wavelength of the system is presently around 10 μm, while the IF-bandwidth is 1.4 GHz using an acousto-optical spectrometer (AOS) at a frequency resolution of 1.4 MHz. The IFbandwidth of the system is presently limited by the AOS bandwidth and the characteristics of the HgCdTe-mixer detector, but an extension to 3 GHz is in progress. A confocal Fabry-Perot type ring-resonator serves as an efficient diplexer to superimpose the LO and the signal radiation. Depending on availability of suitable mixers and lasers the operating range of THIS may extend from 3 to 30 μm. The observed system temperature of about 3000 K is only two times the quantum limit at 30 THz, which is identical with the performance of similar CO_2 laser pumped systems. The frequency of the QCL is locked to a resonance of the diplexer, which in turn is locked to a frequency stabilized HeNe laser. The resulting frequency stability over many hours is in the range of 1 MHz rms ($\nu/\Delta\nu \approx 3 \cdot 10^7$). The amplitude stability is demonstrated by means of Allan variance measurements with a minimum time above 50 sec. THIS is particularly useful for the detection of symmetric molecules like CH_4, C_2H_2, C_2H_4, …, since such important species are not detectable at mm/submm frequencies because of their missing permanent dipole moment. The instrument is fully transportable and can be attached to any infrared telescope.

As a first step measurements of Ozone in the Earth's atmosphere have been carried out. Also, first observations of signals from Mars and Venus have been made, which demonstrate the usefulness of THIS for planetary science. Using the narrow linewidth of the non-LTE emission of CO_2 on Mars, the wind speed in the upper atmosphere has been determined. Also, signals of molecules like Water and SiO have been detected in sun spots. Astronomical observations from ground-based infrared telescopes and the air-borne observatory SOFIA are planned for the future. Particularly observations of the very weak rotational quadrupole transitions of interstellar molecular Hydrogen at 17 or 28 μm are of high interest in astrophysics.