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# Compact Setup of a Heterodyne Infrared Spectrometer for Observation of Atmospheric Trace Gases

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## Abstract

Infrared heterodyne spectroscopy offers the capability of very high spectral resolving power (greater than $10^7$) combined with relatively high sensitivity. In addition the spatial resolution is inherently higher when compared to heterodyne observations at mm and submm wavelength. This high spectral and spatial resolution enables unique high sensitivity studies of the physical and chemical processes in planetary atmospheres through measurement of fully resolved lineshapes of transitions of molecular species.[1]

## 1. Introduction

Whenever highest spectral resolution is required heterodyne systems are advantageous because of their high optical throughput and compact instrument dimensions compared to direct detection methods like grating spectrometers or Fourier-Transform-Spectroscopy. Only two instruments worldwide are using heterodyne techniques for astronomical observations in the infrared wavelength: NASA GSFC's HIPWAC (Heterodyne Instrument for Planetary Winds And Composition) and THIS (Tuneable Heterodyne Infrared Spectrometer). The latter was designed and build by our group at University of Cologne and is the only astronomical receiver making use of newly developed tuneable quantum-cascade lasers (QCLs) as local oscillators (LOs) allowing us to target the whole mid-IR from 7 to 14 m wavelength [2]. The present dimensions of the receiver are about 80x80x45$cm^3$ and it weights 80kg.

### 1.1. Setup

Fig.1 shows the scheme of the future heterodyne receiver. In every heterodyne instrument the broadband radiation to be analyzed is superimposed to a monomode LO (blue) and focused to a fast detector. As a mixer we use a mercury-cadmium-telluride

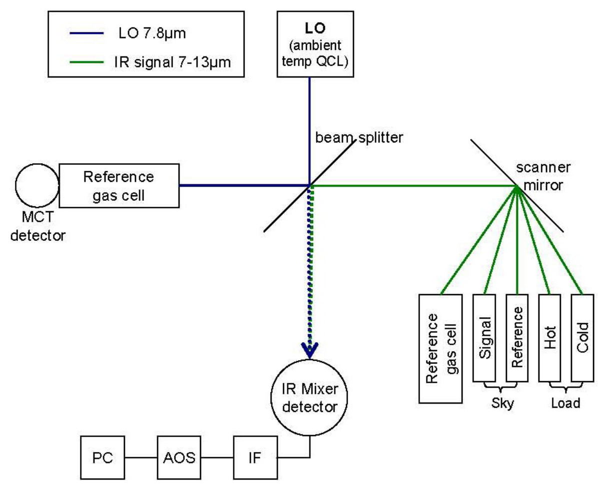


Figure 1: Schematic view of the new heterodyne receiver with beam splitter. The IR signal from the telescope or the calibration loads (green) is combined to the radiation from a suitable LO (red) and detected on a MCT mixer. Hereby a difference frequency signal is generated which is used for spectral analysis.

(MCT) photovoltaic detector with a quantum efficiency of up to 80%. The frequency analysis is done by a 6000 channel acousto-optical spectrometer (AOS) with a total bandwidth of 3 GHz.

The long-term objective is to reduce size and weight of the spectrometer to make it even more feasible for transportation and handling and as a breadboard for a possible flight instrument in the future. Therefore the beam combining subsystem will be composed of a ZnSe beam splitter which reflects ≈90% of the signal radiation and transmits ≈10% of the LO-beam towards the IR-detector. This path of ray leaves the opportunity to create a system for frequency stabilization of the LO as well as the determination of spetrca through a reference gas cell simultaneously. Therefore, and due to the great transmission losses at the beam splitter, this setup requires a powerful LO, which will be guaranteed by a peltier cooled room temperature QCL at 7.8 $\mu m$ with up to $100 mW$ power.

## 2. Outlook

The purpose of redesigning the instrument is to become more suitable for airborne platforms like SOFIA [3] or satellite missions like orbiters to Venus and Mars. Additionally ground-based observations of Mars and Venus as well as the outer planets and studies of the dynamical properties of the Earth' atmosphere will be a subject for future projects. Mid-IR observations allow measurements of Doppler-shifts of stratospheric ozone features as well as possibly the use of the same non-LTE features apparent on Mars and Venus.[4]

## References


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