Within the solar system Mars is the most Earth-like planet. Thus it is one of the very few we can study closely and learn about general laws regarding atmospheric behavior. Understanding the chemical and physical processes in Mars' atmosphere, including composition, temperature, winds and thermodynamic effects, is essential for the development of general circulation models (GCM) as well as for longterm climate predictions. By analyzing the line profiles of spectroscopic features originating in the atmosphere the abundance distribution of molecular species, important for the chemical and dynamical stability of the atmosphere can be deduced, and physical boundary conditions like temperature and wind speed can be derived. A requirement for this is the use of ultra high spectral resolution (>10^6) which can only be achieved in the infrared (IR) wavelength region by heterodyne spectroscopy. The principle behind this is quite simple: the broadband IR radiation to be analyzed is superimposed with a monochromatic emission source, the so called local oscillator (LO), and, while focused onto a photo mixer, it provides a radio-frequency signal which preserves the spectral information contained in the original IR signal.
Methane has been established to be present in the atmosphere of Mars in 2003 by Mumma et al. and is claimed by various groups who found strong variation with season, latitude and longitude. Almost all current detections of methane have been made around 3.3 µm. In the course of this thesis observations were performed using the Cologne Tuneable Heterodyne Infrared Spectrometer (THIS) to probe methane in Mars' atmosphere. The measurements were intended as first unambiguous test for the presence of methane on Mars at 7.8 µm wavelength.
Furthermore, I examined the method for retrieving temperatures of the mesosphere of Mars taking into account the influence of extended beam size of ground based observations and the variability of temperature/pressure profiles in the lower atmosphere based on satellite data and model calculations. Observations were carried out using THIS and the NASA/Goddard Heterodyne Instrument for Planetary Wind and Composition (HIPWAC).
The second part of this thesis deals with the development and evaluation of a Quantum Cascade Laser system with an external cavity (EC-QCL) used as LO, which yields a tunable, broadband laser source. Such a system will enable easy, efficient and economical investigations of molecular lines of different molecules compared to using DFB-QCLs. Primary goal is the detection of other molecules related to methane like SO_2 which can provide additional clues about the origins of methane as well as atmospheric boundary conditions.