Geophysical Research Abstracts
Vol. 12, EGU2010-13795, 2010
EGU General Assembly 2010

Using Infrared Laser Heterodyne Radiometry to Search for Methane in the Atmosphere of Mars

Richard Passmore (1), Neil Bowles (1), Damien Weidmann (2), and Kevin Smith (2)

(1) Atmospheric, Oceanic and Planetary Physics, Clarendon Laboratory, University of Oxford, Parks Road, Oxford. OX1 3PU. U.K. (passmore@atm.ox.ac.uk), (2) Space Science & Technology Department, STFC Rutherford Appleton Laboratory, Harwell Science & Innovation Campus, Didcot, Oxfordshire. OX11 0QX. U.K

Introduction

Methane has been detected in the atmosphere of Mars by several research teams in the last few years. Ground-based observations [1][2] and space-based instruments (e.g. the Planetary Fourier Transform spectrometer on Mars Express [3]) have reported low levels of methane gas (approximately 10 ppb) in the Martian atmosphere. Methane detection is important as its presence could imply a biological origin, and Martian methane sources are still unknown. However, current methane concentration measurements are at instruments' lower limits of detection.

The viability of remote sensing using infrared laser heterodyne radiometry (LHR) to detect methane in the Martian atmosphere is investigated. The LHR technique allows high spectral resolution (greater than 0.001 cm^{-1}) measurements over a narrow spectral range ($\sim$10 cm^{-1}) when a distributed feedback quantum cascade laser (QCL) is used as local oscillator. The advantages of such an instrument, including its compact lightweight design, over current remote sensing spectral instruments are reviewed.

The Laser Heterodyne Radiometer

Laser heterodyne radiometers have been used extensively, and with much success, for atmospheric studies such as work on stratospheric ozone [4], mainly because the ultrahigh spectral resolution of the instrument allows fully resolved narrow molecular absorption line-shapes, which contain information on vertical concentration profiles. It has been shown that a carefully selected specific high resolution micro-window provides as much vertical profile information as a medium resolution radiometer covering a broad spectral range [5]. In addition to the high spectral resolution, the LHR is also extremely compact and robust and so has a significant advantage when targeting specific trace species over larger instruments such as high-resolution Fourier Transform spectrometers.

Quantum Cascade Laser as Local Oscillator

At the heart of the current generation infrared LHR is the use of a Quantum Cascade Laser (QCL) as the local oscillator. QCLs are an ideal local oscillator for this instrument as they emit in the mid infrared region where molecular "fingerprints" lie, they provide the necessary optical power and have spectral purity in the kHz to MHz range [5]. They have the advantage of continuous frequency tuning over a specific spectral window that can be precisely tailored to specifications. They also have the advantage of being compact, robust and reliable devices which make them ideal candidates for flight and satellite deployment.

Instrument Development

Although heterodyne spectroscopy is not a new idea, recent advancements in local oscillator technology offer the possibility of significant instrument miniaturisation relevant to space deployment. We present our current work on the LHR which involves adapting an existing 10 μm laser breadboard design to operate at 7.7 μm in order to target the ν_4 fundamental band of methane. The optical and mechanical designs of the instrument, as well as an evaluation of the LHR's flight potential, are discussed.

References

[1] Krasnopolsky et al. (2004) *Icarus*, 172, 537-547. [2] Mumma et al. (2009) *Science*, 323, 1041. [3] Formisano

et al. (2004) *Science*, 306, 1758-1761. [4] Weidmann et al. (2007c) *Applied Optics*, 46, 7162-7171. [5] Weidmann et al. (2007b) *Review of Scientific Instruments*, 78, 73107.