



UNIVERSITY OF LEEDS

This is a repository copy of *Broadband terahertz gas spectroscopy through multimode self-mixing in a quantum cascade laser*.

White Rose Research Online URL for this paper:  
<http://eprints.whiterose.ac.uk/152703/>

Version: Accepted Version

---

**Conference or Workshop Item:**

Han, YJ [orcid.org/0000-0003-2141-3077](https://orcid.org/0000-0003-2141-3077), Partington, J, Valavanis, A  
[orcid.org/0000-0001-5565-0463](https://orcid.org/0000-0001-5565-0463) et al. (13 more authors) (2018) Broadband terahertz gas spectroscopy through multimode self-mixing in a quantum cascade laser. In: NATO Advance Research Workshop on Terahertz (Thz), Mid InfraRed (MIR) and Near InfraRed (NIR) Technologies for Protection of Critical Infrastructures against Explosives & CBRN, 05-09 Nov 2018, Liblice, Czech Republic.

---

This is the author's version of an abstract of a presentation made at the NATO Advance Research Workshop on Terahertz (Thz), Mid InfraRed (MIR) and Near InfraRed (NIR) Technologies for Protection of Critical Infrastructures against Explosives & CBRN.

**Reuse**

Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

**Takedown**

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing [eprints@whiterose.ac.uk](mailto:eprints@whiterose.ac.uk) including the URL of the record and the reason for the withdrawal request.



[eprints@whiterose.ac.uk](mailto:eprints@whiterose.ac.uk)  
<https://eprints.whiterose.ac.uk/>

# Broadband terahertz gas spectroscopy through multimode self-mixing in a quantum cascade laser

Y. J. Han<sup>1,\*</sup>, J. Partington<sup>1</sup>, A. Valavanis<sup>1</sup>, R. Chhantyal-Pun<sup>1</sup>, M. Henry<sup>2</sup>, O. Auriacombe<sup>2</sup>, T. Rawlings<sup>2</sup>, L. H. Li<sup>1</sup>, J. Keeley<sup>1</sup>, M. Oldfield<sup>2</sup>, N. Brewster<sup>2</sup>, D. Rui<sup>1</sup>, P. Dean<sup>1</sup>, A. G. Davies<sup>1</sup>, B. N. Ellison<sup>2</sup> and E. H. Linfield<sup>1</sup>

<sup>1</sup> School of Electronic and Electrical Engineering, University of Leeds, Leeds LS2 9JT, UK

<sup>2</sup> Rutherford Appleton Laboratory, STFC, Harwell Oxford, Didcot OX11 0QX, UK

y.han@leeds.ac.uk

In the terahertz (THz) frequency range, CBRN agents and explosives have unique spectral signatures, which can be used for their identification and analysis. Quantum cascade lasers (QCLs) are important sources for spectroscopy within the 2–5 THz range, and self-mixing (SM) interference in a laser cavity enables the laser device to act both as a radiation source and as a coherent detector. This technique removes the need for additional detectors [1, 2]. Here, we present a SM spectroscopy technique, with an integrated frequency monitoring system and demonstrate the measurement of methanol spectral features simultaneously from two modes of a multi-mode THz QCL over a 17 GHz bandwidth.

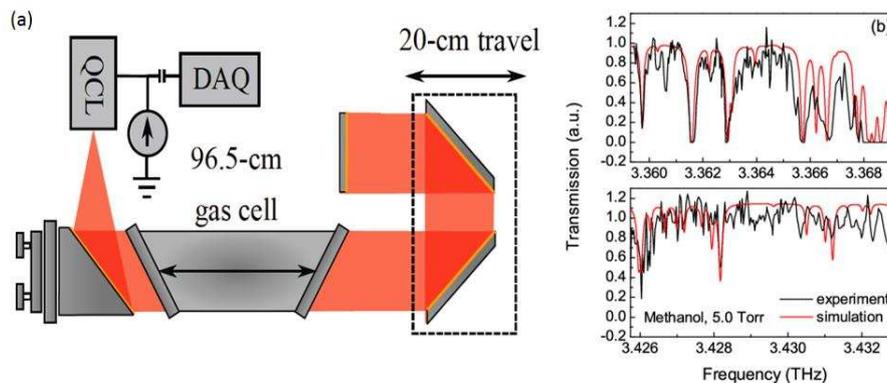


Fig1. (a) Schematic illustration of the configuration of the gas spectroscopy system. (b) Transmission spectra of 5.0-Torr methanol.

The optical configuration of the spectroscopy system is illustrated in Fig. 1(a). The emitted radiation from the QCL was directed through a 96.5-cm-long gas cell and was reflected back using a mechanically-adjustable optical delay-line into the QCL along the same optical path. The SM-perturbations to the QCL voltage were measured as a function of the optical delay time, and a Fast Fourier Transform (FFT) was used to infer the full-band emission spectra of the QCL. Normalized transmission spectra of methanol at a pressure of 5.0 Torr are shown in Fig. 1(b). More than seven absorption peaks were resolved within a 17-GHz range, among which the absorption at 3.3597 THz, 3.3616 THz, 3.3629 THz, and 3.4282 THz were the most clearly resolved.

Acknowledgment: Research supported by UK Centre for Earth Observation Instrumentation (RP10G0435A03); European Space Agency (GSTP 4000114487/15/NL/AF); Royal Society (WM150029); Engineering and Physical Sciences Research Council (EPSRC) (EP/J017671/1, EP/P021859/1); European Research Council (ERC) (THEMIS 727541).

## References

- [1] T. Hagelschuer et al, Appl. Phys. Lett. 109, 191101 (2016).
- [2] R. Chhantyal-Pun et al, Opt. Lett. 43, 2225 (2018).