

# David Burghoff

## Curriculum Vitae

Massachusetts Institute of Technology  
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### EDUCATION

- 2014            **Ph.D., Electrical Engineering and Computer Science**  
**Massachusetts Institute of Technology**  
Thesis: Broadband Terahertz Photonics  
Committee: Qing Hu (advisor), Erich Ippen, Keith Nelson  
GPA: 5.0/5.0, Minor in Neurobiology
- 2009            S.M., Electrical Engineering and Computer Science  
Massachusetts Institute of Technology  
GPA: 5.0/5.0, Advisor: Qing Hu
- 2007            B.S., Electrical and Computer Engineering (Highest Honors)  
University of Illinois at Urbana Champaign  
GPA: 3.94/4.0, Minor in Physics

### PROFESSIONAL APPOINTMENTS

- 2014-present    **Postdoctoral Associate, Research Scientist, and Postdoctoral Fellow**  
**Massachusetts Institute of Technology**  
PI: Qing Hu, Collaborators: Jacob Khurgin (*Johns Hopkins*), John Reno (*Sandia*),  
Gerard Wysocki (*Princeton*), Christian Jirauschek (*TU Munich*), J-R. Gao (*TU Delft*)

### RESEARCH EXPERIENCE

- 2015-present    **Terahertz laser dual comb spectroscopy**
- By using two semiconductor frequency combs, demonstrated high-speed broadband dual comb spectroscopy at terahertz wavelengths, in a system with only chip-sized active components and no moving parts
  - Developed a novel signal processing algorithm that allowed for perfect phase correction of a multiheterodyne signal; signal processing requires no additional hardware and makes dual comb technique much more practical
  - Collaborated with spectroscopists to perform molecular spectroscopy
- 2014-present    **Terahertz laser frequency combs**
- Demonstrated first dispersion compensation in quantum cascade lasers, which,

in concert with nanostructure engineering, allowed them to passively form frequency combs at terahertz frequencies for the first time

- Showed that combs could also be used as heterodyne detectors, eliminating need for another detector
- Developed SWIFT spectroscopy, a non-autocorrelative spectroscopic technique for measuring the coherence and temporal profile of frequency combs whose time-domain profiles are not pulse-like
- Collaborated with theorists to perform detailed modeling of comb dynamics

2014-present

**Optomechanically-tuned quantum cascade lasers**

- Using an integrated MEMS comb drive, created first broadly continuously electrically tunable terahertz lasers (7% of laser frequency)
- Also used MEMS to tune the output of mid-infrared quantum cascade laser frequency combs

2010-present

**Ultrafast spectroscopy of intersubband nanostructures**

- Integrated photoconductive antennas with intersubband nanostructures to probe light-matter interaction with broadband terahertz pulses
- Used technique to measure gain and loss of quantum cascade laser structures, mechanisms affecting temperature performance, and waveguide dispersion

**PUBLICATIONS**

2017 D. Burghoff, T. Zeng, Y. Yang, J. L. Reno, Q. Hu, “Optomechanical tuning of mid-infrared quantum cascade laser combs,” in preparation (2017).

2017 Y. Yang, D. Burghoff, J. Reno, and Q. Hu, "Achieving comb formation over the entire lasing range of quantum cascade lasers," *Optics Letters* 42, 3888 (2017).

2017 N. Henry, D. Burghoff, Y. Yang, Q. Hu, J. B. Khurgin, “Pseudorandom dynamics of frequency combs in free-running quantum cascade lasers,” *Optical Engineering* 57, 1 (2017).

2017 P. Tzenov, D. Burghoff, Q. Hu, C. Jirauschek, “Analysis of Operating Regimes of Terahertz Quantum Cascade Laser Frequency Combs,” *IEEE Transactions on Terahertz Science and Technology* 7, 351–359 (2017).

2016 D. Burghoff, Y. Yang, J. L. Reno, and Q. Hu, “Dispersion dynamics of quantum cascade lasers,” *Optica* 3, 2334-2536 (2016).

2016 D. Burghoff<sup>†</sup>, Y. Yang<sup>†</sup>, and Q. Hu, “Computational multiheterodyne spectroscopy,” *Science Advances* 2, e1601227 (2016).

2016 D. Burghoff, Y. Yang, and Q. Hu, “Computationally-enabled multiheterodyne spectroscopy,” U.S. Patent Application No. 15/259,687 (2016).

2016 P. Tzenov, D. Burghoff, Q. Hu, C. Jirauschek, “Time domain modeling of terahertz quantum cascade lasers for frequency comb generation,” *Optics Express* 24, 23232-23247 (2016).

- 2016 Y. Yang<sup>†</sup>, D. Burghoff<sup>†</sup>, D. J. Hayton, J-R. Gao, J. L. Reno, and Q. Hu, “Terahertz multiheterodyne spectroscopy using laser frequency combs,” **Optica** 3, 499 (2016). (**Optica Top Download, Optica Special Collection on Frequency Combs, media coverage**)
- 2015 D. Burghoff, Y. Yang, D. J. Hayton, J-R. Gao, J. L. Reno, and Q. Hu, “Evaluating the coherence and time-domain profile of quantum cascade laser frequency combs,” *Optics Express* 23, 1190–1202 (2015).
- 2014 D. Burghoff, T-Y. Kao, N. Han, C. W. I. Chan, X. Cai, Y. Yang, D. J. Hayton, J-R. Gao, J. L. Reno, and Q. Hu, “Terahertz laser frequency combs,” **Nature Photonics** 8, 462–467 (2014). (**Cover article, media coverage**)
- 2014 N. Han, A. de Geofroy, D. Burghoff, C. W. I. Chan, A. W. M. Lee, J. L. Reno, and Q. Hu, “Broadband all-electronically tunable MEMS terahertz quantum cascade lasers,” *Optics Letters* 39, 3480–3483 (2014).
- 2012 D. Burghoff, C. Wang Ivan Chan, Q. Hu, and J. L. Reno, “Gain measurements of scattering-assisted terahertz quantum cascade lasers,” *Applied Physics Letters* 100, 261111–4 (2012).
- 2012 A. Wei Min Lee, T-Y. Kao, D. Burghoff, Q. Hu, and J. L. Reno, “Terahertz tomography using quantum-cascade lasers,” *Optics Letters* 37, 217–219 (2012).
- 2011 D. Burghoff, T-Y. Kao, D. Ban, A. W. M. Lee, Q. Hu, and J. Reno, “A terahertz pulse emitter monolithically integrated with a quantum cascade laser,” *Applied Physics Letters* 98, 061112 (2011).

<sup>†</sup> indicates equal contributions

## SELECTED AWARDS AND HONORS

- 2017 Intelligence Community Postdoctoral Research Fellowship  
Awarded by Office of the Director of National Intelligence (ODNI) and the U.S. Department of Energy (DOE)
- 2014 Jin-Au Kong Outstanding Doctoral Thesis Award, first place  
Awarded by Department of Electrical Engineering and Computer Science at Massachusetts Institute of Technology for best PhD thesis in EE
- 2006 Vodafone Undergraduate Full Scholarship  
Awarded by Vodafone Group
- 2004-2007 James Scholar, Chancellor’s Scholar, Eta Kappa Nu, Dale and Wanda Weaver Scholarship, Frank Mock Scholarship, State of Missouri Robert C. Byrd Scholarship

## INVITED TALKS

- 2017 “Chip-scale terahertz frequency combs and multiheterodyne spectroscopy,” OSA Webinar, December 2017.

- 2017 “Terahertz Quantum Cascade Laser Combs and Multiheterodyne Spectroscopy,” OSA Advanced Photonics Congress, Optical Sensors, July 2017.
- 2017 “Terahertz quantum cascade laser combs and multiheterodyne spectroscopy,” Terahertz Science and Technology Mansion Meeting, May 2017.
- 2017 “Terahertz quantum cascade laser frequency combs,” Conference on Lasers and Electro-Optics, May 2017.
- 2017 “Chip-scale frequency combs and nonlinear optics in quantum cascade lasers,” MIT Applied Physics seminar, March 2017.
- 2016 “Terahertz quantum cascade laser frequency combs: spectroscopy and physics,” Lincoln Laboratory seminar, November 2016.
- 2015 “Terahertz quantum cascade laser frequency combs for compact spectroscopy,” RIEC-RLE meeting, October 2015.
- 2014 “Terahertz quantum cascade laser frequency combs,” International Quantum Cascade Lasers School & Workshop, September 2014.
- 2013 “Terahertz laser frequency combs,” University of Massachusetts Boston seminar, November 2013.

## **CONTRIBUTED TALKS**

- 2017 L. Sterczewski, J. Westberg, Y. Yang, D. Burghoff, J. L. Reno, Q. Hu, G. Wysocki, “Terahertz Multiheterodyne Spectroscopy With Quantum Cascade Lasers – A Feasibility Study,” International Conference on Infrared, Millimeter and Terahertz Waves (September 2017).
- 2017 Jacob B Khurgin, Nathan Henry, D. Burghoff, Y. Yang, Q. Hu, “Temporal Dynamics of QCL frequency combs,” International Conference on Intersubband Transitions in Quantum Wells (September 2017).
- 2017 J. Westberg, L. Sterczewski, L. Patrick, Y. Yang, D. Burghoff, J. L. Reno, Q. Hu and G. Wysocki, “Terahertz multiheterodyne spectroscopy of molecular samples with quantum cascade laser frequency combs,” International Conference on Intersubband Transitions in Quantum Wells (September 2017).
- 2017 Y. Yang, D. Burghoff, J. L. Reno, Q. Hu, “Full dynamic range comb formation in terahertz quantum cascade lasers,” International Conference on Intersubband Transitions in Quantum Wells (September 2017).
- 2017 Y. Yang, D. Burghoff, J. L. Reno, and Q. Hu, “Fully Dispersion Compensated THz Quantum Cascade Laser Frequency Combs,” Conference on Lasers and Electro-Optics (May 2017).
- 2016 Y. Yang, D. Burghoff, J. L. Reno, and Q. Hu, “Pulsed THz dual-comb spectroscopy using quantum cascade laser combs,” International Quantum Cascade Lasers School and Workshop (September 2016).

- 2016 P. Tzenov, D. Burghoff, Q. Hu, and C. Jirauschek, "Temporal dynamics of THz quantum cascade laser frequency combs with strong injector anticrossing", International Conference and School on Quantum Electronics: Laser Physics and Applications (September 2016).
- 2016 P. Tzenov, D. Burghoff, M. Riesch, Q. Hu, and C. Jirauschek, "Coupled transmission line-Maxwell Bloch simulation approach for analysis of active mode locking in terahertz quantum cascade lasers," International Quantum Cascade Lasers School and Workshop (September 2016).
- 2016 Y. Yang, D. Burghoff, J. L. Reno, and Q. Hu, "Computational-assisted THz dual-comb spectroscopy using quantum cascade laser frequency combs," Conference on Lasers and Electro-Optics (May 2016).
- 2016 P. Tzenov, D. Burghoff, Q. Hu, and C. Jirauschek, "Analysis of operating regimes of terahertz QCL frequency combs," International Quantum Cascade Lasers School and Workshop (September 2016).
- 2015 D. Burghoff, Y. Yang, J. L. Reno, and Q. Hu, "Coherent breathing of laser modes in terahertz quantum cascade lasers," International Conference on Intersubband Transitions in Quantum Wells (September 2015).
- 2015 Y. Yang, D. Burghoff, J. L. Reno, and Q. Hu, "Towards THz dual-comb spectrometer based on quantum cascade laser frequency combs," International Conference on Intersubband Transitions in Quantum Wells (September 2015).
- 2015 D. Burghoff, Y. Yang, D. J. Hayton, J-R. Gao, J. L. Reno, and Q. Hu, "Evaluating the temporal profile of quantum cascade laser frequency combs," Conference on Lasers and Electro-Optics (May 2015).
- 2014 D. Burghoff, T-Y. Kao, N. Han, C. W. I. Chan, X. Cai, Y. Yang, D. J. Hayton, J-R. Gao, J. L. Reno, and Q. Hu, "Development of terahertz laser frequency combs," Conference on Lasers and Electro-Optics (May 2014).
- 2013 D. Burghoff, N. Han, T-Y. Kao, D. Levonian, Q. Hu, and J. L. Reno, "Evidence of comb formation in terahertz quantum cascade lasers," International Conference on Intersubband Transitions in Quantum Wells (September 2013).
- 2013 N. Han, Chun Wang I. Chan, David P. Burghoff, Alan Wei Min Lee, T-Y. Kao, Q. Hu, and John L. Reno, "Broadband Electrically-Tunable Terahertz Quantum Cascade Lasers," International Conference on Intersubband Transitions in Quantum Wells (September 2013).
- 2011 D. Burghoff, T-Y. Kao, A. W. M. Lee, C. W. I. Chan, S. Kumar, J. L. Reno, and Q. Hu., "Gain measurements of terahertz quantum cascade lasers with metal-metal waveguides using mode-matched emitters," International Conference on Intersubband Transitions in Quantum Wells (September 2011).
- 2011 A. W. M. Lee, T-Y. Kao, D. Burghoff, Q. Hu, and J. L. Reno, "THz optical coherence tomography based on quantum cascade lasers," International Conference on Infrared, Millimeter and Terahertz Waves (September 2011).

2011 D. Burghoff, T-Y. Kao, A. W. M. Lee, C. W. I. Chan, D. Ban, S. Kumar, J. L. Reno, and Q. Hu., "Gain measurements of terahertz quantum cascade lasers using integrated terahertz pulse emitters," Conference on Lasers and Electro-Optics (May 2011).

## **TEACHING EXPERIENCE**

2014-present **Massachusetts Institute of Technology**  
Mentor to graduate students Yang Yang and Tianyi Zeng

2010-2014 **Massachusetts Institute of Technology, Teaching Assistant**  
Physics for Solid-State Applications (Spring 2010, partial Spring 2012, Spring 2014)

2005 **University of Illinois at Urbana-Champaign**  
Undergraduate homework tutor (Fall 2005)

## **RESEARCH GRANTS**

2017 Chip-scale spectrometer based on quantum cascade laser frequency combs (sole author)  
Oak Ridge Institute for Science and Education (ORISE)

2014 Monolithic THz and LWIR QCL frequency combs for threat detection and identification (major contributor)  
Defense Advanced Research Projects Agency (DARPA)

2014 Development of THz Laser Frequency Combs (major contributor)  
National Science Foundation (NSF)

## **PROFESSIONAL & COMMUNITY SERVICE**

2018 Program committee, International Quantum Cascade Laser School and Workshop 2018

2015 Session presider, CLEO 2015

2015 Organizing committee, Research Laboratory of Electronics Photonics Immersion

2011-present Journal reviewer (23 manuscripts)  
Nature Photonics (3), Optica (3), Nature Communications (1), ACS Photonics (1), Applied Physics Letters (5), Optics Letters (2), Optics Express (7), Sensors (1)

2009-present Member of OSA, IEEE, and IEEE Photonics Society