Workshop on TeraHertz
Lille University-Ghent University

Tuesday, March, 10, 2015	
10:15 to 10:25	Arrival
10:25 to 10:30	Dr. Mathias Vanwolleghem: Introduction to the Workshop.
10:30 to 11:00	Prof. Erwin Bente: Integrated dual wavelength semiconductor lasers for millimetre wave generation.
11:00 to 11:30	Prof. Guillaume Ducournau: THz communication using UTC-PD devices.
11:30 to 12:00	Dr. Bart Kuyken: An integrated Silicon platform for the Terahertz spectral region.
12:00 to 12:30	Dr. Raffaele Colombelli: THz quantum cascade lasers: a playground for advanced "photonic" concepts.
12:30 to 13:30	Lunch
13:30 to 14:00	Prof. Laurent Margules: Terahertz spectroscopy in the gas phase of molecules with astrophysic interest
14:00 to 14:30	Prof. Francis Hindle: Construction and application of high-resolution THz spectrometers to gas analysis
14:30 to 15:00	Prof. Johan Stiens: GHz-THz wave sensing and imaging activities @ ETRO-VUB
15:00 to 15:15	Break
15:15 to 15:45	Dr. Juliette Mangeney: Terahertz Generation from Graphene Excited by Femtosecond Optical Pulses at Room Temperature
15:45 to 16:15	Dr. Stefano Barbieri Investigating the coherence properties of terahertz quantum cascade lasers with fs-laser combs
16:15 to 16:45	Dr. Pascal Szriftgiser: Brillouin fiber laser for highly coherent thz wave generation: perspectives in free space ultra-high rate communications

16:45 to 17:00	Break
17:00 to 18:00	Discussion

10:30-11:00: Integrated dual wavelength semiconductor lasers for millimetre wave generation.

Prof. Erwin Bente

Technische Universiteit Eindhoven, COBRA Research Institute

In the framework of the FP7 iPHOS project the optical generation of millimetre waves for datacommunication using semiconductor lasers has been studied and integrated devices have been realised in InP based technology. After a brief overview of the project, results on lasers that support two wavelengths in the cavity will be discussed.

11:00-11:30: THz communication using UTC-PD devices.

Prof. Guillaume Ducournau

Institut d'Electronique, de Microélectronique et de Nanotechnologie UMR CNRS 8520

Polytech Lille, Université Lille 1

With the mass development of mobile data transfers, wireless communications have recently entered a new area: the carrier frequency which is now entering the THz region. After a brief overview of context, and key features of THz communication, focus is given on photonic-based THz emitters based on quasi-optic UTC-PDs. A special design of wideband photomixer is presented and its applications for narrow bandwidth THz generation and communication links at 200, 400 and 600 GHz.

11:30-12:00: An integrated Silicon platform for the Terahertz spectral region.

Dr. Bart Kuyken

Ghent University

The integration of photonic components has been enormously beneficial for applications in the field of telecommunication. The silicon-on-insulator (SOI) platform has become the dominant platform for integrated optics, due to its CMOS compatible fabrication process. More recently researchers have demonstrated the use of the chip in other sensor-oriented applications. It is envisaged that an SOI inspired platform for the THz wavelength could allow the integration of e.g. THz gas sensors on a silicon chip. In the presentation first proof of concept results will be shown. The fabrication and demonstration of chip scale low loss terahertz dielectric waveguides, consisting out of high resistivity silicon as a core material, will be discussed.

12:00-12:30: THz quantum cascade lasers: a playground for advanced "photonic" concepts

Dr. Raffaele Colombelli

Institut d'Electronique Fondamentale - UMR8622 CNRS

Université Paris-Sud

Quantum cascade lasers are versatile semiconductor laser sources which are able to cover the mid-infrared and THz ranges of the electromagnetic spectrum. They owe their appealing characteristics (for instance wavelength agility, output power…) to powerful electronic-band engineering concepts.

Very recently, the application of photonic-band engineering techniques has permitted the development of novel electromagnetic resonators which – in combination with quantum cascade lasers – has led to their further improvement. In particular in the THz range of the electromagnetic spectrum, the use of metallic resonators is particularly promising.

In the first part of the talk, I will review these developments, together with the issues that photonic-band engineering allows to address and solve. I will discuss the possible application potential.

In the second part of the talk, I will discuss a more fundamental issue. Most of the devices producing electromagnetic radiation belong to one of two distinct worlds. The world of electronic devices, where radiation is produced by accelerated electrons and coupled to real electronic currents (antennas, radars...). And the one of photonic devices, where photons are coupled to quantum transitions (atomic lasers, semiconductor LEDs and lasers). These two worlds are separated in frequency, but this separation is unfortunate for applications, since each of the device families has peculiar functionalities which would benefit the other one.

The unification/hybridization of these two frameworks would permit the demonstration of optoelectronic devices with previously unavailable functionalities. I will show that, at least in the THz range, the development of hybrid photonic-electronic devices is indeed possible. In particular, I will discuss how to reach this goal relying on the development of novel architectures borrowing concepts from meta-material science.

13:30-14:00: Terahertz spectroscopy in the gas phase of molecules with astrophysic interest

Prof. Laurent Margules

Laboratoire de Physique des Lasers, Atomes et Molécules PHLAM CNRS 8523

Université Lille 1

The Terahertz domain is particularly interesting for spectroscopy of astrophysics interest species since the rotational spectra of complex organic molecules l have their absorption maximum in this range. Up to few years ago the source commonly used in terahertz domain were the backward wave oscillators. These radiation sources provide relatively high output power (several milliwatts) in the frequency range up to 1.2 THz However the BWOs are not easy to handle: they need high voltage supply (2 - 6 kV), water cooling, magnetic field up to 1 Tesla, and a phase locked loop to give accurate frequency measurements.

With the arrival of telescopes working in the THz range, great improvements were achieved in the development of solid state devices based on Schottky diodes. The new spectrometer in Lille take advantage of this development and is now based on a frequency multiplication chain using these devices. The spectrometer covers more than 80% of the frequency range 0.05 - 1.5 THz, and we need about 150 hours to record the spectra in this range with high resolution.

We will present two short-term projects for the spectrometer. The first one is to increase the frequency range up to 1.9 THz in order to have the full coverage of Herschel telescope. The second one is to speed up the experimental setup.

14:00-14:30 Construction and application of high-resolution THz spectrometers to gas analysis

Prof. Francis Hindle

Université du Littoral Côte d'Opale

Numerous THz spectrometers have been developed and are routinely used for high resolution studies of gases. An opto-electronic conversion is used to cover the range from 300 GHz to 3 THz, while a frequency comb provides an excellent metrology of the measured line positions. An amplified frequency multiplication chain provides a practical solution for frequencies below 1 THz. The simplicity and accessibility of this solution has allowed a wider range of applications to be undertaken such as analysis of industrial emissions and real time measurement of photolysis products.

14:30-15:00 GHz-THz wave sensing and imaging activities @ ETRO-VUB

Prof. Johan Stiens

Vrije Universiteit Brussel

In this presentation we will give an overview of the various sensor and imaging applications in the GHz-THz EM spectrum under development in the Electronics and Informatics department (ETRO-IR-VUB) @ VUB (University of Brussels). The group is working on the electromagnetic design of sensors, the assemblage of sensor and imaging systems, and the post-processing of data (e.g. inverse problem solving, compressive sensing). The results of a few sensors, including high-Q resonators, meta-material sensors or sub-wavelength radar and sub-wavelength near-field sensors will be discussed. With some of our sensor designs we achieve world record sensitivities. As the sensor applications under development are in various industrial domains ranging from the food (drying), biotech (measurements of bio-molecular concentrations and interactions in nano-liter liquids) and pharmaceutical (chromatography,…) industry, there is a need for strong collaboration with inter-disciplinary teams. We will discuss a few examples where simulations of other domains support our sensor signals. In a second part of the presentation we will reveal the benefits of graphene in the sub-THz domain for the development of novel amplitude, phase modulators, sensors,…

15:15-15:45 Terahertz Generation from Graphene Excited by Femtosecond Optical Pulses at Room Temperature

Dr. Juliette Mangeney

Laboratoire Pierre Aigrain - UMR 8551

Ecole Normale Supérieure Paris

We will present coherent THz emission from graphene excited by femtosecond optical pulses via dynamical photon drag effect. This second-order nonlinear effect relies on the transfer of light momentum to the carriers by the ponderomotive electric and magnetic forces. Our experimental and theoretical study highlights the key roles of next-C-neighbor couplings and of unequal electron and hole lifetimes in the observed second-order response. Finally, our results indicate that dynamical photon drag effect in graphene can provide emission up to 60 THz, opening new routes for the generation of ultra-broadband terahertz pulses at room temperature.

15:45-16:15 Investigating the coherence properties of terahertz quantum cascade lasers with fs-laser combs

Dr. Stefano Barbieri

Laboratoire Matériaux et Phénomènes Quantiques, Université Paris-Diderot and

CNRS

A near-infrared fs-laser comb in combination with electro-optic mixing can be used to generate a multi-line THz heterodyne receiver spanning a bandwidth of several THz. The use of a fast balanced detection allows the achievement of broad IF bandwidths (>1GHz) with a shot noise limited detection sensitivity. This presentation will overview the application of this coherent detection technique to THz quantum cascade lasers, from early results up to the most recent progress [1]. A special emphasis will be given to the investigation of the coherence properties of this class of lasers, from the characterization of their frequency noise spectral density [2], their mode-locking operation [3], to the properties of recently demonstrated multimode lasers with a spectral bandwidth beyond 1THz [4].

[1] Sirtori et al. Nature Photon. 7, 691 (2014)
[2] Ravaro et al. Opt. Expr. 5, 25654 (2012)
[3] Barbieri. et al. Nature Photon. 5, 306-313 (2011)
[4] M. Rösch, et al. Nature Photon. **9**, 42 (2015).

16:15-16:45 Brillouin fiber laser for highly coherent thz wave generation: perspectives in free space ultra-high rate communications

Dr. Pascal Szriftgiser

Laboratoire de Physique des Lasers, Atomes et Molécules (PhLAM), UMR CNRS 8523, Université Lille 1

Free space communications with huge data capacity have become a key point for the development of mobile access, services, and network technologies convergence. Wireless links using emerging terahertz technologies is an intensive research field since waves at the millimeter/submillimeter frontier remain more robust in terms of scintillation, dielectric obstacles, and fog compared with near-infrared signals. Moreover the electromagnetic spectrum at low frequencies (< 100 GHz) is almost saturated while there is the opportunity for very wide bandwidth transmission in the THz window [1]. Modern vector modulation formats require highly coherent low phase noise sources. We here show that thanks to photo-mixing, Brillouin fiber laser can provide tunable highly coherent THz wave sources [2]. Compared to electronic frequency multiplication, there is hardly no phase noise degradation. Linewidth below 100 Hz have been observed and emission up-to 1 THz has also been demonstrated. Recent developments and perspectives will also be presented.

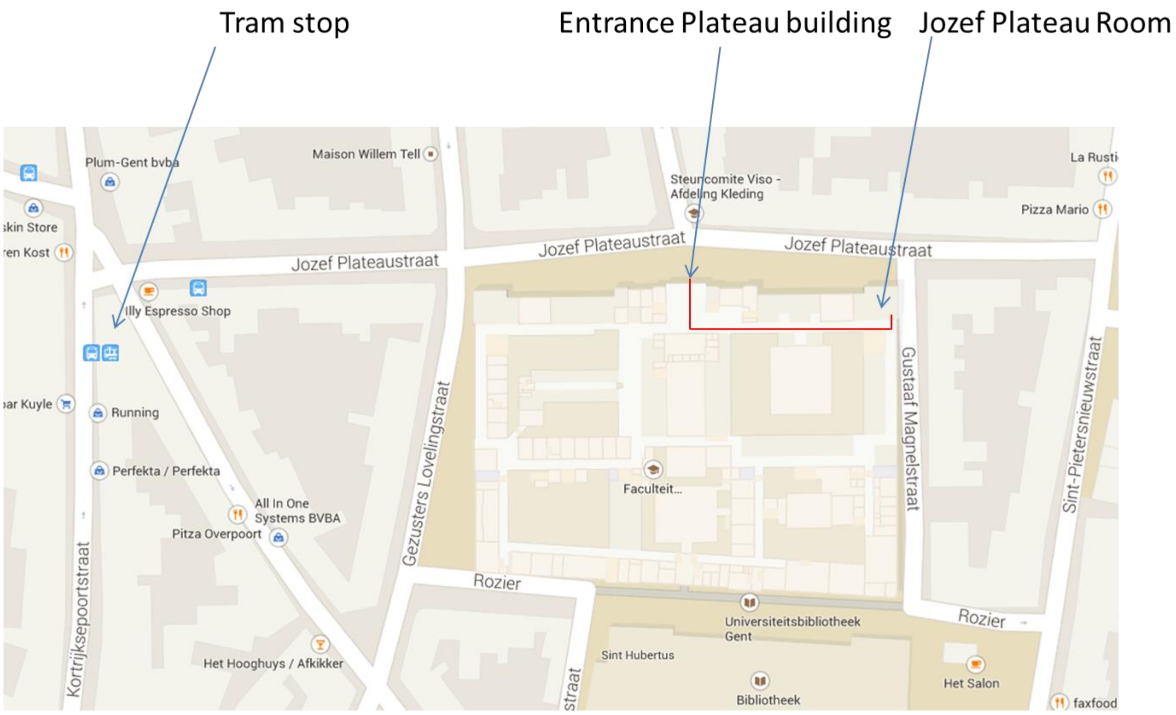
[1] *Ultra wide bandwidth single channel* 0.4 THz *wireless link combining Broadband quasioptic Photomixer and coherent detection*, G. Ducournau, P. Szriftgiser, A. Beck, D. Bacquet, F. Pavanello, E. Peytavit, M. Zaknoune, T. Akalin1, and J.-F. Lampin, Terahertz Science and Technology, IEEE Transactions on, **4**, 328 – 337 (2014).

[2] *Highly coherent terahertz wave generation with a dual-frequency Brillouin fiber laser and a 1.55 µm photomixer*, G. Ducournau, P. Szriftgiser, T. Akalin, A. Beck, D. Bacquet, E. Peytavit and J.F. Lampin, Optics Letters **36**, 2044 (2011).

How to reach the venue

Address:

Jozef Plateau Zaal/Jozef Plateau Room
Faculty of Engineering Jozef Plateau Building
Jozef Plateaustraat 22,
9000 Gent



By Train: train to Gent-Sint-Pieters

- Taxi drive: from the Gent-Sint-Pieters train station to the Jozef Plateaustraat is about 5 minutes
- Tram 1: leaves every 6 minutes from Gent-Sint-Pieters
  - Take tram 1 direction Evergem or Wondelgem or Korenmarkt.
  - Get off at Gent-Verlorenkost (4 stops)
  - Walk up Jozef-Plateaustraat (see map)