

## Master and Engineer Internship: 2020-2021

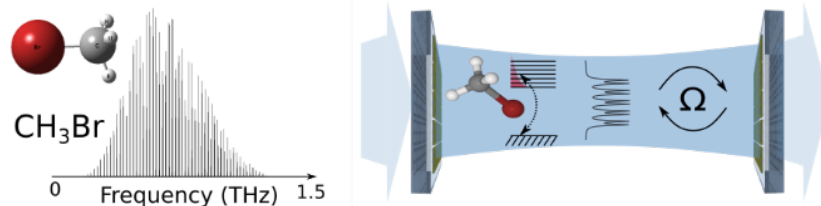
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### Title: Using strong coupling to detect gas traces in the THz

**Abstract** Halogen (ie  $\text{CH}_3\text{X}$ ;  $\text{OX}$  and  $\text{HX}$ ;  $\text{XX}$  being  $\text{Cl}$ ,  $\text{I}$  or  $\text{Br}$ ) gas are produced by numerous industries, oceans and several other bio systems. During the past decades, researchers demonstrated their major role in the atmosphere. They act on pollutants and particles through reactional cycles and are involved in the radiative forcing. They are major players of the Earth's energy budget and global warming. Still, today no technics exist able to measure these species at realistic concentration in real time.

In this multidisciplinary internship, we propose to implement an innovative physical concept shown on figure 1: coupling of the molecular frequency comb of a halogen gas as to the optical frequency comb of Fabry-Perot cavity. This coupling will enhance the light matter interaction and consequently enable to detect extremely small concentration of gas. We will probe this system using [terahertz time domain spectroscopy](#) (TDS) and a dedicated algorithm developed in the team to the study of gas by TDS.



*Figure 1 : Left, molecular frequency comb (MFC) of bromomethane given as an example (changing the halogen will not change much the spectrum; other radicals change the spectrum but keep the comb behavior). Right the cavity made by two facing metasurface mirrors building the optical frequency comb (OFC) and enabling the coupling between the OFC and the MFC*

The goal of this research internship is to launch this study. The student will have to take over several of the many aspects gradually. The student will have to pick two tasks on which he/she will spend most of his/her time.

The student will work with a team of experienced researchers in the THz-Photonics group at IEMN Laboratory (<https://photoniquethz.univ-lille.fr/en/>). The group has a long lasting experience in the conception and realization of THz optoelectronic devices, and is fully equipped to carry out this project. We are looking for physics or engineering master student or equivalent. Having one of the following skills would greatly increase the chance of success of any application:

- Coding (python) or algorithmic / optimization
- Optical experiments or spectroscopy
- Photonics/electromagnetic simulation

The exact tasks in which the student will be involved will be discussed together with him/her and the team and will depend on its capacities and taste as the needs of the team. We strongly advise any potential candidate to contact us by email or elsewhere to begin the discussion before any formal application.

**Key words:** TeraHertz, Time domain spectroscopy, Metasurface, strong coupling, algorithmic