UV-Dual-Comb Spectroscopy for Atmospheric Trace Gas Detection
Open position: 2-years PostDoc

Start: beginning of 2024

Context:

Probing the atmosphere with laser radiation has revealed great potential for in situ characterization of the atmosphere. Taking advantage of the spectral signature of molecular absorption, laser-based systems can detect the presence of molecular species in the atmosphere, remotely and over large distance.

Dual comb spectroscopy (DCS) is one of the emerging methodology for addressing atmospheric trace gases [1,2]. DCS uses **two frequency combs,** femtosecond mode-locked pulsed lasers, with a slightly different repetition rate, which gives an intrinsic optical path delay between the two trains of pulses. This allows measuring a temporal interferogram, Fourier Transform of which reveals the absorption pattern of the absorbing species along the light path. DCS shows high acquisition rate (<ms), over large bandwidth (>10 THz in the optical domain) with high resolution (100 MHz) and has been successfully used in the IR range for the detection of VOC and H_2O though an open-path experiment [3].

The ATMOS (ATMospheres, Optics and Spectroscopy) team of ILM (Institute of Light and Matter) is currently developing an original **Dual-Comb spectrometer** in a view to realizing an instrument able to monitor **the highest reactive atmospheric molecules of the atmosphere in the UV range** (Ozone, OH, NO_2, HONO…) which play a central role in atmospheric chemistry.

DCS has never been used in the UV range for the open-path detection of atmospheric trace gas; the challenges is to have two laser sources that present **sufficient average power and mutual coherence.**

We demonstrated in a recent simulation study [4] that a **TiSa based-laser source is the most promising technology to perform UV-DCS for atmospheric trace-gases studies.** We have developed an original TiSa cavity laser in a ring configuration that allows generating two mutually coherent frequency combs [5]. The first experimental results demonstrate the ability of our laser system to perform UV-DCS with sufficient resolution (at the GHz level) in the scope of atmospheric trace-gases detection [5].

Missions:

By joining the ATMOS team, the candidate will participate in the development of **Dual-Comb spectroscopy in the UV range** using a TiSa Laser. The work is essentially experimental: laboratory spectroscopic measurements will be performed to test the performances of the system before carrying out open-path measurements.

Required qualifications:

Candidates must hold a PhD in experimental physics. The candidate must have strong interests and skills and in Optics, Lasers and spectroscopy. Competence in programming (Python and/or Labview) is essential for the deep analysis of the Fourier-type measurements.

Potential candidates should contact Sandrine Galtier sandrine.galtier@univ-lyon1.fr. Applications should include a cover/motivation letter, CV and contact information of at least one reference.

Bibliography with previous related work [4-6]

[1] I. Coddington, N. Newbury and W. Swann, "Dual-comb spectroscopy" Optica, **3**, n°4 (2016)

[2] N. Picqué et. al., « Frequency comb spectroscopy », Nature Photonics **13**, 146 (2019)

[3] D. Herman *et al*, Science, **7** n°14 (2021)

[4] S. Galtier, C. Pivard and P. Rairoux, "Towards DCS in the UV Spectral Range for Remote Sensing of Atmospheric Trace Gases". Remote Sensing, 12, 3444 (2020)

[5] C. Pivard, PhD thesis, UCBL Lyon 1 (2021)

[6] S. Galtier, C. Pivard, J. Morville and P. Rairoux," High-resolution dual comb spectroscopy using a free-running, bidirectional ring titanium sapphire laser" Optics Express, 30, 12 (2022)