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PROPOSITION DE SUJET DE THESE

Intitulé: Backward Optical Parametric Processes for Remote Sensing Applications

Référence : **PHY-DPHY-2026-10**

PhD start date : Octobre 2026	**Application closing date : June 2026**

Key Words: Lasers, Nonlinear Optics, Optical Parametric Oscillators, Spectroscopy, Infrared, LIDAR

Profile & Competencies

Candidates with a Master Degree in Engineering or Physics including experimental skills in photonics, nonlinear optics, or laser sources. Applications are open to candidates from ESA member states.

Présentation du projet doctoral, contexte et objectif

In the frame of laser source development for spaceborne atmosphere remote sensing applications, parametric frequency down-converters and amplifiers offer the attractive prospects of high-output power and wavelength tunability well into the mid-infrared, where the main gases of interest (CO_2, CH_4, and water vapor) can be probed with absorption spectroscopy methods. Recently introduced as a promising candidate for these applications, the backward wave optical parametric oscillator (BWOPO) is a specific type of frequency down-converter, where the infrared parametric waves (signal and idler) are travelling in opposite directions, which gives rise to many remarkable properties such as high-conversion efficiency and intrinsic narrow linewidth emission.

In this context, the thesis project aims at exploring original experimental implementations of BWOPOs in order to improve their current performances in terms of output power, spectral linewidth and stability, or to produce new functionalities taking advantage of the fact that the BWOPO can directly transfer near-infrared pump laser properties to the mid-infrared parametric waves. Amongst the many open research paths, it is for example proposed to study the spectral characteristics of a BWOPO generating 2 µm radiation for CO_2 remote sensing when pumped with the second harmonic of a Nd:YAG laser, as it is expected to bring significant improvements in terms of spectral stability with respect to the pump laser pointing drifts. Other experiments will consist in actively shaping the temporal and spectral properties of a hybrid fiber-bulk ytterbium amplifier with electro and acousto-optics modulators. This could be done in order to either improve the BWOPO spectral properties or to produce original spectral shapes such as frequency combs that could be directly transferred for spectroscopy applications. Finally, the PhD student will have the opportunity to apply the BWOPO to actual remote sensing experiments currently carried out in the lab at ONERA for greenhouse gases concentration measurement with the differential absorption lidar method.

The proposed research work is built in the continuation of previous and current research activities: ESA OSIP project (https://activities.esa.int/4000143989), and the H2020 European project SIROCO (https://siroco.onera.fr/en). The PhD student will thus benefit from an attractive environment including collaboration opportunities with multiple partners from France, Germany, and Sweden.

Collaborations envisagées

European Space Agency (ESA), Institut d'Optique Graduate School (IOGS), Stockholm Royal Institute of Technologies (KTH), Institute of Laser Technologies (Fraunhofer ILT), SpaceTech (GmbH)

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