The **French-German Research Institute of Saint-Louis (ISL)** situated in the border triangle of Germany, France and Switzerland is an internationally renowned research institute belonging to a global industrial and economic network.
The spectrum of our core activities comprises a variety of topics: aerodynamics, energetic and advanced materials, lasers and electromagnetic technologies, protection, security and situational awareness. Our activities are related to both basic and applied research.

ISL is offering a **PhD Position**

Research field: Laser and electromagnetic technologies

Mid-infrared nonlinear Raman conversion in gas-filled Hollow-Core silica Photonic Crystal Fibers pumped at 2 µm

Context

3–5 µm mid-infrared (mid-IR) laser sources are of particular interest as they match with the atmospheric transmission window, thus allowing to address different applications such as optical countermeasures, lidars, surgery or free-space telecommunications to name a few.

Mid-IR laser sources have been developed at ISL for several years. The laser sources basic architecture is composed of a 2 µm laser source pumping a nonlinear medium, in order to convert the 2 µm radiation into the 3–5 µm spectral domain (so-called band II). Nonlinear converters used so far at ISL have been free-space OPO cavities and fluoride fibers. In the last years, very good results in band II have been obtained using OPO cavities (> 35 W between 3 and 5 µm) and fluoride fibers (> 10 W of supercontinuum generation continuously extending from 2 to 5 µm). Nevertheless, free-space OPO cavities are still suffering from thermal and optical alignment issues (limited robustness and compactness of the laser system). In the case of fluoride fiber nonlinear waveguides, compactness and robustness are improved, but this nonlinear material suffers from a lack of power handling due to low maturity of this fiber technology. Moreover, fluoride fibers are still difficult to splice to silica fibers when pumped by a 2 µm fiber laser (development of an all-fibered band II laser source).

Project

The aim of this thesis is to study another nonlinear effect naturally present in most materials to achieve the 3–5 µm bandwidth when pumping at 2 µm: Stimulated Raman Scattering (SRS). The idea is to use a silica fiber as a nonlinear waveguide to keep a very good potential of integrability and robustness of the laser source. Nevertheless, as standard step index silica fibers are known to strongly absorb 3–5 µm radiation, they are impossible to use as a mid-IR nonlinear optical waveguide. Recent progress in Hollow-Core (HC) silica Photonic Crystal Fibers (PCFs) development has shown a very good transmission in the mid-IR (< 1 dB/m) and can now be used as a mid-IR waveguide. In standard HC-PCF fibers, the centered fiber core is an air-filled hole extending along the entire fiber. SRS nonlinear conversion in air-filled HC-PCFs would require too much optical pump power to emit in the 3–5 µm bandwidth. In this thesis, we propose to inject a high-Raman-gain gas (methane, hydrogen, deuterium etc.) into the fiber core so as to achieve nonlinear conversion in the 3–5 µm regime when pumping at 2 µm.

In order to study the nonlinear SRS mid-IR conversion in gas-filled HC-PCF pumped at 2 µm, the candidate will perform different research activities at the Max Planck Institute for the Science of Light and at ISL, including: the development of the HC-PCF fiber; the study of the high-Raman-gain gases; the set-up of an experimental table for pumping of the gas-filled HC-PCF with a 2 µm fiber laser and measuring the nonlinear conversion.

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