Post-Doc (M/F) 18 months : Physical modeling of free-space optical telecommunications through scattering atmosphere in MWIR range

Dec. 2023 version

Laboratory :

Institut Fresnel, UMR 7249 CNRS/Centrale Méditerranée/Aix-Marseille Univ
Contact : Julien Fade, MCF HDR, ECM, DiMABio Team
Email : julien.fade@fresnel.fr
Tel : +33 (0)4 13 95 54 94
Website: **https://www.fresnel.fr**

Partners :

- **ONERA-DOTA (French Aerospace Lab, Optics dpt.), Palaiseau**
- **LTCI Lab, Palaiseau**

Description of the job :

In the applicative context of free space optical telecommunications (FSOT) (see project summary below), you will be involved in the physical and numerical modeling of optical wave propagation through complex and turbid atmosphere, and in the performance assessment of balisting photons filtering approaches in the SWIR and MWIR wavelength ranges. Using realistic applicative scenarii, and medium characteristics (size distribution of scatterers, type of scatterers, spectroscopic properties, dynamical properties…), the absorption, scattering and depolarization properties of the medium will be simulated, relying on analytical models and validated through numerical simulations (vectorial Radiative Transfer Equation solved with Monte-Carlo simulations). The impact of propagation of light through turbid atmosphere on the (classical or chaos-based) temporal modulation waveforms encoded onto the light beam will be also analyzed with similar modeling tools, taking into account the geometrical characteristics of the telecommunication system (e.g., aperture of the detection device) : this study should provide an estimate of the maximal range and bandwidth of FSOT as a function of the fog properties.

Then, you will be in charge of a theoretical and numerical evaluation of the benefits of ballistic/serpentile photons filtering approaches (polarization or temporal-modulation based) on the quality of FSOT in the SWIR/MWIR. Relying on the simulation building blocks set up, you will simulate the implementation of such a serpentile/ballistic photon filtering technique by temporal modulation of intensity and/or polarization, and analyze the potential gain in telecommunication performance. As far as possible, these numerical approaches will be backed up by analytical studies of possible performance gains in modulated signal discrimination, using the tools of statistical information theory. Finally, you will handle the definition of technological specifications for the design of appropriate optical phase/polarization modulation devices in the SWIR/MWIR ranges to implement ballistic photons filtering for FSOT and increase the range and throughput of free-space optical telecommunication systems in the presence of fog.

Public summary of the collaborative project :

Free-space optical telecommunications (FSOT) in the infrared represent an increasingly attractive alternative to the progressive saturation of channels dedicated to wireless technologies, and to the growing bandwidth requirements. However, this promising, rapidly deployable technology is vulnerable to weather conditions such as fog. Indeed, when the optical beam propagates through a scattering medium, it undergoes absorption and scattering phenomena that attenuate the optical signal and, at high data rates, cause time elongation of modulation signals. The greater the transmission distance, the greater these effects, endeavouring communication reliability or bandwidth. In addition, the multiple scattering of the beam means that the signal can be intercepted by an opposing party at a suitable distance. Securing transmitted data and increasing the range of encrypted telecommunication systems through turbid environments such as fog is therefore a fundamental challenge for defense and industrial applications.

The aim of this collaborative project is to propose new telecommunication strategies to significantly increase the range and throughput of free-space optical telecommunication systems in the presence of fog. Data security will be achieved using a cryptographic method that exploits the temporal chaos of quantum cascade laser sources. The proposed strategy involves the combination of three innovative approaches : (i) chaos-based cryptographic encoding ; (ii) ballistic/serpentile photons filtering ; (iii) wavefront correction through adaptive optics techniques to correct for the effects of scattering. One of OPTOPIRAT's objectives will also be to compare telecommunication performance at different wavelengths, moving from the near infrared (SWIR) to mid-infrared (MWIR, LWIR), while covering the main fog conditions (advective and convective).

Provisional starting date : **Feb.-April 2024**

Remuneration : **2 300 - 2 500 €/month gross salary (depending on work experience)**

Training requirements : **Engineering school and/or Master 2 with a major in physics/optics and/or applied mathematics. PhD in optics, applied mathematics, or signal/information processing.**

Experience & skills : Good skills in **optics, physical modeling and programming** are required.

An appetite for statistics and signal/information processing will be appreciated.

Programming : Matlab, Python.

Application procedure : **Please send CV, transcripts, copy of diplomas, contact details of PhD supervisor and references of Master's thesis supervisors.**