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PROPOSITION DE STAGE EN COURS D'ETUDES

Référence : **DOTA-2020-43**
(à rappeler dans toute correspondance)

Lieu : Châtillon

Département/Dir./Serv. : DOTA/HRA

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DESCRIPTION DU STAGE

Thématique(s) : Maîtrise du front d'onde et optique adaptative

Type de stage : ☒ Fin d'études bac+5 ☐ Master 2 ☐ Bac+2 à bac+4 ☐ Autres

Intitulé : Atmospheric turbulence impact on the continuous-variable quantum key distribution with space-ground optical links

Sujet : In the context of the future space-ground optical links and telecommunication networks, the issue of securing the transmission channel using quantum resources is currently under intense investigation in France and around the world [1] [2], because of the promise it holds for security levels impossible to reach solely by classical means. Quantum key distribution is a communication method enabling two parties to share a secret key used to encrypt and decrypt the exchanged messages with information-theoretic (unconditional) security. Among prevalent QKD technologies, continuous-variable quantum key distribution (CV-QKD) systems offer the major advantage of being compatible with standard coherent telecommunication technologies, which could greatly facilitate and limit the cost of their deployment. Since the demonstration by the LIP6 team that such systems could be suitable for long-distance fibered communication (~100 km) on the ground [3], this technology has been the subject of intense developments worldwide.

We consider the case of a space-to-ground CV-QKD, where a low Earth orbit satellite crossing the sky aims at establishing a secret key with an optical station on the ground. The quantum signal, from which the secret key is extracted, is a low intensity coherent laser beam generally with a Gaussian modulation of its amplitude and phase. After propagation through a turbulent atmospheric channel, the transmitted signal is coupled into a single-mode optical fiber on the ground, and is then coherently detected and post-processed. Ultimately, a secret key is extracted, and the "key generation rate" (bit/s) quantifies the performance of the system. As in classical (i.e. non quantum) optical telecommunication, the turbulence degrades the phase and amplitude of the propagating signal, which hampers the coherent detection of the coupled flux, and will in some way degrade the CV-QKD performance. Based on recent modeling and experimental studies on classical optical telecommunication links, the use of adaptive optics (AO) techniques appears as a very promising technology to mitigate these turbulence-induced effects on the signal phase and to recover coupled flux statistics compatible with high performance telecommunication links.

The main goal of this internship is to identify the most critical parameters enabling to estimate the impact of the transmission channel and the AO correction on the CV-QKD performance.

After a bibliography study, the student will be provided with the parameters of the space-to-ground CV-QKD : orbit of the satellite, satellite laser terminal performance, expected coupled flux on the ground, atmospheric transmission conditions, etc. The student will then get acquainted with the particiliarities of the available analytical and numerical tools dedicated to : turbulence and AO modeling, coupled flux statistics estimation, key extraction and key generation rate computation. By identifying the interfaces between these codes, he/she will develop a new numerical tool allowing to assess the key generation rate directly from the coupled flux statistics. Ultimately, this work will enable the identification of specific parameters of the AO design allowing to meet the requirements of the CV-QKD performance.

The ONERA team has especially exploited its expertise in turbulence modeling and wavefront sensing and correction to realize ambitious projects for CNES and ESA as well as academic work in the field of free-space satellite telecommunication [4-6]. This internship will be realized in close collaboration with the LIP6 -

CNRS, Sorbonne Université (supervisor : Eleni Diamanti), which expertise in CV-QKD is recognized internationally through large-scale European projects and high impact academic work. The numerical tools allowing to estimate the coupled flux statistics after AO correction and to compute key generation rates are available. The student will also be given the opportunity to pursue his work in the context of a PhD thesis LIP6 - CNRS, Sorbonne Université / ONERA.

[1] Diamanti et al., npj Quantum Inf 2, 16025 (2016)

[2] Dequal et al., Quantum Information and Measurement (QIM) V: Quantum Technologies, Rome, 2019, p. T5A.89

[3] P. Jouguet, S. Kunz-Jacques, A. Leverrier, P. Grangier, et E. Diamanti, Nat. Photonics, vol. 7, no 5, p. 378-381, mai 2013

[4] N. Védrenne et al., Proc SPIE, p. 97390E, 2016.

[5] N. Védrenne et al., Proc ICSOS, p. 6, 2012.

[6] L. Canuet et al., J. Opt. Soc. Am. A, vol. 35, no 1, p. 148, janv. 2018.

Est-il possible d'envisager un travail en binôme ? **Non**

Méthodes à mettre en oeuvre :

☒ Recherche théorique	☐ Travail de synthèse
☒ Recherche appliquée	☐ Travail de documentation
☐ Recherche expérimentale	☐ Participation à une réalisation

Possibilité de prolongation en thèse : **Oui**

Durée du stage : Minimum : 5 months Maximum : 5 months (6 months if exemption)

Période souhaitée : start in February or March 2020

PROFIL DU STAGIAIRE

Connaissances et niveau requis :	Ecoles ou établissements souhaités :
Optics, quantum physics, modeling tools, notions in cryptography.	Master 2 or Engineering schools with majors in Physics, Optics, Quantum Physics