Master 2: ***International Centre for Fundamental Physics***

INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Matériaux et Phénomènes Quantiques
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Internship location: Laboratoire Matériaux et Phénomènes Quantiques

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: PEPR

Quantum error correction using continuous degrees of freedom of single photons

Quantum information can be encoded in discrete systems (as qubits, which are two-level systems) or in continuous ones, as the position or momentum of particules or the electromagnetic field's quadratures. We develop in our team an original way to encode continuous variables in single photons continuous modes, as for instance their frequency or their time of arrival. In this context, different theoretical tools should be developed [1], and the quantum protocols and measurement strategies, as well as the notion of quantum resources should be adapted, as for instance in the study of quantum metrology [2,3] or quantum error correction (QEC) in continuous variables (CV) [4]. There are different strategies for QEC in CV depending on the type of errors one wishes to protect for (as for instance photon losses or displacements in phase space), and in [4] we studied in details an error correcting code based on frequency combs, showing that it can protect for path (or time delay) imperfections, frequency drifts or photon losses. In this internship, we aim to study in detail another well-known CV QEC code, "cat-codes", where qubits are encoded in Schrödinger cat like states. This type of codes is well studied for intense fields, where quantum information is encoded in the field's quadratures, but it is not clear what its properties are in the case of encoding information in the modal variables of single photons. Typical questions to address are what are the errors this type of code can protect for in the present configuration and how do protection scales with the number of photons used in the encoding.

In the internship we'll use mainly analytical tools, and we'll encourage discussions with the experimental photonics group of our team (QITE).

[1] N. Treps, A. Keller, P. Milman, Time and frequency as quantum continuous variables, Physical. Rev. A 105, 052429 (2022).
[2] E. Descamps, N. Fabre, A. Keller and P. Milman, Phys. Rev. Lett. 131 (3), 030801 (2023).
[3] O. Meskine et al. arXiv:2309.10633 (2023).
[4] E. Descamps, A. Keller and P. Milman, arXiv:2310.12618 (2023).

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:
Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: YES