

Experimental Quantum Optics and Quantum Information Processing project, based on an integrated heralded single photon source

The project is part of the research work of the group of prof. Roberto Morandotti, at the Institut National de la Recherche Scientifique (INRS), (<http://www.nonlinearphotonics.com>), and it is conducted in group's lab, at the INRS-EMT center, situated close to Montreal, Quebec, Canada.

The project is based on the integrated microring resonator and nonlinear source, developed by the group of prof. Morandotti in the last years [PCP⁺13], and used here as a source of heralded single photons [RCC⁺14, RKC⁺15]. The subjects relevant to the project are Quantum Optics (QO), in particular in-fiber experimental QO, and Quantum Information Processing (QIP), in particular Quantum Key Distribution (QKD). For the experimental part of the project, relevant subjects will also be fast electronics, instruments interfacing and synchronization, and data processing. The data processing will be an important part of the project, and it will be performed using the Python programming language. After implementing some already established QKD protocols, the project will aim at the exploitation of the specific characteristics of the heralded single photon source, so to use it for more specific QKD protocols, and also for other types of QIP protocols, also with applications different from QKD. In particular for this latter part, but not limited to it, the project will involve relevant theoretical work, on the subjects of QO, nonlinear optics and QIP. The scientific environment will be multi-disciplinary in nature, involving physics, engineering and computer science.

The project is in its early stages, and there are intermediate results about the ability for the generation of heralded single photons, and the synchronized modulation of their phase in a self-compensating in-fiber interferometer [KMD91, MHH⁺97]. The measured high visibility of the interferometer, above 97%, assures the ability to perform encoding and decoding of quantum information in the phase of the single photons, so to implement a QKD protocol [GYS04].

This project will be supervised by doc. Fabio Grazioso, who is a senior postdoctoral fellow in the group, and it will be developed in collaboration with prof. Louis Salvail, who works in the group of theoretical and quantum informatics at the Université de Montréal (<http://www.iro.umontreal.ca/~utheorie/>). Prof Salvail has a long and relevant background in QKD, and he started his career collaborating with prof. Gilles Brassard, since the first experimental implementations of the BB84 QKD protocol [BB84, BBB⁺92].

For contacts and inquiries on the project, please write to the following email address: fabio.grazioso@emt.inrs.ca.

References

- [BB84] C. H. Bennett and G. Brassard. Quantum Cryptography: Public key distribution and coin tossing. In *Proceedings of the IEEE International Conference on Computers, Systems, and Signal Processing, Bangalore*, page 175, Bangalore, 1984. IEEE International Conference on Computers, Systems, and Signal Processing.
- [BBB⁺92] C. H. Bennett, F. Bessette, G. Brassard, L. Salvail, and J. Smolin. Experimental quantum cryptography. *Journal of Cryptology*, 5:3, 1992.
- [GYS04] C. Gobby, Z. L. Yuan, and A. J. Shields. Quantum key distribution over 122 km of standard telecom fiber. *Applied Physics Letters*, 84(19):3762, 2004.
- [KMD91] A. D. Kersey, M. J. Marrone, and M. A. Davis. Polarisation-insensitive fibre optic michelson interferometer. *Electronics Letters*, 27(6):518, March 1991.
- [MHH⁺97] A. Muller, T. Herzog, B. Huttner, W. Tittel, H. Zbinden, and N. Gisin. “plug and play” systems for quantum cryptography. *Applied Physics Letters*, 70(7):793, 1997.
- [PCP⁺13] A. Pasquazi, L. Caspani, M. Peccianti, M. Clerici, M. Ferrera, L. Razzari, D. Duchesne, B. E. Little, S. T. Chu, D. J. Moss, and R. Morandotti. Self-locked optical parametric oscillation in a cmos compatible microring resonator: a route to robust optical frequency comb generation on a chip. *Optics express*, 21(11):13333, Jun 2013.
- [RCC⁺14] C. Reimer, L. Caspani, M. Clerici, M. Ferrera, M. Kues, M. Peccianti, A. Pasquazi, L. Razzari, B. E. Little, S. T. Chu, D. J. Moss, and R. Morandotti. Integrated frequency comb source of heralded single photons. *Optics express*, 22(6):6535, 2014.
- [RKC⁺15] C. Reimer, M. Kues, L. Caspani, B. Wetzal, P. Roztocky, M. Clerici, Y. Jestin, M. Ferrera, M. Peccianti, A. Pasquazi, B. E. Little, S. T. Chu, D. J. Moss, and R. Morandotti. Cross-polarized photon-pair generation and bi-chromatically pumped optical parametric oscillation on a chip. *Nature communications*, 6:8236, 2015.