PHOTONICS - EUROPHOTONICS MASTER COURSE

PROPOSAL FOR A MASTER THESIS

Course 2015 –2016

Laboratory/Institution: ICFO-Institut of Photonic Sciences
City, Country: Castelldefels, Barcelona, Spain

Title of the master thesis: Design of an experiment to measure the phase of a photon with enhanced precision.

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Summary of the subject (maximum 1 page):
In [1] they observed the change of phase ($\Delta\varphi \sim 1 \times 10^{-7}$ to 1×10^{-8} rad) of a weak coherent beam ($N \sim 3 \times 10^{6}$ photons per pulse) after interacting with a single photon in a waveguide. The precision of the measurement, i.e., the phase that they could detect, was $\Delta\varphi \geq 1/N^{1/2}$, which is the typical condition for coherent beams. In [2-4] they considered quantum states, that even though still make use of coherent states, they can be employed to achieve better precision ($\Delta\varphi \geq 1/N$) by appropriately engineering entanglement between the coherent beam and single photons. In this project the goal is to design theoretically the experiment that could generate these new quantum states and see how to use them to observe the phase of a photon with enhanced precision.

References
[1] N. Matsuda, R. Shimizu, Y. Mitsumori, H. Kosaka and K. Edamatsu, *Observation of optical fiber Herr nonlinearity at the single photon level*, Nature Photonics **3**, 95 (2009).
[2] C. C. Gerry, *Generation of optical macroscopic quantum superposition states via state reduction with a Mach-Zehnder interferometer containing a Kerr medium*, Physical Review A **59**, 4095 (1999).
[3] C. C. Gerry and R. Grobe, *Nonlocal entanglement of coherent states, complementarity, and quantum erasure,* Physical Review A **75**, 034303 (2007).
[4] L. Zhang, A. Datta, and I. A. Walmsley, *Precision Metrology Using Weak Measurements*, Physical Review Letters **114**, 210801 (2015).

Keywords: Entanglement, coherent states, quantum-enhanced metrology
Additional information:
* Amount of the monthly allowance (if it is the case):
* **Required skills:** Interest in quantum theory, interest in calculations about that concerns entanglement, operators
* **Miscellaneous:** This calculation will be the basis for a posterior experiment