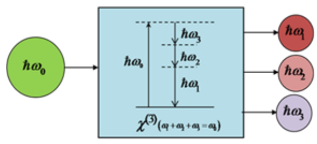
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2021-2022

Title: Triple photon generation in crystal optical nonlinear waveguides

General Scope: This position concerns Triple Photons Generation (TPG). It is based on a third order nonlinear optical interaction is the most direct way to produce pure quantum states of light, called three-photons states. These states exhibit three-body quantum entanglement and their statistics go beyond the usual Gaussian statistics relevant to coherent sources and optical parametric twin-photon generators, offering thus outstanding potential applications in the field of quantum information.
Undoubtedly, three-photons states are new quantum tools to study the non-intuitive properties of quantum mechanics. In 2004, we made the first experimental demonstration of a pure TPG [Opt. Lett. 29, 2794-2796 (2004)], which means that the three photons were created from a single one, using a two-wave stimulation scheme in a phase-matched $KTiOPO_4$ (KTP) bulk crystal. This pioneer work has opened new exciting opportunities in quantum optics. We made the classical and quantum theories of TPG [J. Opt. Soc. Am. B 25(1), 98 – 102 (2008); Phys. Rev. A, 85(4) 02389 1-12 (2012); Phys. Rev. Lett. 120, 043601-1-5 (2018)].



Research topic and facilities available: TPG was first performed in a bulk crystal, which was possible only by stimulated the process using two modes of the field. We have then proposed a novel approach for spontaneous TPG in a guided configuration based on a conventional glass fiber [Opt. Lett. 26(15), 3000-3002 (2011); Opt. Lett., 40(6), 982 (2015) ; invited conference at Non Linear Optics, Hawaii, 27 July 2015]. TPG can benefit from both strong confinement and long interaction length. This result is very important since it indicates that an optical waveguide can enable to achieve a spontaneous TPG, which is completely impossible using a bulk medium. However, because the phase matching is only possible in an optical fiber between two different modes of propagation with a poor spatial and phase overlap, the efficiency of TPG is expected to be very poor (about one triplet/s in a 10 meters long fiber) The work that is proposed in the framework of this internship is to combine the benefit of the high non linearity of bulk crystals such as KTP and the long interaction length and the strong confinement of an optical waveguide [Opt. Express, 24(9), 9932(2016)]. It will be based on a ridge waveguide cut in a KTP bulk crystal (typically, a section of 10x10 μm^2 and a length of about two centimeters). After the first experiments that the group has performed and published recently on second and third harmonic generations in x-cut and y-cut ridge waveguides [Opt. Lett., 43(15) 3770(2018), Opt. Express, 29(14) 22266 (2021)], we are now working on TPG and quantum experiments using CW as well as pulsed laser sources, and nanowires superconductors as photon-counting detectors.

Possible collaboration and networking: FemtoST (Besançon), Centre de Nanosciences et de Nanotechnologies - C2N (Saclay), GAP (Université de Genève), Tel Aviv University (Tel Aviv).

Possible extension as a PhD: It is strongly expected.

Required skills: A background in laser optics, nonlinear optics, quantum mechanics or quantum optics will be useful for the purpose of the project.

Starting date: February or March 2022

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