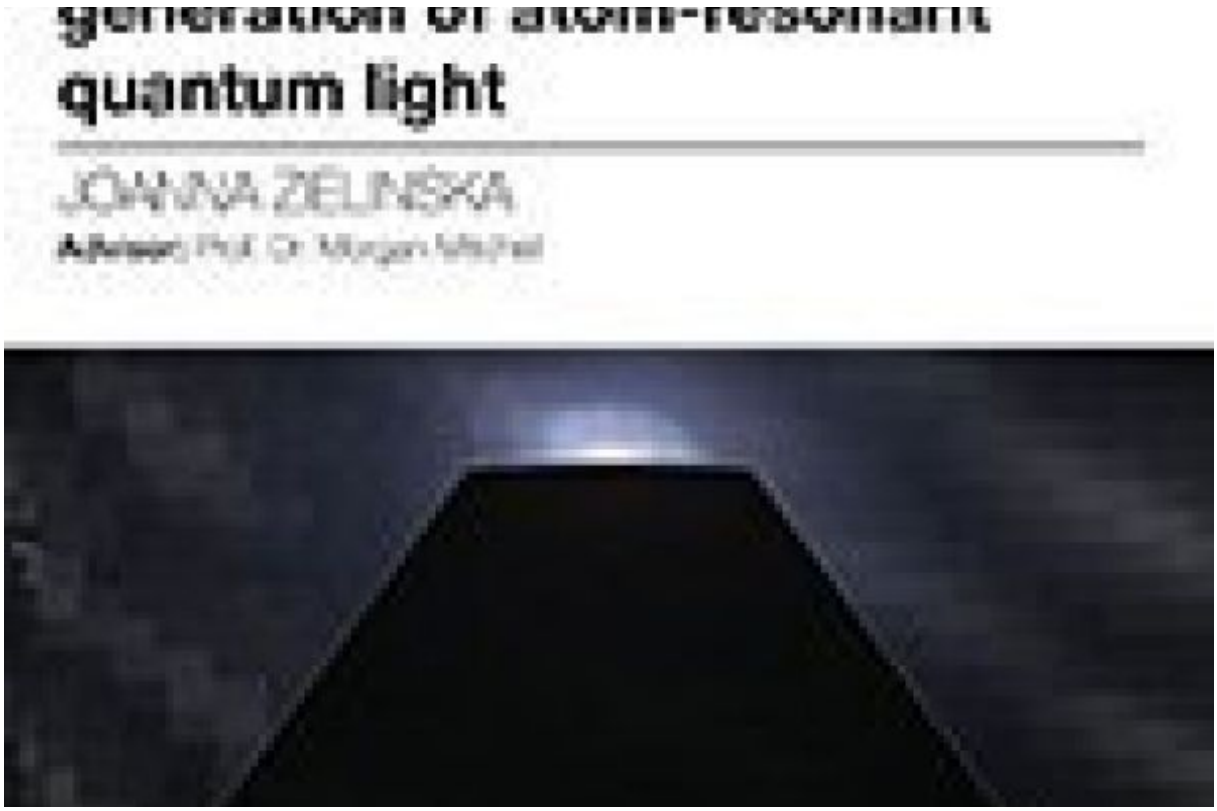

PhD Thesis Defense JOANNA ZIELINSKA 'Spontaneous parametric down-conversion sources for generation of atom-resonant quantum light'

JOANNA ZIELINSKA

March 19, 2018

Monday, March 19, 11:00. ICFO Auditorium

JOANNA ZIELINSKA

Quantum Information With Cold Atoms And Non-classical Light

ICFO-The Institute of Photonic Sciences

This thesis studies different designs of optical parametric oscillators as sources of atom-resonant quantum light resonant with the rubidium D1 line.We analyze the mode structure and filtering techniques in a conventional OPO based on a crystal inside a ring

cavity. We also present a first fully-tunable design of a monolithic doubly-resonant OPO.

The first part presents the study of a multimode optical parametric oscillator from the theoretical point of view, calculating a multimode Bogoliubov transformation and a time-domain intensity correlation function. Next, we experimentally observe signatures of multi- and singlemode OPO output in pairwise time-of-arrival correlations of the generated photons, achieved thanks to Faraday anomalous dispersion filtering technique based on optical properties of atomic vapor in magnetic field.

The second, more extensive part of the thesis features the study of a new design of the OPO, a monolithic cavity (crystal polished and coated so that it forms a cavity) that allows full tunability even in a multiply resonant configuration. The architecture we propose combines the advantages of a conventional ring cavity based OPO, with robustness, lowmaintenance, compactness and stability characteristic of monolithic systems. The tunability of the doubly-resonant monolithic OPO is realized by maintaining different sections of the crystal at different temperatures and pressing it with a piezoelectric actuator. The tuning method is tested when the system is employed as a second harmonic generator. In addition, we describe a new nonlinear effect that comes into play when the monolithic cavity is pumped with 795 nm light. The phenomenon,that we call a photo-Kerr effect causes the cavity behavior resembling optical bistability due to Kerr nonlinearity, but with the magnitude (Kerr coefficient) dependent on the long-time average of intra-cavity power. The model we propose agrees well with the experimental results. The effect simplifies greatly the cavity stabilization, causing the cavity to maintain itself close to resonance even as the laser wavelength is changed by more than a free spectral range. The thesis concludes by studying the suitability of the monolithic cavity with the photo-Kerr effect for squeezed light generation. We test the monolithic cavity as an OPO and demonstrate 1.6 dB of quadrature squeezing via homodyne detection.

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Thesis Advisor: Prof Dr Morgan W. Mitchell

