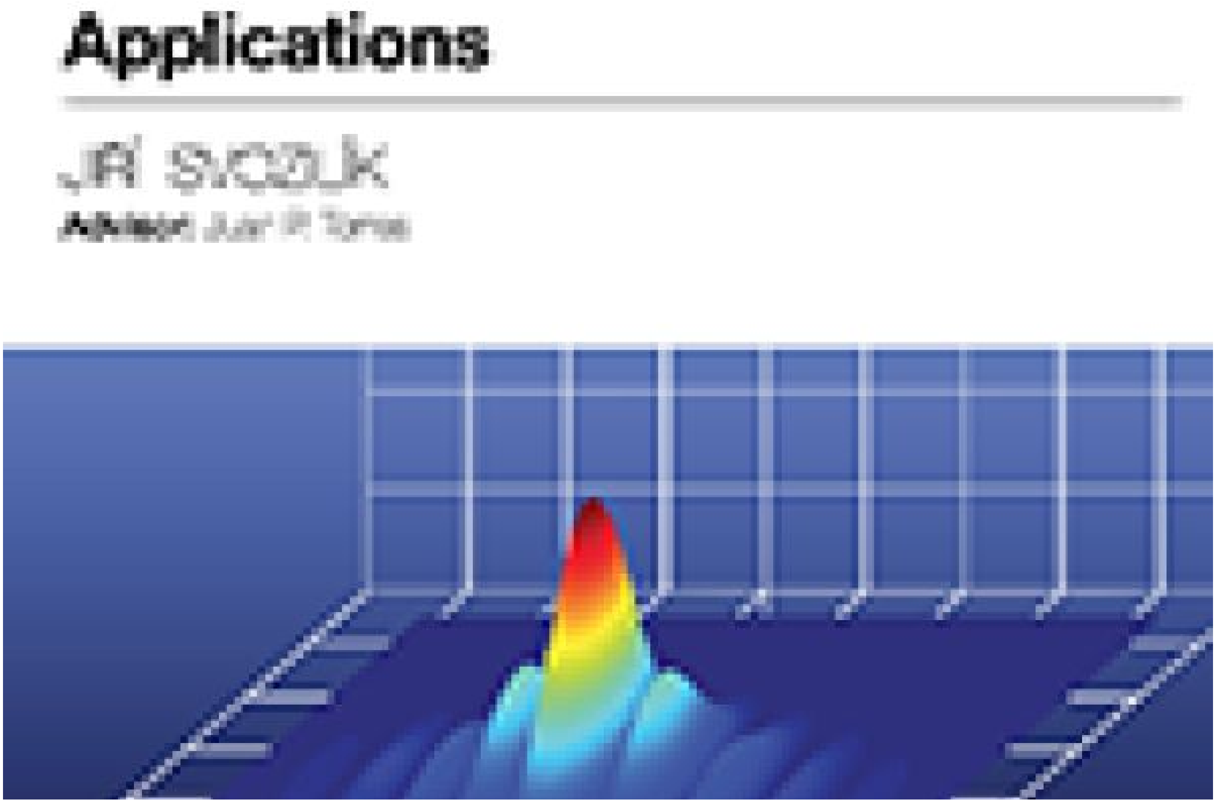

PhD Thesis Defense JIRI SVOZILIK 'Photonic Entanglement: New Sources and New Applications'

JIRI SVOZILIK

October 17, 2014

Friday, October 17, 11:30. ICFO Auditorium

JIRI SVOZILIK

Quantum Engineering of Light

ICFO-The Institute of Photonic Sciences, SPAIN

Non-classical correlations, usually referred as entanglement, are ones of the most studied and discussed features of Quantum Mechanics, since the initial introduction of the concept in the decade of 1930s. Even nowadays, a lot of efforts, both theoretical and experimental, are devoted in this topic, that covers many distinct areas of physics, such as a quantum computing, quantum measurement, quantum communications, solid state physics, chemistry and even biology. The fundamental tasks that one should consider related to the

entanglement are:
How to create quantum entangled states.
How to maintain entanglement during propagation against sources of decoherence.
How to effectively detect it.
How to employ the benefits that entanglement offers.
This thesis, divided into four chapters, concentrates on the first and last tasks considered above.

In Chapter 1, a brief introduction and overview of what it is entanglement is given, starting with the famous paper of Einstein, Podolsky and Rosen, and continuing with John Bell's formulation of the so-called Bell's inequalities. We define here general concepts about entangled quantum states and introduce important entanglement measures, that are later used all over the thesis. In this chapter, sources of entangled particles (namely photons) are also mentioned. The importance is put on sources based on the nonlinear process of spontaneous parametric down-conversion. The last part of this chapter is then dedicated to a list of applications that benefit from the use of entangled states.

Chapter 2 is devoted to the systematic study of the generation of entangled and non-entangled photon pairs in semiconductor Bragg reflection waveguides. Firstly, we present a source of photon pairs with a spectrally uncorrelated two-photon amplitude, achieved by a proper tailoring of the geometrical and material dispersions via structural design of waveguides. Secondly, Bragg reflection waveguides are designed in such a way, that results in the generation of spectrally broadband paired photons entangled in the polarization degree of freedom. Finally, we present experimental results of entangled photon pairs generation in this type of structures.

In Chapter 3, we explore the feasibility of the generation of photon pairs entangled in the spatial degree of freedom, i.e. in the orbital angular momentum (OAM). Firstly, we examine how to create a highly multidimensional Hilbert space using OAM modes obtained in a chirped-poled nonlinear bulk crystals. Here, we show how an increase of the chirp of the poling can effectively increase the Schmidt number by several orders of magnitude. Secondly, we investigate periodically poled silica glass fibers with a ring-shaped core, that are capable to support the generation of simple OAM modes.

The final Chapter 4 is dedicated to the Anderson localization and quantum random walks. At the beginning of this chapter, we present an experimental proposal for the realization of discrete quantum random walks using the multi-path Mach-Zehnder interferometer with a spatial light modulator that allows us to introduce different types of statistical or dynamical disorders. And secondly, we show how the transverse Anderson localization of partially coherent light, with a variable first-order degree of coherence, can be studied making use of entangled photon pairs.

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Thesis Advisor: Prof. Juan Perez-Torres