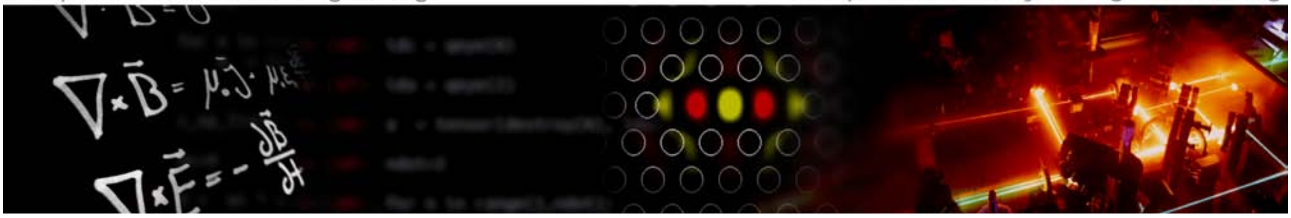

M.Sc. project in Nanophotonics Theory

Optical properties of photonic crystal microcavities and waveguides

Photonic crystal microcavities and waveguides can be formed by removing holes in the photonic crystal membrane (Fig. 1). These structures are of interest for fundamental studies of light-matter interaction such as cavity quantum electrodynamics and slow light but also for practical applications such as single-photon sources, optical switches, memories etc.

When designing a photonic device, computer simulations of Maxwell's equations are used to describe the behaviour of the electromagnetic field and to study the properties of the component. For most photonic devices the geometry is complicated and the field cannot be described analytically. Instead numerical simulations must be performed to compute the optical field (Fig. 2). Performing full 3D vectorial simulations of the optical field in photonic crystal structures is a highly challenging task. The absence of symmetry leads to large memory requirements and long computation times.

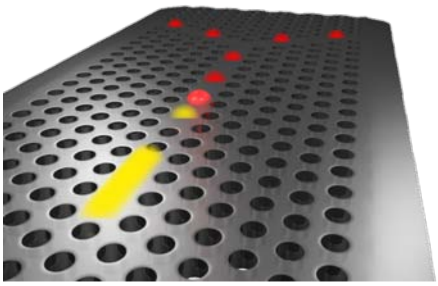

Fig. 1: Photonic crystal membrane.

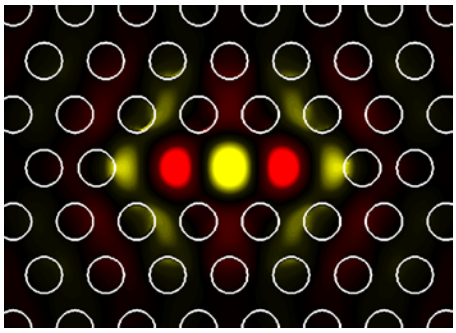

Fig. 2: Electric field profile of the L3 cavity mode.

In this project the student will study the optical properties of a photonic crystal geometry, for example the emission profile of a L3 microcavity or the local density of states in a W1 waveguide. The student will employ the Fourier Modal Method to perform the numerical simulations. This technique allows for an in-depth understanding of the physical properties of the photonic crystal geometry, however it is so new that commercial software packages do not yet exist. The student will thus program his or her own numerical simulation tool in Matlab.

The main project tasks are the following:

- Program a full 3D vectorial simulation tool in Matlab based on the Fourier Modal Method. This tool will incorporate advanced boundary conditions and Bloch mode formalism.
- Investigate the optical properties of a photonic crystal geometry, e.g. the L3 cavity or the W1 waveguide. The particular geometry may be chosen according to the students interests.
- Propose a new design with improved properties for fabrication by the experimental groups.

Knowledge of electromagnetics (Maxwell's equations), waveguide theory, Matlab programming, Fourier transformations and linear algebra is recommended.

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