

Abstract

This thesis is an accumulation of the work and that was carried out and published as two articles and two book chapters. Throughout the thesis, we develop and present theoretical as well as numerical model to extend the existing techniques to study the optical properties of photonic crystals, plasmonic photonic crystals and photonic quasicrystals.

We start with a background review, where we cover the theoretical aspects of light–matter interaction. That is followed by a review of the physics of photonic crystals. In that chapter, we discuss the different properties of photonic crystals, plasmonic photonic crystals as well as the topic of localization. We then delve into the numerical aspects of the subject. We provide a review on the frequency domain method and the finite–differences–time–domain methods which they are both used in the work to perform different types of simulations.

The frequency domain method is, then, extended to enable the numerical analysis of the optical properties in plasmonic photonic crystals. We use first order perturbation theory to study the effect of surface plasmon polaritons on the photonic band structure of plasmonic photonic crystals. We developed a simple numerical tool that extends the standard frequency domain methods to compute the photonic band structure of plasmonic photonic crystals.

We then employ the two stage cut and project scheme to generate a dodecagonal two–dimensional quasiperiodic structure. The finite–differences–time–domain method is applied to simulate the propagation of electromagnetic modes in the system. We compute the transmission coefficients as well as the inverse participation ratio for a quasicrystal consisting of dielectric cylindrical rods. The analysis has shown that crystal has critical states. Furthermore, we apply the frequency domain method to quantify the localized modes in the vicinity of defects in a two–dimensional photonic crystal. We compute the intensity of those modes in the surroundings of the defects sites to identify their nature. Finally, we use the finite–differences–time–domain method to provide a second example of a quasicrystalline structure, where the states are localized.