Spectral analysis of lattice-of-rod photonic crystals

Markus Holzmann

We consider photonic crystals consisting of periodically ordered and infinitely long rods; cf. Figure 1. The goal is to design the crystal in such a way that (specially polarized) light with given frequency can not propagate in the medium. In order to study whether an electromagnetic wave with given frequency can propagate in the crystal or not, the spectra of two scalar differential operators with periodic coefficients have to be analyzed.

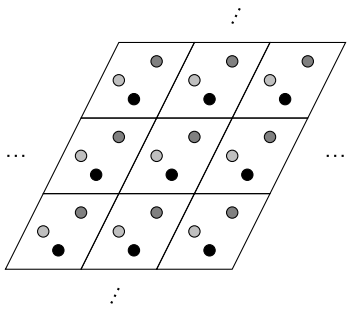

Figure 1: Example of a crystal which is investigated (the period cell is included).

We are going to show the following main result: given a finite number of frequencies it is possible to design a photonic crystal of the above form with high contrast dielectric permittivity ε such that transverse magnetic modes with such frequencies can not propagate in the crystal. This result is connected with the spectrum of the operator $-\varepsilon^{-1}\Delta$ in $L^2(\mathbb{R}^2)$. Furthermore, we show that spectral gaps for transverse electric modes are relatively small, if they exist. This behavior is connected with the spectral properties of $-\mathrm{div}(\varepsilon^{-1}\mathrm{grad})$ in $L^2(\mathbb{R}^2)$. These results fit to experimental observations obtained for such crystals with simple geometries [1].
This talk is based on a joint work with V. Lotoreichik.

References:

[1] J. D. Joannopoulos, S. G. Johnson, J. N. Winn, and R. D. Meade. *Photonic Crystals: Molding the Flow of Light (Second Edition)*. Princeton University Press, 2 edition, 2008.