Joint
APPLIED MATHEMATICS COLLOQUIUM
And
IMAGING AND COMPUTING SEMINAR

Robust and Efficient Computation of Two-dimensional Photonic Crystal Band Structure Using Second-kind Integral Equations

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Abstract:
Photonic crystals are dielectric structures with periodicity on the scale of the wavelength of light. They have a rapidly growing range of applications to signal processing, sensing, negative-index materials, and the exciting possibility of integrated optical computing. Calculating their `band structure' (propagating Bloch waves) is an elliptic PDE eigenvalue problem with (quasi-)periodic boundary conditions on the unit cell, i.e. eigenmodes on a torus. Since the material is piecewise homogeneous, boundary integral Equations (BIE) are natural for high-accuracy solution.

In such geometries BIEs are usually periodized by replacement of the free space Greens function kernel by its quasi-periodic cousin. We show why this approach fails near the (spurious) resonances of the empty torus. We introduce a new approach which cures this problem: imposing the boundary conditions on the unit-cell walls using layer potentials, and a finite number of neighboring images, resulting in a second-kind integral equation with smooth data. This couples to existing BIE tools (including high-order quadratures and Fast Multipole acceleration) in a natural way, allowing accuracies near machine precision. We also discuss inclusions which intersect the unit cell walls, and how we use a small number of evaluations to interpolate over the Brillouin zone to spectral accuracy. Joint work with Leslie Greengard (NYU).

Monday November 9th 2009
4:30 PM
Building 4, Room 370
Refreshments are available in Building 2, Room 290
(Math Common Room) between 3:30 – 4:30 PM