Abstract submission for EPOTIM-13 for a contributed talk: Some eigenvalue problems involving "Epsilon-near-zero" materials with dielectric inclusions

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This talk will present some results on eigenvalue problems in photonics arising from the use of "Epsilon-near-zero" (ENZ) materials. We begin with two and three dimensional problems of a closed resonator with PEC boundary conditions: the resonator is made up of an ENZ background with one or more dielectric inclusions in the interior– in applications these are exciting because in certain settings they are, at leading order, insensitive to the geometry of the outer shell and only depend on the geometry of the inclusions (and in 2D, the area of the shell). In two dimensions we are led to a complete understanding of the robustness of such a resonator for nonzero, but small $|\delta|$. In three dimensions while answering the same robustness question we are led to an interesting and non-standard generalized eigenvalue problem that we completely analyze for both simple, and multiple eigenvalues. When the inclusion is spherical, we demonstrate that infinitely many "electrostatic" resonances exist where the magnetic field vanishes to leading order in the shell. This part of the talk is joint work with Robert V. Kohn (NYU).

Time permitting, we will then consider a class of disordered two-phase composites with dielectric inclusions in an ENZ background, and show that the resulting divergence form operator, $-\nabla \cdot \varepsilon^{-1}\nabla$ describing TM waves, possess band gaps (not unlike periodic composites), provided the inclusion centers satisfy a *hyperuniformity* condition. This analysis validates studies based on numerical experiments by Torquato and collaborators. This work is based on joint work with Kerrek Stinson (U. Utah).

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