Sujet de thèse

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Titre : **Modeling of dispersive electromagnetic resonators from modal expansion**

Description :

Electromagnetic resonators are the basic elements of new composite materials such as photonic crystals, metamaterials and metasurfaces. These resonant elements are the key tools to obtain exotic optical properties: effective indices that can be lower than the one of the vacuum or even negative, significant field enhancements or gradients of effective index. These properties offer a vast range of potential applications in optical sensors, cloaking, flat and ultra-thin optics, innovative display devices [1-2] etc.

This Ph. D. thesis research program aims to establish a rigorous modal expansion modeling of the electromagnetic dispersive resonators in open free space. This modeling will be based on the formalism of the auxiliary fields which leads to express the dissipative Maxwell equations in the form of a conservative Schrödinger evolution equation which involves a self-adjoint Hamiltonian operator [3-4-5]. This augmented formulation of Maxwell's equations will be used to perform a first rigorous spectral analysis of electromagnetic resonators on the real frequency axis. In a second step, techniques of complex analysis will be used to move from the real frequency axis to the lower half-plane of complex resonances, with the aim of establishing a rigorous modeling of resonators in terms of modes associated with the complex resonances of the system. The objective is to establish a rigorous theory of the method of modal expansion for electromagnetic resonators in this setting.

The research program will begin with the study of the simple case of a spherical resonator located in free space and filled with a homogeneous and dispersive material. This study will be carried out thanks to the analogy with the case of homogeneous dispersive layers [6]. The separable geometry of this resonator will have the advantage of allowing analytical calculations by using expansions of the considered fields on spherical harmonics (Mie theory). The rest of the research program will address more general theoretical examples, the numerical modeling of resonators [7-8] (in collaboration with the team ATHENA of the Institut Fresnel (which uses the finite element method in such setting) or the engineering of metamaterials and metasurfaces [9].

Knowledge of the candidate in electromagnetism, Fourier analysis, spectral theory and complex analysis is desired. This Ph. D. proposal is at the interface between theoretical physics and applied mathematics.

Références

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