COMPUTATIONAL (NANO) PHOTONICS

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ABSTRACT. Novel photonic materials such as photonic crystals and metamaterials are scientifically engineered to interact with and control electromagnetic waves in ways that cannot be achieved with conventional materials. Photonic crystals exhibit bandgap phenomena and have proven very important as an integrated component in many optical devices including waveguides, fibers, lasers, cloaks, superlenses. At sub-wavelength scales, the interaction between electromagnetic waves and conduction electrons at metallic interfaces leads to surface plasmon polaritons and to the confinement of electrognatic fields over very small spatial dimensions with applications in heat trasnfer, energy harvesting and sensing. These and other novel applications have attracted considerable research interest. However, fundamental challenges abound about the design and fabrication of these photonic strcutures in order to yield a given set of prescribed properties. For instance, it is currently beyond the stateof- the-art to compute robust designs that exhibit prescribed properties subject to fabricability constraints. The issue of fabrication adaptivity (adapting a given computed design so that it is fabricable, without signficantly deteriorating the design quality) is particularly important in practical applications since the desired length scales and material distributions are often at the limit of our fabrication capability and hence geometric design tolerances (in relative scale) need to be larger. Another important issue to address in the design optimization is the uncertainty arising in the mathematical model since physical phenomena can rarely be modeled with complete fidelity even under the best of circumstances. We will described a range of numerical simulation and optimization algorithms for the design of photonic and plasmonic structures. These will include our multi-scale high order Hybridized Discontinuos Galerkin method, including novel approaches for accurate wave propagation, our topology optimization approach via modern convex optimization techniques, particularly semi-dfinite programming (SDP) interior-point methods, and our fabrication adaptive optimization algorithrm. We will illustrate our algorithms with examples in both photonic crystal design and plasmonics.

Keywords: Hybridized Discontinuous Galerkin, Photonic Crystals, Plasmonics

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