Accurate and Versatile High-Order Modeling of Electromagnetic Scattering on Plasmonic Nanostructures

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Metallic nanoparticle structures obtained significant attention in the last 15 years due to Surface Plasmon Polariton (SPP) phenomena, which is the result of coherent coupling of photons to free electron oscillations on the surface of a good metal. The applications of these structures have been materialized in several cutting-edge applications ranging from optical imaging to quantum optics. Unfortunately the high cost of fabricating nanophotonic and nanoplasmonic devices is a great barrier in the development of future nanoplasmonic structures. Therefore, efficient numerical methods are essential in order to accurately simulate and verify the performance of these devices prior to the fabrication of the actual structure.

Earlier works in this area are mainly based on finite difference methods such as the finite-difference time-domain (FDTD) and the finite element method (FEM). One disadvantage of these methods is that the entire volume containing the structure out to an absorbing boundary must be discretized. This, increases the number of unknowns and therefore increases the complexity of the method. More recent works exploit a more computationally efficient approach, namely, the surface integral equation (SIE) formulation. This method brings important advantages when compared to the aforementioned volumetric approaches. They only discretize the surface of the object rather than the entire volume, thus resulting in a substantial reduction in the number of unknowns. Additionally, no absorbing boundary conditions or surrounding empty space need to be specifically discretized. Preceding works in SIE analysis of nanoplasmonic structures have exploited the well-known method of moments (MoM). Although it's a power tool to solve integral equations, it's complex and typically requires an expensive double integration (Gedney, Stephen D., et.al, Computational Electromagnetics, Raj Mittra, Ed. Springer New York, 2014. 149-198.)

In this work, we exploit a high-order analysis method, namely the Locally Corrected Nyström (LCN) method to accurately and efficiently solve the electromagnetic scattering of nanoplasmonic structures. The LCN utilizes basis functions of higher orders defined on large curvilinear geometrical elements, which significantly reduces the number of unknowns for a given problem. Compared to other methods the LCN is computationally efficient, straightforward to implement and provides exponential convergence. A full comparison, in terms of time and complexity between the proposed method and previous works for a few 3D nanoplasmonic structures are presented to validate the accuracy, efficiency and flexibility of the proposed method.