A Numerical Approach for Efficient Simulation and Design of Yagi-Uda Nanoantennas

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In this work, an optical nanoantenna is designed to obtain high directivity. The Yagi-Uda nanoantenna consists of vertically stacked nanoloops as the directors and the driven element. A metallic ground is placed at the bottom as the reflector. To ensure the desired optical functionality and fabrication practicality, the loops are comprised of gold, which is mathematically described by a Drude-type dispersive model.

To effectively simulate this class of Yagi-Uda nanoloop array antennas, a temporal finite-element/spectral-element method is developed, in which the entire computational region is divided into multiple subdomains, and each subdomain is allowed to contain non-dispersive media, dispersive media or a hybridization of both. In particular, for the volumes occupied by the dispersive media, one additional auxiliary differential equation (ADE), besides the Maxwell's equations, is required for each pole of the dispersive model. An E-J collocated scheme facilitates the inversion of the mass matrix of the ADEs to more efficient vector manipulations, which reduces the computational burden significantly. Hp-refinement is employed for different subdomains according to their geometrical characteristic to decrease the degrees of freedom (DoF), and a Riemann solver is utilized to calculate the numerical flux flow between these non-conformal subdomains. The Runge-Kutta method is employed to realize the time integration.

Due to the combination of domain decomposition, hp-refinement and one-shot wideband analysis capability, higher simulation efficiency in terms of the design of circular nanoloop Yagi-Uda antennas is achieved when compared with commercially available software packages. We envision the applications of this method in the efficient design of various types of nanoantennas that may involve Drude dispersive media.