Multiscale Computational Electromagnetics and Microwave Imaging

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System-level electromagnetic design problems are multiscale and very challenging to solve. They remain a significant barrier to system design optimization for a foreseeable future. Such multiscale problems often contain three electrical scales, i.e., the fine scale (geometrical feature size much smaller than a wavelength), the coarse scale (geometrical feature size greater than a wavelength), and the intermediate scale between the two extremes. Existing commercial tools are based on single methodologies (such as finite element method or finite-difference time-domain method) and are unable to solve large multiscale problems.

We will present our recent work in solving realistic multiscale system-level EM design simulation problems in both frequency domain and time domain. The discontinuous Galerkin method is used as the fundamental framework for interfacing multiple scales with finite-element method, spectral element method, and finite difference method. In time domain, we further incorporate a nonlinear circuit solver, making it possible to perform nonlinear circuit simulation with RF interactions in a seamless manner. Several previously intractable multiscale problems will be illustrated. Finally, application in super-resolution microwave imaging will be presented with experimental data.