Steps Towards Modeling (Ultra) Wideband-Electromagnetic Scattering from Electrically Large Densely Discretized Objects

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Understanding electromagnetic field distribution plays a key role in a range of devices; from photonic circuits to packaging to metamaterials to antennas to EMC/EMI issues, etc. While this list is long, the ability of to simulate electromagnetic fields in realistic devices requires the discretization to span multiple scales; from $10^{-5}\lambda - 10^{-1}\lambda$. Such wide variation in mesh density implies that any methodology should be (i) mesh-robust, highly adaptable and well conditioned and (ii) integrated with a methodology whose computational cost and memory complexity scale almost linearly with the number of the unknowns. This talk will present some of our work to date on addressing these two problems.

The approach that we have espoused to tackling the first relies on a variant of the method of moments. Traditional solution to integral equations encountered in electromagnetics relies on either the use Rao-Wilton-Glison (RWG) basis functions or their higher order equivalents, and over the years, these functions have become the workhorse of computational electromagnetics. However, they do have significant limitations. We have departed significantly from these basis functions, in that, the framework that we have developed does not rely on continuity constraints. As a result, we will be able to show that using this framework, Generalized Method of Moments, together with a quasi-Helmholtz type representation has a number of benefits. Namely, (i) it shows excellent convergence, (ii) it permits inclusion of different orders of polynomials or different functions as basis functions without imposition of additional constraints, (iii) the method can easily handle non-conformal meshes, and (iv) the method is well conditioned at all frequencies.

Next, it is well known that objects will dense discretization, significantly more than what is necessary to capture phase variation, pose a bottleneck to the use of acceleration techniques. The problem can be rephrased as those occurring at transition points in the electromagnetic spectrum, from RF to DC and RF to optics. This talk will focus on both recent and no-so recent efforts to bridge these transitions. Examples illustrating the efficacy of these methods and their application to a range of problems will be presented.