Abstract for an Invited Paper
for the DPP07 Meeting of
The American Physical Society

Reduced-Order Simulation of Large Accelerator Structures[1]

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Simulating electromagnetic waves inside finite periodic or almost periodic three-dimensional structures is important to research in linear particle acceleration, high power microwave generation, and photonic bandgap structures. While eigenmodes of periodic structures can be determined from analysis of a single unit cell, based on Floquet theory, the general case of aperiodic structures, with defects or non-uniform properties, typically requires 3D electromagnetic simulation of the entire structure. When the structure is large and high accuracy is necessary this can require high-performance computing techniques to obtain even a few eigenmodes [1]. To confront this problem, we describe an efficient, field-based algorithm that can accurately determine the complete eigenmode spectrum for extended aperiodic structures, up to some chosen frequency limit. The new method combines domain decomposition with a non-traditional, dual eigenmode representation of the fields local to each cell of the structure. Two related boundary value eigenproblems are solved numerically in each cell, with (a) electrically shielded, and (b) magnetically shielded interfaces, to determine a combined set of basis fields. By using the dual solutions in our field representation we accurately represent both the electric and magnetic surface currents that mediate coupling at the interfaces between adjacent cells. The solution is uniformly convergent, so that typically only a few modes are used in each cell. We present results from 3D simulations that demonstrate the speed and low computational needs of the algorithm.

[1] Z. Li, et al, Nucl. Instrum. Methods Phys. Res., Sect. A 558 (2006), 168-174.

[1]This work is supported by the Office of Naval Research.