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High-order accelerated integral scattering solvers for frequency- and time-domain simulation, optimization and design

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We present a family of computational methodologies for the solution of the acoustic and Maxwell wave equations in the frequency- and time-domain, with application to simulation, optimization, and design. In particular, a novel "rectangular-polar" high-order integral-equation scattering solver [3] will be described which can produce accurate solutions to the Helmholtz and Maxwell's equations, with high order accuracy, for general two- and three-dimensional structures in the frequency domain—and, by additionally exploiting a time windowing-and-recentering frequency-time synthesis technique [1], in the time domain as well. An effective integral equation acceleration method, the "Interpolated Factored Green Function" method (IFGF) [2] will be presented and demonstrated which, without recourse to the Fast Fourier Transform (FFT) (thus lending itself to effective distributed-memory parallelization), evaluates the action of Green function-based integral operators for an N-point surface discretization at a complexity of $\mathcal{O}(N \log N)$ operations instead of the $\mathcal{O}(N^2)$ cost associated with unaccelerated methods. A number of computational illustrations, including applications to photonic optimization and design problems [4, 5, 6], will be presented.

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