Discrete green's function approach for computational photonics

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It is possible to reduce the computational cost of the conventional finite difference time domain (FDTD) method in electromagnetic calculations for structures with small (compared to the wavelength) features while maintaining high accuracy. The FDTD method is useful to solve a wide variety of electromagnetic propagation and scattering problems, but when the wavelength is large compared to the scatterer (but still small enough that Rayleigh theory is inaccurate), the computational cost is very high because many grid points must be used just to represent the scatterer. Computational cost can be greatly reduced by using a discrete Green's function (DGF) to solve the difference equations that result from discretizing Maxwell's equations. Once the DGF is known (it need be computed only once), the scattered field can be computed using any source.

The DGF can be found using a modified form of what is called nonstandard (NS) FDTD, which is based on a NS model of Maxwell's equations. We verify the accuracy of our methods by comparing with Mie theory for electromagnetic scattering off spheres and cylinders.

The accuracy of the NS-DGF method is slightly lower than for NS-FDTD, but still much better than that of the conventional (standard) FDTD method.

References

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[2] Cole, J. B, N. Okada, and S. Banerjee, Advances in Finite Difference Time Domain Calculation Methods in: A. A. Kohhanovsky, (ed.), Light Scattering Reviews, Vol. 6, Springer, Berlin (2011), pp. 115-175.

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Figures

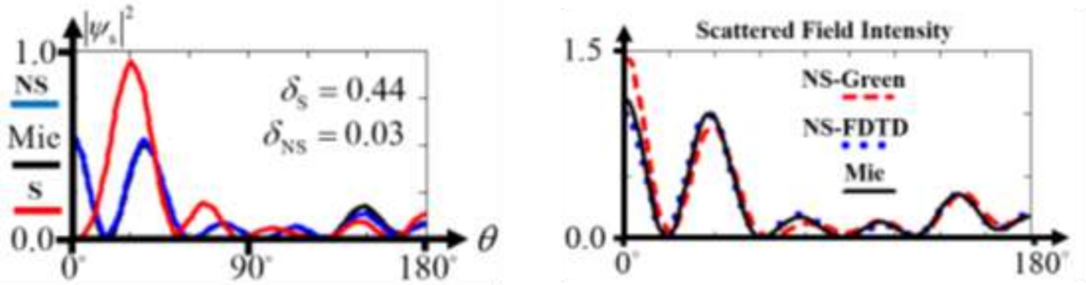

Figure 1. Scattered field intensity (vertical axis) as a function of scattering angle computed with different methods. Left: Comparison of S-FDTD ("S") and NS-FDTD ("NS") with Mie theory ("Mie"). Right: Comparison of NS-FDTD ("NS-FDTD") with the DGF computed using NS-FDTD ("NS-Green").