Exact solution of Maxwell's equations for optical interactions with a macroscopic random medium: addendum

Snow H. Tseng, Jethro H. Greene, and Allen Taflove

Department of Electrical and Computer Engineering, Northwestern University, Evanston, Illinois 60208

Duncan Maitland

Medical Physics and Biophysics Division, Lawrence Livermore National Laboratory, Livermore, California 94550

Vadim Backman and Joseph T. Walsh, Jr.

Department of Biomedical Engineering, Northwestern University, Evanston, Illinois 60208

Received August 17, 2004

This Addendum provides a revised set of figures containing converged numerical data for total scattering cross section (TSCS), replacing the figures in our recent publication [Opt. Lett. **29,** 1393 (2004)]. Due to the use of an overly large time step, our original TSCS data exhibited a systematic, nonphysical diminution above 150 THz for all cases studied. We have determined that numerical convergence in the temporal sense for the pseudospectral time-domain (PSTD) algorithm employed previously requires limiting the time step to no more than 1/60th of the sinusoidal period at the maximum frequency of interest, which in the previous case was 300 THz. This is an important point that we hereby report to future users of PSTD simulations in electrodynamics and optics. Note that all our original conclusions remain valid.

OCIS codes: 240.6680, 060.0060, 060.2320, 240.6690, 170.3880, 290.7090.

In our recent publication,[1] we employed the pseudospectral time-domain (PSTD) method for the full-vector Maxwell's equations to compute the total scattering cross section (TSCS) of a bundle of randomly positioned dielectric cylinders in two dimensions. While all the conclusions reported in Ref. 1 remain valid, in this Addendum we provide a set of modified figures that contain converged numerical data for the TSCS above 150 THz, which in Ref. 1 exhibited a systematic diminution of TSCS for all cases studied. For a 160-μm-diameter bundle of dielectric cylinders, we have determined that numerical convergence is achieved by reducing the time step used in the PSTD algorithm to 1/60th of the sinusoidal period at 300 THz. Figures 1–4 in this Addendum show the new results.

We conclude that, in all future applications of PSTD for large-scale models of optical interactions, it is mandatory to maintain a temporal resolution of at least 60 samples per sinusoidal period at the highest frequency of interest. This temporal resolution exceeds that previously reported in the literature.[2,3]

S. H. Tseng's e-mail address is s-tseng@northwestern.edu.

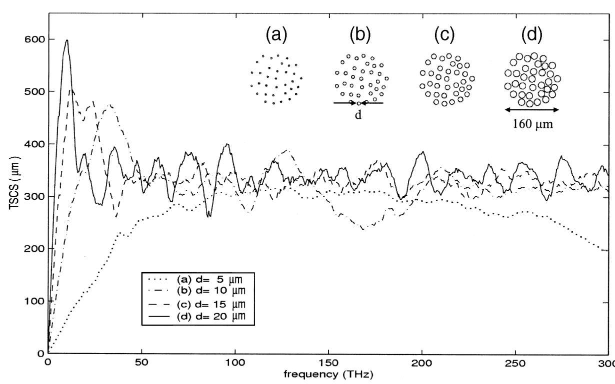

Fig. 1. PSTD-computed TSCS of a 160-μm overall-diameter cylindrical bundle of 34 randomly positioned, noncontacting, $n = 1.2$ dielectric cylinders of individual diameter d. Four cases are shown ($d = 5, 10, 15, 20$ μm) with the position of each cylinder fixed. As d exceeds approximately 10 μm, the TSCS above 60 THz saturates.

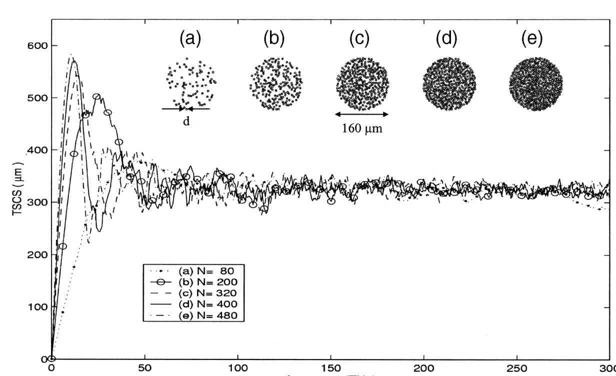

Fig. 2. PSTD-computed TSCS of a 160-μm overall-diameter cylindrical bundle of N randomly positioned, noncontacting, $n = 1.2$ dielectric cylinders of fixed individual diameter $d = 5$ μm. Five cases are shown ($N = 80, 200, 320, 400, 480$). As N exceeds approximately 200, the TSCS above 60 THz saturates at the level indicated in Fig. 1.

References

1. S. H. Tseng, J. H. Greene, V. Backman, D. Maitland, and J. T. Walsh, Opt. Lett. **29,** 1393 (2004).
2. Q. H. Liu, in *Proceedings of the 1997 IEEE Antennas and Propagation Society International Symposium*, Vol. 1 (Institute of Electrical and Electronics Engineers, New York, 1997), pp. 122–125.
3. A. Taflove and S. C. Hagness, *Computational Electrodynamics: the Finite-Difference Time-Domain Method* (Artech House, Norwood, Mass., 2000), p. 852.

0146-9592/05/010056-02$15.00/0

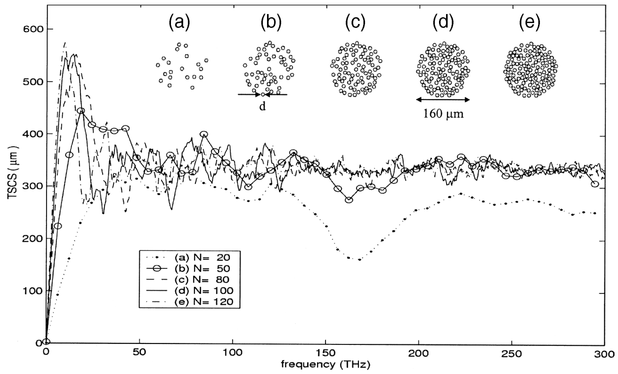

Fig. 3. PSTD-computed TSCS of a 160-μm overall-diameter cylindrical bundle of N randomly positioned, noncontacting, $n = 1.2$ dielectric cylinders of fixed individual diameter $d = 10$ μm. Five cases are shown ($N = 20, 50, 80, 100, 120$). As N exceeds approximately 50, the TSCS above 60 THz saturates at the same level as in Figs. 1 and 2.

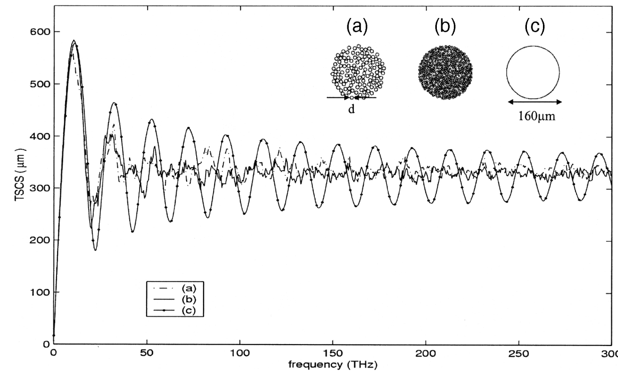

Fig. 4. PSTD-computed TSCS of (a) 160-μm overall-diameter cylindrical bundle of 120 randomly positioned, noncontacting, $n = 1.2$ dielectric cylinders of individual diameter $d = 10$ μm; (b) same as in (a) but for 480 cylinders of individual diameter $d = 5$ μm; and (c) single cylinder of refractive index $n = 1.0938$, the average refractive index for cases (a) and (b).