Comprehensive thematic T-matrix reference database: a 2017–2019 update

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PII: S0022-4073(19)30738-1
DOI: https://doi.org/10.1016/j.jqsrt.2019.106692
Reference: JQSRT 106692

To appear in: *Journal of Quantitative Spectroscopy & Radiative Transfer*

Received date: 11 October 2019
Accepted date: 12 October 2019

Highlights

- This compilation lists relevant *T*-matrix publications on electromagnetic scattering by particles and particle groups that have appeared since 2017.

Review

Comprehensive thematic *T*-matrix reference database: a 2017–2019 update

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Abstract

Since its inception in the mid-1960s, the *T*-matrix method has been one of the most versatile and efficient numerically exact computer solvers of the time-harmonic macroscopic Maxwell equations. It has been widely used for the computation of electromagnetic scattering by single and composite particles, discrete random media, periodic structures (including metamaterials), and particles in the vicinity of plane or rough interfaces separating media with different refractive indices. This compilation is the ninth update to the comprehensive thematic database of peer-reviewed *T*-matrix publications initiated in 2004 and lists relevant publications that have appeared since 2017. It also includes a few earlier publications that have so far been overlooked.

Keywords:
electromagnetic scattering
T-matrix method
macroscopic Maxwell equations
complex scattering objects

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1. Introduction

Waterman's *T*-matrix method summarized in his 1971 paper [1] has been one of the most efficient numerical techniques for the computation of electromagnetic scattering based on direct computer solutions of the macroscopic Maxwell equations. The thematic database of *T*-matrix publications on electromagnetic scattering by particles and particle groups was initiated in 2004 [2] and was continued in the form of eight updates [3–10]. The current ninth update lists and classifies into specific categories 285 new publications [11–295]. Most of the new entries have appeared since 2017, although a handful of older publications omitted inadvertently in Refs. [2–10] are also included.

The current update is compiled by adhearing to the same four general selection criteria:

- The database includes only publications dealing with the scattering of macroscopic time-harmonic electromagnetic fields.
- In general, publications on scattering by isolated infinite cylinders and systems of parallel infinite cylinders in an unbounded space are excluded.
- Publications on the Lorenz–Mie theory and its various extensions to individual isotropic spherically symmetric scatterers are not covered.
- The database contains only references to books, peer-reviewed book chapters, and peer-reviewed journal papers, while references to unrefereed conference abstracts as well as Masters, PhD, and Habilitation dissertations are not included.

Also, we continue to use the same operational definition of the *T*-matrix method, i.e.,

> In the framework of the *T*-matrix method, the incident and scattered time-harmonic electric field vectors are expanded in series of suitable vector spherical wave functions; the relation between the columns of the respective expansion coefficients is established by means of a transition matrix (or *T* matrix). This concept applies to the entire scatterer or to separate parts of a composite scatterer.

Consistent with this definition, this database includes publications dealing with what is often referred to as the multi-sphere method or the generalized Lorenz–Mie theory.

As before, all publications included in this update are taken at their face value, which implies that the inclusion of a publication does not constitute any formal endorsement or quality certification on our part. However, we do attempt to enhance the practical value of this database by classifying all publications into a set of narrower subject categories. Depending on its specific content, a reference can appear in one or more subject categories.

As a slight deviation from the "no comment" rule, we would like to highlight the inclusion in this update of three recent monographs [71,136,226]. In addition, we note the renewed interest in electromagnetic scattering by the simplest nonspherical particle, viz., a spheroid. Also of note is the large number of publications on radar remote sensing based on the *T*-matrix method. It definitely appears that the *T*-matrix method has become the preferred modeling tool in this discipline.

As always, we ask the users of this reference database to e-mail us missing old *T*-matrix publications as well as information on new books, book chapters, and peer-reviewed journal papers for inclusion in a forthcoming update.

2. Particles in infinite homogeneous space

2.1. Books, reviews, and tutorials

[71,92,136,190,226,251]

2.2. Mathematics of the T-matrix method

[58,66,70,149,239]

2.3. Extended boundary condition method and its modifications, generalizations, and alternatives

[65,78,121,124,210]

2.4. T-matrix theory and computations for anisotropic, chiral, gyrotropic, magnetic, and charged scatterers

[16,17,121,129,179]

2.5. Multi-sphere and superposition T-matrix methods and their modifications, including related mathematical tools

[62,64,66,108,127,153,207,224,239,240]

2.6. T-matrix theory and computations of electromagnetic scattering by periodic and aperiodic arrays of particles, photonic crystals, and metamaterials

[26,52,53,196,227,280]

2.7. T-matrix theory and computations of electromagnetic scattering by discrete random media and particulate surfaces

[19,56,62,63,111,147,152,164,165,166,178,182,185,187,207,246,253]

2.8. Relation of the T-matrix method to other theoretical approaches

[58,210]

2.9. Convergence of various implementations of the T-matrix method

[239,240,279]

2.10. Software implementations of the T-matrix method

[279]

2.11. T-matrix databases

[82,141]

2.12. T-matrix calculations for homogeneous spheroids

[11,12,13,14,15,22,30,31,33,34,35,36,38,39,44,45,46,47,48,49,50,55,58,61,65,69,73,75,81,82,83,85,86,87,88,89,91,93,95,96,100,102,104,106,107,109,114,115,116,120,122,123,126,129,130,132,133,134,136,142,148,149,150,155,156,159,160,161,162,163,167,168,170,171,172,173,174,176,180,181,188,193,194,197,201,202,203,204,206,211,212,214,216,217,220,228,230,231,234,235,238,241,242,243,244,245,247,248,249,252,257,258,259,260,261,269,271,274,275,279,287,292,293,294,295]

2.13. T-matrix calculations for Chebyshev and generalized Chebyshev particles

[129,269,272,287,290]

2.14. T-matrix calculations for finite circular cylinders

[18,24,32,42,43,45,48,51,65,69,74,85,90,103,112,127,167,214,219,262,269,287]

2.15. T-matrix calculations for various rotationally symmetric particles

[47,77,151,230]

2.16. T-matrix calculations for ellipsoids, polyhedral scatterers, and other particles lacking axial symmetry

[24,29,30,100,101,135,136,182,183,189,225,232,268,271,278,279,284]

2.17. T-matrix calculations for layered and composite particles

[25,29,268]

2.18. T-matrix calculations for clusters of homogeneous and core–mantle spheres

[19,20,26,28,37,54,57,59,60,61,67,68,76,94,98,99,105,111,117,119,128,131,138,139,141,143,144,145,146,158,163,164,165,177,184,185,186,187,191,192,195,199,209,218,219,222,224,229,232,236,237,246,250,255,264,266,267,270,281,283,291]

2.19. T-matrix calculations for clusters of nonspherical, inhomogeneous, and optically active monomers

[56,108,152,153,198,208,224,239,285]

2.20. T-matrix calculations for particles with one or multiple (eccentric) inclusions

[25,47,79,86,117,138,145,146,218,264,291]

2.21. T-matrix calculations of optical resonances in nonspherical particles and multi-particle clusters

[20,32,90,91,199,216,227]

2.22. T-matrix calculations of optical and photophoretic forces and torques on small particles

[68,84,100,101,179,190,191,233,251,263,273]

2.23. T-matrix calculations of internal, surface, and near fields and near-field energy exchange

[54,267]

2.24. Illumination by shaped and pulsed beams

[19,56,92,108,125,263]

2.25. Use of T-matrix calculations for testing other theoretical techniques and approximations

[31,53,74,77,78,102,103,134,140,147,150,153,219,225,236,255,256,266,271,292]

2.26. Use of T-matrix calculations for analyzing laboratory, in situ, and remote-sensing data

[18,45,46,91,98,135,148,192,208,213,214,223,229,250,252,278,282,288]

2.27. T-matrix modeling of scattering properties of mineral aerosols in the terrestrial atmos-

phere and soil particles

[13,22,29,38,44,69,82,85,128,131,135,159,160,162,170,171,172,173,174,181,201,232,231,242,268,269]

2.28. T-matrix modeling of scattering properties of carbonaceous and soot aerosols and soot-containing aerosol and cloud particles

[23,28,69,76,79,86,97,137,138,139,140,141,143,144,145,146,171,172,173,177,211,192,219,222,232,256,264,268,269,276,277,288,291]

2.29. T-matrix modeling of scattering properties of cirrus cloud particles

[24,36,39,48,73,136,154,255,278]

2.30. T-matrix modeling of scattering properties of hydrometeors and atmospheric radar targets

[11,12,14,15,33,34,35,40,49,50,55,74,75,80,81,83,86,87,88,89,95,96,104,106,107,109,110,114,115,116,120,122,123,126,130,132,133,142,155,156,157,167,168,169,175,176,180,193,197,200,206,212,221,228,230,234,235,238,247,248,249,254,257,258,259,260,261,265,274,275]

2.31. T-matrix modeling of scattering properties of volcanic, stratospheric, and noctilucent cloud particles

[27,161,188,203,241,243,245,294,295]

2.32. T-matrix modeling of scattering properties of hydrosols

[47,244]

2.33. T-matrix modeling of scattering properties of vegetation

[127]

2.34. T-matrix modeling of scattering properties of aerosol and cloud particles in planetary atmospheres

[42,43,51,112,184,236,262]

2.35. T-matrix modeling of scattering properties of interstellar, interplanetary, cometary, regolith, and planetary-ring particles

[57,60,61,93,94,118,119,158,163,183,204,217,229,236,237]

2.36. T-matrix computations for biophysical and biomedical applications

[220,272]

2.37. T-matrix computations of anisotropic and aggregation properties of colloids and other disperse media

[68,105,207,209]

3. Particles near infinite plane or rough interfaces

[21,72,205,113]

Acknowledgements

I think Nadezhda Zakharova for comprehensive assistance and Zoe Wai for helping me obtain copies of publications that were not readily accessible. This project was sponsored by the NASA Radiation Sciences Program managed by Hal Maring.

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