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Note

Comprehensive *T*-matrix reference database: A 2007–2009 update

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ABSTRACT

The *T*-matrix method is among the most versatile, efficient, and widely used theoretical techniques for the numerically exact computation of electromagnetic scattering by homogeneous and composite particles, clusters of particles, discrete random media, and particles in the vicinity of an interface separating two half-spaces with different refractive indices. This paper presents an update to the comprehensive database of *T*-matrix publications compiled by us previously and includes the publications that appeared since 2007. It also lists several earlier publications not included in the original database.

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1. Introduction

As evidenced by numerous citations, the original database of *T*-matrix publications [1–3] has proved to be a very useful research tool. Its customers have indicated to us many times that they would like to see a continually updated version, which appears to be quite reasonable given the steadily increasing popularity of the *T*-matrix approach (Fig. 1). As in the two previous updates [2,3], the way in which we accommodate this request is twofold. First, we have made the necessary corrections and straightforward updates in the original database [1–3], and the result has been posted at http://www.giss.nasa.gov/staff/mmishchenko/publications/. Second, this new paper lists several earlier publications that had been omitted inadvertently in [1–3] as well as the most recent *T*-matrix publications that have appeared since 2007. The total number of newly added publications is 253 [4–256].

As in [1–3], the database is kept at a manageable size by adhering to the following general restrictions:

- With a few important exceptions, the database contains only publications dealing with electromagnetic scattering.
- Publications on scattering by isolated infinite cylinders and systems of parallel infinite cylinders in unbounded space are excluded.
- Publications on the Lorenz–Mie theory and its various extensions to radially inhomogeneous spherically symmetric scatterers are excluded.
- The database contains only references to books, peer-reviewed book chapters, and peer-reviewed journal papers.

Also, we have continued to use the following operational definition of the *T*-matrix method:

> In the *T*-matrix method, the incident and scattered electric fields are expanded in series of suitable vector spherical wave functions, and the relation between the

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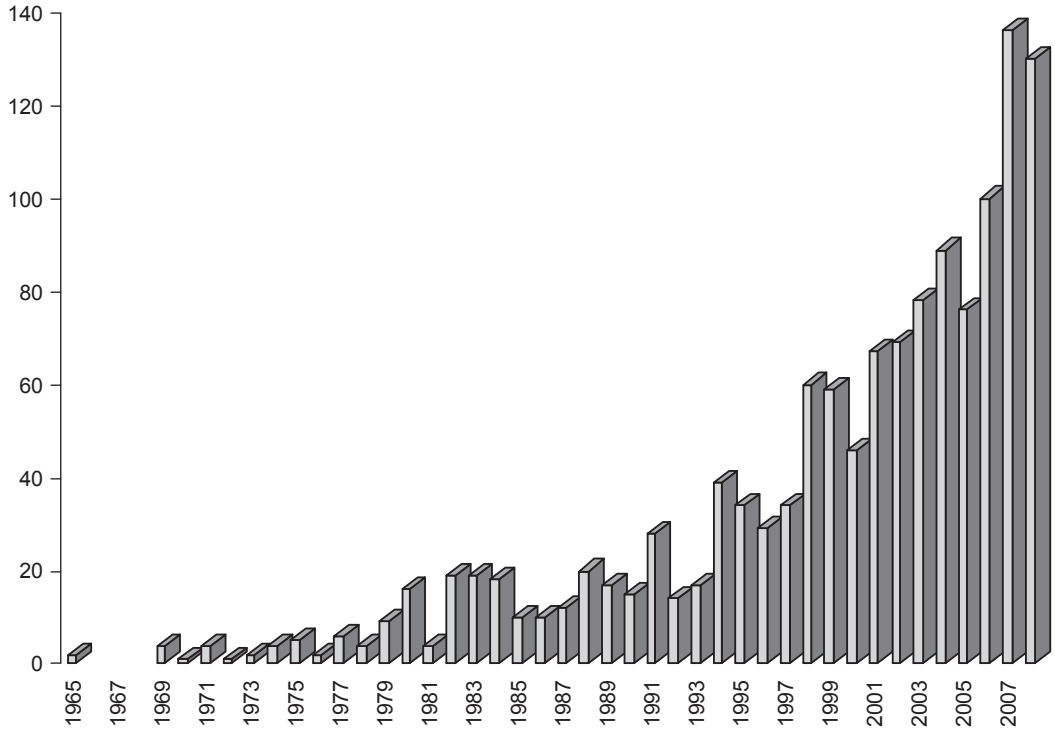

Fig. 1. Annual frequency distribution of the *T*-matrix publications.

columns of the respective expansion coefficients is established by means of a transition matrix (or *T* matrix). This concept can be applied to the entire scatterer as well as to separate parts of a composite scatterer.

This definition is consistent with the general methodology pursued in [257–259] and is significantly wider than the original notion of the extended boundary condition method (EBCM) [260]. According to our terminology, EBCM is just one of many potential techniques for the actual numerical calculation of the *T* matrix.

As in the original database, the use of the reference list is facilitated by classifying the various references into a set of narrower subject categories (Sections 2 and 3). This set is largely the same as in [1–3]. However, several original categories are not populated since no relevant publications have appeared during the past three years.

As previously, we do not assess or discuss the validity and importance of the results described in the specific *T*-matrix publications forming the reference list, which means that the inclusion of a publication does not constitute any formal endorsement or quality certification on our part. As before, we plan to maintain the updated version of the combined database on-line and, therefore, ask the readers to communicate to us corrections and missing references to existing and future publications on the *T*-matrix method and its practical applications.

2. Particles in infinite homogeneous space

2.1. Books

[252].

2.2. Reviews

[83,176].

2.3. Extended boundary condition method and its modifications and generalizations

[108,176,181,231,236,237,240,241,252].

2.4. T-matrix theory and computations for bi-isotropic, anisotropic, and chiral scatterers

[11,23,181,186].

2.5. Superposition T-matrix method and its modifications, including related mathematical tools

[39,73,236,237,240,241].

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

[61,91,92,93,149,197,211].

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

[11,14,120,123,127,142,205–207,221].

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

[98,99,111,176,220,232,252].

2.9. Symmetry properties of the T matrix and analytical ensemble-averaging approaches

[22,83,111,150].

2.10. Convergence and efficiency of various implementations of the T-matrix method

[26,106,159,223,231,232,236,237,239,240,241,252].

2.11. T-matrix calculations for homogeneous spheroids

[4,9,16,19,20,21,26,32,34–36,38,42,43,46,47,51,53,55–59,62,63,66,69,71,77,81,84,85,87–89,90,96,97,107,114,115,117,118,121,124,125,126,128,129,131–133,136,140,144–148,151,152,163,165–167,169–175,177,178,182,185,187,190,193,194,197,200,201,214,215,216,218,223–225,227,229,230,233,234,238,245,252,253].

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

[105,121,128,129,203,204,230,252].

2.13. T-matrix calculations for finite circular cylinders

[21,36,51,57,61,67,78,80,103,128,129,145,147,149,158,180,211,219,222,226,227,235,237,240,241,252].

2.14. T-matrix calculations for various rotationally symmetric particles

[75,86–88,94,156,157,161,188,195].

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

[180,181,236,237].

2.16. T-matrix calculations for layered and composite particles

[6,79,154,155,160,186,237].

2.17. T-matrix calculations for clusters of homogeneous spheres

[4,5,13–15,25,28–31,37,40,41,44,45,48–50,54,72,74,82,92,93,102,110,112,119,120,122,123,125,134,137,141–143,146,153,162,164,183,184,192,197,198,199,202,206–210,212–214,217,221,227,228,242–244,246,247,249,250].

2.18. T-matrix calculations for clusters of layered spheres

[91,92,93,197,217].

2.19. T-matrix calculations for clusters of nonspherical monomers

[61,149,197,237].

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

[160].

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

[4,5,15,18,26,40,48,49,61,72,74,79,86–88,92–94,100,154,155,164,169,183,184,197,198,199,211,228,233].

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

[12,24,25,42,95,113,138,139,189,190,191].

2.23. T-matrix calculations of internal, surface, and local fields

[13,23,26,31,37,40,112,134,153,162,198,206,207,247].

2.24. Illumination by focused beams and non-plane waves

[25,70,138,189,190,191].

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

[27,34,54,68,69,78,85,102,103,109,131,152,167,202,210,212–214,216,218,221,223,236,238,244,249,250].

2.26. Comparisons of T-matrix and effective-medium-approximation results

[23,102].

2.27. Comparisons of T-matrix and controlled laboratory results

[28–30,37,61,64–66,91,94,119,167–169,178,243].

2.28. Use of T-matrix calculations for analyzing laboratory data

[4–6,8,9,34,35,38,56,62,63,67,86,132,171,173,174,193,200,201,226,227,246].

2.29. T-matrix modeling of scattering properties of mineral aerosols in the terrestrial atmosphere and soil particles

[16,43,58,59,71,81,107,114,118,126,128,129,140,144,147,148,170,172,215,227,229,234].

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

[6,107,110,146,227,249,250].

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

[103,135,145,177,180,193,194,196,226,227].

2.32. T-matrix modeling of scattering properties of hydrometeors

[7,10,19,20,33,46,60,97,104,105,115,116,130,136,163,179,187,195,203,204,214,224,225,245,248,251,253,254].

2.33. T-matrix modeling of scattering properties of terrestrial stratospheric aerosol and cloud particles

[166].

2.34. T-matrix modeling of scattering properties of noctilucent cloud particles

[17,21,77,175,222].

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

[51,84,151,192,208,219,235].

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

[44,45,53,96,101,117,121,122,127,162,202,205,206,207,216].

2.37. T-matrix computations for industrial and military applications

[14,69,137,173,174,217].

2.38. T-matrix computations for biomedical applications

[4,5,8,9,34,35,38,41,47,55–57,62,63,67,69,80,88,132,133,136,171,173,174,188,200,201,209,218,238].

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

[89,132].

3. Particles near infinite interfaces

3.1. Spherically symmetric particles

[52,76,255].

3.2. Non-spherically symmetric finite particles and particle aggregates

[52,211,255,256].

3.3. Finite particles on incident side of planar interface

[52,211,255,256].

3.4. Tools for particle characterization

[76,256].

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