The invariant imbedding approach to the Debye series for light scattering by nonspherical particles

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The Debye series was first proposed for light scattering by an infinite circular cylinder [1]. It has been demonstrated to be valuable for optical interpretation of light scattering by spheres, coated spheres, and spheroids (e.g., [2–4]). By applying the extended boundary condition method (EBCM) [5,6] and expanding the Green's dyadic into the third and fourth vector spherical wave functions, Xu *et al.* [7,8] derived the Debye series for a homogeneous and coated nonspherical particle. However, like the EBCM-based T-matrix method for computing light scattering by nonspherical particles, the EBCM-based Debye series approach has similar numerical convergence issues in calculating light scattering when the particle size and/or aspect ratio (e.g., for spheroid) gets large. In this talk, we report the progress in using an invariant imbedding approach (IIA, [9]) to compute the Debye series for a large nonspherical particle. The IIA has been successfully applied to compute the T-matrix for large nonspherical particles [10] and found to be also applicable in the framework of the Debye series. First, we show that the T-matrix can be explicitly expanded in terms of an infinite series. To compute the IIA-based Debye series, we derive four matrices associated with the reflection and transmission of wave interaction upon the boundary from the medium to the particle and from the particle to the medium. Second, we demonstrate that the four matrices satisfy the Riccati differential equations which can be solved by the Runge–Kutta method. The results are analytically validated for a sphere and numerically validated for nearly spherical particles (against the results computed by the EBCM-based Debye approach). Finally, the new insights into light scattering by nonspherical particles gained from the Debye series approach are illustrated with representative examples, such as the optical interpretation of light backscattering by nonspherical particles.

References

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