Static-limit *T*-matrix for a dielectric torus

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Semi-analytic expressions for the static limit of the *T*-matrix for electromagnetic scattering are derived for a circular torus, expressed in either a basis of toroidal harmonics or spherical harmonics. The scattering problem for an arbitrary static excitation is solved using toroidal harmonics, and these are then compared to the extended boundary condition method to obtain analytic expressions for auxiliary *Q*- and *P*-matrices, from which $\mathbf{T} = \mathbf{PQ}^{-1}$, where these matrices are expressed in a basis of toroidal harmonics. The electrostatic solution for a dielectric torus has been known since 1972 [1] as a combination of a continued fraction and a recurrence relation, rather than a matrix inverse. The method applied here leads to independent calculations of the plasmon resonances, including a set of resonances unobtainable via the continued fraction approach. Also, by applying the basis transformations between toroidal and spherical harmonics, the quasi-static limit of the electric-electric multipole coupling block $\mathbf{T}^{22}$ of [2] is obtained. This allows computations of static limits of the optical cross-sections, and also to obtain analytic expressions for the limit of a thin ring. We discuss the existence of the *T*-matrix for an object of such a complex shape in the Rayleigh limit.

References

[1] Love, J., 1972: *J. Math. Phys*. **13**, 1297.

[2] Mishchenko, M. I., L. D. Travis, and A. A. Lacis, 2002: *Scattering, Absorption, and Emission of Light by Small Particles.* Cambridge University Press, Cambridge, UK.

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