Electromagnetic scattering of a plane wave by a radially inhomogeneous sphere in the short wavelength limit

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The interior and exterior electric and magnetic fields for scattering of a plane wave by a radially inhomogeneous sphere with refractive index \( N(r) \) are expressed in terms of TE- and TM-polarized partial wave scalar radiation potentials. The wave equation for these potentials is approximately solved in the short wavelength limit using the WKB method. The WKB solution is expanded in terms of a Debye series, whose terms are interpreted as multiple internal reflections of the interior wave at the sphere surface. The sum over the partial wave contributions to the fields is approximately evaluated using the method of stationary phase. The final expressions for the far-zone scattered fields provide a generalization of both ray theory and Airy theory to scattering by a radially inhomogeneous sphere. This wave theory approach provides a rigorous foundation to various results that have previously appeared in the literature based on an analogy to scattering by a homogeneous sphere. The physical interpretation of the TE-polarized fields is straightforward. But the TM-polarized fields possess a number of additional terms beyond those expected by appealing to an analogy to TM ray scattering by a homogeneous sphere.

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