Debye series analysis of plane wave scattering by a charged sphere

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Electromagnetic scattering has applications in optical tweezers [1], optical communications [2], etc. Most of these applications involve the interaction of a plane wave with a particle. Most studies about the interaction of waves with particles are based on the assumption that the particles are not charged. However, most encountered particles are charged owing to many reasons, for instance, frequent collisions between particles or contacts with reactor walls. Many researches have been devoted to the scattering of a plane wave by a charged sphere [3–5] based on the Lorenz–Mie theory (LMT), which is a rigorous solution of the Maxwell equations and contains all the effects that contribute to scattering. However, the LMT gives few clues to the scattering processes. By writing each term of the Mie series as another infinite series, the Debye series can give a physical interpretation of various scattering processes [6–9].

In this paper, the Debye series is employed to solve the plane wave scattering by a charged sphere, and various scattering phenomena, such as rainbows, are analyzed. The far-field scattered intensity of a charged sphere illuminated by a plane wave is studied, and the effects of various parameters (including the charge, scattering process (namely Debye mode p), etc.) on the far-field scattered intensities are mainly discussed. Such results have important applications in various fields, including particle sizing, optical tweezers, etc.

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