Electromagnetic Field for Randomly Oriented Particle Located in Laser Beam

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There are a lot of practical applications involving particle, such as particle size measurements using a phase Doppler instrument, light scattering by aerosols in atmosphere, trapping the particle in laser tweezers, the absorption in the human head of electromagnetic waves emitted by hand phones and the effect of radomes (spheroidal dielectric covers) on radar and communications antennas. Many investigations on the scattering from particle have been carried out GLMTs describe the interaction between an arbitrary shaped beam and a class of scatterers exhibiting a regular surface. In GLMTs, the most difficult task concerns the description of the illuminating beam. Gouesbet et al. have provided approaches for expansions of the incident shaped beam propagating parallel to the coordinate axis (i.e., an off-axis beam).

In this paper, we provide the description of the arbitrarily shape beam, for example, a plane wave or a Gaussian beam, for any angle incidence by virtue of the Generalized Lorenz-Mie theory. The incident beam is decomposed into an infinite series of elementary constituents, such as partial wave or plane waves, with amplitudes and phases given by a set of beam-shape coefficients. We derive the transformation of spherical vector wave functions with reference to the two different spherical coordinate systems under rotated translation and obtain the general expression of beam shape coefficients $g_{n,TE}^{ms}$, $g_{n,TE}^{\prime ms}$, $g_{n,TM}^{ms}$, $g_{n,TE}^{\prime ms}$ for the randomly oriented scatterer.

Once the beam-shape coefficients in coordinates are determined, the solution of scattering for arbitrary shaped beam by a particle is obtained by means of the method of separation of variables. The fields are expanded in the terms of the spherical vector wave functions. The unknown coefficients of scattered and internal electromagnetic fields are determined by solving a system of linear equations derived from the boundary conditions. The exact analytic solution of scattering from a randomly oriented axisymmetric particle with an arbitrarily shaped beam illumination can be obtained by means of the method of separation of variables. Also, the numerical results for the beam scattering properties for particle is given. The associated code, developed under Matlab, is suitable for computing the scattering properties of the randomly oriented particles, allowing one to extensively investigate the dependence of scattering properties on the particle size, shape, refractive index, magnitude and location of beam waist. This study is suggestive and useful for interpretation of electromagnetic scattering phenomena from oriented particles.