

Structured light interaction with small particles: GLMT and EBCM theoretical treatments

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With the enhancement of techniques in manipulating optical fields, various structured beams with brand new properties, e.g., non-diffractive Bessel beams, Laguerre–Gaussian beams with orbital angular momentum, self-accelerating Airy beams, and others, are generated by manipulating the amplitude, phase, and polarization of a basic Gaussian beam or a plane wave. Novel applications in optical manipulations, super-resolution imaging technique, biological detection, and other fields are extended significantly, which brings a promising research in the investigation of structured beam interactions with small particles [1].

From a theoretical perspective, great efforts have been devoted to deal with the scattering of structured beams by small particles in the past decades. The Lorenz–Mie theory (LMT), which provides a rigorous way to describe the interaction between a linearly polarized plane wave and a homogeneous spherical particle, was greatly developed and extended after the name of generalized Lorenz–Mie theory (GLMT) mainly from two aspects: (i) from plane wave to arbitrary structured beams, and (ii) from homogeneous sphere to various regular shaped/structured particles [2]. The GLMT is now a well-known and widely used tool in the structured beams scattering by regular particles. Although only regular particles can be handled by the GLMT since this analytical method is implemented based on the separation of variables, the expansion description of arbitrary structured beams in GLMT can be combined with the Extended Boundary Condition Method (EBCM), or the Null-Field Method (NFM) [3] to construct a synthetic T-matrix solution for the structured beams scattering by arbitrary shaped particles [4]. This technique is of great interest and much favorable in several research fields since the advantage of T-matrix: “The elements of T-matrix are independent of the incident field ..., so that the T-matrix needs to be computed only once and then can be used in computations for any directions of light incidence and scattering” [5] holds, and fruitful results for the expansion description of arbitrary structured beams in the GLMT can be directly used.

In this talk, most recent developments in the theoretical treatments of structured light interactions with spherical/nonspherical particles are briefly reviewed. Description and expansion of structured beam [6,7], evaluation of beam shape coefficients (BSCs) for use in the GLMT and EBCM [8, 9], the synthesis between the GLMT and EBCM [4], and some results concerning the far-field, internal, and near-surface field distributions will be discussed.

References

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