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Analysis of scattering of high-order Laguerre-Gaussian vortex beam by biological cells

T. Qu, Z.S. Wu, Q.C. Shang, Z. J. Li, and L. Bai
School of Physics and Optoelectronic Engineering, Xidian University, Xi'an, China

As a beam with spiral phase distribution, high-order Laguerre-Gaussian vortex beam carry orbital angular momentum in addition to the spin momentum associated with the polarization state of the photons. The beam conquers the shortcoming of Gaussian beam in optical manipulation for low refractive index particles than the surrounding medium and can rotate the particles as designed. The study of the scattering the high-order Laguerre-Gaussian vortex beam by particles is the precondition for the study of the optical manipulation and can be helpful for the understanding of this process. However, the study of the scattering the high-order Laguerre-Gaussian vortex beam by particles has never been reported.
Using Generalized Lorenz Mie Theory (GLMT) the scattering of high-order Laguerre-Gaussian vortex beam by biological cells is analyzed. Based on the expansion of Hermite Gaussian beam in terms of spherical vector wave functions (SVWFs) utilizing complex source point method and the relation between Hermite Gaussian beam and high-order Laguerre-Gaussian vortex beam, derived the expansion of high-order Laguerre-Gaussian beam in terms of SVWFs. The analytical expression of beam shape coefficient (BSCs) for high-order high-order Laguerre-Gaussian vortex beam are calculated. HeLa cervical cancer cell and mononuclear blood cell are appropriately modeled as homogeneous sphere and five-layered sphere. Scattered field of different types of biological cells are obtained utilizing GLMT. The angular distributions of scattering field of high-order Laguerre-Gaussian vortex beam by a cancer cell and five-layered lymphocyte are numerically simulated. The results are compared with that by Gaussian beams and high-order Laguerre-Gaussian beams without vortex phase distribution. The effects of the radial and azimuthal mode index of LG vortex beam on the angular distribution of scattering field are numerically discussed. Moreover, the illustrations of the different angular distribution under different modes high-order Laguerre-Gaussian beam illumination are given in detail. The theory in this paper is useful for the optical manipulation of high-order Laguerre-Gaussian vortex beam and can be applied in the biomedical diagnosis and treatment.