Features of Scattering of Electromagnetic Vortex Bessel Beams by a Gyrotropic Cylinder

Vasiliy A. Es'kin* [(1)] and Alexander V. Kudrin[(1)]
(1) University of Nizhny Novgorod, Nizhny Novgorod 603950, Russia

We study features of scattering of E- and H-polarized electromagnetic vortex Bessel beams by a gyrotropic cylinder located in free space in the case where the symmetry axes of the beam and the cylinder coincide. As a medium filling the cylinder, a magnetoplasma in the radio-frequency range and an artificial material constituted from graphene-sandwiched dielectric disks in the infrared range are considered.

Main attention is focused on the case of an electrically thin cylinder in an external magnetic field that is sufficient for ensuring a well-pronounced splitting of multipole quasistatic resonances of the cylindrical scatterer. It is shown that in the case where the frequency and topological charge of the vortex Bessel beam are equal to the frequency and azimuthal index of the cylinder multipole resonance, respectively, significant enhancement of the beam scattering occurs. Moreover, the field components that are absent in the incident-beam field are present in the scattered field. For example, in the case of scattering of the E-polarized Bessel beam, the axial magnetic field appears, whereas in the case of scattering of the H-polarized Bessel beam, the axial electric field is observed. The transverse structure of these scattered components represents a divergent nonsymmetric cylindrical wave. In these cases, the absolute values of the scattering coefficients increase from 0 to 0.5 if the axial propagation constant of the beam increases from zero to the free-space wave number. At the same time, such a variation in the propagation constant results in that the coefficient of scattering of the E-polarized beam to the axial electric-field component increases from 0 to 0.5 in absolute value, while the coefficient of scattering of the H-polarized beam to the axial magnetic-field component decreases from 1 to 0.5 in absolute value. If the propagation constant of the beam tends to the free-space wave number, then the axial electric-field component in the case of scattering of the E-polarized Bessel beam and the axial magnetic-field component in the case of scattering of the H-polarized Bessel beam take the form of a convergent cylindrical wave as a result of interference of the scattered and incident waves. It is established that due to the presence of components which are absent in the incident field, but contribute to the scattered field, the beam with a given topological charge can efficiently be detected among a set of vortex Bessel beams propagating along the same axis.

The results obtained can be used for diagnostics of media of natural or artificial origin, as well as for developing new devices capable of separating and detecting vortex beams for the needs of telecommunication systems.