Generating Gaussian beams using energy-efficient phase DOEs

S.N. Khonina [1,2], A.A. Almazov [2]
[1] Image Processing Systems Institute of RAS;
[2] Samara State Aerospace University

Abstract

This work is devoted to the design of energy efficient helical phase diffractive optical elements (DOEs), type exp (imϕ,) for the generation of Gauss–Laguerre modes, Ψ_{0m} (r, ϕ), |m|≤M. DOEs are designed using the modified Lezem method. An optimal aperture radius is calculated for the elements that operate with a plane illuminating wave. In case of illumination with a Gaussian beam, an optimal effective radius of the Gaussian beam is calculated. Though in this case the main criterion for assessing the quality of synthesized DOEs is the energy efficiency (i.e., maximizing the content of specified Gauss-Laguerre modes in the generated light fields), the root-mean-square and geometric errors are very low. The results of the experimental simultaneous generation of 24 beams with different helical components in different diffraction orders are also presented.

Keywords: Gaussian beam, phase DOE, Gauss–Laguerre mode, Lezem method, aperture radius, illuminating wave, diffraction order.

Citation: Khonina SN, Almazov AA. Generating Gaussian beams using energy-efficient phase DOEs. Computer Optics 2002; 24: 102-109.

Access full text (in Russian)

References

[1] Gahagan KT, Swartzlander GA Jr. Optical vortex trapping of particles. Opt Lett 1996; 21(11): 827-829.
[2] Paterson L, MacDonald MP, Arlt J, Sibbett W, Bryant PE, Dholakia K. Controlled rotation of optically trapped microscopic particles. Science 2001; 292: 912-914.
[3] Shinmura Y, Ezoe H, Yoshikawa M. Observation of mode in graded-index optical fibers with bending and cross talk in MDM. IEICE Trans Electron 1997; E80-C(6): 828-830.
[4] Johnson EG, Stack J, Koehler C. Light coupling by vortex lens into graded index fiber. J Light Technol 2001; 19(5): 753-758.
[5] Chen YF, Lan YP, Wang SC. Generation of Laguerre-Gaussian modes in fiber-coupled laser diode end-pumped lasers. Appl Phys B 2001; 77: 167-170.
[6] Aagedal H, Schmid M, Beth T, Teiwes S, Wyrowski F. Theory of speckles in diffractive optics and its application to beam shaping. J Mod Opt 1996; 43(7): 1409-1421.
[7] Walford JN, Nugent KA, Roberts A, Scholten RE. High-resolution phase imaging of phase singularities in the focal region of a lens. Opt Lett 2002; 27(5): 345-347.
[8] Roux FS. Diffractive optical implementation of rotation transform performed by using phase singularities. Appl Opt 1993; 32(20), 3715-3719 (1993).
[9] Basistiy IV, Bazhenov VYu, Soskin MS, Vasnetsov MV. Optics of light beams with screw dislocations. Opt Comm 1993; 103: 422-428.
[10] Abramochkin E, Losersky N, Volostnikov V. Generation of spiral-type laser beams. Opt Comm 1997; 141: 59-64.
[11] Szwaykowski P. Self-imaging in polar coordinates. J Opt Soc Am A 1988; 5(2): 185-191.
[12] Padgett M, Arlt J, Simpson N, Allen L. An experiment to observe the intensity and phase structure of Laguerre-Gaussian laser modes // Am. J. Phys. 64(1), 77-82 (1996).
[13] Lesem LB, Hirsh PM, Jordan JA. The kinoform: a new wavefront reconstruction device. IBM J Res Dev 1969; 13(3): 150-155.
[14] Kotlyar VV, Khonina SN, Melekhin AS, Soifer VA. Fractional encoding method for spatial filters computation. Asian J Phys 1999; 8(3): 273-286.
[15] Khonina SN, Almazov AA. Design of multichannel phase spatial filter for selection of Gauss–Laguerre laser modes. Proc SPIE 2002; 4705: 30-39.
[16] Kotlyar VV, Khonina SN. Phase filter for selection of angular harmonics [In Russian]. Computer Optics 2000; 20: 51-55.
[17] Kotlyar VV, Khonina SN, Soifer VA, Wang J. Measuring the orbital angular momentum of the light field with a diffractive optical element [In Russian]. Avtometriya 2002; 38(3): 33-44.