Calculation of generalized Fish-Eye lenses of Maxwell and Eaton-Lippmann

V.V. Kotlyar [1,2], F.S. Melekhin [2]
[1] Image Processing Systems Institute of RAS
[2] Samara State Aerospace University

Abstract

Integral equations for the rays in two gradient lenses with a spherically symmetric dependence of the refractive index on coordinates are derived and solved using the Abel transform. The first lens shaped as a half-sphere with a spherically symmetric distribution of the refractive index focuses a flat beam of rays that falls perpendicular on the flat surface of the half-sphere to a point lying on the axis of the incident beam and at a certain distance from the half-sphere. Such a lens appeared to be a generalization of the well-known Maxwell's fisheye lens. The second lens is a generalization of the well-known Eaton-Lipman lens and it reflects (or deflects) any ray at a given angle. The generalized Eaton-Lipman lens forms an incident parallel beam of rays into conical waves, that is, it is a gradient axicon. In addition, an integral equation was derived and solved for calculating a gradient, spherically symmetric focusator, shaped as a half-sphere, which focuses a parallel beam of rays falling perpendicular to its flat surface into a radially symmetric region of a plane with a given intensity distribution, located perpendicular to the beam axis at a certain distance from the half-sphere.

Keywords: Fish-Eye lense, Eaton-Lipman lens, Maxwell's lens, half-sphere, gradient axicon, focusator.

Citation: Kotlyar VV, Melekhin FS. Calculation of generalized Fish-Eye lenses of Maxwell and Eaton-Lippmann. Computer Optics 2002; 24: 53-57.

Access full text (in Russian)

References

[1] Kotlyar VV, Melekhin AS. Abel transform in the problems of design of gradient optical elements. Computer Optics 2001; 22: 29-36.
[2] Luneburg RK. Mathematical theory of optics. Providence, RI: Brown University Press; 1944.
[3] Morgan SP. General solution of the Luneburg lens problem. J Appl Phys 1958; 29: 1358-1368.
[4] Fletcher A, Murphy T, Young A. Solution of two optical problems. Proc Math Phys Eng Sci 1954; 223: 216-225.
[5] Mikaelyan AL. Application of a layered medium to focusing of waves [In Russian]. Doklady Akademii Nauk SSSR 1951; 81: 569-571.
[6] Maxwell JC. The scientific papers of James Clerk Maxwell. Vol 1. London: Cambridge University Press Warehouse; 1890.
[7] Prokhorov AM. Encyclopedia of physics. CRC Press Inc LLC; 1992.
[8] Flores JR. Gradient-index with spherical symmetry. J Mod Opt 1999; 46(11): 1513-1525.
[9] Flores JR. Spherically symmetric GRIN amplitude formers. J Mod Opt 2001; 48(7): 1225-1238.
[10] Born M, Wolf E. Principles of optics: Electromagnetic theory of propagation, interference and diffraction of light. 7th ed. Cambridge: Cambridge University Press; 1999.
[11] Greisukh GI, Bobrov ST, Stepanov SA. Optics of diffractive and gradient–index elements and systems. Bellingham: SPIE Press; 1997.
[12] Prudnikov AP, Brychkov YA, Marichev OI. Integrals and series. CRC Press Inc; 1992.