18a-C13-5

Rotating longitudinally polarized field in the focal region

IMRAM, Tohoku Univ., °Sunil Vyas, Yuichi Kozawa, Shunichi Sato

E-mail: sunil@tagen.tohoku.ac.jp

Spatial distribution of light field in the focal region with desired features of intensity, phase and polarization is an area of current interest. Presence of a strong longitudinal electric field component in the focal region is an asset for many applications. Highly localized field distribution created by tightly focused radially polarized beam has become an important tool in many areas of advanced studies, for example, high resolution imaging, particle acceleration, and Raman spectroscopy. In addition, longitudinal field component generated by focusing radially polarized field has strong connection with the biological sciences via microscopy and optical tweezers techniques.

Strong longitudinal field component with the property of rotation has not been dealt so far. Motivated by the above fact, in this study, by using numerical simulations, we have shown a rotating longitudinally polarized field can be created in the focal region by annular shaped phase mask having two concentric regions with opposite spiral phase variations. As comparison to the previously reported result, the strength of the longitudinal field component is enhanced due to the presence of an annular mask [1]. The phenomena of rotation of the field can be explained by analogy with a superposition of two higher order Bessel beams, which have the property of rotation and orbital angular momentum [2]. The calculations of the field distribution under high numerical aperture focusing are performed using vector diffraction theory [3]. Properties of longitudinal field component are analyzed in detail. Figure 1 shows the calculated field distribution in the focal region. It can be clearly seen that a strong longitudinal field with the property of rotation is formed in the focal region. Due to the nondiffracting property of the Bessel beam, the focal field has a long depth of focus. Rotating longitudinally polarized field may find important application in the field of 3D imaging of single molecule, particle acceleration, and optical tweezers.

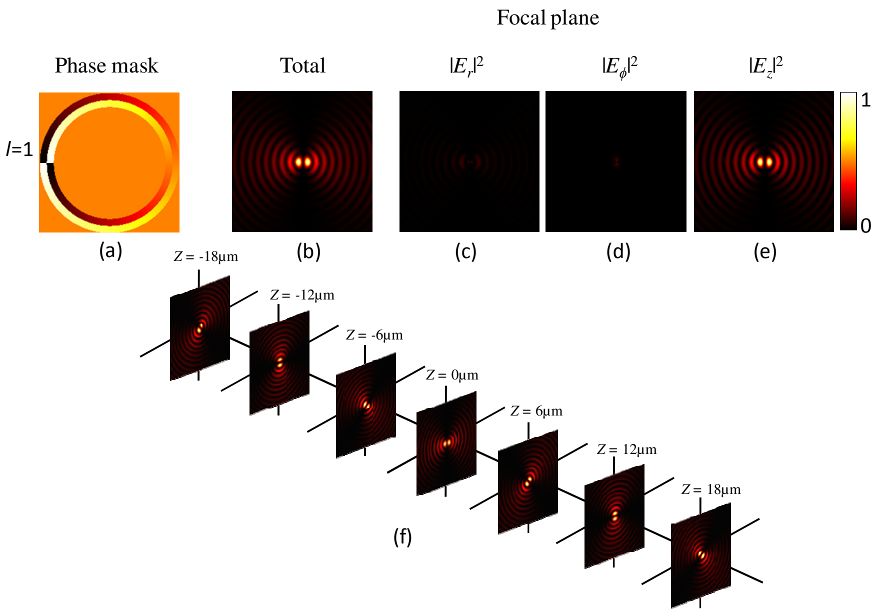

Fig.1. Field distribution in the foal region, (a) annular phase mask, (b) total intensity distribution, (c) radial field component, (d) azimuthal field component, (e) longitudinal field component, (f) longitudinal field component at different z-planes in the focal region. (λ = 632.8nm, refractive index n = 1, NA = 0.95, w_0 = 3mm and f = 3mm.)

References:

[1] S. Vyas, Y. Kozawa, and S. Sato, “Tailoring of twisted longitudinally polarized field in focal region” Frontiers in Optics 2012, Rochester, New York, USA.

[2] A. Dudley, and A. Forbes “From stationary annular rings to rotating Bessel beams” J. Opt. Soc. Am. A **29**, 567-573 (2012).

[3] B. Richards and E. Wolf, “Electromagnetic diffraction in optical systems II. Structure of the image field in an aplanatic systems,” Proc. Soc. London, **253,** 358-379 (1959).