Focal Switch Effect of Focused Cosine Gaussian Beam

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The light intensity on axis and the focal switch effect of cosine Gaussian beam focused by a thin lens without aperture is studied in detail by using Collins formula. The third-order algebraic equation determining the position of the axial maximum intensity and the formula of the relative transition height are derived. It is shown that the relative focal shift and the focal switch depend on the optical system parameter s/f, beam parameter $\alpha = w_0\Omega_0$, and Fresnel number of beam N_w. Numerical calculation results are presented to illustrate the theoretical predictions. It is shown that if the beam parameter α is smaller than 1, there only exist one axial irradiance maximum, and the focal shift changes slowly with the change of the optical system parameter. So the focal switch of cosine Gaussian will not occur. When the beam parameter α is bigger than 1, the on-axis light intensity is split into two-peaks, which are separately at the both sides of the geometrical focus. The two peaks reach the same height when the optical system parameter s/f equals 1. The relative focal shift changes from negative to positive number, and the focal switch occurs at this point. For example, when the parameters for calculation are Fresnel number of beam $N_w = 2$ and the beam parameter $\alpha = 1.5$, the relative focal shift changes from the left of geometrical focus ($z_{f1} = -0.1779$) to the right of geometrical focus ($z_{f2} = 0.1779$). It is also found that the relative transition height $\Delta z_f = |z_{f1} - z_{f2}|$ increases with the increase of the beam parameter s/f, and decreases with the increase of Fresnel number of beam N_w. Numerical calculation results show that when the beam parameter α is bigger than 1, there exists a hollow between two peaks on the axiswhich becomes deep with the increase of the beam parameter. When the beam parameter is bigger than 3.5, the intensity near the hollow approximately equals zero.