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Propagation intensity and phase distribution of Beam

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Abstract

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1. INTRODUCTION

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2. MODEL OF A BEAM

At the source plane, the electric fields of the LGVB beam can be expressed as[4]:

$$E(r_0,0) = \frac{w_{0x}w_{0y}}{\left(w_{0x}^2+x_0^2\right)\left(w_{0y}^2+y_0^2\right)} \times \exp\left(-\frac{x_0^2+y_0^2}{w_0^2}\right) \times \left(\frac{x_0+iy_0}{w_0}\right)^M, \tag{1}$$

where $r_0 = (x_0, y_0)$ is the position vector at the source plane z_0, w_{0x} and w_{0y} are the parameters related to the beam widths in the x and y directions, respectively, w_0 is the waist width of the Gaussian part of the Lorentz–Gauss vortex beam, and M is the topological charge of Lorentz–Gauss vortex beam[5]:

$$W(r_{01};r_{02};0) = \langle E(r_{01},0)\, E^*(r_{02},0)\rangle = \sqrt{I(r_{01},0)I(r_{02},0)} \times \mu(x_{01}-x_{02}, y_{01}-y_{02}), \tag{2}$$

where $\mu(x_{01}-x_{02},y_{01}-y_{02})$ represents the spectral degree of coherence and is represented as follows:

$$\mu(x_{01}-x_{02},y_{01}-y_{02}) = \exp\left[-\frac{(x_{01}-x_{02})^2}{2\sigma_x^2}-\frac{(y_{01}-y_{02})^2}{2\sigma_y^2}\right], \quad (3)$$

when σ turns into infinity, $\mu(x_{01}-x_{02},y_{01}-y_{02})=1$, thus becoming

$$W(r_{01};r_{02};0)=\sqrt{I(r_{01},0)I(r_{02},0)}, \quad (4)$$

and when $r_{01}=r_{02}$ then

$$W(r_{01};r_{02};0)=I(r_{01},0) \quad (5)$$

Substituting Eq. (1) into Eq.(3), partially coherent Lorentz-Gauss vortex beam at the source plane can be expressed as[6]:

$$\begin{aligned} W(r_{01};r_{02};0) = {} & \frac{1}{w_0^{2M}}\frac{w_{0x}w_{0y}}{\left(w_{0x}^2+x_{01}^2\right)\left(w_{0y}^2+y_{01}^2\right)} \\ & \times\exp\left(-\frac{x_{01}^2+y_{01}^2}{w_0^2}\right)\times(x_{01}+iy_{01})^M \\ & \times\frac{w_{0x}w_{0y}}{\left(w_{0x}^2+x_{02}^2\right)\left(w_{0y}^2+y_{02}^2\right)} \\ & \times\exp\left(-\frac{x_{02}^2+y_{02}^2}{w_0^2}\right)\times(x_{02}-iy_{02})^M \\ & \times\exp\left[-\frac{(x_{01}-x_{02})^2}{2\sigma_x^2}-\frac{(y_{01}-y_{02})^2}{2\sigma_y^2}\right], \end{aligned} \quad (6)$$

Where σ_x and σ_y are the spatial coherence length in the x and y directions respectively . By considering in Eq.(6), the relation between the Hermite-Gauss function and the Lorentz distribution function [6]:

$$\begin{aligned} & \frac{1}{\left(w_{0x}^2+x^2\right)\left(w_{0y}^2+y^2\right)} = \\ & \frac{\pi}{2w_{0x}^2w_{0y}^2}\sum_{m=0}^{N}\sum_{n=0}^{N}a_{2m}a_{2n} \\ & H_{2m}\left(\frac{x}{w_{0x}}\right)H_{2n}\left(\frac{y}{w_{0y}}\right) \\ & \times\ \exp\left(-\frac{x^2}{2w_{0x}^2}-\frac{y^2}{2w_{0y}^2}\right). \end{aligned} \quad (7)$$

Where H_{2m} and H_{2n} are the $2m$ and $2n$ order Hermite polynomial, and H_{2m} can be expressed as[7]

$$H_{2m}(x)=\sum_{L=0}^{m}\frac{(-1)^L(2m)!}{L!(2m-2L)!}(2x)^{2m-2L}. \quad (8)$$

Similarly, H_{2n} can be expressed as in Eq.(8), only m replaced by n. And the expanded coefficients a_{2m} can be rewritten as: [4]

$$\begin{aligned} a_{2m} = {} & \frac{(-1)^m}{2^{2m-1}\sqrt{\pi}}\left\{\frac{1}{m!}\sqrt{\frac{\pi}{2}}\,\mathbf{e}^{(1/4)^2}\mathrm{erfc}\left[\frac{1}{\sqrt{2}}\right]\right. \\ & +\sum_{s=1}^{m}\frac{2^{2s}}{(2s)!(m-s)!}\left[\sqrt{\frac{\pi}{2}}\,\mathbf{e}^{(1/4)^2}\times\right. \\ & \left.\left.\mathrm{erfc}\left[\frac{1}{\sqrt{2}}\right]+\sum_{t=1}^{s}(-1)^t(2t-3)!!\right]\right\}. \end{aligned} \quad (9)$$

where erfc $[x]=1-$ erf $[x]$, and with an increasing in numbers $2m$ the values of a_{2m} will dramatically decrease. Now, recalling the following equation [7]:

$$(x+iy)^M=\sum_{L=0}^{M}\frac{M!i^L}{L!(M-L)!}x^{M-L}y^L, \quad (10)$$

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2.1. Simulation and discussion

In this section, the average intensity, phase, and vortex properties of the beam propagating. Figures 1 and 2 ...

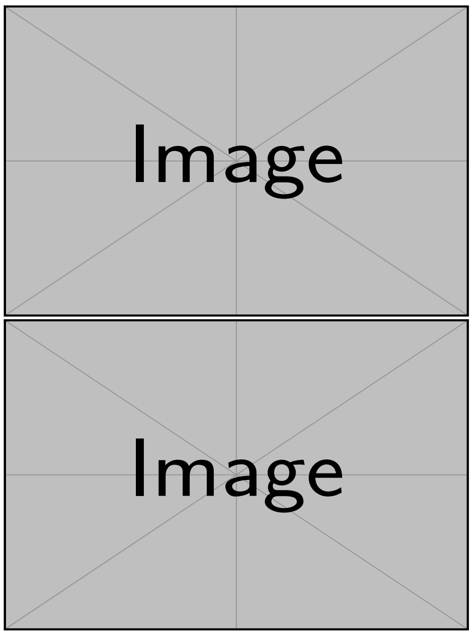

Figure 1. Normalized intensity and the phase distribution with different values of $w_{0x}=w_{0y}$.

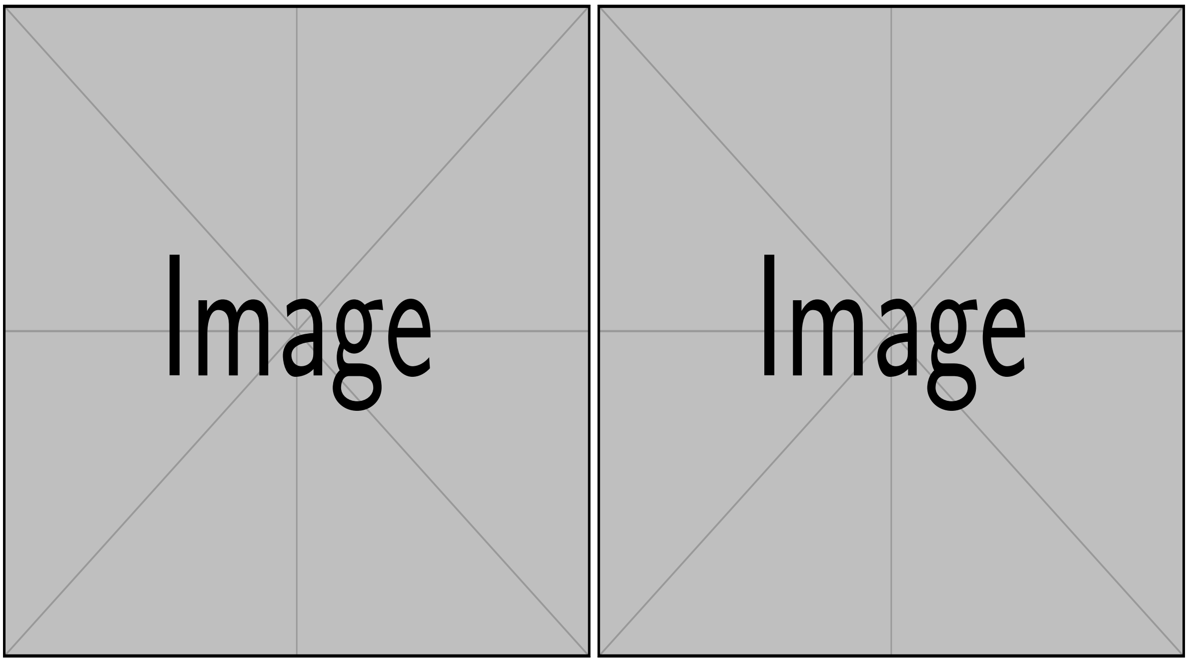

Figure 2. Normalized intensity and the phase distribution with different values of $w_{0x} = w_{0y}$.

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3. CONCLUSION

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