

Simulation of the formation of vortex beams during diffraction by a thin spiral aperture

V. I. Logachev

Aperture

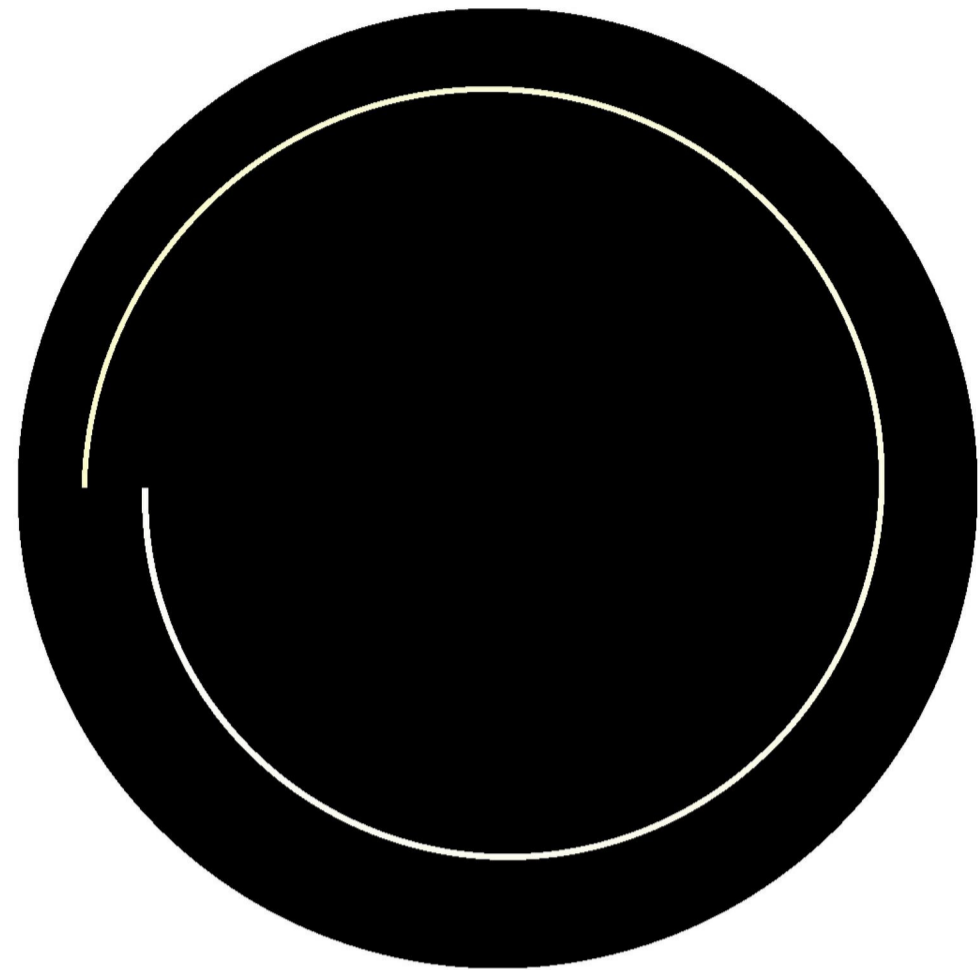


Fig. 1. Cross section of the slit in the form of an Archimedean spiral ($r_0 = 8$ mm, $d^1 = 0,1$ mm, $z = 1000$ mm, $\lambda = 635$ nm, $l = 4$, $\varphi \in [0, 2\pi]$)



Fig. 2. Cross section of the slit in the form of a logarithmic spiral ($a = 0,022$, $b = 0,2$, $d = 0,1$ mm, $\varphi \in [0, 6\pi]$)

¹ – thickness of a spiral

References

- [1] Allen, L. Orbital angular momentum of light and the transformation of Laguerre-Gaussian laser modes / L. Allen, M. W. Beijersbergen, R. J. C. Spreeuw, J. P. Woerdman. // Physical Review A. – June 1992. – Vol. 45(11). – P. 8185–8189.
 [2] He, H. Direct observation of transfer of angular momentum to absorptive particles from a laser beam with a phase singularity / H. He, M. E. J. Friese, N. R. Heckenberg, H. Rubinsztein-Dunlop. // Physical Review Letters. – July 1995. – Vol. 75(5). – P. 826–829.
 [3] Yang, Y. Anomalous Bessel vortex beam: Modulating orbital angular momentum with propagation / Y. Yang, X. Zhu, J. Zeng, X. Lu, C. Zhao, Y. Cai. // Nanophotonics. – January 2018 – Vol 7(3). – P. 677–682.

Archimedean spiral

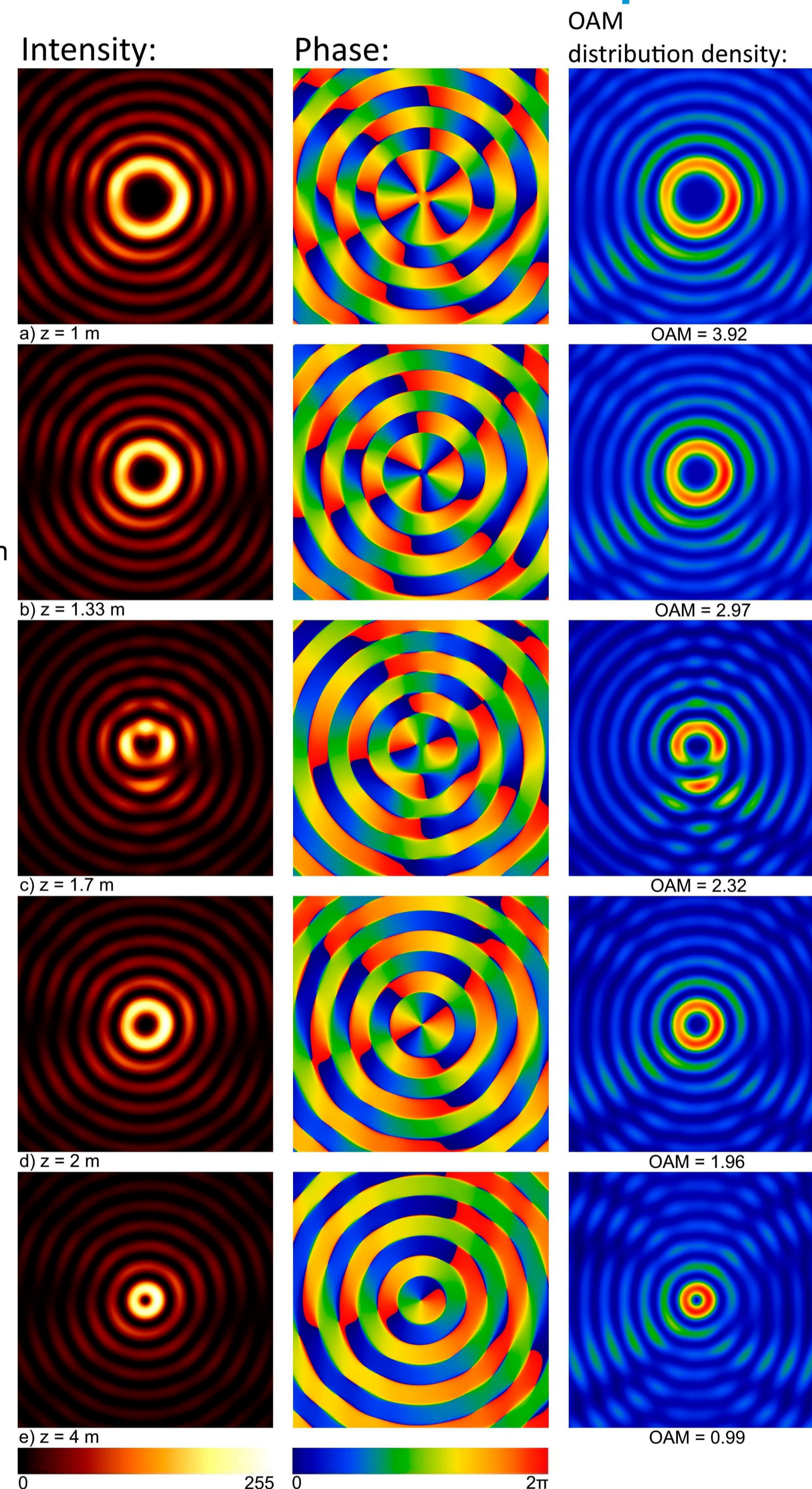


Fig. 3. The intensity, phase and OAM distribution density of a Bessel beam at distances from 1 to 4 meters with the parameters of a spiral slit from Fig. 1

Logarithmic spiral

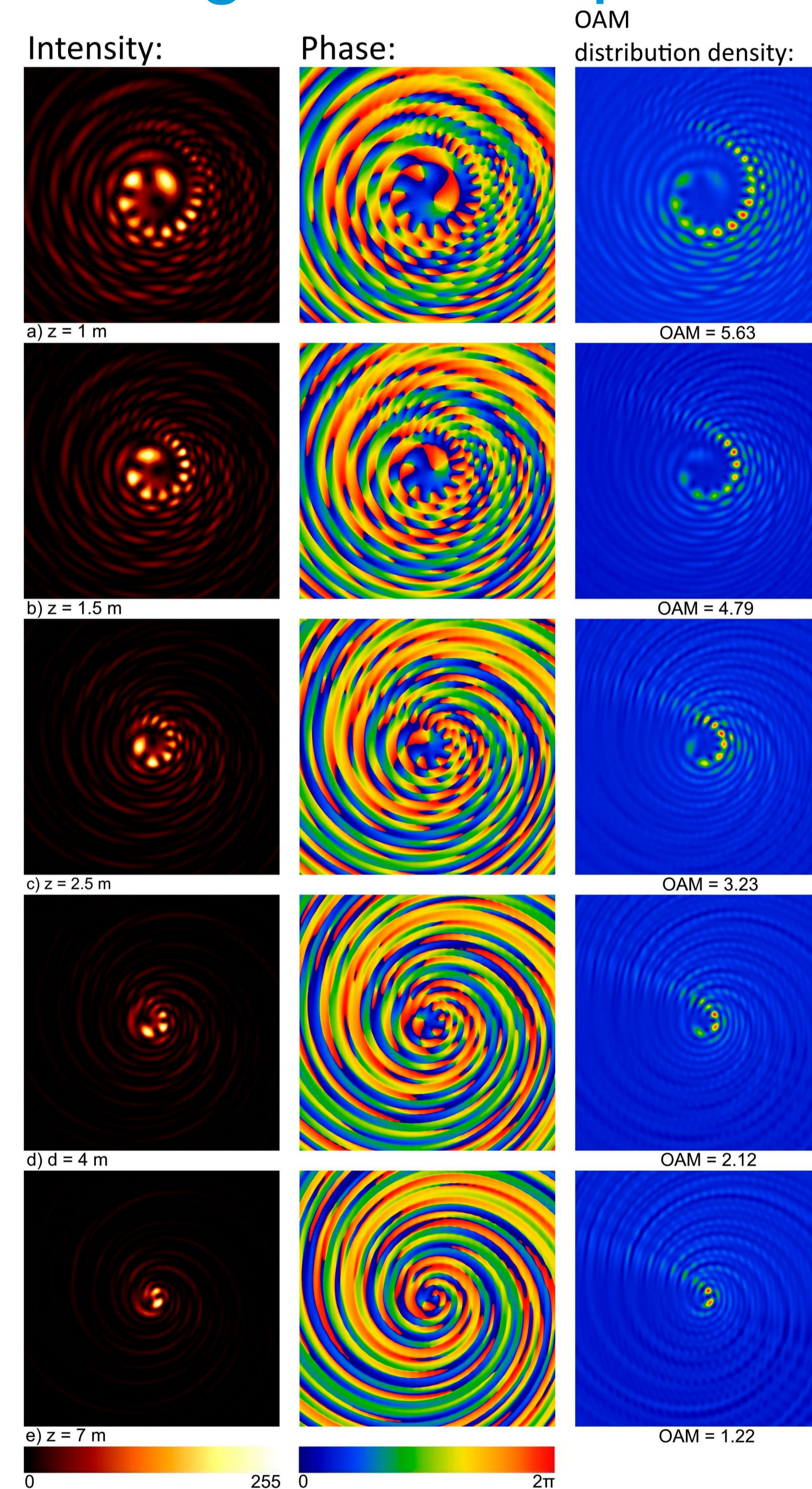


Fig. 4. The intensity, phase and OAM distribution density of a Bessel beam at distances from 1 to 4 meters with the parameters of a spiral slit from Fig. 2

Charts

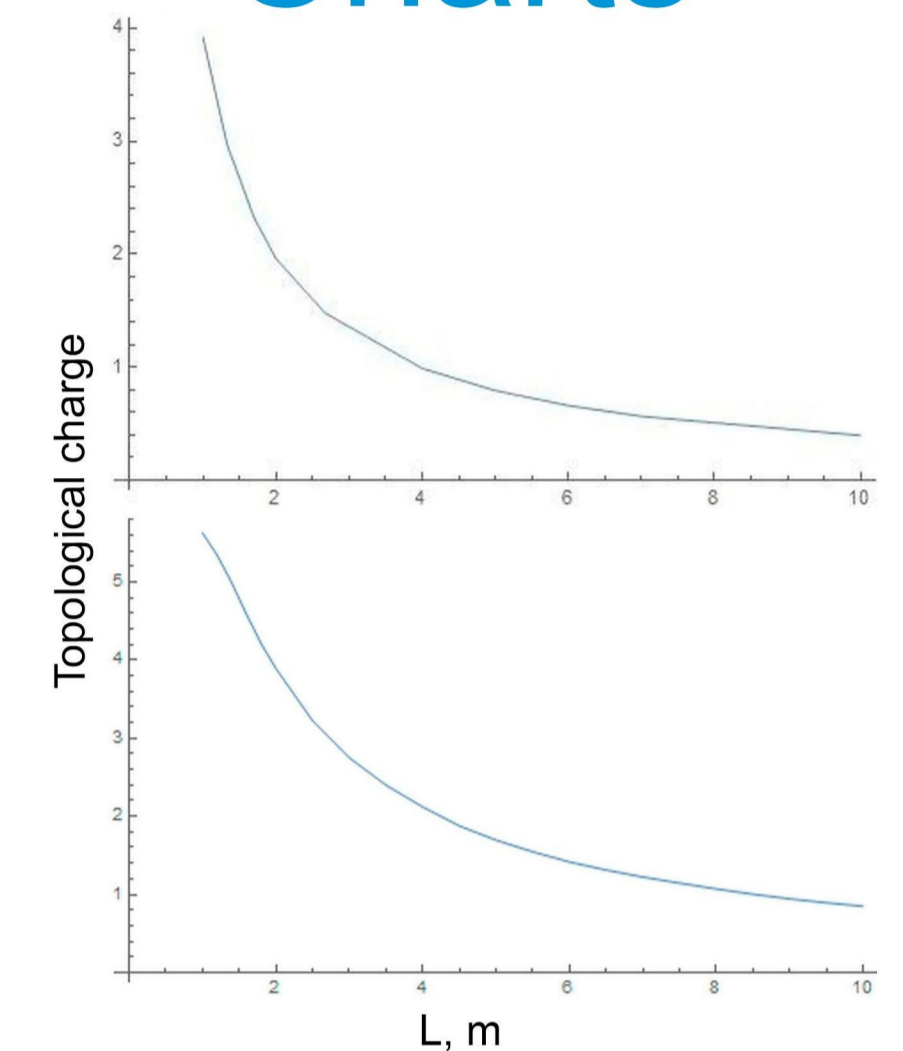


Fig. 5. Dependence of the topological charge on the distance along the z-axis of propagation for the Archimedean spiral from Fig. 1 (top) and the logarithmic spiral from Fig. 2 (bottom)

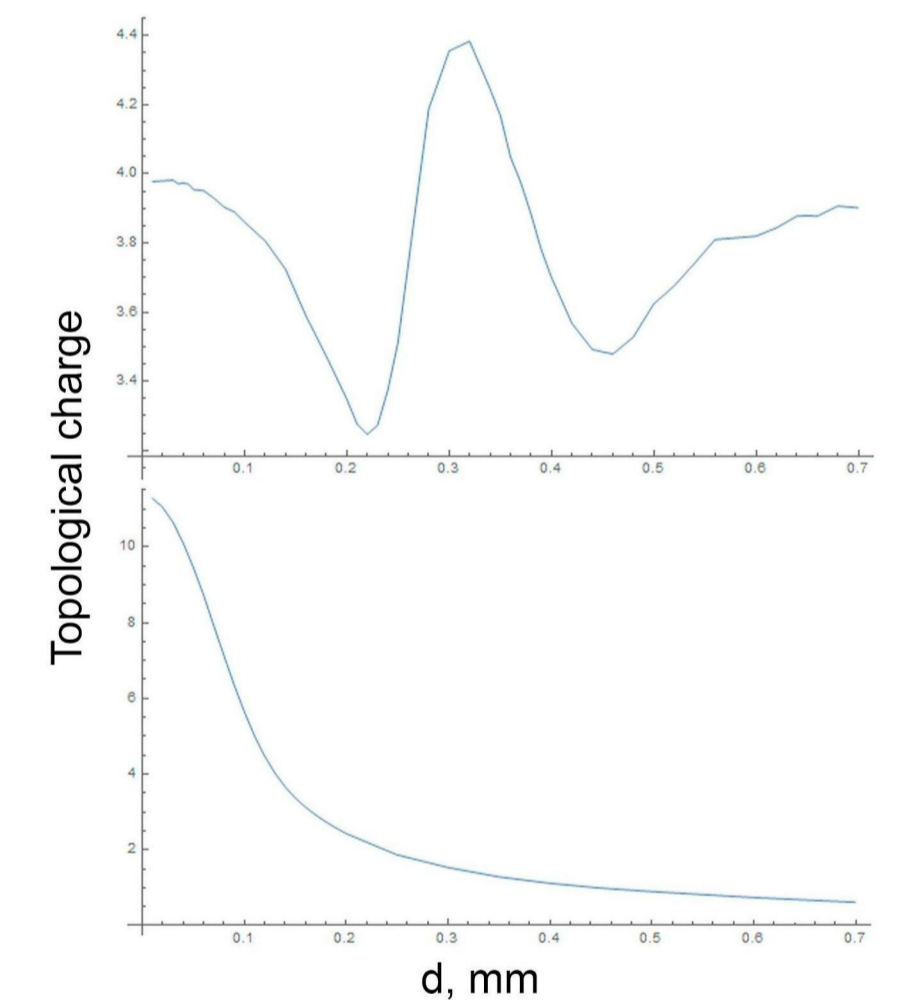


Fig. 6. Dependence of the topological charge on the thickness of the spiral for the Archimedean spiral from Fig. 1 (top) and the logarithmic spiral from Fig. 2 (bottom)

Conclusion

In this paper, we numerically show that the topological charge of a vortex Bessel beam formed by a spiral slit is inversely proportional to the propagation distance. This property can be claimed in optical capture and manipulation, since it provides a simple way to vary the properties of the formed beam only by shifting it to a certain distance from the input plane.