# High quality quasi-Bessel beam generated by oblate-tip axicon


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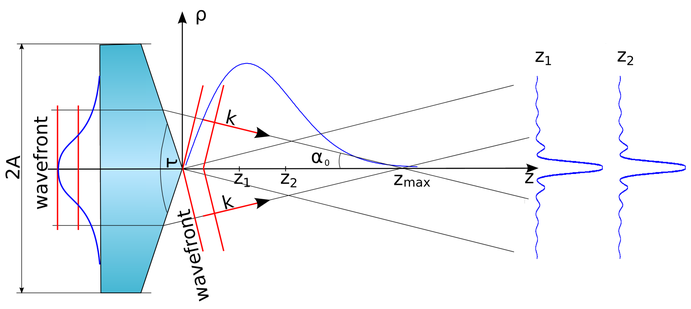
## Abstract


**We study theoretically and experimentally the influence of the oblate-tip of conical lens – axicon on the spatial intensity profile of the zero-order Bessel beam formed behind the axicon. Such a tip generates a refracted beam that interferes with the quasi-Bessel beam behind the axicon and this leads to generation of undesired optical intensity modulation. We show how the spatial filtration of the beam in the Fourier plane improves the spatial beam profile and removes the modulation created behind the oblate axicon tip.**

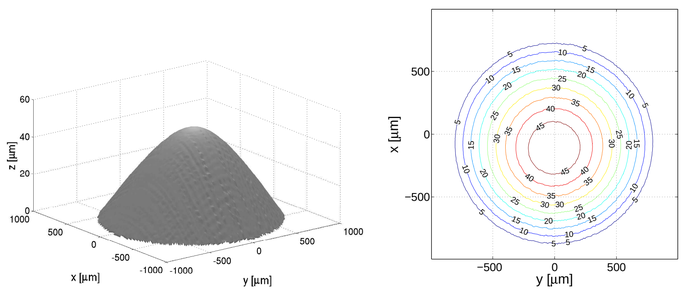

## Quasi-Bessel beam – ideal axicon

Behind the axicon the wavevectors of plane waves cover the surface of a cone with semi-apex angle $\alpha_0$ and the quasi-Bessel beam is a product of their interference.



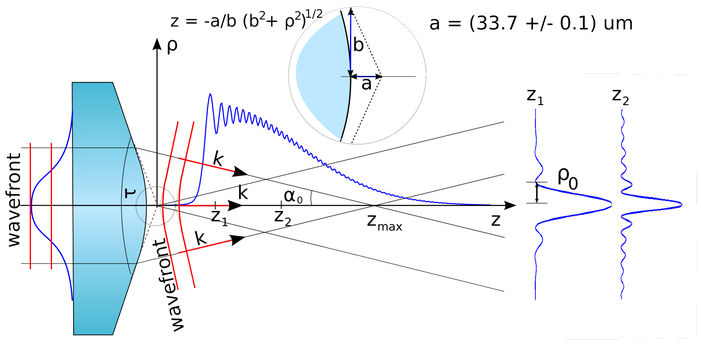

## Real axicon

The shape of the oblate-tip axicon (EKSPLA 130-0270, $\tau = 170°$) was measured by optical profilometer (MicroProf FRT, Fries Research & Technology GmBH) and it was fitted by hyperboloid.



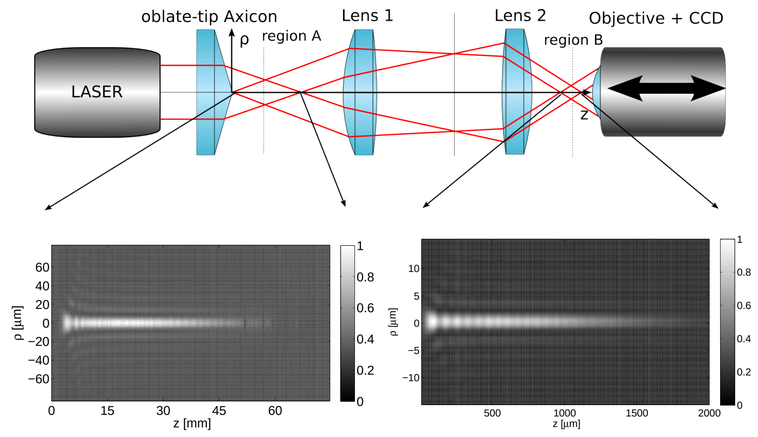

## Quasi-Bessel beam – oblate-tip axicon

The hyperboloid tip ⇒ nearly spherical waves interferes with plane waves ⇒ optical intensity modulation with a period $\lambda/(1-\cos\alpha_0)$ on the optical axis

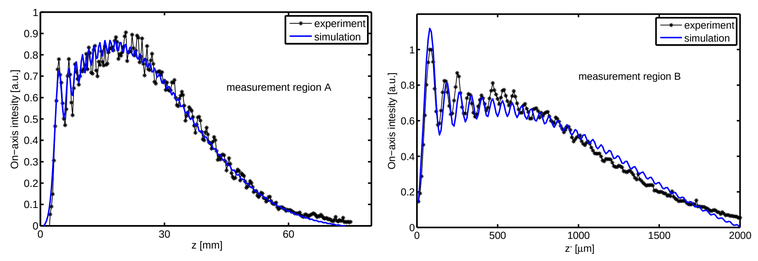



## Measured quasi-Bessel beam profile

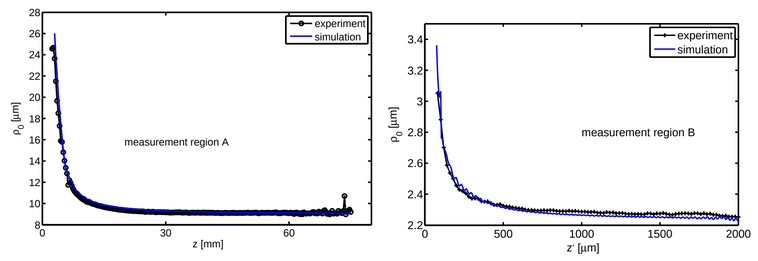
Laser: IPG, YLM-10-1064-LP, $\lambda = 1064$ nm, beam waist $w_0 = 2140$ $\mu$m; axicon: EKSPLA 130-0270, apex angle $\tau = 170°$; lenses $L_1$, $L_2$: focal lengths $f_1 = 50$ mm and $f_2 = 11$ mm; objective: Mitutoyo M Plan Apo SL 80X; CCD camera: IDT X Stream VISION XS-3




Axial intensity

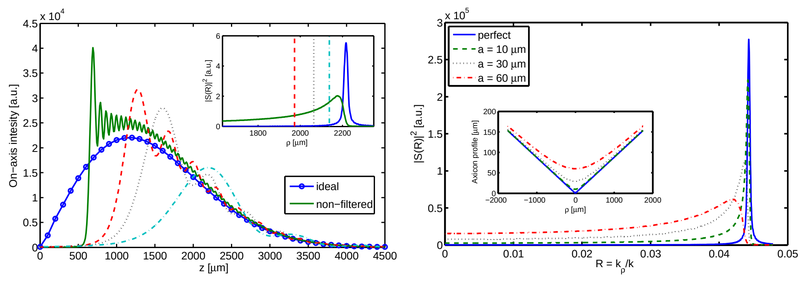



Bessel beam core radius $\rho_0$



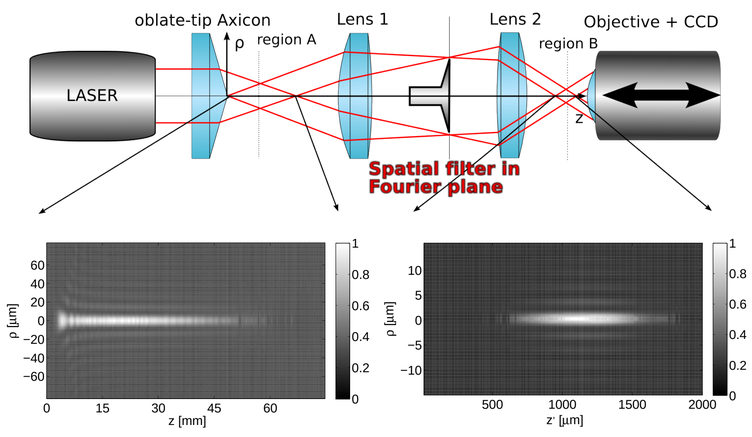

## Spatial filtration

Simulation of the field behind the oblate-tip axicon using free-space propagation method. Spatial filter in the Fourier plane removes the high frequency modulation but absorbs certain amount of energy.

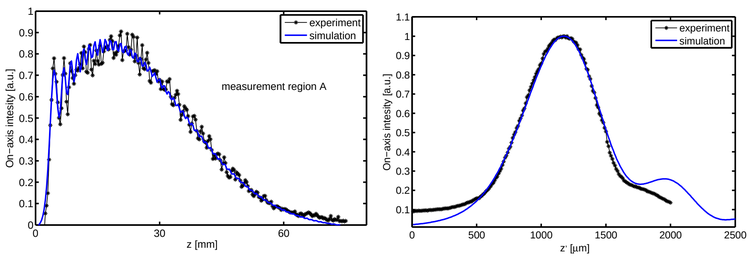



## Filtered quasi-Bessel beam profile

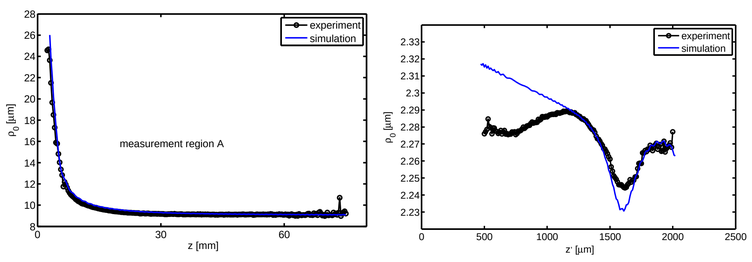
The radius of the spatial filter is $R = (1925 \pm 5)$ $\mu$m




Axial intensity




Bessel beam core radius $\rho_0$




## Conclusion

We demonstrated that the axicon with oblate-tip in the range of tens of micrometers does not generate quasi-Bessel beam with expected invariant beam properties. Sever axial oscillations of the optical intensity occur due to the interference between the quasi-Bessel beam, formed by off-axis part of the axicon, and the wave refracted by the oblate-tip of the axicon. We further demagnified the beam by a telescope and demonstrated how the spatial filtration of the beam in the telescope helps to remove the undesired modulation and establish the original invariant intensity beam profile.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[1] O. Brzobohatý, et al., Submitted to Optics Express

[2] T. Čižmár, "Optical traps generated by non-traditional beams", Ph.D. thesis, Masaryk University in Brno (2006).
URL http://www.isibrno.cz/omitec/download.php?Cizmar PhD thesis.pdf.