Generation of “droplet” quasi-Bessel and Bessel beams based on conically refracted laser radiation

S.H. Abdulrazak, V. Yu. Mylnikov, D.V. Chistyakov, S.N. Losev, N.G. Deryagin, V.V. Dudelev, and G.S. Sokolovskii
Ioffe Institute, St.Petersburg, Russia

Over the past decade there has been considerable interest in the class of nondiffracting light beams known as Bessel beams. Bessel beams are widely used for optical manipulation of microscopic objects due to their ability to propagate a considerable distance without diffraction and to self-restore after passing an obstacle.

In this work we demonstrate two methods: generation quasi-Bessel beams by use of conical lens (axicon) and by converting conically refracted radiation of a semiconductor laser by an axicon.

The advantage of presented methods in comparison with bulky and expensive optical schemes based on SLM is the simplification and compensation of the experimental setup, which leads to a reduction in the cost of manufacturing components and, as a result, of the setup as a whole.

A semiconductor laser with a wavelength of 1064 nm was used to generate the quasi-bessel beams. The longitudinal beam intensity distribution for a conical lens with an apex angle of 140° shows that the side ring intensity is periodically cancelled - side ring cancellation. The length of the waist, the central spot without side rings, is 40 μm.

Interference due to rounded tip of the axicon can be overridden by using conically refracted light. In the region of waist of conical refraction, two light rings are formed, separated by a dark Pagendorff ring. Raman distribution of conical refraction allows to obtain a center spot for semiconductor lasers of tens of microns in size. A semiconductor laser with a wavelength of 637nm, a biaxial crystal located along the radiation propagation axis of one of the optical axes, and an axicon with an angle at the top of 160° were used for generation. The diameter of the central spot of the beam is 3 μm, but lacks the effect of cancellation of side lobs.

This innovative techniques can offer significant potential for developing a "lab-on-a-chip" apparatus. These beams can generate "bottle" beams and can entrap micro-objects with either low refractive index or high absorption index at the device's operating wavelength.

Keywords: optical tweezers, semiconductor lasers, conical refraction, Bessel beams

My research is focused on the study of methods for the generation of quasi-bessel beams based on the emission of semiconductor lasers for optical manipulation, which has been successfully developing since 2015. The results of my research on quasi-bessel beam generation have been published in several papers in WoS and Scopus indexed journals. I have given several oral and poster presentations on the topics of my work at international conferences over the past years, including OSA Biophotonics Congress, International Conference Laser Optics, PhysikA.SPb and ICONO/LAT. Now I am actively developing the topic of optical manipulation based on conically refracting semiconductor laser radiation with the goal of developing an affordable tool for microbiological studies worldwide.