Study of caustics in the diffraction of a plane laser beam by a slit in form of a prescribed curve

Lyubov B. Dubman[1]

[1]Samara University, Samara, Russia; e-mail: lyuba.dubman13@gmail.com

Aim

A study of Fresnel diffraction of a plane laser beam by slit apertures in the form of curves described using the Gielis transformation was carried out. Circular, elliptical and others geometries are considered to analyze the influence of curve shape and curvature distribution on the resulting diffraction pattern.

Methods

For the investigated curves, analytical expressions for the evolutes were obtained by calculating derivatives of the parametric equations. The Gielis transformation was used as a universal method for defining smooth curves with controllable geometric characteristics, allowing variation of the size of individual lobes, and the order of rotational symmetry of the aperture. Numerical simulation of diffracted optical field propagation was performed using the Fresnel transform, which is based on the Fourier transform and enables the investigation of diffraction pattern formation in the near field, as well as the analysis of intensity and amplitude distributions at different propagation distances [1].

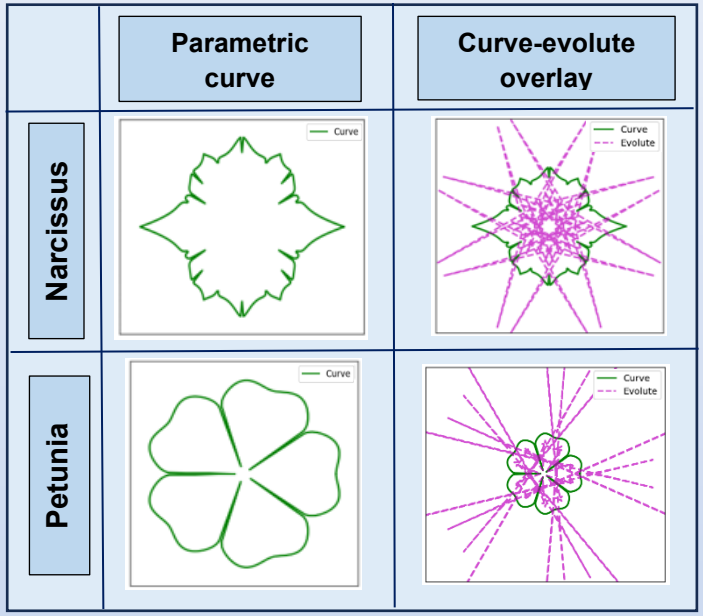
Conclusion

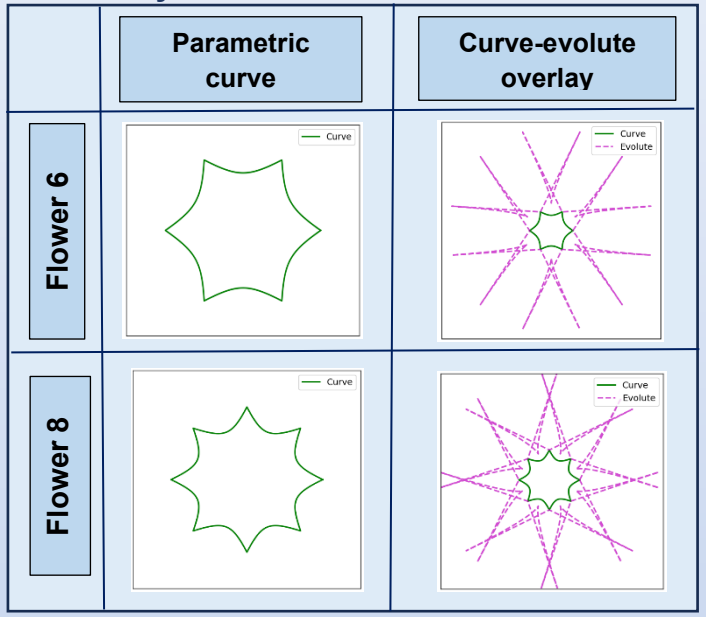
Although the global symmetry of the field is preserved for each geometry, noticeable differences arise in peripheral regions and in the spatial modulation of intensity. The obtained results may be useful for controlled beam shaping applied in optical capture and manipulation of microparticles [2].

[1] S.N. Khonina et al., Near-field propagation of vortex beams: models and computation algorithms, Optical Memory and Neural Networks 23(2), 50-73 (2014).

[2] A. P. Porfirev et al., Optical Manipulation of Airborne Light-Absorbing Microparticles Using Structured Laser Beams, Phys. Wave Phen. 32, 83-92 (2024).

Evolutes of curves modeling floral forms defined by the Gielis formula





Fresnel diffraction patterns of slit curve apertures