Study of photonic nanojets in the diffraction wave fields of complex-shape dielectric particles

A. S. Rudnitsky, N.N.Poleschuk

Belarusian State University/ 4 Nezavisimosti Avenue, Minsk, 220030, Belarus
polestchuk@bsu.by

INTRODUCTION

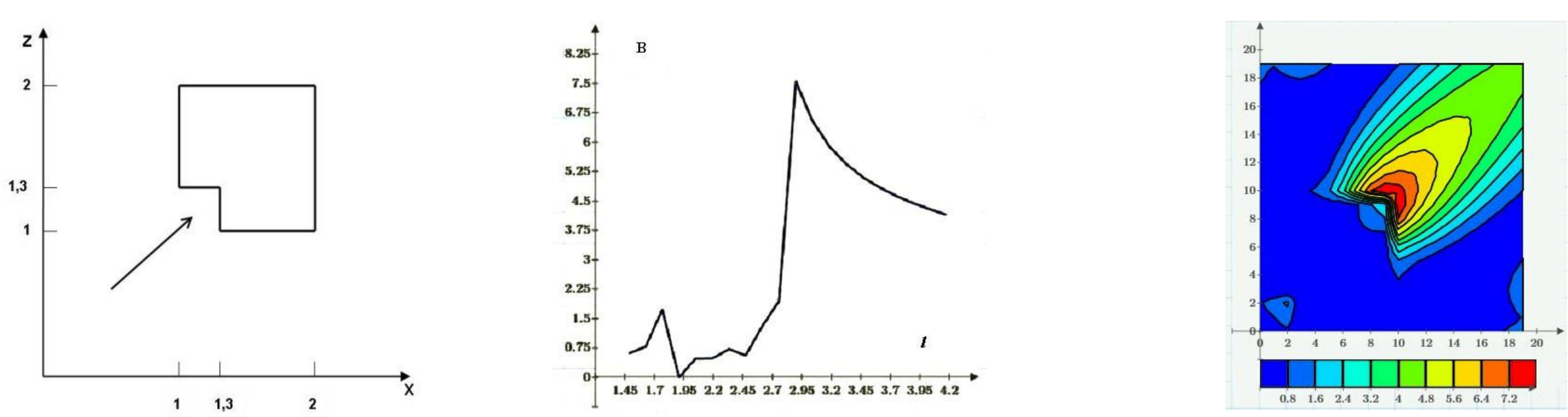
In diffraction fields of dielectric particles, with the dimensions of the wavelength order, the areas formed in their vicinity are characterized by the increased intensity of the wave field, with a subwavelength size of the photon flux, called the photonic nanojets. This feature is of particular importance for practical applications in nanophotonics, biology, medicine, nanoelectronics, and data storage systems [1].

METHOD AND RESULTS

Based on a rigorous solution of the two-dimensional wave field diffraction problem for the dielectric cylinder, the structure of photonic nanojets has been investigated. The dielectric permeability of the cylinder material is equal to 2 and that of the environment to 1. The section dimensions at wavelengths are equal to $1 \le x \le 2, 1 \le z \le 2$ It has been established that, on propagation of the exponential flat wave along the diagonal of the square, the increased intensity area of the wave field is formed near the angle vertex from the outer side of the surface, i.e., at the edge of the surface. Maximal excess of the intensity for the incident wave is approximately equal to 4. When deviation of the particle shape from the regular one is minor, as shown in the figure, a decrease in the cross-sectional size of a photonic jet is observed. Further improvement of the photonic jet parameters is achieved by exposing the dielectric particle to superposition of two flat waves and we have

$$u_0(x,z) = cos[ksin\gamma(xsin\vartheta - zcos\vartheta)] \times exp[-ikcos\gamma(xcos\vartheta + zsin\vartheta)]$$

A peak intensity of the diffraction wave field exceeds the intensity of the incident wave field by more than a factor of seven. The figure shows the geometrical shape of a particle and the two-dimensional distributions of a relative intensity of the diffraction wave field $(B(x,z) = |u(x,z)|^2/|u_0(0,0)|^2)$, inside and outside the particle at a wavelength distance from the surface (area $1 \le x \le 3, 1 \le z \le 3$) as well as at the diagonal normalized to the wavelength *l*, where $\vartheta = \pi/4, \gamma = \pi/8$.



a) b) c)

Figure 1. The geometrical shape of particle (a), the diagonal (b) and two-dimensional (c) distributions of a relative intensity of the diffraction wave field inside and outside the particle at a wavelength distance from the surface.

CONCLUSIONS

When deviation of the particle shape from the regular one is minor a decrease in the cross-sectional size of a photonic jet is observed. Further improvement of the photonic jet parameters is achieved by exposing the dielectric particle to superposition of two flat waves. A peak intensity of the diffraction wave field exceeds the intensity of the incident wave field by more than a factor of seven.

REFERENCES

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