Poincaré beams in sharp focus

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Introduction

Vortex laser beams [1] are currently being actively studied, which is associated with their wide application. Currently, laser beams with inhomogeneous polarization, for example, with radial or azimuthal polarization, are also being actively studied [2]. Such beams are called cylindrical vector beams and represent the sum of two optical vortices with different directions of rotation of circular polarization and opposite topological charges. In this paper, we study Poincaré beams [3–4]. This class of beams includes special cases of uniformly polarized beams with linear and circular polarization, cylindrical vector beams with radial and azimuthal polarization, and beams with inhomogeneous elliptical polarization.

Parameters of simulation

The sharp focusing of Poincaré beams is studied theoretically and numerically using the Richards-Wolf formalism. It is shown that the energy flow is twisted in the transverse plane and contains areas in which the longitudinal projection of the energy flow contains negative values (the region of the reverse energy flow). Numerical simulation was carried out using the Richards-Wolf integral. It was considered that focusing is carried out by an aplanatic objective with a numerical aperture NA=0.95 for a wavelength λ = 0.532 nm. The Poincare beam with parameters $\theta = \pi/4$, $\psi = \pi/4$, n = 0 was considered.

Simulation results

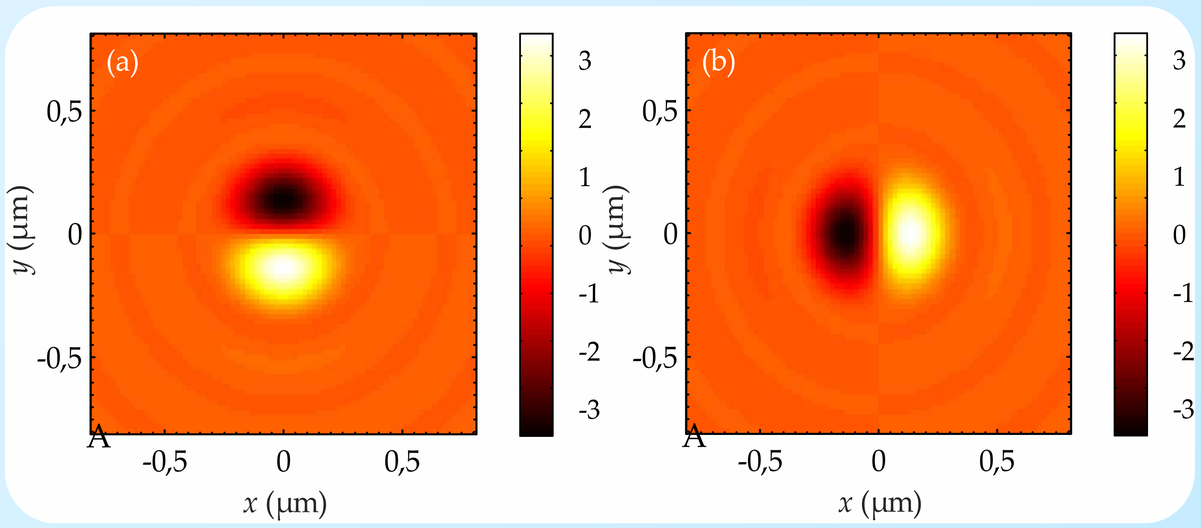

Fig 1. Distribution of the components of the transverse energy flux (projections of the Poynting vector) in the region of a sharp focus: Px (a), Py (b) for the Poincaré beam $\theta = \pi/4$, $\psi = \pi/4$, n = 0

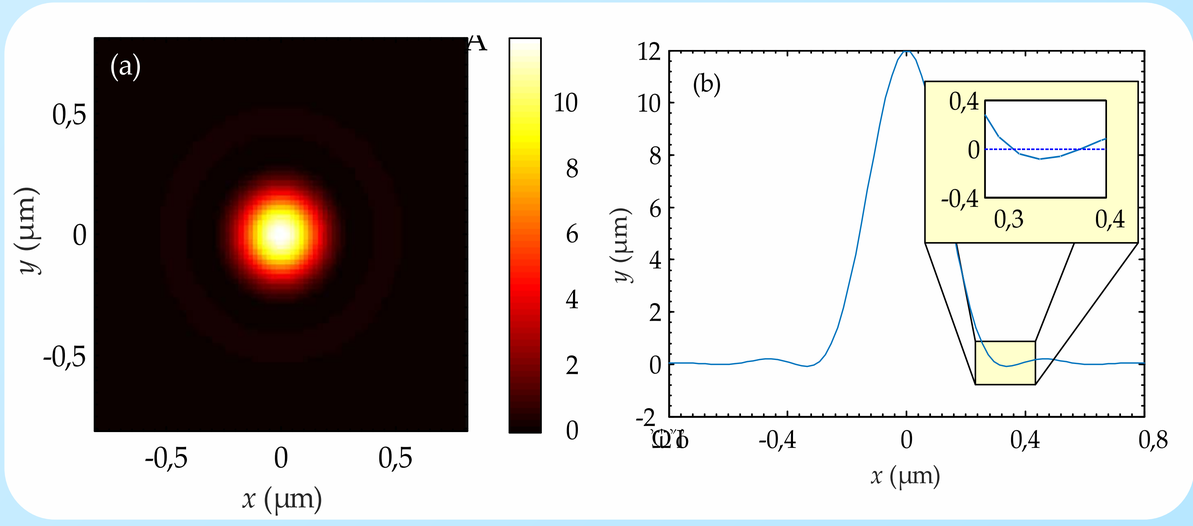

Fig. 2. Distribution of the longitudinal projection of the Poynting vector (a) and its cross section along the x axis (b) for the Poincare beam $\theta = \pi/4$, $\psi = \pi/4$, n = 0

In this paper, Poincaré beams have been theoretically and numerically investigated. Using the Richards-Wolf formalism, expressions are found for the strength of the electric and magnetic fields, the components of the Poynting vectors, and the spin angular momentum near the sharp focus of these beams. The conditions for the formation of a reverse energy flow on the axis were found, and it was also shown that the energy flow is twisted in the transverse plane.This work was supported by the Russian Science Foundation (grant no. 22-12-00137).

References

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