RESEARCH PAPER

Optical fiber parameters effect on light propagation in a coiled multimode fiber

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ABSTRACT:

An experimental investigation behavior of speckle pattern of light at propagating in a coiled multimode optical fiber with a step refractive index. Discovered rotation of special pattern depended on the helical pitch, that is turn speckle pattern change when changing the helical pitch. It is independent of the mode composition of the light propagating in the Optical fiber.

KEY WORDS: Optical fiber, coiled multimode fiber, helical pitch

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1. INTRODUCTION:

The electric field $E$ of light propagating in a multimode optical fiber with a step refractive index profile is a superposition of Bessel beams of different orders with dislocations (phase singularities) wave front [1]. The existence of a particular expression indicates $E$ the presence of factor exp ($i\phi$), here $\phi$ - the azimuth angle in the cross section of the fiber core, and the value of $l$ is called the topological charge wave front dislocation [2].

The sign and magnitude of the topological charge $l$ determine the type and direction of rotation of the wave front, as well as the trajectory of the Poynting vector.

Rytov [3], Vladimir [4], and much later, and on the basis of quantum adiabatic theorem Bury [5-7], it was shown that the propagation of linearly polarized light by a non-planar path such that the direction of the input and output ends of the path are the same, observed rotation of the polarization plane, and the rotation angle in radians is numerically equal to the solid angle in stereo radian that the unit sphere cuts the tangent to the trajectory of a non-planar. Experimentally rotation of the polarization plane has been demonstrated in the propagation of linearly polarized light in a single mode optical fiber [8]. This rotation can be interpreted as the effect of the emergence of topological optical activity associated with Berry phase, namely, the propagation of light on non-planar trajectory refractive indices for left and right circularly polarized light are different [9].

It is well known that the rotation of the plane of linear polarization observed in the Faraday effect caused by the different propagation speeds ($V_+$) to the right and ($V_-$) for a left circularly polarized light, or what is the same, different values of the refractive index $n$ for the left-hand $n+$ and right circular polarization.

It propagation velocities inequality $V_+ \neq V_-$ leads to Besides that a few-mode optical fiber placed in an axial magnetic field, there is the speckle pattern by changing the rotation direction of the magnetic field [10, 11]. However, in multimode optical fiber placed in a longitudinal magnetic field distortion experimentally speckle pattern observed not rotate, and the degree of distortion is proportional to the applied external magnetic field [12].
In [13] rotation of the speckle pattern was also observed in the propagation of light in low-mode optical fiber, twisted into a spiral, as the pitch of the helix. The question arises, what will happen to the speckle pattern of light that has passed through not a few-mode, but a multimode optical fiber, twisted into a spiral, a change of the helical pitch?

The purpose of this work an experimental study of the behavior speckle pattern of light propagating in a multimode optical fiber with a step index profile, twisted into a spiral, as the pitch of the helix.

To carry out experimental investigation we used a multimode optical fiber with the following parameters: fiber core radius \( \rho = 0.1 \text{ mm} \), core refractive index \( n_{co} = 1.458 \), cladding refractive index \( n_{cl} = 1.441 \), wavelength of laser \( \lambda = 532 \text{ nm} \). In order to determine the angle of the speckle pattern rotation with high accuracy, we used the method based on the optical phase conjugation of the radiation transmitted through an optical fiber [14, 15]. The phase conjugation of circular polarized light transmitted through a multimode optical fiber allows inverting light propagation and obtaining a narrow light beam at the other fiber end. As a result, the optical Magnus effect leads to the rotation of only one spot around the fiber axis under the circular polarization sign changing. This method makes it possible to work with only one spot instead of the whole speckle pattern and to observe relatively small changes in the behavior of the speckle pattern.

The studies were conducted on a multimode optical fiber a stepped refractive index profile of length 60 cm and a core radius \( \rho = 0.1 \text{ mm} \). The fiber is twisted in a helix with a uniform single loop, spiral radius \( R \) had the value of \( R = 10 \text{ cm} \), the condition \( R \gg \rho \). This condition is ensured relative \( \rho \) lack of stress in an optical fiber, which could affect the nature of the propagation of light.

Figure 1 shows the experimental setup. Radiation of He-Ne laser 1 with a wavelength of \( \lambda = 532 \text{ nm} \) passed through the polarizer 3 and focused on the input of the multimode optical fiber 5 via the lens 4. The fiber was wound around a cylinder 6 of radius \( R = 10 \text{ cm} \), thus provides a spiral path of the fiber, through which the linearly polarized radiation. Speckle pattern of radiation transmitted through the fiber, was visually observed on the screen 7. To register the speckle pattern used CCD.

Fig. 1 Experimental setup.

1 - He-Ne laser 2 - filters 3 - polarizer 4 - lens 5 - the fiber 6 - cylinder 7 - screen or CCD

The laser beam was introduced at different angles to the fiber axis, on the screen there was a speckle pattern in the form of a ring (Fig. 2). The radius of the ring is completely determined by the angle of radiation input, and the width of the ring - the angular width of the focused beam on the entrance.

The behavior of the speckle pattern when changing the helical pitch. Visually clearly against the background of slight distortion was observed the rotation of the speckle pattern. By increasing the pitch of the helix of the speckle pattern rotates clockwise. Registered at each pitch of the helix of the speckle pattern images were processed by a special program [12].

Fig. 2. The image of the speckle pattern of light passing through the multimode optical fiber, twisted into a spiral.
As can be seen from Fig. 3, experimentally, the propagation of light in a multimode fiber, twisted into a spiral, a change of the helical pitch is observed rotation of the speckle pattern, and the angle of rotation is increase bey increase the helical pitch.

CONCLUSION

Thus, as a result of experimental studies it is shown that the propagation of radiation in a coiled multimode optical fiber (spiral-shaped) when changing the pitch of the helix change rotation of the speckle pattern, by increasing the helical pitch the angle of rotation speckle pattern increase, and does not depend on the mode composition of the radiation propagating in the fiber.

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