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Visualization of light polarization forms in the laser conoscopic method

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ABSTRACT

The laser conoscopic method enables visual estimation of radiation polarization. Visually identifying the forms of light polarization is convenient at the stage of pre-characterizing the polarization properties of the light used. Using the conoscopic patterns of a crystal plate with its entry face perpendicular to its optical axis, it is possible to allocate linearly polarized, circularly polarized, and elliptically polarized radiation. There are two typical appearances of conoscopic patterns, which correspond to two different intervals of phase shift: $0 < \delta < \pi/2$ and $3\pi/2 < \delta < 2\pi$, and $\pi/2 < \delta < \pi$ and $\pi < \delta < 3\pi/2$ are characteristic of elliptically polarized radiation.

1. Introduction

Knowledge of light polarization forms is important for conducting research using optical methods; at present, photometric and visual methods to determine the form of optical light polarization are known [1,2]. A photoeffect phenomenon underlies the photometric method to determine the form of optical light polarization. The light polarization form (elliptical, circular, or linear) is determined by the value of the intensity measured. The photometric method enables the determination of the form of optical light polarization with a high degree of confidence, but requires considerable time and expensive stationary equipment.

Typically, an interference phenomenon underlies the visual method for determining the form of optical light polarization. In particular, a light polarization form is determined by the appearance of the interference (conoscopic) pattern. The visual method enables the determination of the form of optical light polarization with a high degree of confidence, and does not require significant time or expensive stationary equipment, because it is an express method to determine the form of optical light polarization.

Conoscopic analysis of interference fringes is one of the most useful tools for investigating the properties of optical crystals and the properties of different types of radiation [3–11]. Moreover, conoscopic patterns are employed in singular optics to study topological and polarization properties of optical beams having a complex wave structure [9].

To determine the polarization form, an optical system is used, which consists of an analyzer and a screen.

The investigated parallel beam of light is transmitted along the axis of the optical system through the analyzer onto the screen, and the changes in the intensity of the light spot on the screen while rotating the analyzer are compared [1]. A light polarization form is determined by the change in the intensity measured. A decrease in the intensity of the light spot on the screen to a minimal value equal to zero is indicative of linear polarization. A decrease in the intensity of the light spot on the screen to a minimal value not equal to zero suggests elliptical polarization. No change in the intensity of the light spot on

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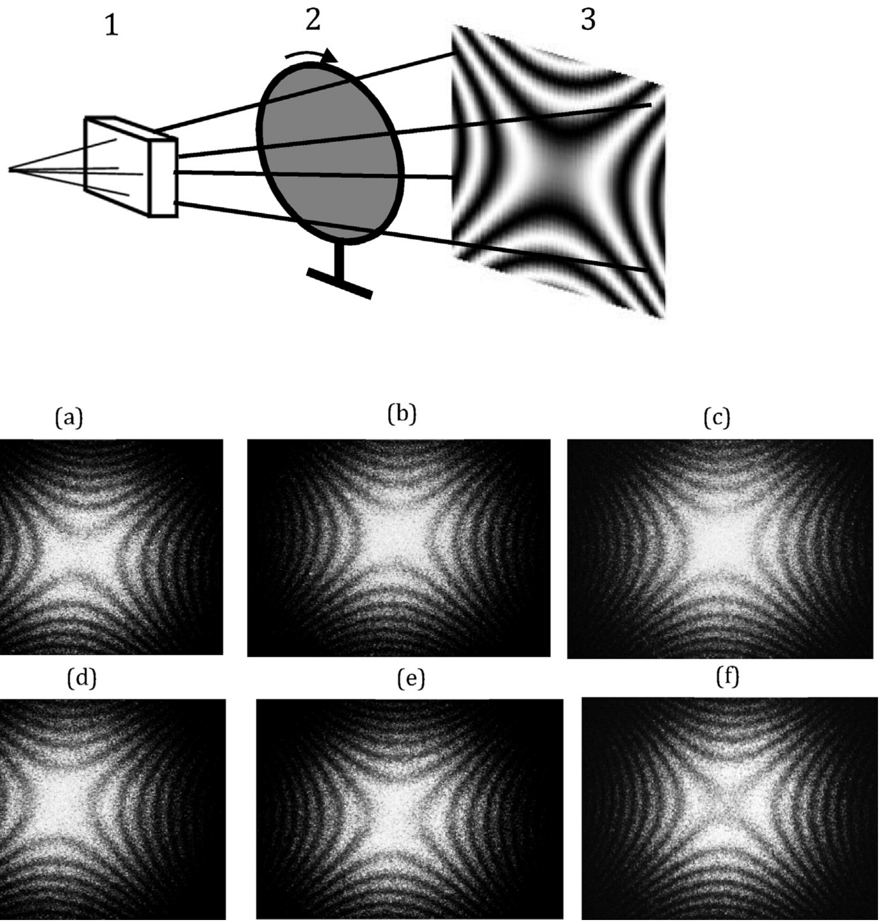

Fig. 1. Diagram of the optical system: 1 – crystal plate, 2 – analyzer, 3 – screen. Conoscopic patterns (a), (d) – circularly polarized light; (b), (e) – elliptically polarized light; (c), (f) – linearly polarized light.

the screen implies either natural light or circularly polarized light. Thus, the given method enables only the determination of linearly and elliptically polarized light and does not enable discrimination between natural or circularly polarized light.

Another method to determine light polarization employs a divergent beam of light, which is transmitted through an optical system consisting of a crystal plate, analyzer, and screen (Fig. 1). A conoscopic pattern is usually observed when the angle of light divergence is 70–100°. The sense of vectors E is the same for all beams emerging from the analyzer and coincides with the analyzer transmission direction.

First, we choose a crystal plate with an optical axis positioned in the plane of the entry face [1]. With natural light, it remains natural while exiting the plate. An interference (conoscopic) pattern on the screen after the analyzer appears as a light spot of uniform intensity. A lack of change in the intensity of the light spot on the screen while rotating the analyzer is indicative of natural light.

With any (elliptically, circularly, or linearly) polarized light, an interference (conoscopic) pattern on the screen appears as two hyperbola systems (Fig. 1).

Upon the analyzer rotation, a conoscopic pattern appears as two hyperbola systems with less contrast, which, upon further rotation of the analyzer, decreases to zero, with the conoscopic pattern on the screen appearing as a light spot of uniform intensity. The change in the conoscopic pattern on the screen is evidence of polarization. Thus, the choice of the crystal plate with an optical axis in the plane of its entry face enables only the determination of the state of polarization and detection of natural and polarized light.

2. Experimental results

2.1. Influence of polarization on the conoscopic patterns of optical crystals

If a crystal plate with its entry face perpendicular to its optical axis is chosen, its conoscopic pattern also appears on the screen. Then, the polarizer is rotated around the axis of the optical system until a certain conoscopic pattern appears,