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Use of λ/4 phase plate in laser conoscopic method

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ABSTRACT

Possibilities of laser conoscopic method expanded due to the introduction of λ/4 phase plate in the optical system. The introduction of λ/4 phase plate with known optical sign leads to changes the conoscopic pattern of the investigated crystal plate. Changes conoscopic patterns allow to quickly and reliably determine the optical sign, the presence of optical activity of the crystal, the direction of rotation of the plane of polarization of radiation in optically active crystal for crystal plates of any thickness and any value of the specific rotation. In addition, changes conoscopic pattern of a crystal of known optical sign indicate the location of the optical axis in the plane of the input face the λ/4 phase plate.

1. Introduction

Initially, the conoscopic patterns obtained with a polarizing microscope were used in optical mineralogy in order to identify minerals based on the data on crystal symmetry and orientation. Conoscopic pattern informativity provides for the possibility to determine orientation and nature of optical indicatrix, measure an angle between the optical axes of a biaxial crystal, determine an optical sign of the crystal, detect optical axes dispersion, identify qualitative and quantitative changes in the optical indicatrix in response to external action, etc [1].

At present, capabilities of the conoscopic method have been greatly expanded. Using the method, researchers have got novel scientific results in studying properties of optically active crystals, liquid crystals. Moreover, elements of the conoscopic method are employed in singular optics to study topological and polarization properties of optical beams having a complex wave structure. However, the classical conoscopic method is still in demand under experimental conditions and has not yet been used up as a tool to study optical properties of crystals [2–10].

The λ/4 phase plate is rather often applied in polarizing measurements to obtaining circular radiation [1].

Addition of λ/4 phase plate between the polarizers of a polarizing microscope makes easier the optical identification of minerals in thin sections of rocks in particular by allowing deduction of the shape and orientation of the optical indicatrices within the visible crystal sections [1]. Use of λ/4 phase plate with the known optical sign in the laser conoscopic method expands his opportunities for practical application in various optical devices.

The objective of the present paper is to expand potential of the conoscopic method for the study of anisotropic optical crystals. To this end, it is proposed to obtain conoscopic patterns using an optical system where diverging laser radiation is let pass through an anisotropic crystal placed between the polarizer and analyzer, rather than using a polarizing microscope. The pattern on the screen is recorded by a digital camera and displayed on a computer (Fig. 1).

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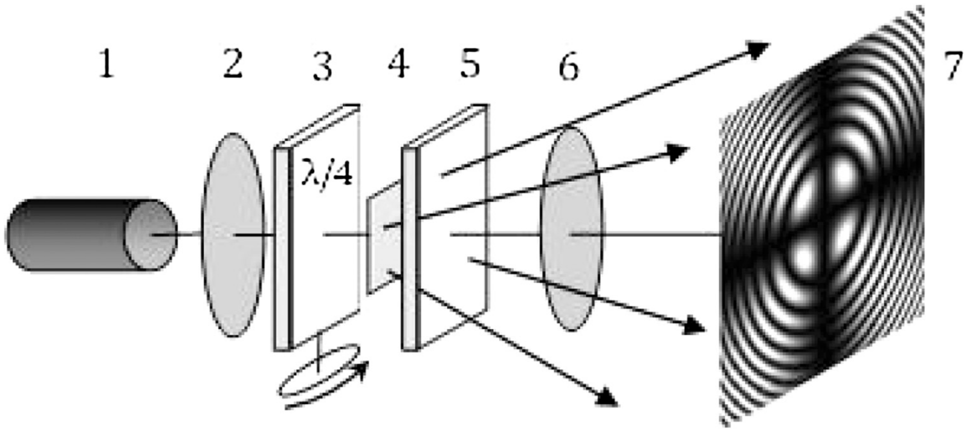

Fig. 1. Diagram of the optical sign identifying system: 1 – He-Ne laser (632.8 nm); 2 – polarizer; 3 – λ/4 phase plate; 4 – diffuser; 5 – investigated crystal plate; 6 – analyzer crossed with polarizer; 7 – screen.

With such observation system, a beam aperture makes 100–150°, and the conoscopic pattern on the screen appears large-scale, sharp and high-contrast. This enables one to identify and register fine details of the interference pattern both at the center of viewing field and on the periphery thereof, which appears difficult when using a polarizing microscope.

This optical system (Fig. 1) allows placing the λ/4 phase plate (optical compensator) mounted in front of the diffuser. Such crystal phase plate may be used either as movable [2] or immovable element in determining the optical sign of a crystal.

Upon rotation of λ/4 phase plate of the known optical sign about the vertical axis (Fig. 1), the conoscopic pattern changes and isochromatic rings get shifted. The shift direction of isochromatic rings correspond to the optical sign of the investigated crystal plate [2].

2. Experimental results

2.1. Use of immovable λ/4 phase plate to simultaneously determine the optical sign and the direction of rotation of the plane of polarization of the optically active crystal

It is known that optically active crystals can have two versions – right and left. Thus relative rotation of the two modifications are equal, and the difference is only in the sign of rotation. If the crystal rotates the plane of polarization of clockwise (to the right) it is called dextrorotatory, if counter – clockwise (to the left) it is called levorotatory. The rotation angle of the polarization plane of radiation can be evaluated when observed toward the light beam. Traditionally, the direction of rotation of plane polarized radiation in optically active crystal is determined on the conoscopic pattern obtained with linear light [1].

The conoscopic pattern of the optically active crystal plate represents the light spot at center surrounded by isochromatic rings with the black M̈altese crossön the periphery of a field of vision [1,8]. This conoscopic pattern has the same form for dextrorotatory and levorotatory optically active crystals.

For optically active crystal plates, particularly thin, under review there is a small number of rings. The peripheral area of the conoscopic pattern is darkened. At continuous rotation of λ/4 phase plate [2] in a conoscopic pattern the shift of isochromatic rings occurs in the darkened area. That doesn't allow to see the direction of shift of isochromatic rings and to define the optical sign of optically active crystal plate.

By means of a immovable plate of λ/4 phase plate with the known optical sign, established in front of the diffuser, receive the clear conoscopic pattern allowing to define precisely the sign optically of an active crystal plate of any thickness.

The conoscopic pattern in this case [9] has an appearance spiral isochrome, twirled on or counterclockwise, with the beginnings of spirals or in the first and third quadrants, or in the second and fourth quadrants (Fig. 2).

The experiment has shown that the optical sign of the optically active crystal plate coincides with the optical sign of the λ/4 phase plate (positive) if the conoscopic pattern has the form of spiral isochrome, twirled clockwise, and with the beginnings of spirals in the first and third quadrants (Fig. 2(ɑ), (b)).

If on the screen observe the conoscopic pattern in the form of spiral, twirled clockwise, with the beginnings of spirals in the second and fourth quadrants, then the optical sign of the optically active crystal plate doesn't coincide with the optical sign of the λ/4 phase plate (negative) (Fig. 2(c), (d)).

If on the screen observe the conoscopic pattern in the form of spiral, twirled counterclockwise, with the beginnings of spirals in the second and fourth quadrants, then the optical sign of the optically active crystal plate coincide with the optical sign of the λ/4 phase plate (positive) (Fig. 2(e), (f)).