Imaging polarimetry with carrier frequency for the linear birefringent media

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The imaging polarimetry is a measuring technique primary used in photoelasticity to examine stress distribution inside materials and for measurements of birefringent structures in biomedicine. The method presented enables the calculation of distribution of both the phase shift between eigen waves propagating in nondichroic, linearly birefringent media and the azimuth angle of the first eigen vector.

1 Introduction

The imaging polarimetry methods based mainly on the phase shift method [1,2]. The imaging polarimetry with carrier frequency is relatively new method. There is some similarity between this method and the interferometry with carrier frequency. However, the carrier frequency principle is not wide used in the imaging polarimetry. In the imaging polarimetry with carrier frequency one obtains the fringe pattern by inserting the Wollastone prism in the path of the light beam. Due to the Wollastone prism the beam has a periodical distribution of the polarization state of light across the beam. The method uses the algorithm of Fast Fourier Transform, similarly as in interferometry with carrier frequency. Implementation of required phase shifting in measuring optical system is performed by use of Liquid Crystal Modulator (LCM). Application of LCM instead of rotational phase plates significantly accelerates measurements and enables recording fast, dynamical variations of both distributions of birefringence and azimuth angle of anisotropic objects.

2 Method

The proposed method enables calculation of 2D distributions of the azimuth angle of the fast wave and the phase shift of linearly birefringent and nondichroic media [3]. Fig. 1 presents the scheme of proposed optical setup. The measurement consists of recording two images of the light intensity, which is transmitted through the system. The first image is recorded for the phase shift given by the Liquid Crystal Modulator equal to 0°, while the second is for 90°. Next, the 2D Fourier Transforms of two distributions of the light intensity recorded at the output of the system is calculated. By filtering the first order of the spectrum in the space of frequency domain, shifting it to the origin of the coordinate system by the value of carrier frequency f_0 and calculating the Inverse Fourier Transform one obtains the complex distribution of c_1 and c_2. Finally, the azimuth angle of the first eigen vector of the object and the phase retardation between the fast and the slow waves behind the object are:

$$\alpha = \frac{1}{2}\arctan\left(\frac{-\operatorname{Im}(c_1)}{\operatorname{Re}(c_2)}\right), \tag{1}$$

$$\delta = 2\arctan\left(\frac{\operatorname{Re}(c_1)}{-\operatorname{Im}(c_1)\cos 2\alpha}\right). \tag{2}$$

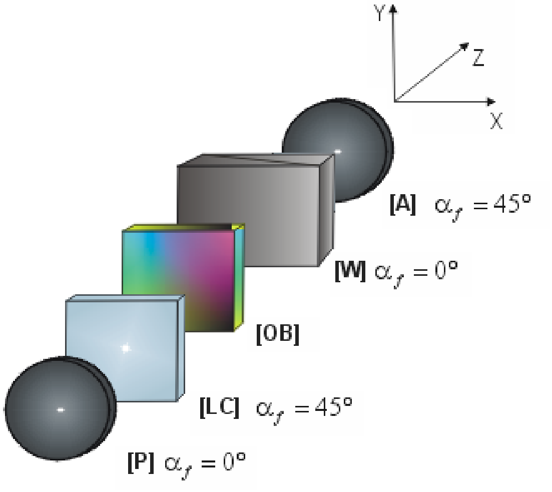

Fig. 1 *Scheme of the optical system. [P] - polarizer, [LC] – liquid crystal, [OB] – examined object, [W] – Wollastone prism, [A] - analyzer.*

3 Conclusions

Using the Liquid Crystal Modulator eliminates rotational phase plates and enables required phase shift and acceleration of the measurements. Algorithm of FFT reduces number of measurements of the light intensity at the system output. To calculate distributions of the azimuth angle and the birefringent of the object one needs only two images. The variations of the phase retardation introduced to measurement by the LCM influences the accuracy of measurement in a smaller degree. This has greater importance in case of dynamic measurements.

References

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