

PhD dissertation

Innovative solutions for systems to measuring parameters of birefringent media using liquid crystal variable retarders, including twisted nematic liquid crystals

Monika Salamaga, MSc

Abstract

This doctoral dissertation focuses on polarimetric systems for testing birefringent media using liquid-crystal variable retarders. It describes a simplified, symmetrical design of a Mueller polarimeter based on two linear liquid-crystal variable retarders and two linear polarizers. The adopted set of eigenstates of the generator (PSG) and analyzer (PSA) resulted in the measurement of only 9 matrix elements, located outside the third row and third column. Procedures were proposed for reconstructing the matrix elements and the properties of a non-dichroic medium from these measurements. The developed numerical algorithm made it possible to remove limitations on the properties of the media that can be studied. An important aspect of this work is the proposed solution to the problem of ambiguity in the obtained sets of results, achieved through a control measurement with the sample rotated by a certain angle. It was shown that, based on such an incomplete matrix, it is still possible to characterize the medium and to complete the matrix to its full form.

Twisted nematic liquid crystals are elements that have the potential to simplify the measurement setup while maintaining its functionality. When an external electric field is applied, not only does the phase difference between their eigenwaves change, but so does the ellipticity of these waves. This dissertation presents the results of measurements of the physical and polarization parameters of two TNLC cells with significantly different values of the linear component of the phase difference. These parameters can be determined based on a developed algorithm for reconstructing this information from the output signal. The requirements that polarimetry places on such cells are specified.

The usefulness of TNLC cells in a non-classical polarimetric setup, in which the same module acts as both a generator and an analyzer of various states of light polarization, was analyzed. The light passes through the medium twice due to reflection from a mirror. Modules using a linear polarizer in combination with only a single TNLC, two TNLCs (operating identically or differently), a TNLC and an LCVR were considered. In the proposed solution, it is not possible to control the PSG and PSA independently. The influence of the PSG/PSA states on the elements of the Mueller matrix indicates the suitability of such a solution for studying linearly birefringent media. Methods for measuring the eigenstates of the PSG and PSA were proposed. All systems were optimized to determine the polarizer azimuth angle that maximizes the system's robustness to measurement noise. Based on the obtained results, it is concluded that the use of TNLCs enables the creation of measurement systems of a new quality, consisting of a small number of components. The usability of the proposed systems depends on the physical parameters of the TNLC cell and its quality. The results of this dissertation show a new and interesting direction for polarimetric solutions and can be used in the design of other polarimeters.