Polarization Analysis and Measurement

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Polarization of light is an important issue in optical system design, performance, and analysis. Measurement of polarization has progressed past the calibration of polarization elements and has become a metrology tool used in a wide variety of fields. Communications, remote sensing, display technologies, and optical computing are a few of the active areas of research that require higher quality polarization elements and better knowledge of instrumental polarization effects. Mathematical analysis of polarization in optical systems, elements, and materials has produced a new understanding that leads to more precise control of polarization in optical systems, new applications that exploit polarization, and a variety of new instruments based on polarization.

The SPIE conference Polarization Analysis and Measurement II that took place in July of 1994 was the latest in a series of conferences on polarization that reported on current developments in analysis of polarization in optical systems, design of polarimeters, applications of polarization measurement, and advances in the mathematical understanding of polarization phenomena.

The 17 papers in this special section describe areas of recent intense interest and development in polarization research. The papers may be conveniently divided into three subgroups: (1) design and measurements of optical components and polarization devices, (2) mathematical analysis and modeling of polarization in materials and optical systems, and (3) new developments in polarimetric instrumentation.

The first group of eight papers describes measurements and design of new polarization elements and optical devices. Interference effects that can occur when photoelastic modulators are used with laser sources are described in the first paper. The author describes the effect and its physical source, and presents corrective steps that can be taken to address this important effect. The second paper presents an analysis of a three-mirror system that can be used to produce retarders for the VUV, a region for which few birefringent materials exist. The third paper describes a novel imaging polarimeter and gives examples of its use. The fourth and fifth papers discuss linear polarizers and birefringent waveplates, respectively. The uniformity and performance of these basic elements is important information for optical engineers who are selecting elements for use in their own systems.

In the sixth paper, a magnetically controllable waveplate using ferrofluids is described that holds potential for fast polarimetric modulation. The seventh paper describes retardance and diattenuation measurement results on a PLZT modulator. These measurements show a surprising dependence of diattenuation on applied voltage. The eighth and last paper in the first group gives results of polarization measurements on a diamond-turned mirror as a function of scattering angle.

Significant research has been carried out on the mathematical constructs for polarization analysis and modeling of optical systems, resulting in better understanding of depolarizing systems, the polarization effects of scattering, and the interpretation of measured Mueller matrix data. In the first paper of this second group, the general theory of unitary matrices is applied to the characterization of depolarizing or scattering systems. Additional information about the optical system in question can be extracted from the eigenvectors of the matrix parameterization of the system. The next paper describes the polarization of scattering and gives modeling and experimental results. A third paper in this second group discusses a unified formalism for polarization optics that is useful in understanding complicated polarization phenomenon in optical media, with particular application to optical fibers and fiber optic systems. The next author describes the latest developments in polarization ray tracing with a comparison of the various polarization formalisms and a descrip-
tion of image formation and aberrations in optical systems. A 
final paper in this group discusses the application of a matrix 
representation of the bidirectional reflectance distribution 
function to radiative transfer.

In the third and last group of papers, a series of two papers 
describes the optimum angles for the polarization elements in 
a common configuration for a Stokes polarimeter, a rotating 
retarder and a fixed polarizer. The next paper documents an 
imaging liquid-crystal-based polarimeter that has been de-
signed, assembled, and tested at the National Solar Observa-
tory for measurement of solar vector magnetic fields. The 
instrument uses ferroelectric liquid crystals for polarimetric 
modulation, and operates at speeds that minimize atmos-
pheric seeing changes. Tests of the liquid crystals and the 
assembled instrument are given. A final paper describes an 
in-line fiber optic polarimeter for analyzing the polarization 
effects of fiber optic cable, fiber optic couplers, isolators, and 
amplifiers.

The papers in this special section show the rate of progress 
in polarization instrumentation and demonstrate the breadth 
of the fields in optics affected by polarization considerations. 
The contributing authors continue to make significant contribu-
tions to the field and we would like to thank each of them 
for their efforts. We would also like to thank the referees and 
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