Dynamic Mueller Matrix Determination Using Generalized Measurements

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Mueller matrices provide a complete description of a medium's response to excitation by polarized light, and their characterization is important across a broad range of applications from ellipsometry in material science to polarimetry in biochemistry, medicine and astronomy. Here we introduce single-shot Mueller matrix polarimetry based on generalized measurements performed with a Poincaré beam. we demonstrate one-shot polarimetry by analyzing the response of a homogeneous sample to a Poincaré probe beam in terms of simultaneous minimum informationally complete positive operator valued measure (MIC-POVM). The chosen POVM are formed by elements defined by states that correspond to the four corners of a tetrahedron lying on the surface of the Poincaré sphere with the tetrahedron inserted in the sphere. Our method builds on recent work by some of the authors, which demonstrated the single-shot state tomography of vector beams by generalized measurements which were performed simultaneously with a Mach-Zehnder type interferometric setup [1]. Here, we demonstrate a significantly improved design for POVM measurements based on a path-displaced Sagnac interferometer, which can operate stably for timescales in the order of hours without need for re-calibration [2]. In combination with a full Poincaré beam as the probe, this allows us to obtain the Mueller matrix of an unknown sample in a single shot, or when observed by camera to record dynamic measurements of optical activities at a time resolution limited only by the frame rate of the camera. We anticipate potential applications in the investigation of fast physical, chemical or biological processes as well as for stress analysis. Althought the setup implementation was demonstrated with a classical light source, the method can be applied to single or photon pair light sources.

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References

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