Ultra-Precise Measurements of Non-Uniform Wave Retardance

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While polarization is commonly used to either encode quantum information in photons [1], or control and manipulate light in quantum systems, the quality of these operations is often limited by how well the birefringent optics can be characterized. The ISO standard for characterizing the retardance of birefringent optics [2] is highly sensitive to errors in the rotational alignment and in the birefringence of the calibration waveplates and polarizers. For a waveplate, this often leads to a retardance uncertainty of about 1°. These errors, when compounded through multiple elements, can have an adverse effect on the quality of entangling and single qubit operations performed on photons. Here we present two improved methods for characterizing birefringent elements that is an order of magnitude more sensitive than the standard ISO approach, while using a relatively simple setup. The first approach, a modified de Sénarmont and Friedel (MDSF) technique, introduces specific angular rotations to cancel out systematic errors in the calibration optics. The second approach is based on four power measurements (FP), and its main advantage is being, in principle, faster than the MDSF method. We demonstrate that both techniques yield $< 0.1°$ uncertainty on the retardance (**Fig. 1a** and **1b**), and we show a preliminary measurement of the position-dependent retardance in our sample (**Fig. 1c**). While delivering a highly accurate and precise measurement of retardance, the MDSF and FP methods can be performed using commercially available optics and components, which makes them widely accessible for in-situ characterization of birefringent optics in an extended range of applications.

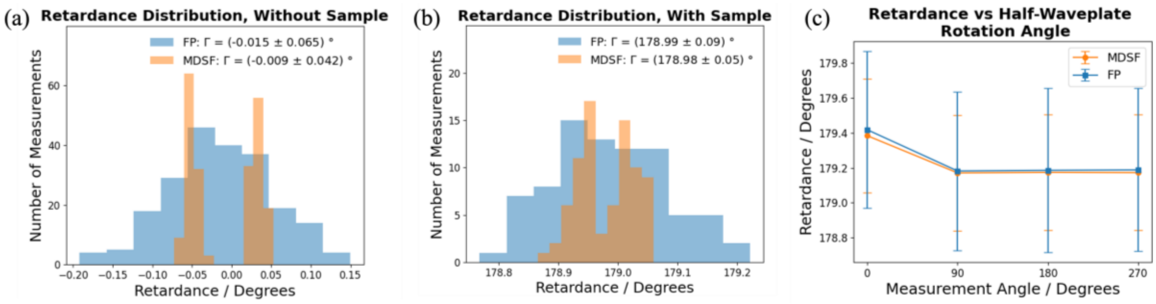

Fig. 1: *(a) Retardance distribution with no sample present in the setup and (b) with the sample, a half-waveplate. (c) Wave retardance measured at four different points in the sample.*

Funding acknowledgement

The authors acknowledge support from the National Science Foundation QLCI OMA-2016244, the National Science Foundation ECCS 2330228, the University of Colorado Quantum Engineering Initiative, and the National Institute of Standards and Technology.

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