

Accounting for the polarizing effects introduced from non ideal quarter-waveplates in lidar measurements of the circular depolarization ratio

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In this study we present a methodology for the calculation of the retardation and rotation errors introduced from a non ideal quarter-waveplate (QWP). We performed laboratory measurements with a lidar elipsometer (LEM) and also on-field with the EVE lidar in order to test two high energy Crystalline Quartz zero order QWPs from Altechna. EVE is a unique depolarization Raman lidar system operating at 355nm that can perform simultaneous measurements of the volume linear and volume circular depolarization ratios (VLDR and VCDR, respectively) using a 2 laser - 2 telescope configuration that enables it to record each beam to each telescope. During the ASKOS campaign in Mindelo, Cape Verde in July and September 2021 we found indications that the two QWPs of EVE installed both in the emission of one of the lasers and in one of the receivers were introducing a systematic error that could not be explained by a rotation error of the order of a few degrees in the placement of the QWPs. In order to identify the source of the problem we performed ellipsometric LEM measurements in Raymetrics S.A., Athens using an Altechna QWP of the same batch as the ones installed in EVE. For these tests, the QWP was placed at 45° in front of a polarizing beamsplitter cube (PBS) and simultaneous measurements of the reflected and transmitted signals were performed using a Quantel Ultra laser at 355nm as a source with its polarization plane at 4 different angles with respect to the PBS. The calibration factor of the LEM, the laser degree of linear polarization, and the rotation error were measured from a $\Delta 90$ measurement with the QWP removed. In this technique we assume that the QWP behaves as a rotated retarder without introducing diattenuation. We form an overdetermined system of linear equations as many as the number of independent states of polarization applied (here 4) which we solve towards the retardation and the rotation error. We found an absolute retardation error of $4.7^\circ \pm 1.08^\circ$ and a small absolute rotation error of $0.67^\circ \pm 0.57^\circ$. It was possible to repeat the same test directly in EVE in order to measure the same properties for the QWP installed in one of the two receivers of EVE because they can rotate similarly to the LEM platform. We measured a retardation error of $4.81^\circ \pm 0.61^\circ$ and $4.95^\circ \pm 0.40^\circ$ using laser A and B, respectively. Likewise we measured a minor rotation error of $0.30^\circ \pm 0.33^\circ$ and $0.56^\circ \pm 0.24^\circ$. As both the laboratory and the on-field results agree within their uncertainties, we assume that the second QWP of EVE installed in the emission suffers from the same retardation error. In the next step we will calculate the GHK parameters taking into account both non ideal QWP and apply them for the calculation of the correct VLDR and VCDR profiles.