Master thesis and internship[BR]- Master's thesis : Towards a laboratory validation of a dual-polarization wavefront sensing with the vortex coronagraph[BR]- Internship

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Towards a laboratory validation of a dual-polarization wavefront sensing with the vortex coronagraph

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In the context of high-contrast imaging, dual-polarization wavefront sensing represents a very promising solution for non-common path aberrations (NCPAs) and aberrations control using the vortex coronagraph. The interest of this method lies in the efficient phase retrieval using the unique polarization behaviour of the vortex coronagraph and the simplicity of its implementation. This method has been progressively implemented on Vortex Optical Demsontrator for Coronagraphic Application (VODCA) test bench using the vortex coronagraph called the Annular Groove Phase Mask (AGPM).

The dual-polarization setup requires the most accurate selection of both orthogonal circular polarizations before and after the focal plane. An accurate polarization setup is optimized to ensure the purest circular polarization for both orthogonal states at more than 97% at the focal plane on VODCA. In order to achieve this level of precision, two polarization measurement methods have been presented. The classical method and the rotating quarter wave plate (QWP) method are compared and the rotating QWP method is used to optimize the accuracy of the circular polarizer being more precise and consistent than the classical method.

With the optimized circular polarizer, the dual polarization setup has been evaluated in terms of two particular performance values, the extinction ratio and the rejection ratio. The setup has achieved a non-expected high performance comparable to particularly efficient results obtained in previous studies. The dual polarization setup with the vortex coronagraph has achieved an extinction ratio of 1521. Moreover, a rejection ratio of 2010 has been obtained for the AGPM. This result has been obtained using a aberration minimization routine to avoid limiting performance due to aberrations in the focal plane. The total contrast achieved by the dual-polarization setup is up to 21e4.

This performance ensured a sufficiently high accuracy of the setup to produce a required diversity for phase retrieval. This produced diversity has been proven by using the deformable mirror (DM) of VODCA to inject specific aberrations in the focal plane and verify the lifting of the sign ambiguity which was confirmed. Following this, a CNN training on aberration identification have led to relative successful wavefront reconstruction tests performed using machine learning.

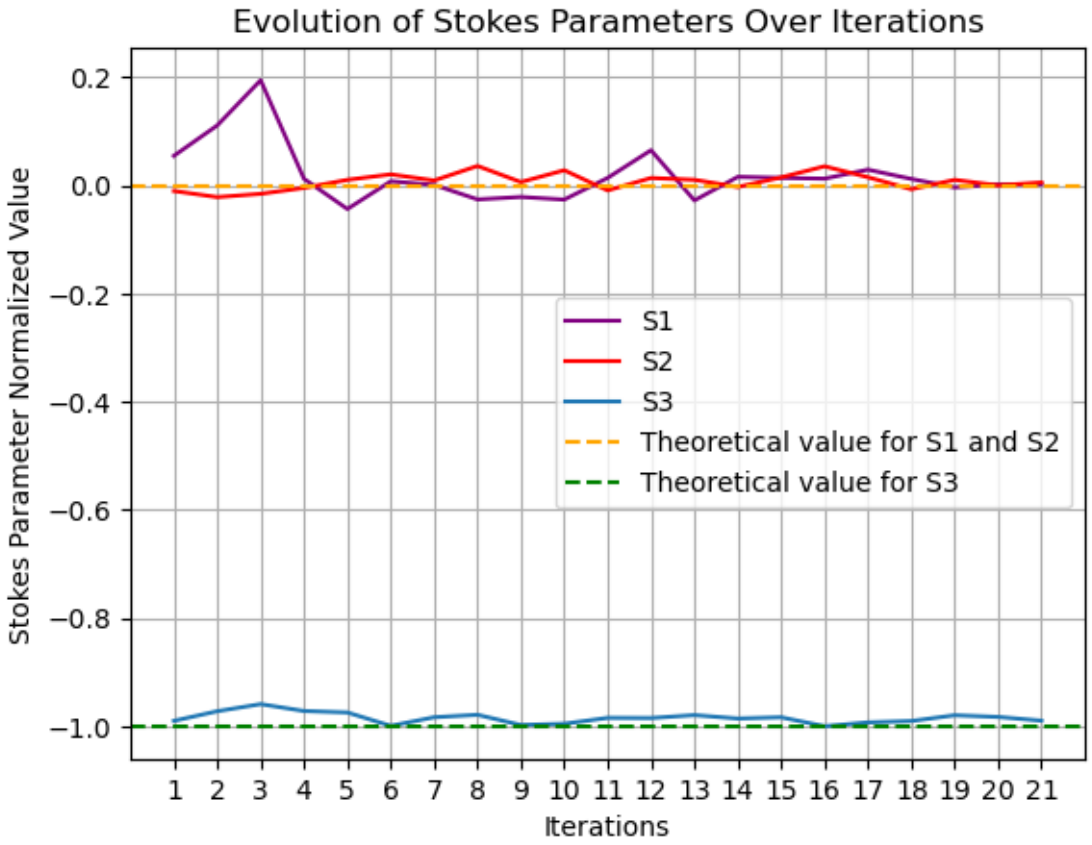

Figure 1: Evolution of the Stokes parameters values for LH polarization during the circular polarizer optimization.

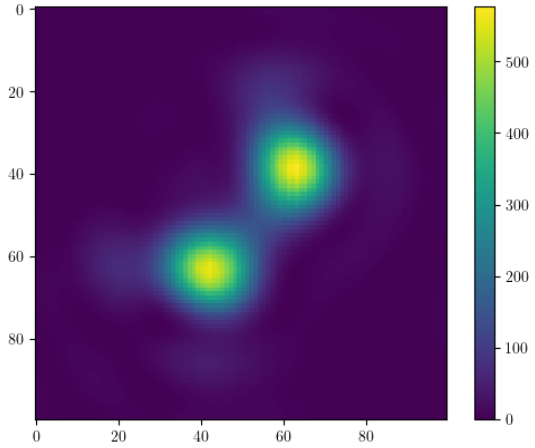

Figure 2: Vertical astigmatism; amplitude = 800 nm; LP1 = 45°, AGPM on-axis.

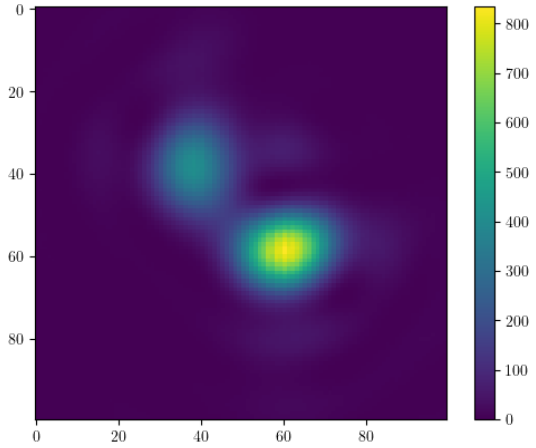

Figure 3: Vertical astigmatism; amplitude = -800 nm; LP1 = 45°, AGPM on-axis.

Figure 4: Demonstration of the lifted ambiguity by comparison between images obtained with vertical astigmatism induced by the DM using the AGPM on-axis with LH circular entrance polarization.

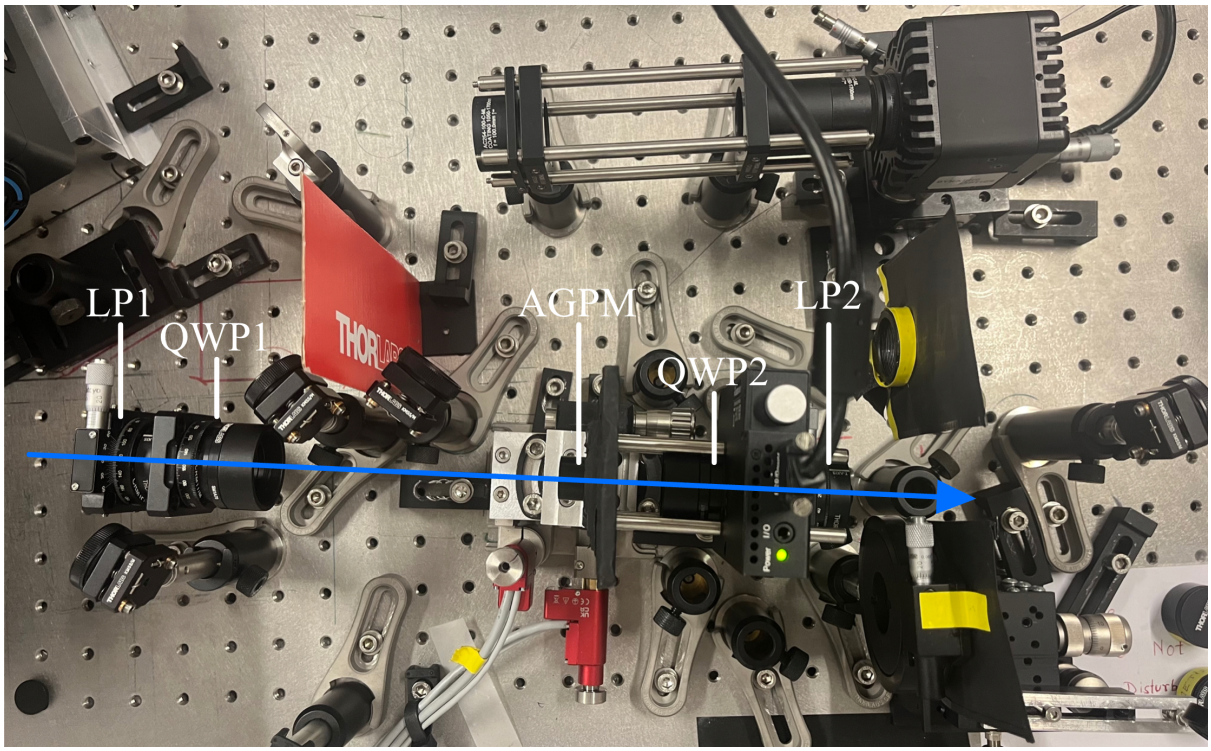

Figure 5: Dual-polarization final setup. The blue arrow representing the direction of the light flux. LP = Linear polarizer, QWP = Quarter wave plate and AGPM = Annular Groove Phase Mask.