# Mueller Matrix Maps of Dichroic Filters Reveal Polarization Aberrations

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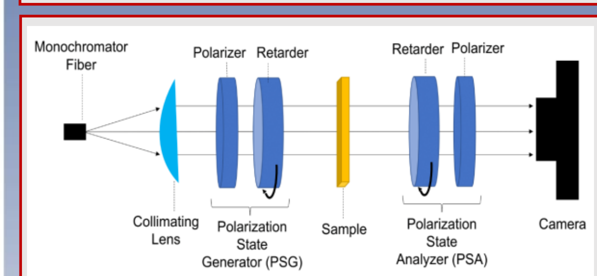
## Motivation:

Dichroic filters are often used by instrument designers to divide a field of view into several spectral bands for simultaneous high-spatial-resolution diffraction-limited imaging applications. One important application is the fore-optics of exoplanet imaging coronagraphs. The polarization properties of the dichroic were measured using Mueller matrix polarimetry. This work seeks to measure and explain how dichroic filters change the incident polarization state and predict how this will affect the performance of vector vortex coronagraphs, while also giving strategies to mitigate these effects.

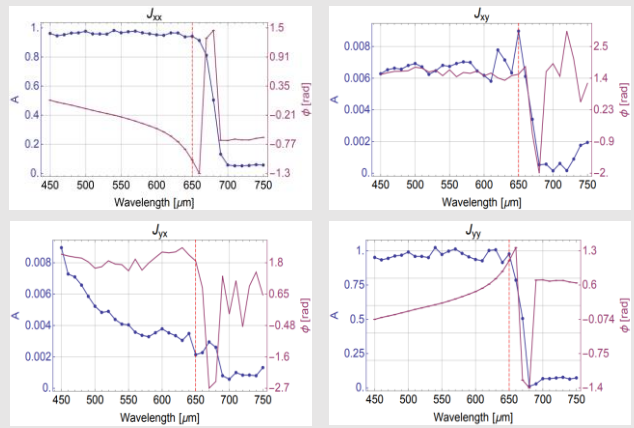
## Dichroic Specifications:

- Maker: Edmund Optics (Stock #69-205)
- Shortpass filter with 650 nm cutoff wavelength
- Operating Angle of Incidence: 45 degrees
- 25 mm diameter




## Mueller Matrix Polarimetry:

Sample measuring Mueller matrix (MM) polarimeters are used to determine the polarization features of the dichroic including retardance and diattenuation. The polarization state generator creates a set of incident Stokes polarization states which pass through the sample creating the MM-Stokes relation M·S. These exiting states are then analyzed by the polarization state analyzer providing the measured flux. This set of linear equations can then be used to solve for the sample's MM elements. See QR code for video of all 10x10 pixel MM over the entire bandwidth.*




## Jones Matrix:

The spatially averaged Jones Matrix data across the visible wavelength region was derived from the MM measurements. The xx and yy phases demonstrate the introduction of retardance and grow inversely proportional with respect to each other as the cutoff region is approached. Magnitudes for xx and yy remain same until cutoff, with yy falling off slightly faster.

## Retardance:

Measurements of the dichroic were taken for both normal and 45° incident light. Normal incidence measurements should show no retardance or diattenuation and act as a control. Average retardance magnitude shows an increasing trend around 470 nm, reaching a π/4 shift at approximately 590 nm. Retardance continues to grow to π/2 at 630 nm, meaning the dichroic exhibits λ/4 and λ/2 retarder tendencies over increasing wavelength until after cutoff.

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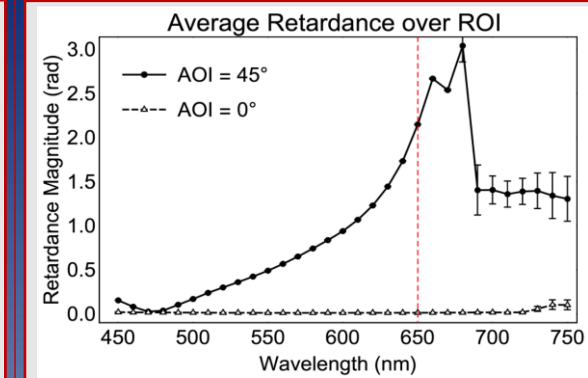
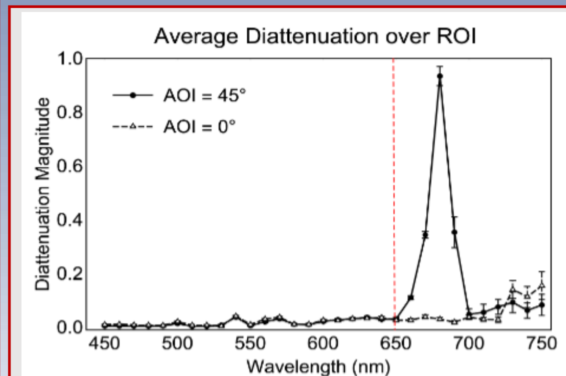



## Diattenuation:

Diattenuation is the transmission difference between s and p-polarization states. As expected, the diattenuation is negligible at normal incidence, but increases rapidly at 45° incidence above the cutoff wavelength. At 680 nm, diattenuation peaks at approximately 0.95 and then decreases.




## Conclusion:

These polarization aberrations are important considerations in high precision optical systems. Dichroics that are upstream of polarization sensitive optics, like vector vortex coronagraphs, would affect the systems performance without corrective optics.