Polarization Change After Propagation Through a Prism Retroreflector

- Output polarization of laser light measured after reflection from each sextant of a prism retroreflector.
  - Retroreflectors are used in various optical setups to return the incoming light parallel to the incoming beam, but with a lateral displacement.
- We have empirically confirmed the transformation of linearly polarized light into elliptically polarized light after propagation through the prism retroreflector.

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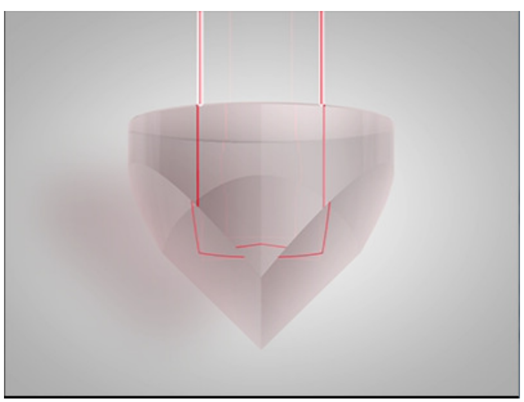
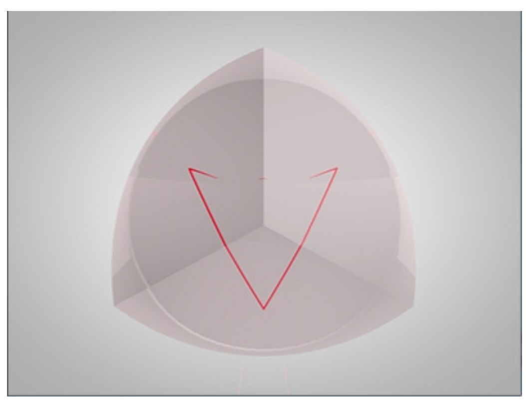
Thorlabs Prism Retroreflectors

- A retroreflector is an optic that returns light in the same direction as the input beam with a lateral offset.
- The optic is generally either a solid prism or hollow with coated mirror surfaces.
- The common corner cube design is pyramid shaped with light entering the base.
- The three faces that make the corner are orthogonal (90 degrees to each other).
- There are always 3 internal reflections before the beam returns, one from each face.





Ray trace through a retroreflector

Theoretical Considerations

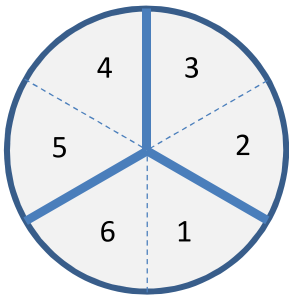
- In a solid prism retroreflector, the beam undergoes total internal reflection at each surface.
- A beam entering normal to the base will be incident upon each face at a 55˚ angle ($\cos^{-1}(1/\sqrt{3})$) [1].
- S- and p-polarization components reflect from each face differently based on the Fresnel reflections [2].
  - More specifically, the s- and p-polarizations will reflect from each face with a different phase delay based on the angle of incidence and refractive indices of the glass and surrounding medium.
- Here we present measured values for a 633 nm stabilized HeNe propagating through the Thorlabs Ø1" N-BK7 prism retroreflector.

[1] J. Liu and R. Azzam, "Polarization properties of corner-cube retroreflectors: theory and experiment," Appl. Opt. 36, 1553-1559 (1997). http://www.opticsinfobase.org/ao/abstract.cfm?uri=ao-36-7-1553

[2] M. Born and E. Wolf. Principle of Optics, 7th ed. Cambridge University Press, Cambridge, UK, 1999. 49-53.

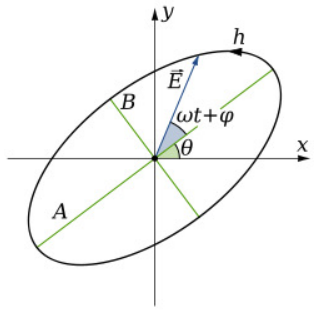
Measurement Notes

- The Stokes vector of the light output from each sextant within the reflector was calculated by measuring the intensity with the polarization set horizontal & vertical, ±45°, and left & right circular.



- A polarizer was used to measure the light in the linear basis and a quarter-wave plate and linear polarizer was used to measure the light in the circular basis.

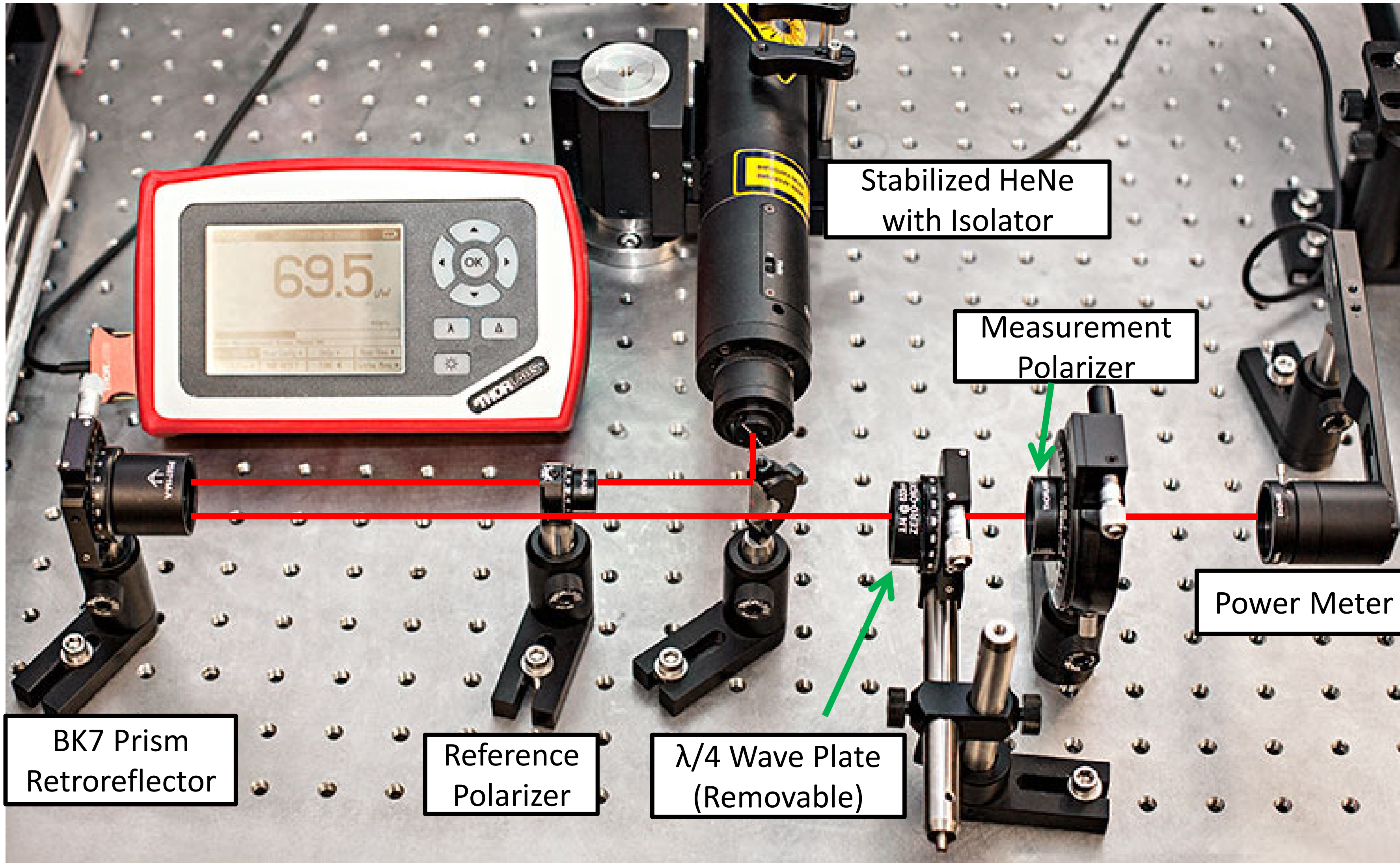
- The ellipticity ($\varepsilon = B/A$) and azimuth angle (θ) of the polarization ellipse were calculated from the Stokes parameters [3].



- The calculated azimuth angle of the polarization ellipse was compared with the rotation location of the maximum and minimum intensity to verify the measurement technique.

[3] D.H. Goldstein. Polarized Light, 3rd ed. CRC Press, Boca Raton, FL, 2011. 250-258.

Experiment Setup



Data Presentation

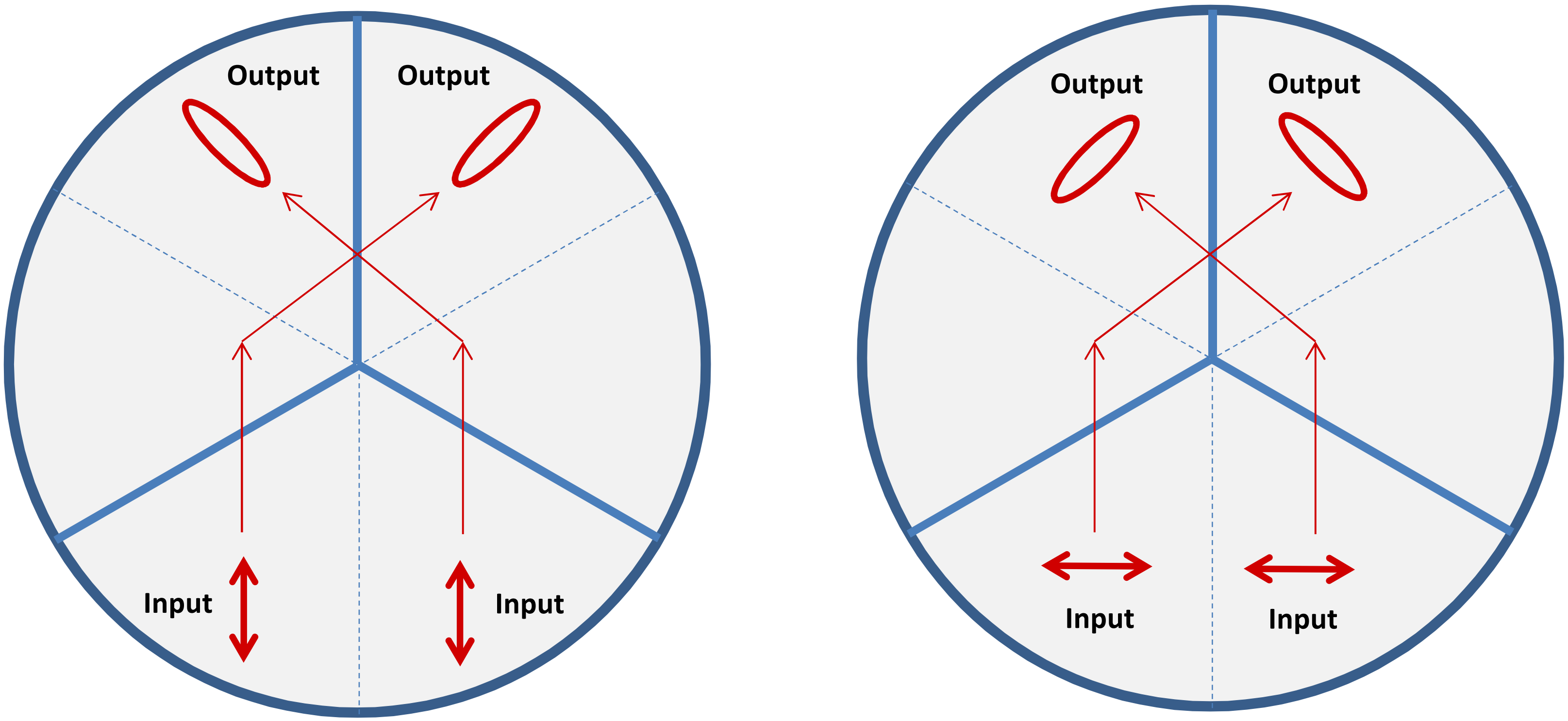
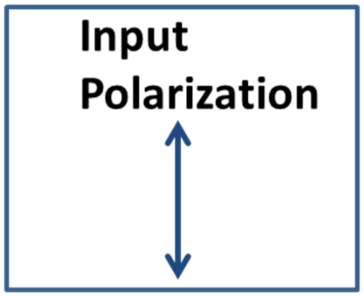


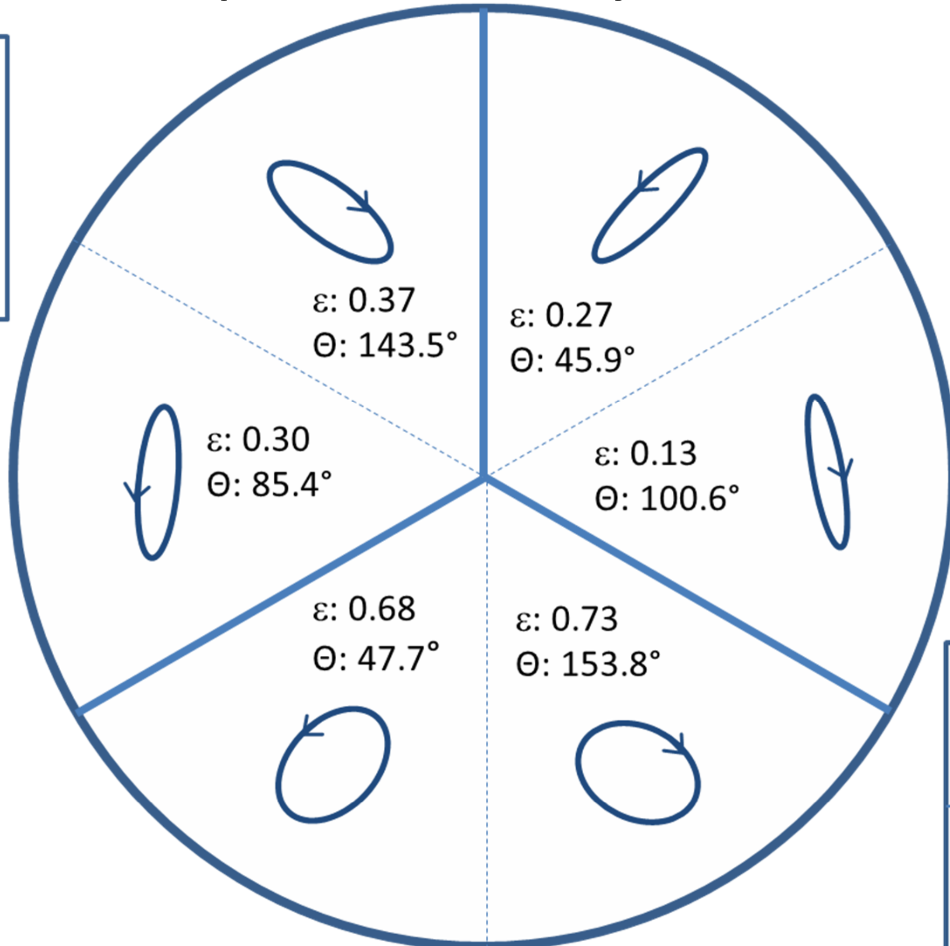
Diagram conventions:

- Output shown is always from linear input into the opposing segment.
- Output and input as seen looking in through the retroreflector base from point of view of observer.

Results: Vertical Polarization



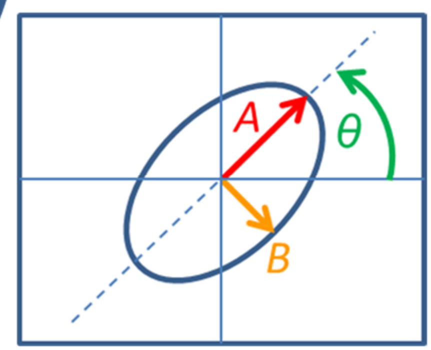
Output Polarization by Sextant



$\underline{\varepsilon = B/A}$

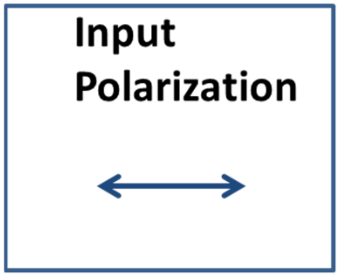
ε = 1: circle

ε = 0: line

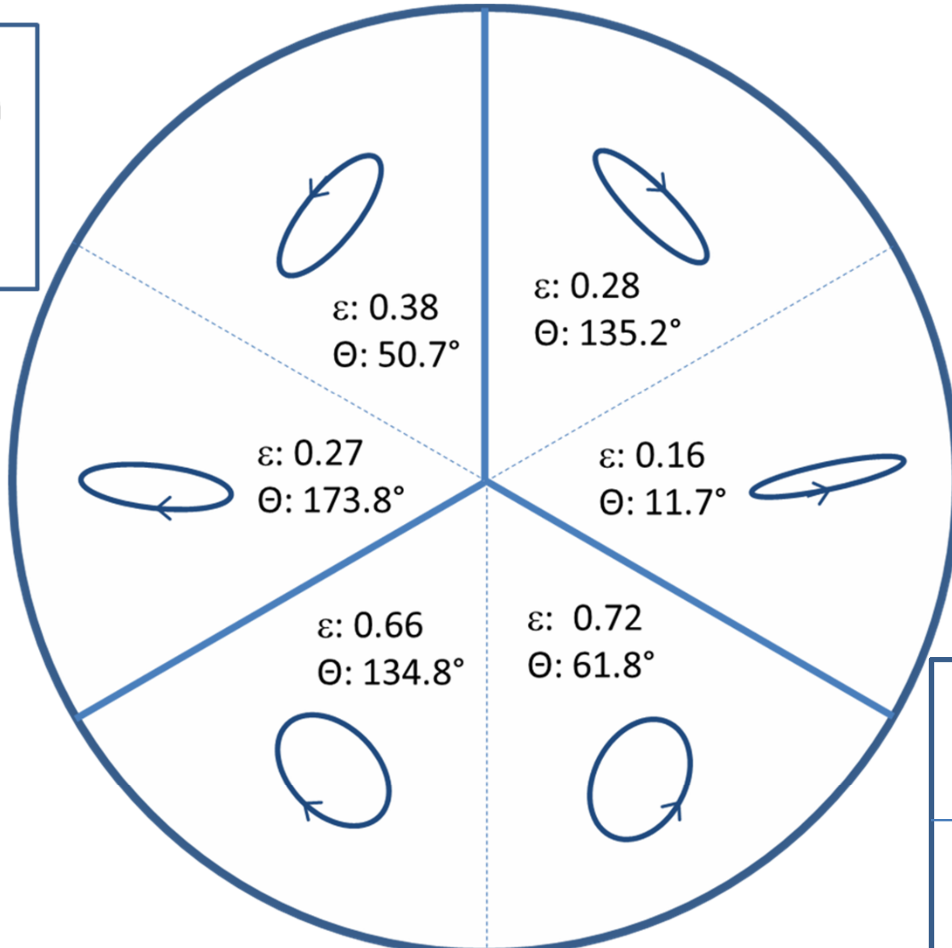


- Electric field polarization ellipse as seen from point of view of the **observer**, theta is measured counterclockwise from horizontal to major axis. Arrow is the handedness of the ellipse.

Results: Horizontal Polarization



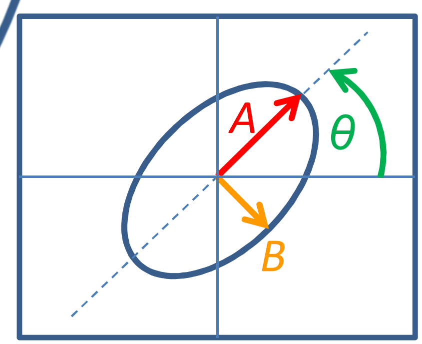
Output Polarization by Sextant



$\varepsilon = B/A$

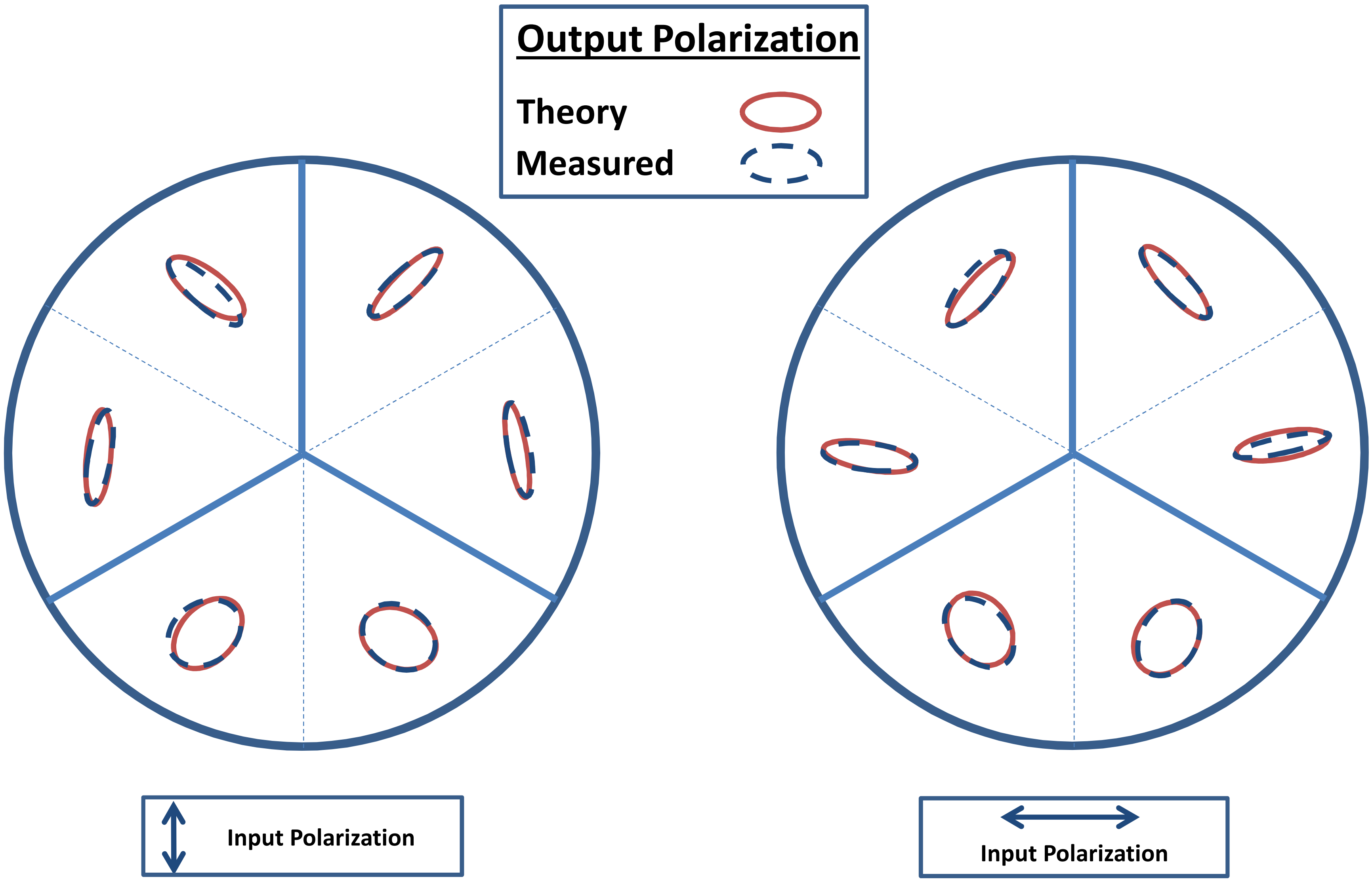
ε = 1: circle

ε = 0: line



- Electric field polarization ellipse as seen from point of view of the **observer**, theta is measured counterclockwise from horizontal to major axis. Arrow is the handedness of the ellipse.

Measured and Theoretical Comparison



Experimental Limitations

- Only a single measurement was recorded in each sextant and we assume minimal spatial dependence of the measurements.
- We took care to align the retroreflector and assume normal incidence upon the base.
- Only a single retroreflector was assessed and we assume no differences will be observed between different retroreflectors.

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Summary

- We have measured the output polarization of the light exiting each sextant of a prism retroreflector.
- The measurements empirically confirm the transformation of linearly polarized light into elliptically polarized light after propagation through the prism retroreflector.
- These results should be considered when using a prism retroreflector in an application where the polarization of the light is critical.