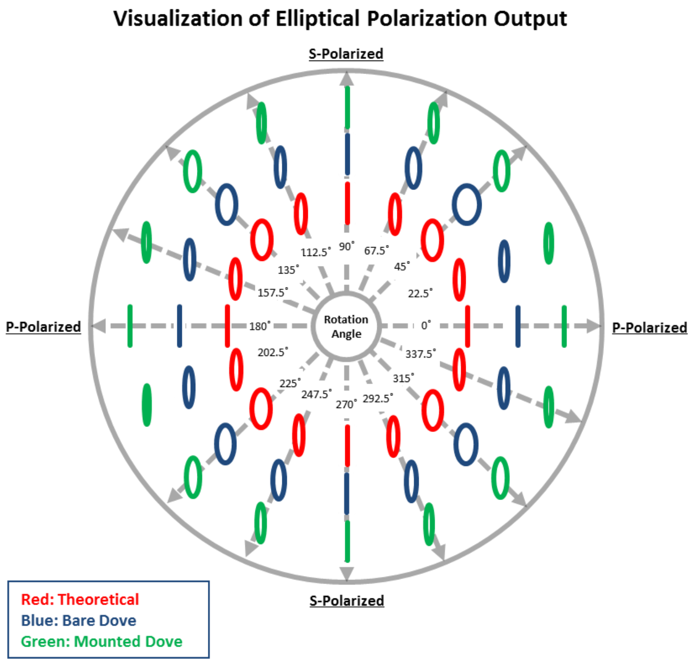
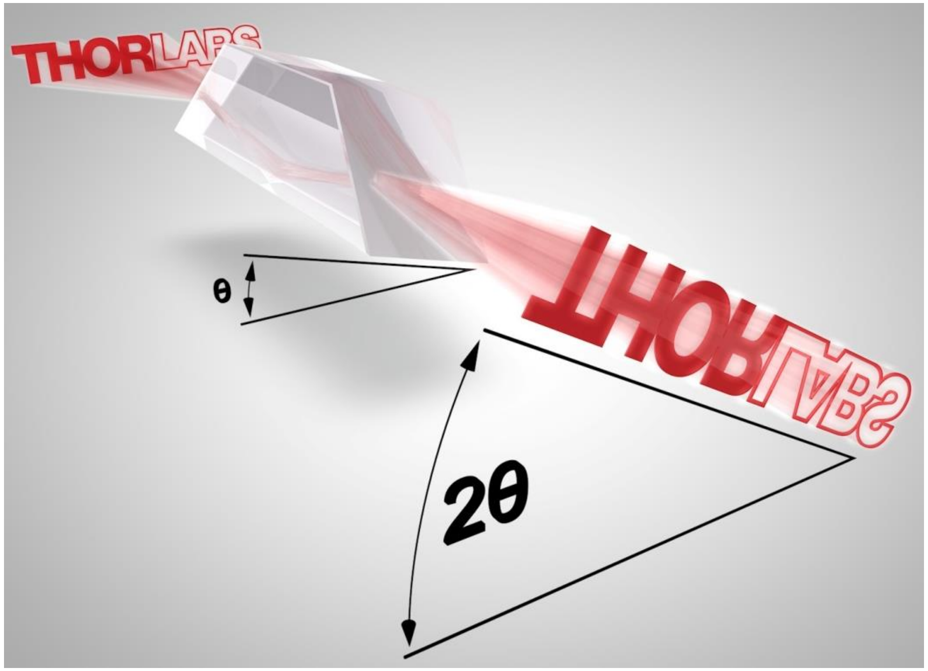
Polarization Change After Propagation Through a Dove Prism

- Linearly polarized light incident upon a Dove Prism will become elliptically polarized upon output.
- Stress-induced birefringence caused by mounting a Dove prism with a single point of contact will further alter the output polarization state.





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Background

- Dove prisms are truncated right-angle prisms typically used to invert or rotate an image without dispersion.
- Dove prisms introduce polarization changes to the input light [1], which could change based on stress-induced birefringence.
- Here we confirm inducing stress within a bare Dove prism can change the output polarization, and the SM1-mounted Dove prism ([PS992M]) induces minimal polarization change.

Dove Prism

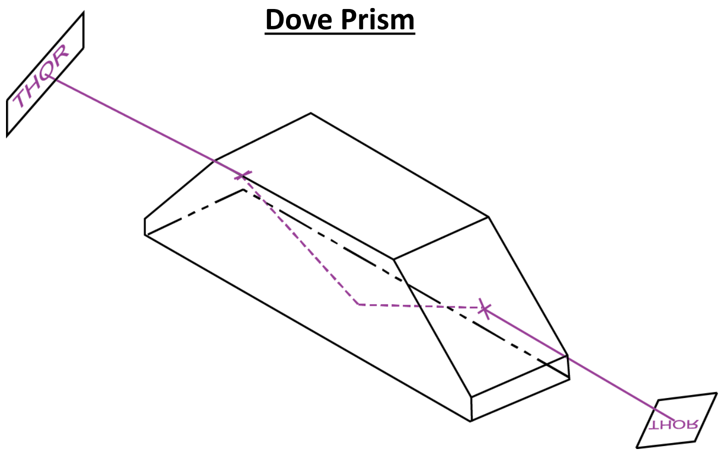
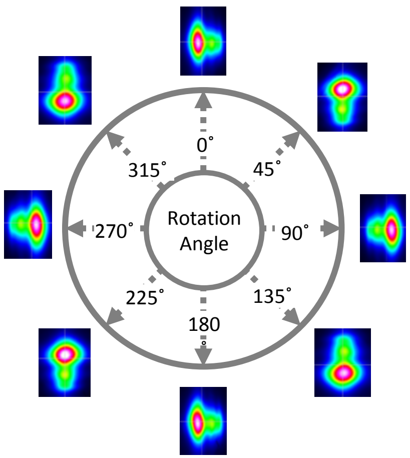


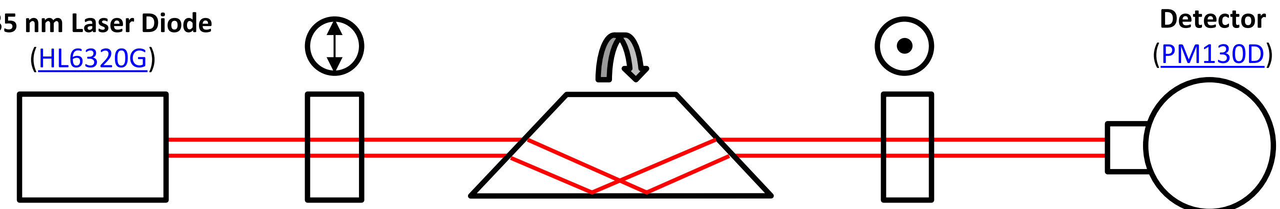
Image Rotation with Angle



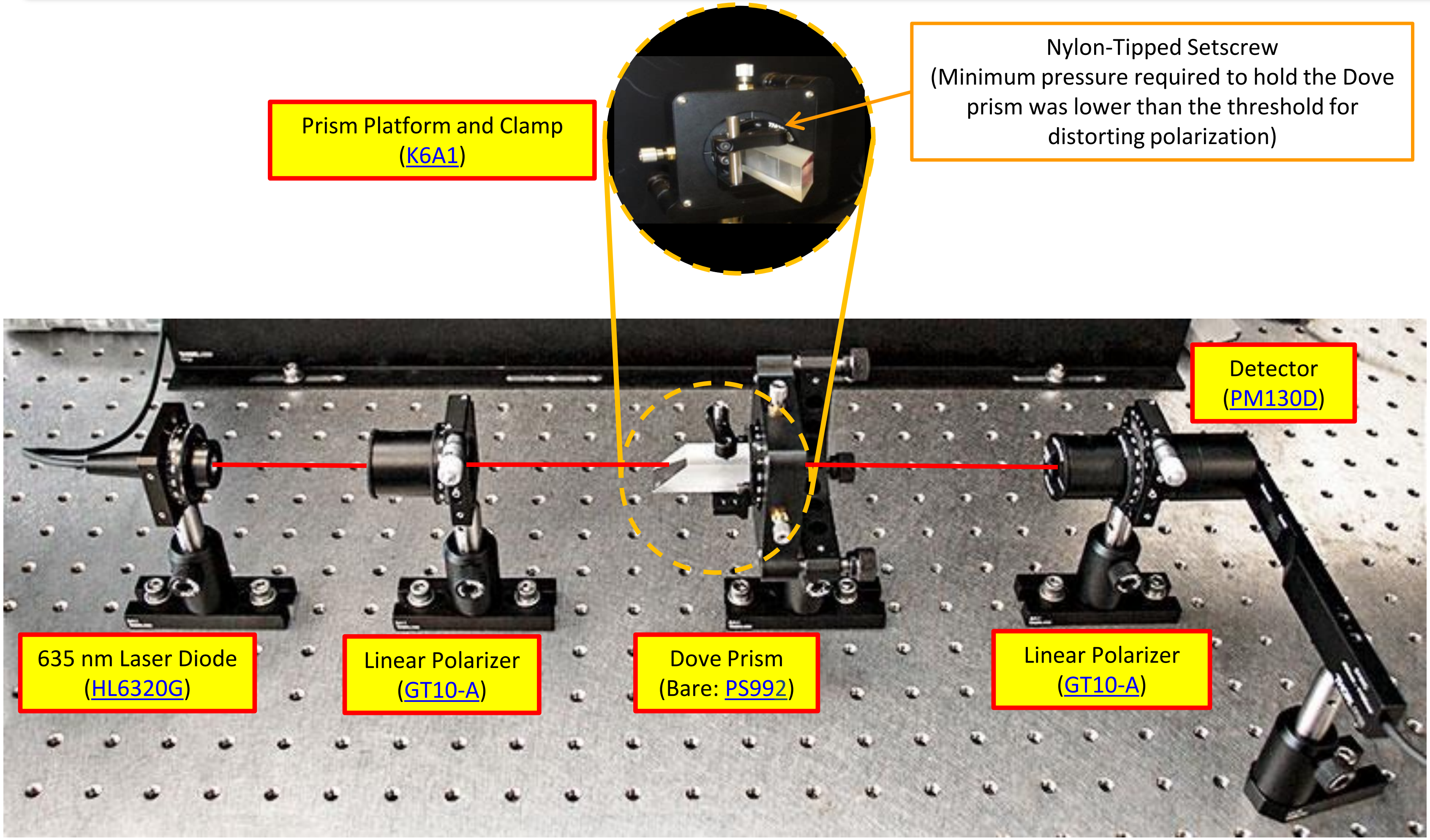
[1] Miles J. Padgett & J. Paul Lesso, "Dove prisms and polarized light," J. Mod. Opt. **46**, 175-179 (1999).

Experimental Setup

- Laser diode (635 nm) aligned with two crossed Glan-Taylor polarizers to produce extinction at the detector; the angle of polarization axes are established.
- Prism mounted between crossed polarizers and then rotated at 22.5˚ steps about optical axis.
- 2nd polarizer rotated at each 22.5˚ step of Dove prism to record minimum and maximum throughput and corresponding angle of polarization ellipse.
- Experiment repeated for:
  - Bare Dove prism mounted on K6A1 prism platform with minimal stress applied by clamping arm
  - Bare Dove prism mounted with excessive stress by tightening clamp setscrew one full turn
  - SM1-Mounted Dove prism.

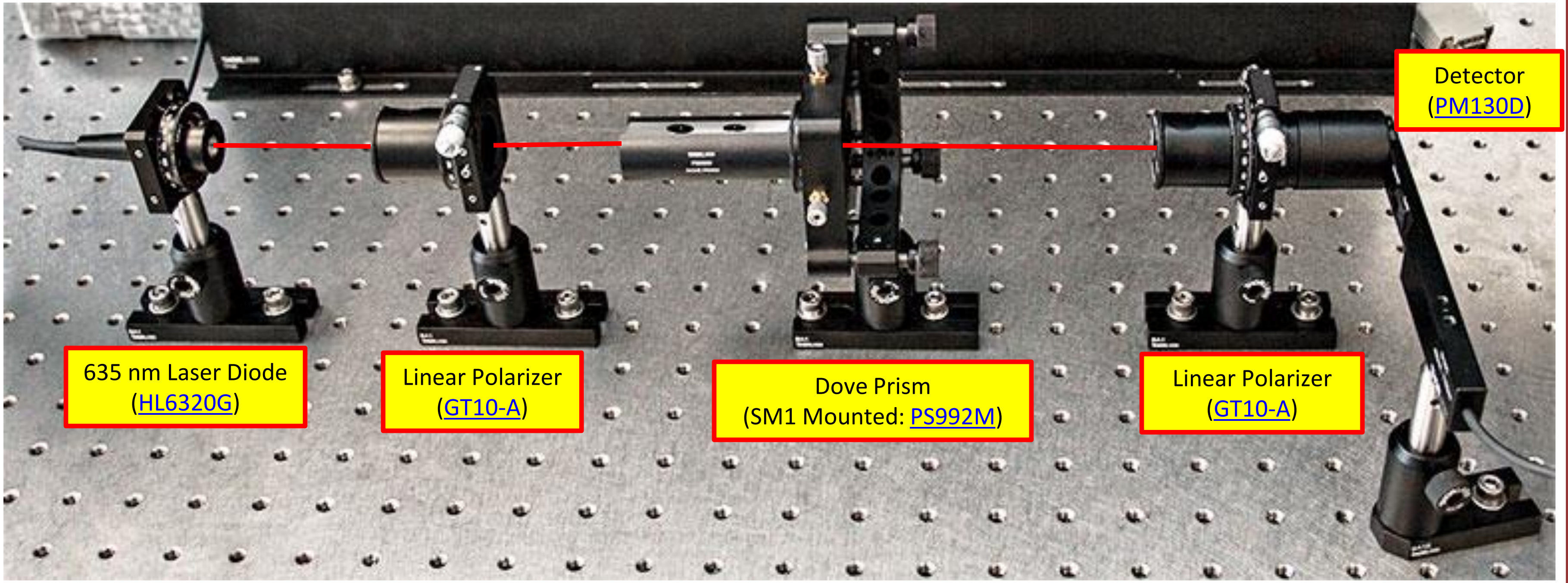


Experiment Setup I



Experimental setup for the PS992 unmounted dove prism. The setscrew of the clamping arm (see insert) was used to study polarization states in both the minimal and excessive stress conditions.

Experiment Setup II

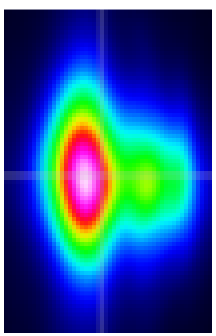


Experimental setup for the PS992M mounted dove prism. This optic was threaded into the K6X optical mount. No excessive force data could be collected in this configuration.

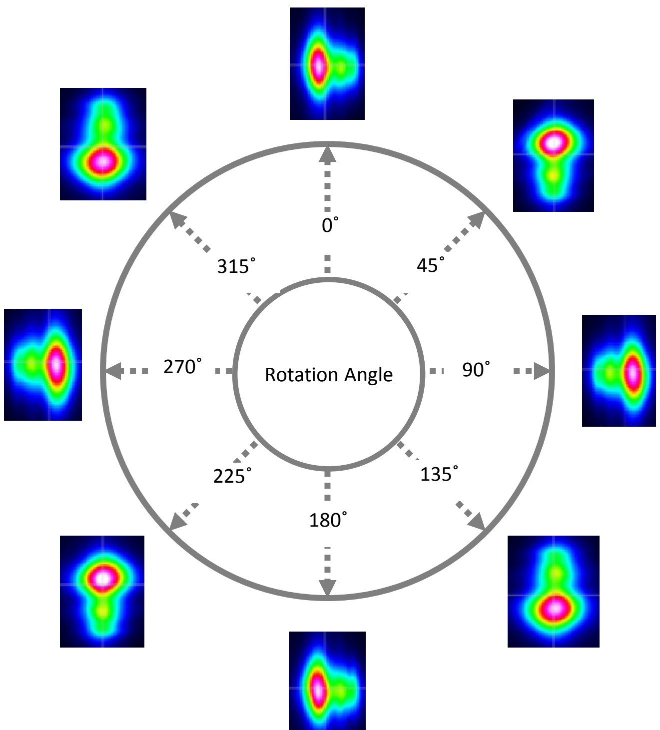
Results: Image Rotation With Angle

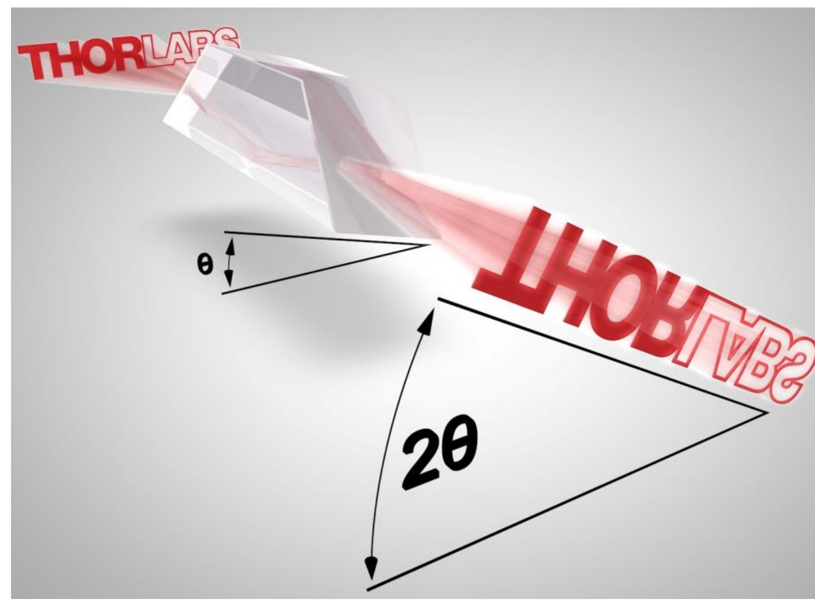
- Collimated elliptical laser diode apodized with iris to create irregular shape.
- Light output transmitted through Dove prism and imaged with CCD camera.
- Dove prism rotated at 45˚ steps to demonstrate the output rotates by twice the rotation angle.

Input Image



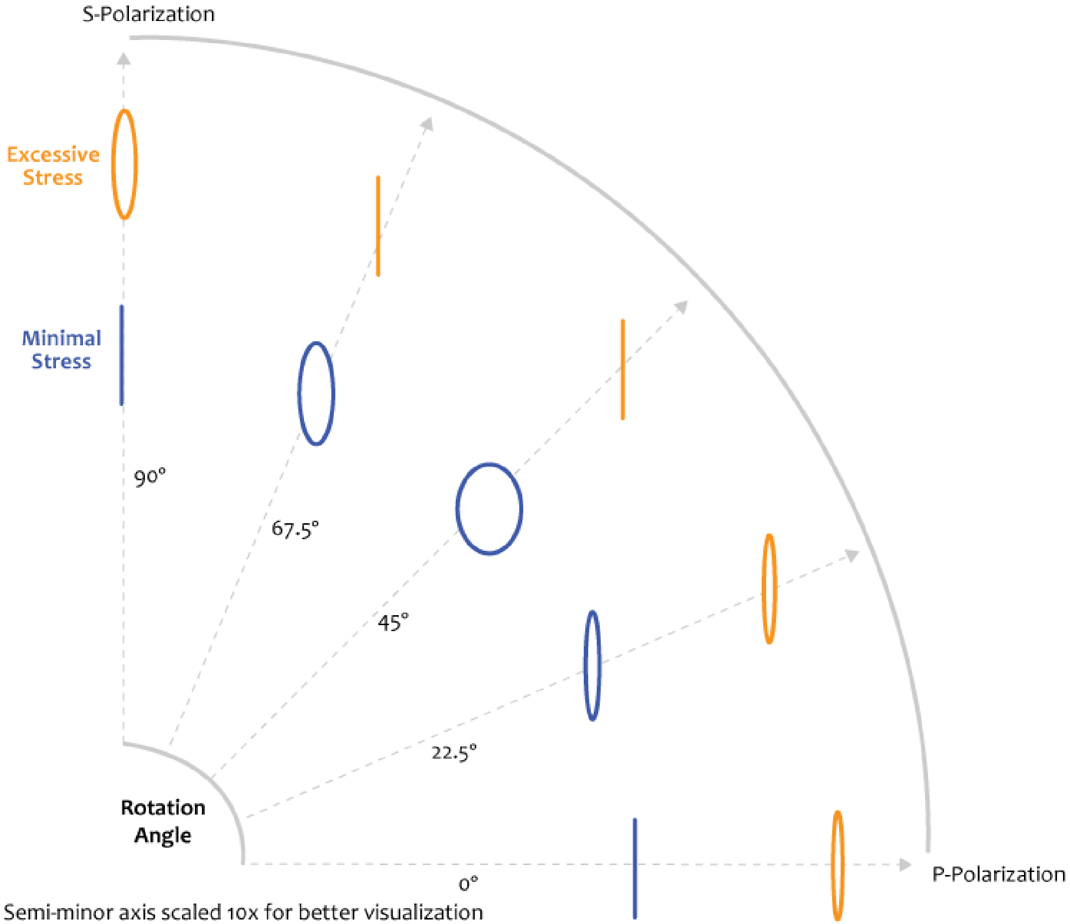
Resulting Image by Prism Angle





Results: Polarization Change with Stress-Induced Birefringence

Visualization of Elliptical Polarization Output



Ellipticity		
Angle	Minimum Stress	Maximum Stress
0°	$7.1*10^{-5}$	0.011
22.5°	0.02	0.009
45°	0.05	0.002
67.5°	0.32	0.002
90°	$4.4*10^{-4}$	0.016

Ellipticity:
ε = Min Power/ Max Power

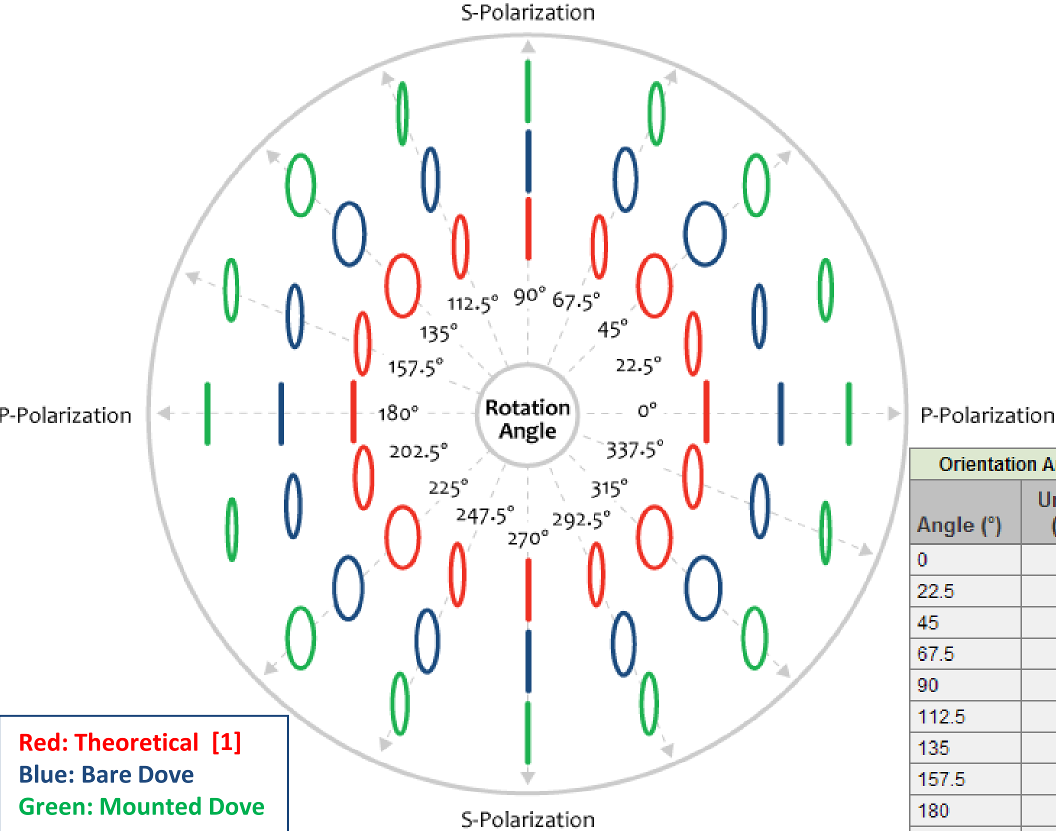
Orientation Angle (From Input Polarization)		
Angle	Minimum Stress	Maximum Stress
0°	0°	0°
22.5°	-2°	-1°
45°	-2°	-2°
67.5°	-1°	-2°
90°	0°	0°

Orientation Angle
α = Angle (Min Power) – Angle (Crossed 2^{nd} Polarizer)

***Important to note input polarizer remained stationary in vertical direction and rotation angle of polarization state dependent on prism rotation.**

Results: Output Polarization Comparison (Mounted and Bare Dove Prisms)

Visualization of Elliptical Polarization Output



Semi-minor axis scaled 10x for improved visualization

***Important to note input polarizer remained stationary in vertical direction and rotation angle of polarization state dependent on prism rotation.**

[1] Born, Max and Wolf, Emil, 1999, *Principles of Optics 7th Edition*, Cambridge University Press, Cambridge, 985 p.

Orientation Angle (From Input Polarization)		
Angle (°)	Unmounted (°) (Min Stress)	Mounted (°)
0	0	0
22.5	-2	-2
45	-2	-2
67.5	-1	-1
90	0	0
112.5	1	0
135	3	-8
157.5	4	-4
180	0	0
202.5	-3	-3
225	-3	-2
247.5	0	-1
270	0	0
295.5	0	2
315	2	2
337.5	3	4

Orientation Angle

α = Angle (Min Power) – Angle (Crossed 2nd Polarizer)

Ellipticity		
Angle (°)	Unmounted (Min Stress)	Mounted
0	$7.1*10^{-5}$	$3.5*10^{-5}$
22.5	0.02	0.02
45	0.05	0.03
67.5	0.03	0.02
90	$4.1*10^{-4}$	$1.0*10^{-4}$
112.5	0.02	0.01
135	0.05	0.04
157.5	0.02	0.02
180	$6.5*10^{-5}$	$2.8*10^{-5}$
202.5	0.02	0.01
225	0.05	0.04
247.5	0.03	0.02
270	$1.8*10^{-4}$	$7.1*10^{-5}$
295.5	0.03	0.02
315	0.05	0.04
337.5	0.02	0.02

Ellipticity:

ε = Min Power / Max Power

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Experimental Limitations

- Experiment was completed with relatively large rotation steps (22.5˚) about the optical axis.
- Only light with a single angle of incidence was assessed.
- Stress was not quantified within the Dove prism and any variation in the amount and/or distribution of stress-induced birefringence could provide different results.
  - Inducing stress may not create more linearly-polarized output.
- Measurement of polarization ellipse orientation angle was accurate within 1˚.

Summary

- Measurements were carried out to determine polarization effects for linearly polarized light transmitted through a Dove prism.
- Experimental results show elliptically polarized light exits a Dove prism when linearly polarized light is incident for all angles other than pure S- or P-polarization.
- Stress-induced birefringence within prism creates an additional polarization effect.
  - These result indicate a clamping arm should not be used to mount a Dove prism when a known polarization state is crucial.
- Results from mounted Dove prism (PS992M) are similar to un-mounted prism with minimal stress.
  - This mounting scheme is a much better way to utilize a Dove prism within an experimental setup.

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