

Simulation of Conical Refraction as a Tool for Polarization Metrology

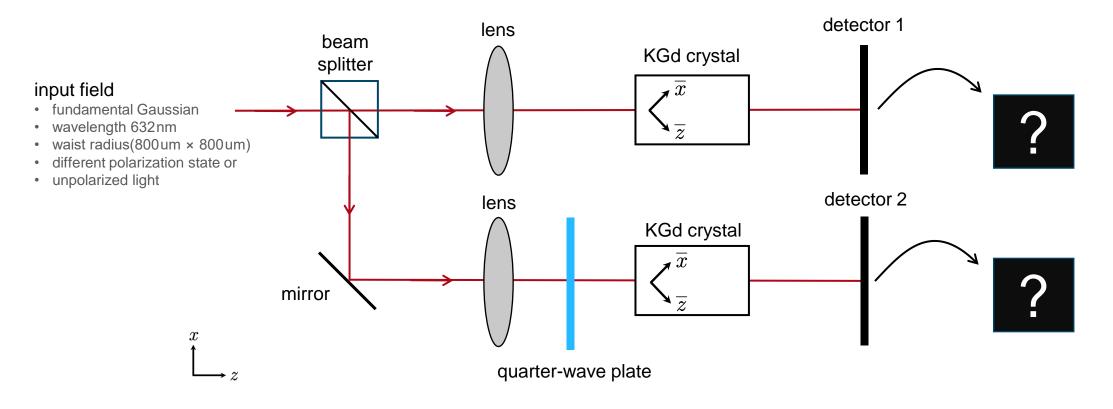
Abstract



Conical refraction is a well-know phenomenon occurring in biaxial crystals, whereby an input Gaussian beam is transformed into a light ring whose intensity distribution is related to the incoming polarization. Several applications have been developed based on this phenomenon, polarization metrology among them. In this use case, we demonstrate the design of a polarimeter with two biaxial crystals, one in each arm of the setup, utilizing the fast physical-optics software VirtualLab Fusion.

Modeling Task

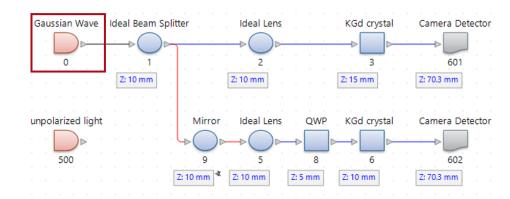
How to identify the polarization state of the incident field from the detected results?



Conical Refraction in Biaxial Crystals

Optical setup follow from Peinado, et al. Optics letters 38.20 (2013): 4100-4103.

System Building Blocks – Polarized Light Source



The input field with different (fully polarized) polarization states is modeled by a single Gaussian Wave.

M^2 Parameter 1 Edit Gaussian Wave X Reference Wavelength (Vacuum) **Basic Parameters** Spectral Parameters Spatial Parameters Select Achromatic Parameter: Polarization Mode Selection Sampling **Ray Selection** Waist Radius (1/e^2) 800 µm \bigcirc Half-Angle Divergence $(1/e^2)$ Global Polarization 0.01440395685° Polarization Input 3.182224379 m Rayleigh Length Linearly Polarized Type of Polarization Linearly Polarized Astigmatism **Circularly Polarized** Angle Elliptically Polarized Offset between y- and x-Plane General Input via Jones Vector Copy to x- and y-Values Normalized Jones Vector 0 Default Parameters Ok

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Polarization

Order

Basic Parameters

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Mode Selection

Spectral Parameters

Sampling

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Ray Selection Spatial Parameters

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800 µm

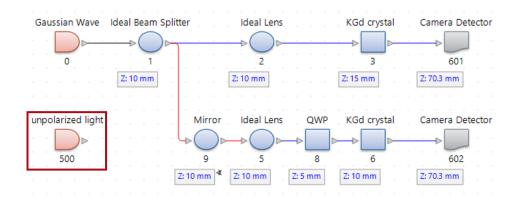
0 mm

Help

0.01440395685°

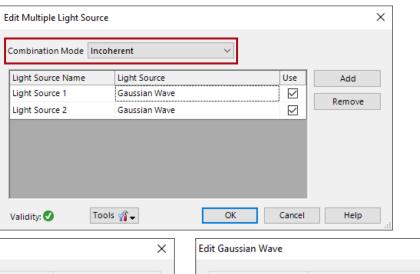
3.182224379 m

System Building Blocks – Unpolarized Light Source



- Unpolarized light gives, statistically, equal projections along any two states forming an orthogonal basis.
- Therefore, we use the *Multiple Light Source* with two Gaussian waves to model the average of the two orthogonal states, in an incoherent manner, to represent unpolarized light.

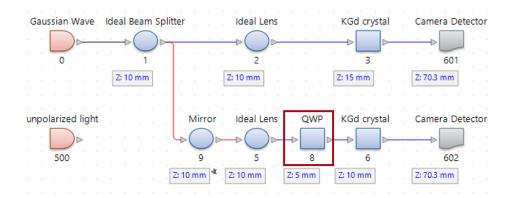
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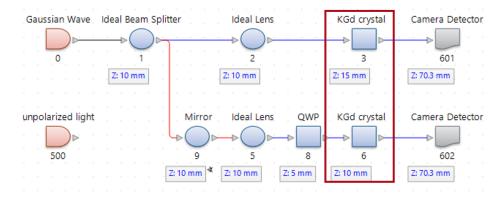
System Building Blocks – Quarter-Wave Plate



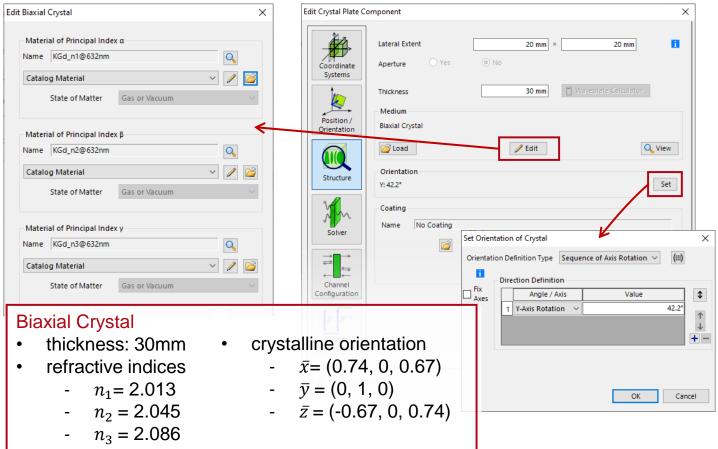
A quarter-wave plate (QWP) is applied in the second arm of the polarimeter and is modeled by the Crystal Plate Component. The thickness of the crystal plate can be calculated from the inbuilt calculator.

Detector	Edit Crystal Plate Co	mponent		×
D1	Coordinate Systems	Lateral Extent Aperture O Yes	20 mm ×	20 mm i
Detector	1 to	Thickness	904.9255441 nm	plate Calculator
D2	Position / Orientation	Medium Uniaval Crystal QWP Carlorad	/ Edit	Q View
Calculation of Waveplate Thickness	×	Coating		
Design Wavelength 632 nm		Name No Coating		
Retardation			0	×
Quarter Wave \checkmark Wavelength Fraction \checkmark	0.25			
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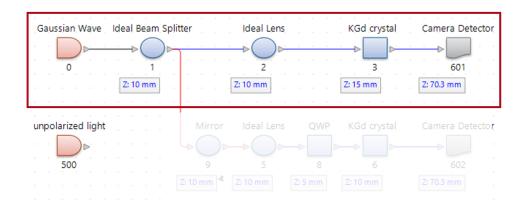
System Building Blocks – Biaxial KGd Crystal



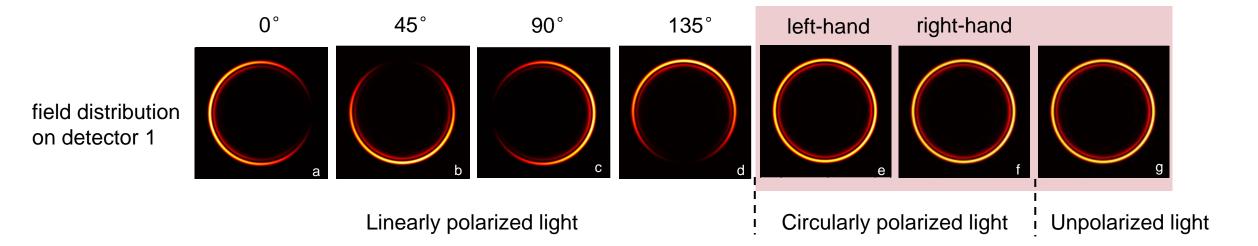
- Use a Crystal Plate Component to model the KGd crystal, then select Biaxial Crystal from the Template category of the Media catalog and define the principal refractive indices.
- Set the crystalline orientation according to the reference, so that the input field will propagate along one of the optic axes of the crystal.



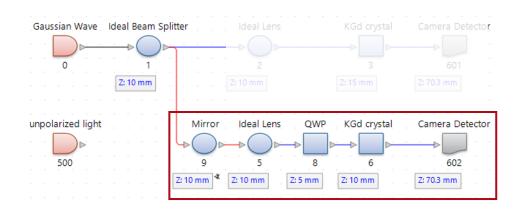
Simulation Results



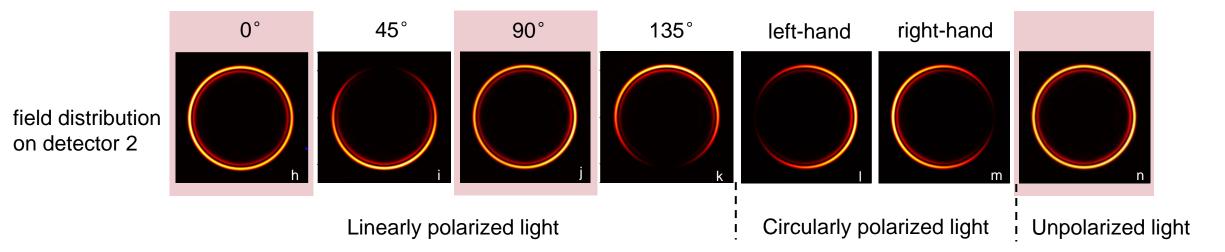
- Run the simulation and vary the polarization state of the input source (linearly polarized, circularly polarized, and unpolarized).
- If only arm 1 is used, there is no distinction between right and left circularly polarized light, and unpolarized light. [see figs. e-g].



Simulation Results

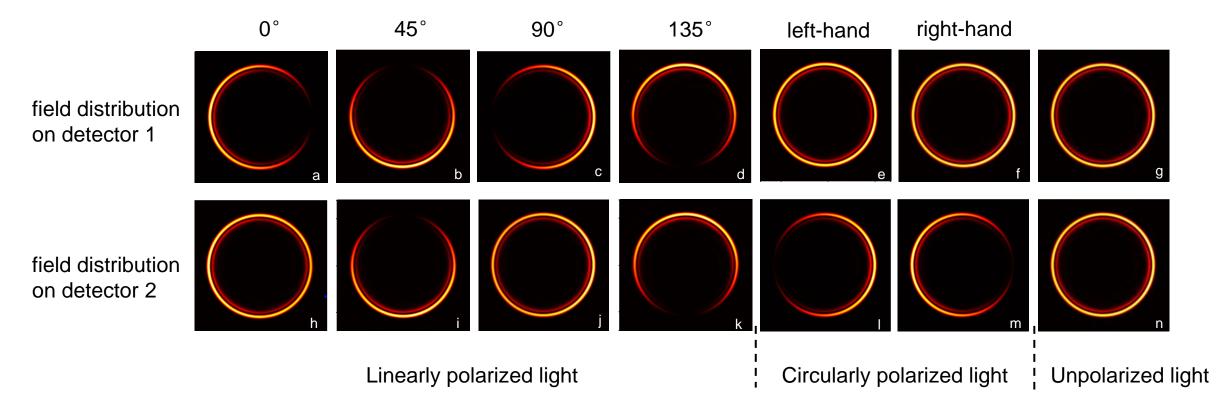


- If the angle between the orientation of the QWP and the input polarization direction is 45°, the linearly polarized beam will change into a circularly polarized one, and vice versa.
- As a result, arm 2 cannot distinguish between linearly polarized light at 0°, 90° and unpolarized light. [see figs. h, j, n].

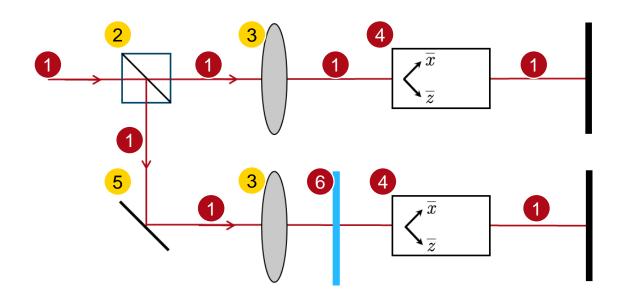


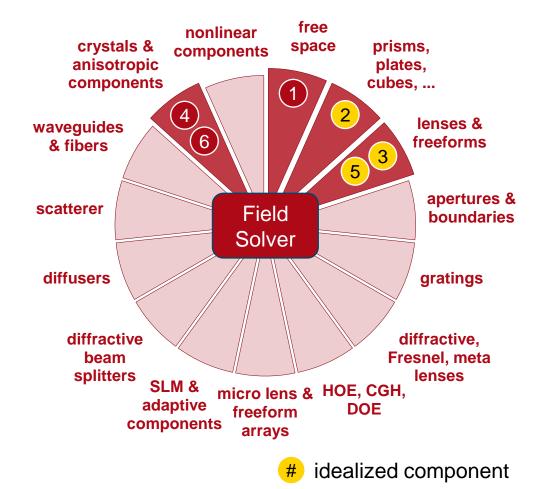
Simulation Results

By comparing the field distribution on the detectors of each of the two arms, we can distinguish each state of input field polarization, including unpolarized light.



VirtualLab Fusion Technologies





title	Conical Refraction as a Tool for Polarization Metrology
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software version	2021.1 (Build 1.180)
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further reading	 Optically Anisotropic Media in VirtualLab Fusion Polarization Conversion in Uniaxial Crystals Conical Refraction in Biaxial Crystals Birefringence Effect of Anisotropic Calcite Crystal