Polarization Conversion in Uniaxial Crystals
Task/System Illustration

analysis of changes in polarization for a focused laser beam propagating through uniaxial crystals
Highlights

- Physical-optics-based simulation includes
  - vectorial effect due to birefrigence,
  - interference.

- Full access to field attributes, includes
  - intensity,
  - phase.
### Specification: Light Source

<table>
<thead>
<tr>
<th><strong>Input laser beam</strong></th>
<th></th>
</tr>
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<tbody>
<tr>
<td><strong>wavelength</strong></td>
<td>633 nm</td>
</tr>
<tr>
<td><strong>mode</strong></td>
<td>Hermite (0, 0)</td>
</tr>
<tr>
<td><strong>waist radius</strong></td>
<td>1.5 mm × 1.5 mm</td>
</tr>
</tbody>
</table>

![Diagram of laser setup with polarizers, lenses, and calcite crystal]
### Specification: Polarizers

<table>
<thead>
<tr>
<th>Polarizer #1</th>
<th>Polarizer #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>direction</td>
<td>direction</td>
</tr>
<tr>
<td>(x)-axis</td>
<td>(x / y)-axis</td>
</tr>
</tbody>
</table>

Polarizer #1 generates a linearly polarized laser beam along \(x\)-axis.

Polarizer #2 is set parallel/orthogonal to #1.
Specification: Lenses

**Lens #1**

- **focal length**: 30 mm

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**Lens #2**

- **focal length**: 30 mm
**Specification: Crystal**

<table>
<thead>
<tr>
<th>Calcite crystal</th>
<th>optic axis</th>
<th>along $z$-axis</th>
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<tbody>
<tr>
<td>refractive indices</td>
<td>$n_o = 1.6558$</td>
<td>$n_e = 1.4852$</td>
</tr>
<tr>
<td>(@ 633nm)</td>
<td></td>
<td></td>
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</tbody>
</table>

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**Diagram:**

A beam of light is polarized by Polarizer #1, passes through Lens #1, and then through a Calcite crystal. The crystal's optic axis is along the $z$-axis. The light then passes through Lens #2 and Polarizer #2, emerging with its polarization altered by the crystal's refractive indices.
Results

Polarizer #2 along $x$ (#2 $\parallel$ #1)

Polarizer #2 along $y$ (#2 $\perp$ #1)

VirtualLab simulation
Results: Comparison

Experimental measurements

Figure from Y. Izdebskaya et al., Opt. Express 17, 18196-18208 (2009)
Results: Vectorial

- Physical-optics-based simulation includes
  - vectorial effect due to birefringence,
  - interference.
- Full access to field attributes, including
  - intensity,
  - phase.

Polarizer #2 along $\boldsymbol{x}$ (#2 $\parallel$ #1)

Polarizer #2 along $\boldsymbol{y}$ (#2 $\perp$ #1)

$|E_\boldsymbol{x}|^2$

$|E_\boldsymbol{y}|^2$
Results: Interference

Highlights

- Physical-optics-based simulation includes
  - vectorial effect due to birefringence,
  - interference,
- Full access to field attributes, including
  - intensity,
  - phase.

Polarizer #2 along \( x \) (#2 \( \parallel \) #1)

Polarizer #2 along \( y \) (#2 \( \perp \) #1)
Results: Phase

- Physical-optics-based simulation includes
  - vectorial effect due to birefringence,
  - interference.
- Full access to field attributes, including
  - intensity,
  - phase.

Polarizer #2 along $x$ (#2 $\parallel$ #1)
Polarizer #2 along $y$ (#2 $\perp$ #1)

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<tr>
<td>author</td>
<td>Site Zhang (LightTrans)</td>
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### Specifications of PC Used for Simulation

<table>
<thead>
<tr>
<th>Processor</th>
<th>i7-4910MQ (4 CPU cores)</th>
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<tbody>
<tr>
<td>RAM</td>
<td>32 GB</td>
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<td>Operating System</td>
<td>Windows 10</td>
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