

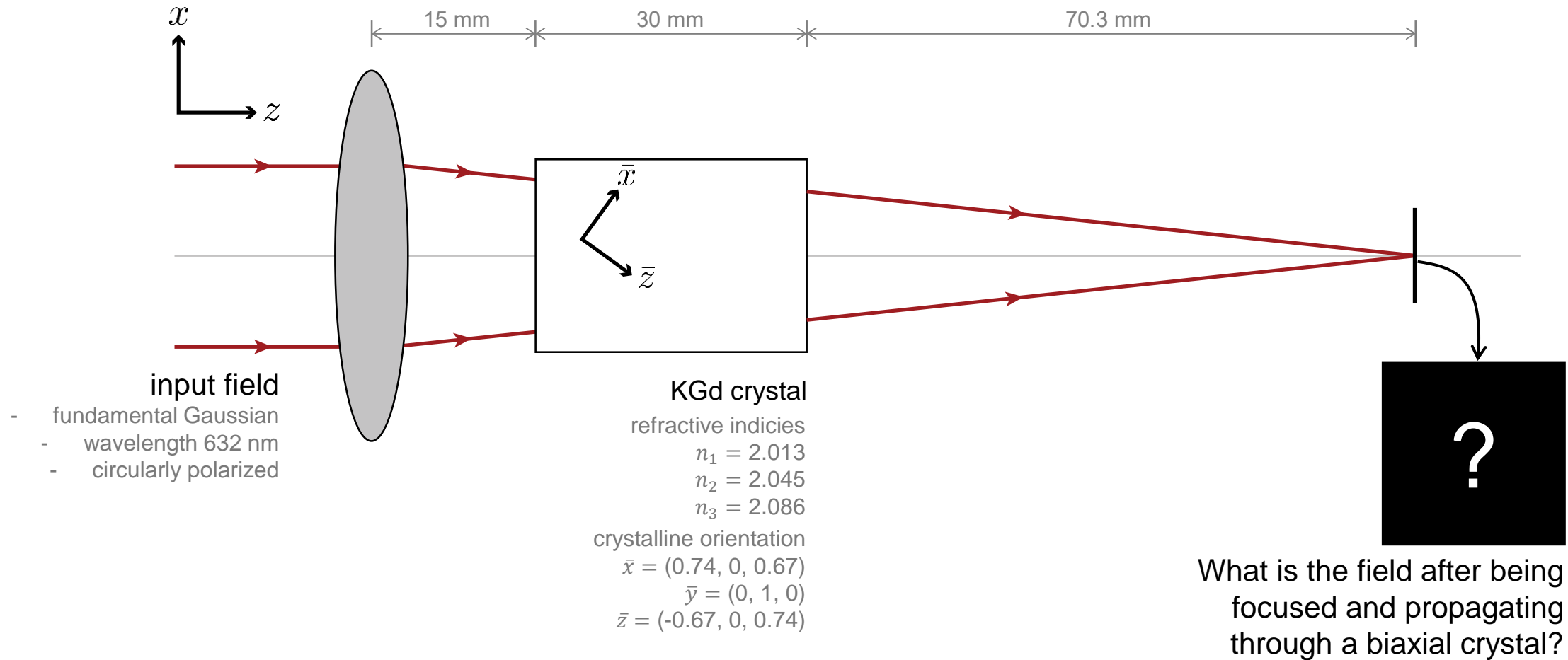
Conical Refraction in Biaxial Crystals

Abstract



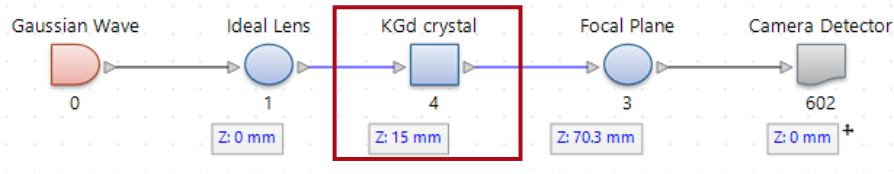
When circularly polarized light propagates through a biaxial crystal along one of its optic axes, the transmitted field evolves into a cone, a phenomenon which is known as conical refraction. Several applications have been developed based on this effect, such as Bessel beam generation and optical tweezers. With the fast-physical-optics simulation technology in VirtualLab Fusion, conical refraction from a KGd crystal is demonstrated.

Modeling Task

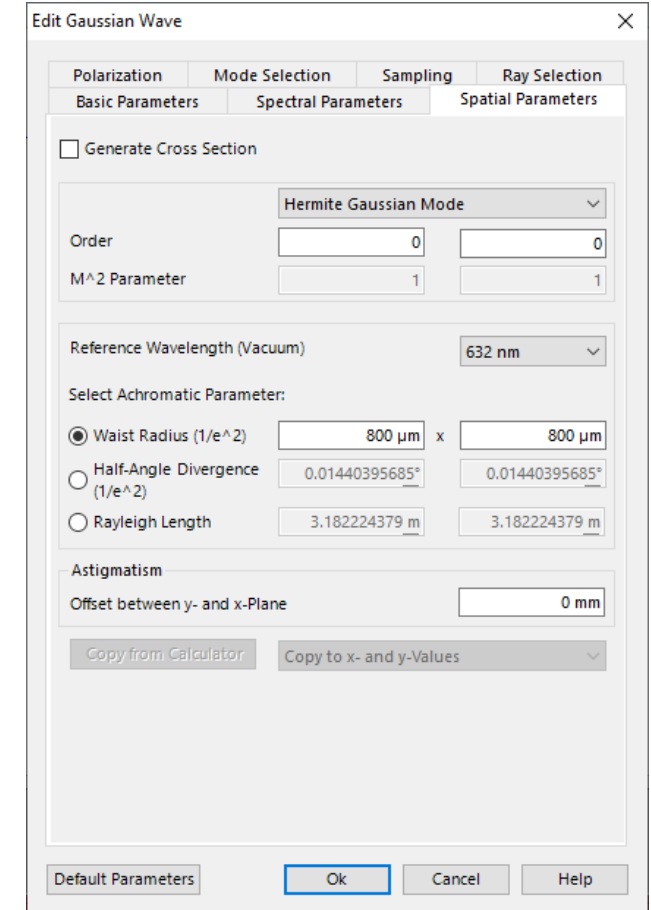
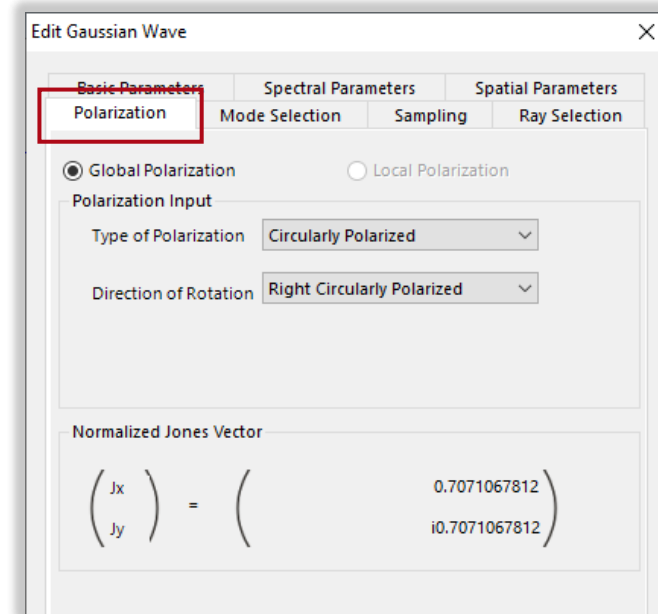


Parameters follow from C. F. Phelan et al., Opt. Express 17, 12891-12899 (2009)

System Building Blocks – Source



A linearly polarized Gaussian field, with a wavelength of 632 nm, is employed as the input. It first passes through a quarter-wave plate, which converts the linear polarization to circular. This effect is included in the source model, directly.



System Building Blocks – Biaxial KGd Crystal

Use a *Crystal Plate Component* to model the KGd crystal, then select *Biaxial Calcite Crystal* from the *Template* 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.

define the refractive index according to the reference

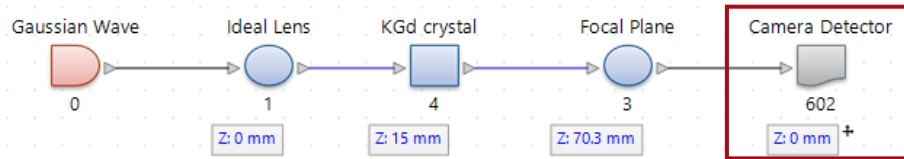
Tips: after configuring the material, use the *Save* tab to save the new material to the *User Defined* material catalog and load it easily for the next simulation.

Biaxial Crystal

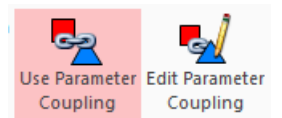
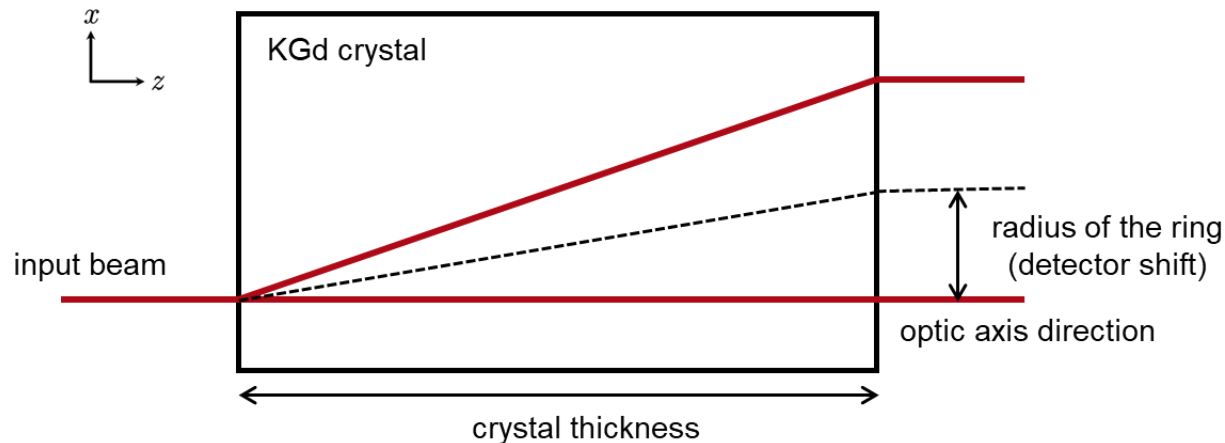
- thickness: 30mm
- refractive indices
 - $n_1 = 2.013$
 - $n_2 = 2.045$
 - $n_3 = 2.086$
- crystalline orientation
 - $\vec{x} = (0.74, 0, 0.67)$
 - $\vec{y} = (0, 1, 0)$
 - $\vec{z} = (-0.67, 0, 0.74)$

Parameters follow from C. F. Phelan et al., Opt. Express 17, 12891-12899 (2009)

System Building Blocks – Automatic Detector Positioning



In conical refraction, a lateral shift occurs at the output. For this reason, we have used the *Parameter Coupling* to link the detector shift with the crystal parameters (crystal thickness and principal indices), in order to achieve automatic positioning. The expression of the mathematical formula can be found in the reference.



Edit Parameter Coupling ✕

Parameter Specification
Setup the parameter(s) to be used as input (independent variable) and output (dependent variable) of the coupling snippet.

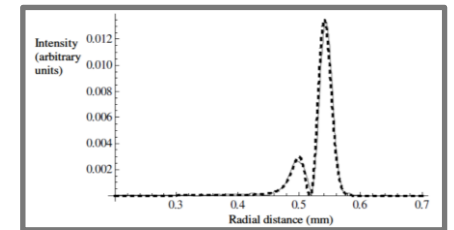
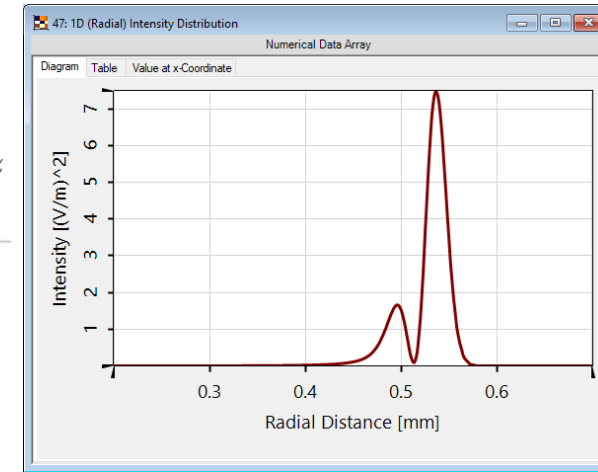
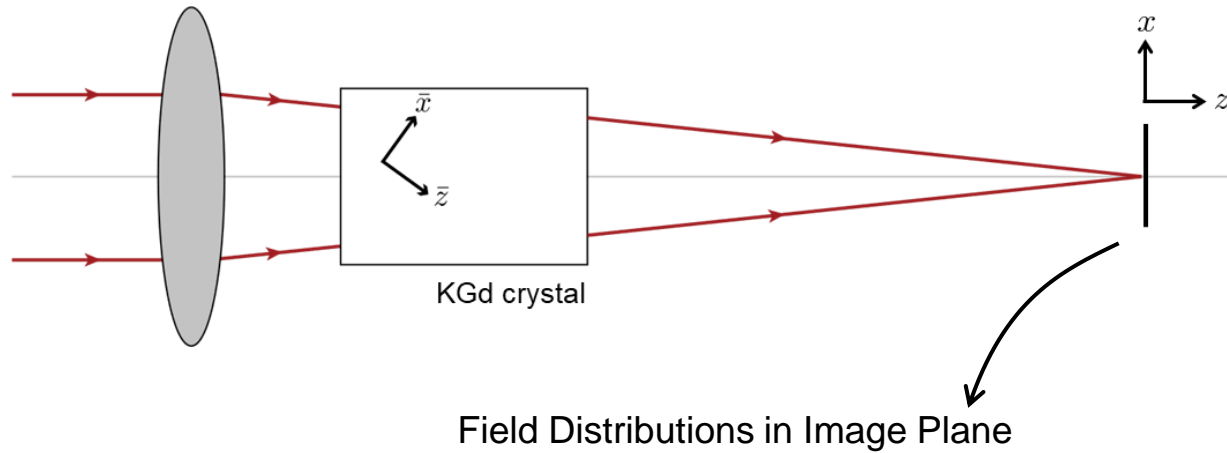
Filter by... ✕ Show Only Used Parameters

1	2	*	Object	Category	Parameter	Use in Snippet	Short Name
			"KGd crystal" (# 4)	Medium (Biaxial Crystal)	Thickness	<input checked="" type="checkbox"/>	Thickness
					Material of Principal Index α (KGd_n1@632nm...	<input checked="" type="checkbox"/>	n_1
					Material of Principal Index β (KGd_n2@632nm...	<input checked="" type="checkbox"/>	n_2
			"Camera Detec...	Basal Positionin...	Lateral Shift X	<input checked="" type="checkbox"/>	Lateral Shift X

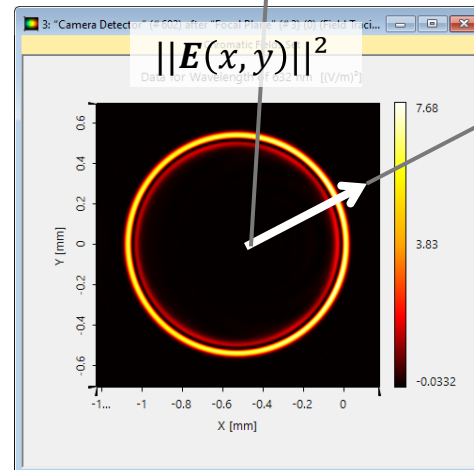
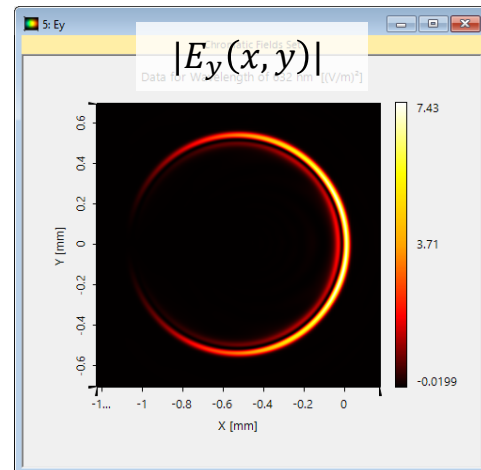
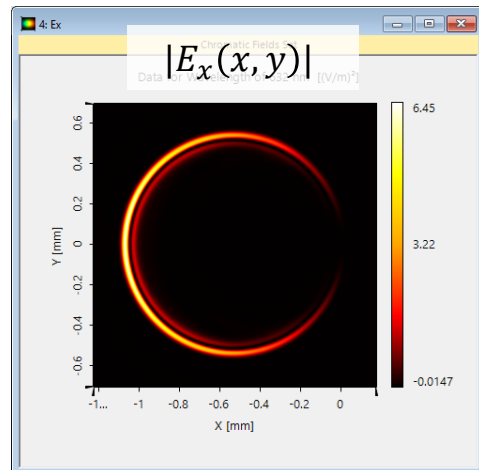
Validity: ✔

Formulas follow from R. T. Darcy et al., Opt. Express 22, 11290-11300 (2014)

Simulation Results

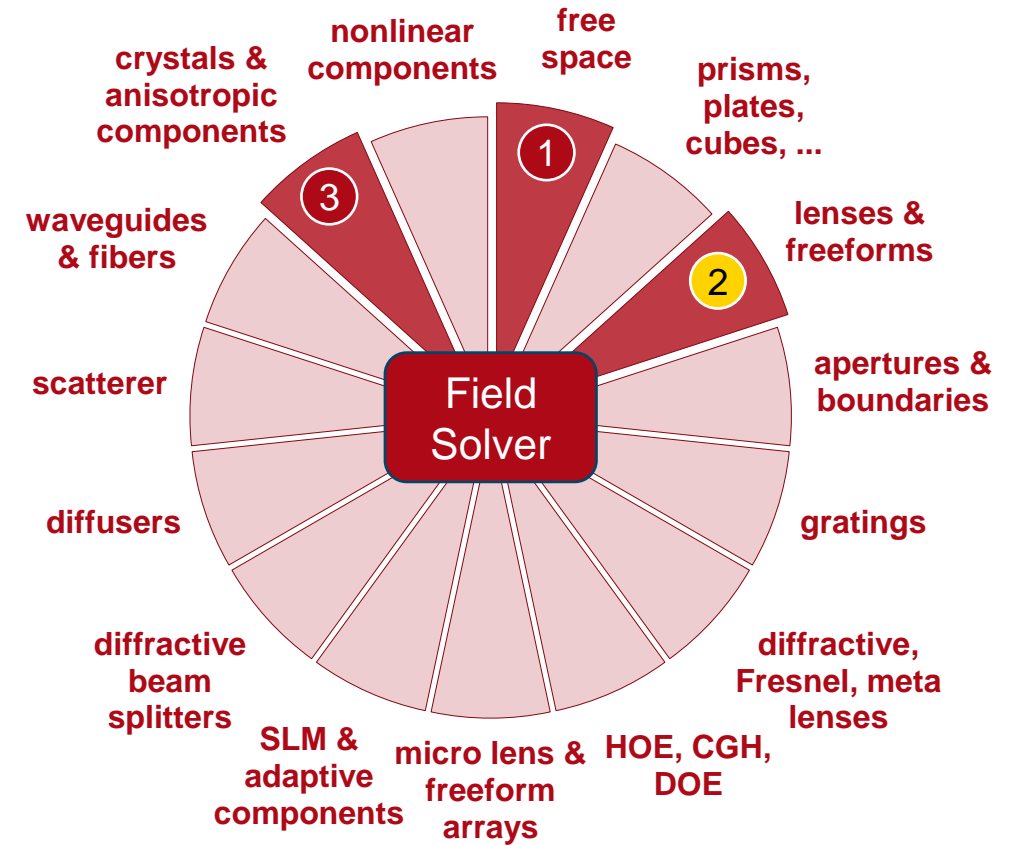
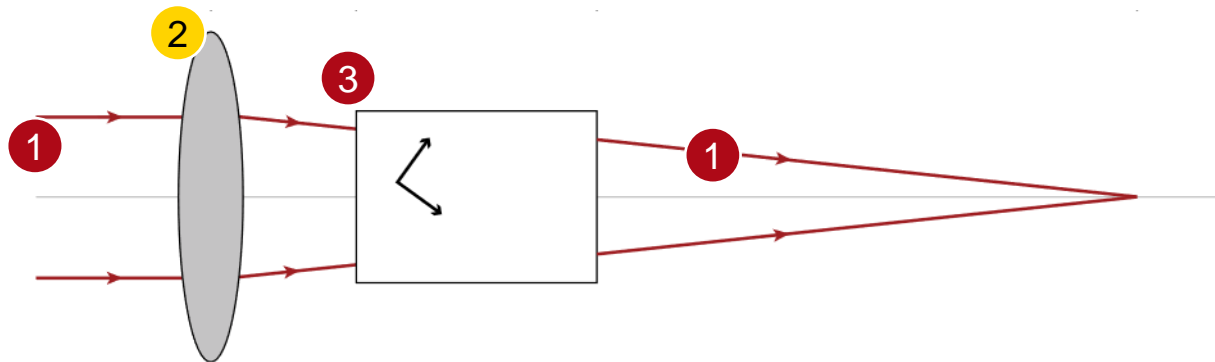


Experimental measurements from C. F. Phelan *et al.*, Opt. Express 17, 12891-12899 (2009)



Both the E_x and E_y components of the field distributions in the focal image plane are exhibiting double-ring patterns, with missing parts on the right and left, respectively. Consequently, in the summed squared amplitude, a complete double-ring pattern is observed.

VirtualLab Fusion Technologies



idealized component

Document Information

title	Conical Refraction in Biaxial Crystals
document code	CRO.0002
document version	1.1
software edition	VirtualLab Fusion Basic
software version	2021.1 (Build 1.180)
category	Application Use Case
further reading	<ul style="list-style-type: none">- <u>Optically Anisotropic Media in VirtualLab Fusion</u>- <u>Polarization Conversion in Uniaxial Crystals</u>- <u>Birefringence Effect of Anisotropic Calcite Crystal</u>