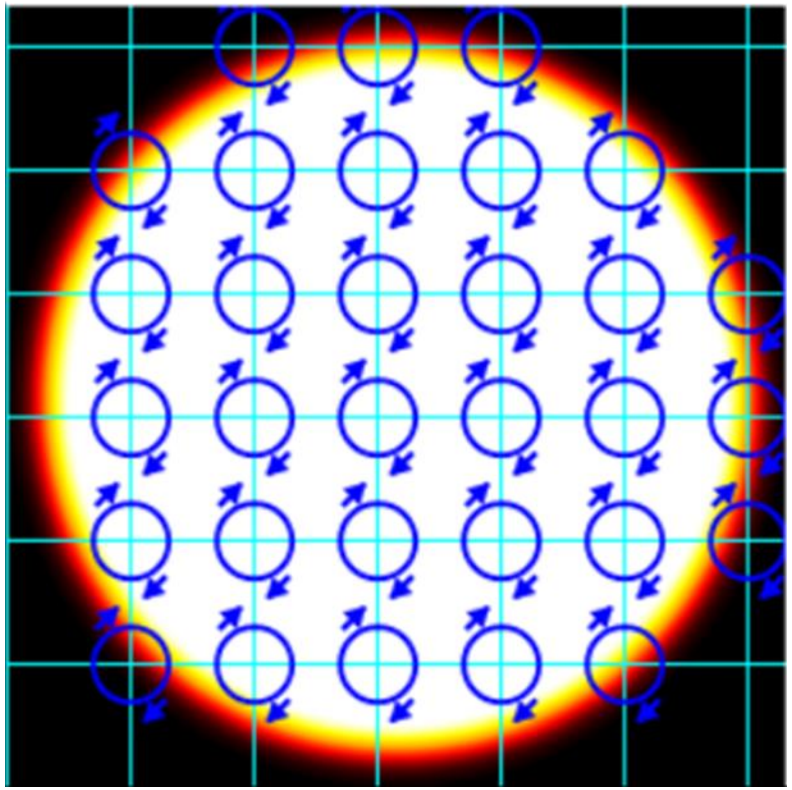
Simulation and Analysis of Anisotropic Coating on Plane and Curved Surface

Abstract



VirtualLab Fusion provides the capability to add birefringent coatings, that is, layers of anisotropic media, to the surfaces of optical components, in order to exploit the extra freedom of polarization control and multiplexing in optical systems. In this example, we introduce this feature – adding anisotropic coatings on surfaces – and investigate the polarization conversion of a lambda/4 coating on a plane surface and a curved surface, respectively.

Quarter-Wave Plate Coating on Plane Surface

anisotropic coating

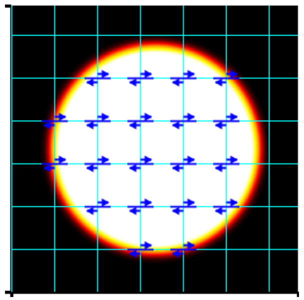
- lambda/4 wave plate
- Calcite crystal (uniaxial)
- $n_{o,e} = (A_{o,e} + \frac{B_{o,e}\lambda^2}{\lambda^2 - C_{o,e}} + \frac{D_{o,e}\lambda^2}{\lambda^2 - E_{o,e}})^{0.5}$

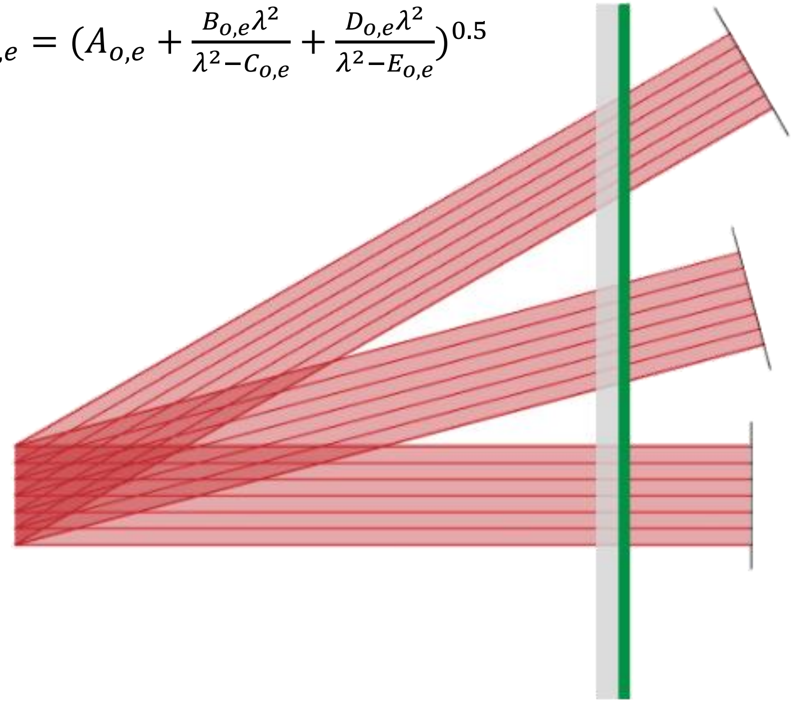
detectors

- perpendicular to beam directions

plane wave

- wavelength: 532nm
- polarization state: linearly polarized along x
- off-axis angle: 0°, 15°, 30°

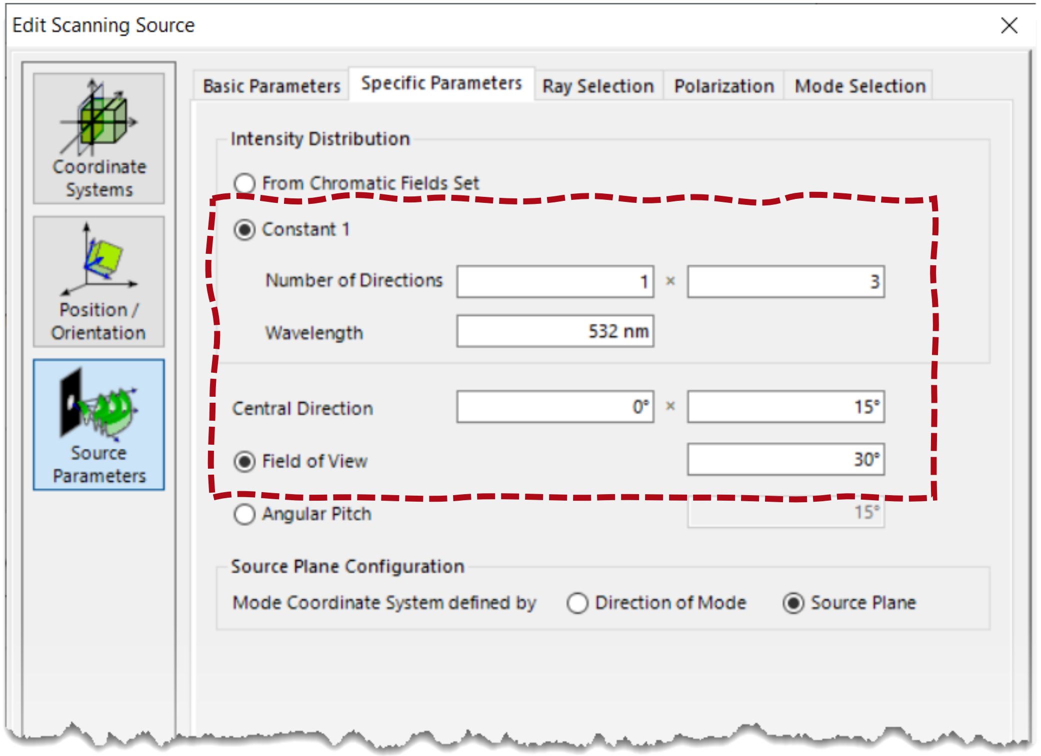


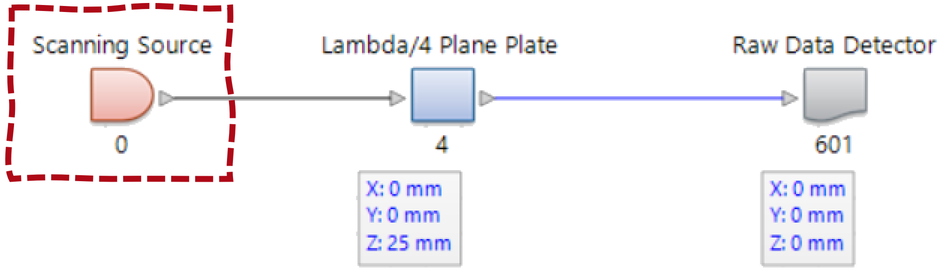


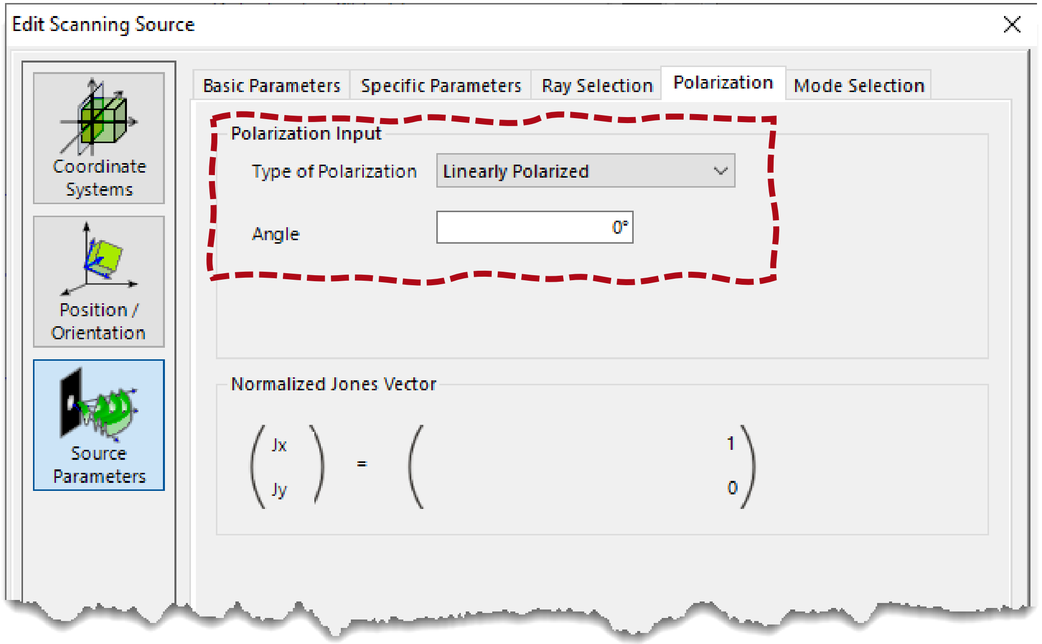
?

How does the polarization state of the input field with different incident angles change after passing through the quarter-wave coating?

System Building Blocks – Source

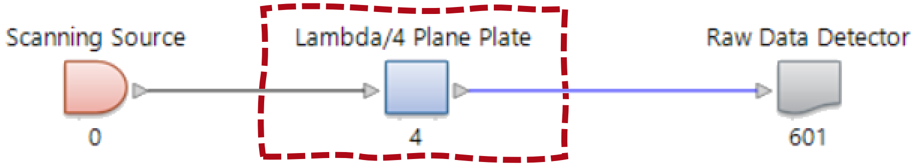




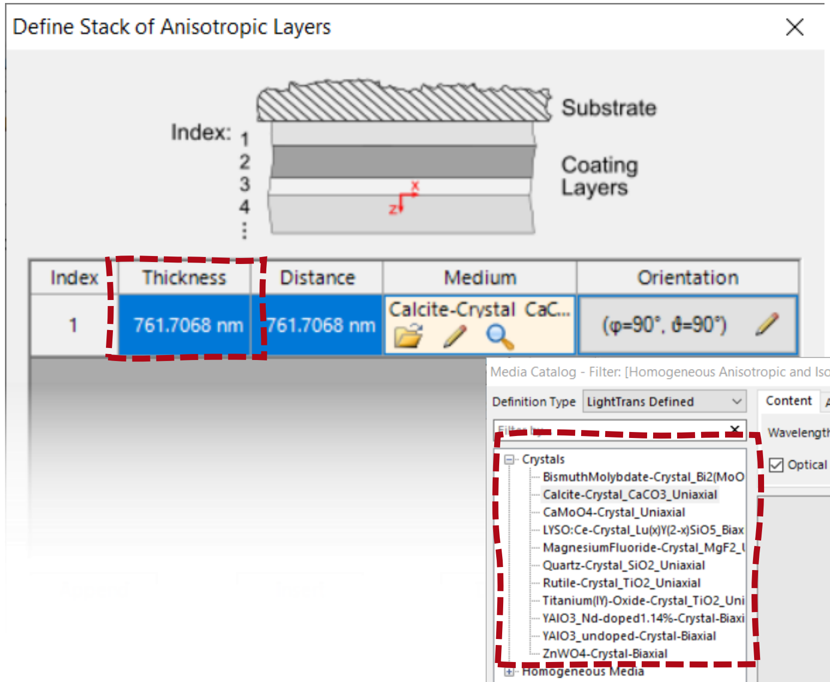


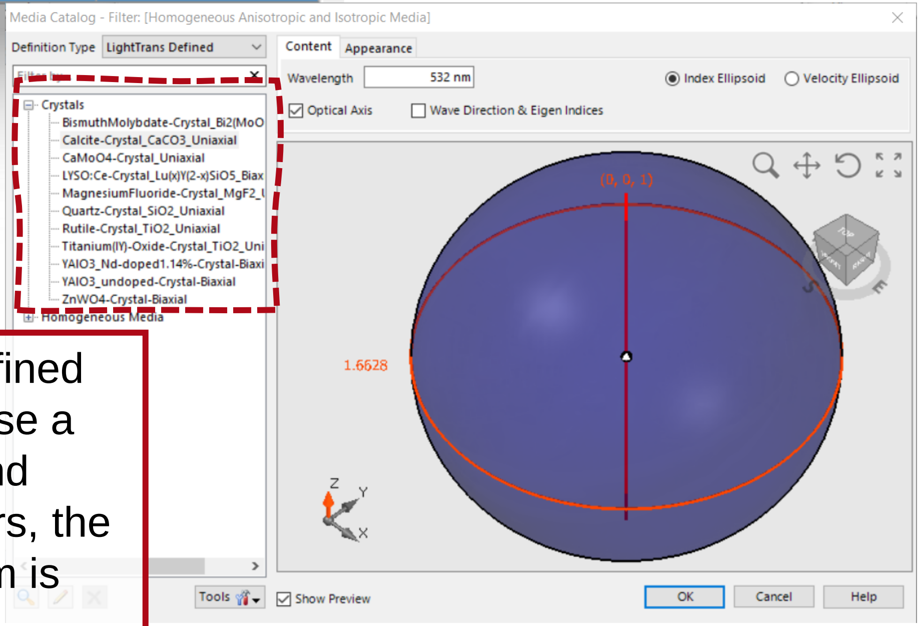
A *Scanning Source* is used to model the input plane waves. It is a convenient tool for the specification of several directions simultaneously and for polarization management.

System Building Blocks – Coating on Surfaces

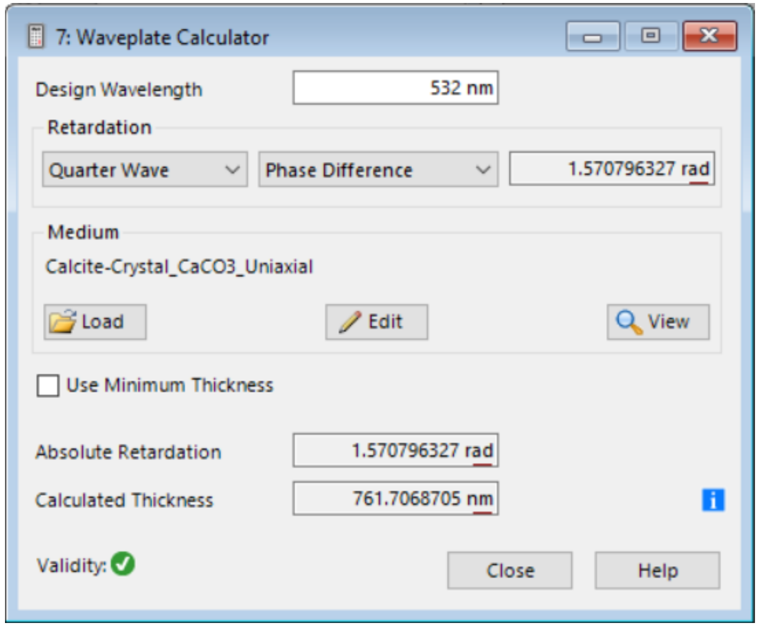


With the help of the *Waveplate Calculator*, the thickness of the coating layers can be calculated to achieve the desired retardation between the field components.



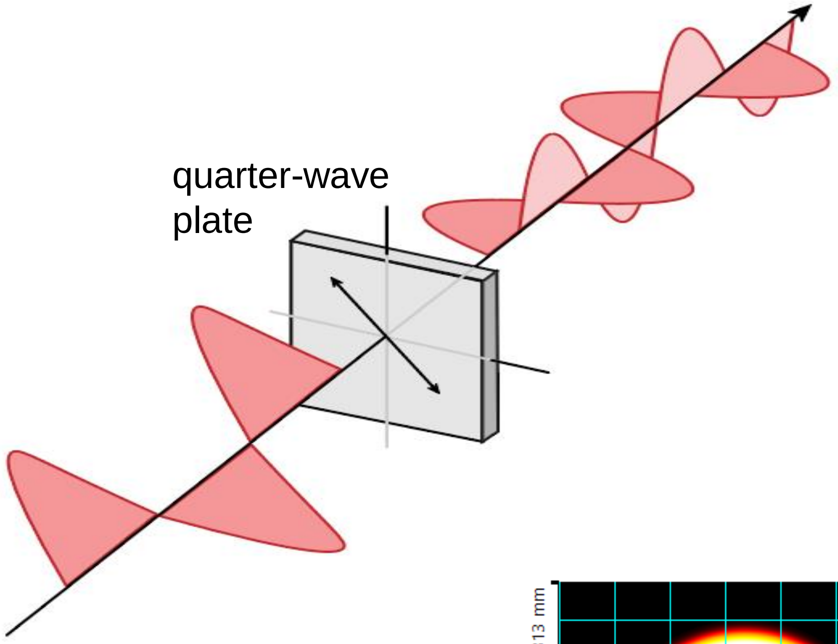


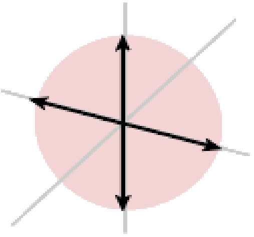
choose from the predefined anisotropic media or use a template medium and customize the parameters, the preview of the medium is shown on the right



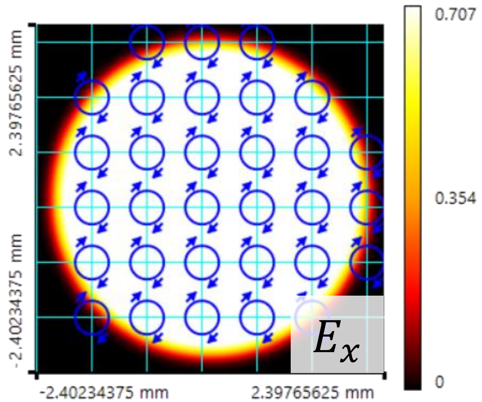
Polarization Conversion at a Quarter-Wave Plate

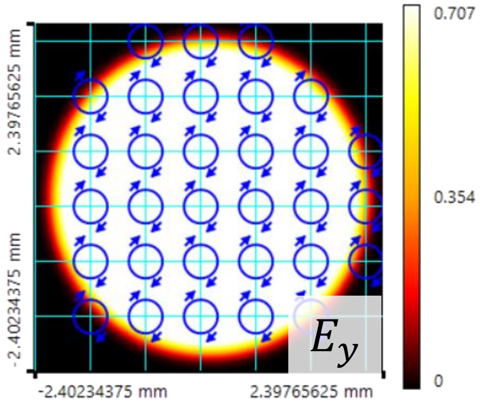
quarter-wave plate

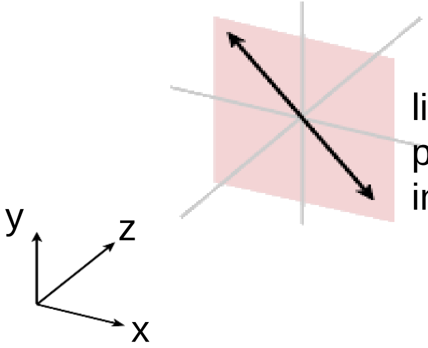




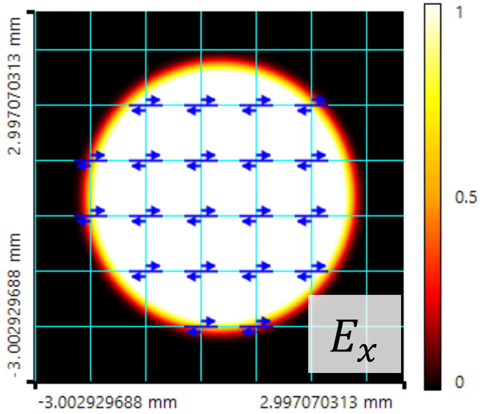
circular polarization out







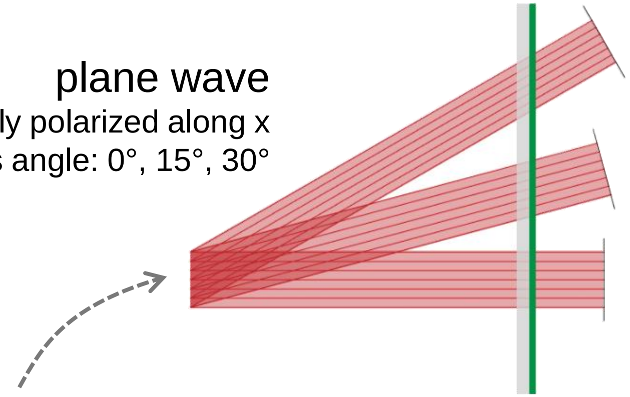
linear polarization in

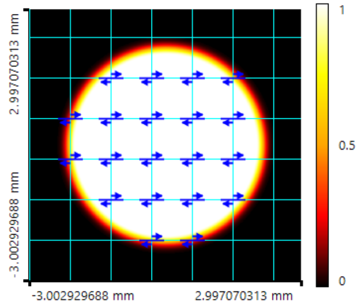


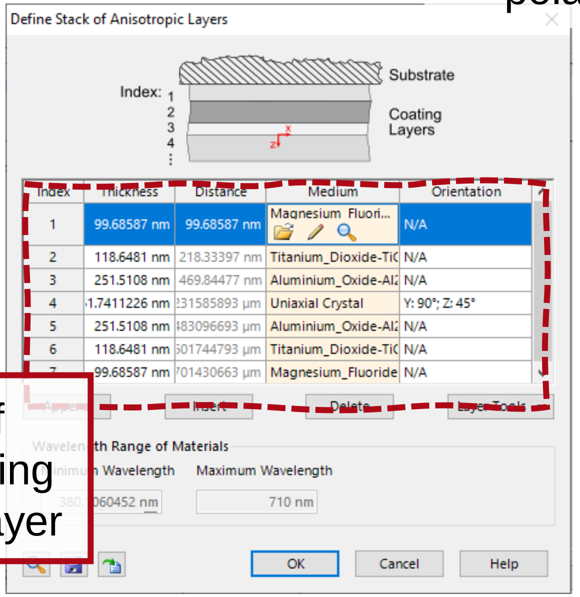
In the idealized situation, when linearly polarized light impinges on a quarter-wave plate at 45° to the optic axis, the transmitted light is divided into two equal electric field components. One of these is retarded by a quarter wavelength and the overlap of both beams at the exit plane of the plate generates circularly polarized light. And vice versa: if the incident light is circularly polarized, it will be transformed into linearly polarized light.

Influence of Fresnel Effect Deviation

plane wave
- linearly polarized along x
- off-axis angle: 0°, 15°, 30°



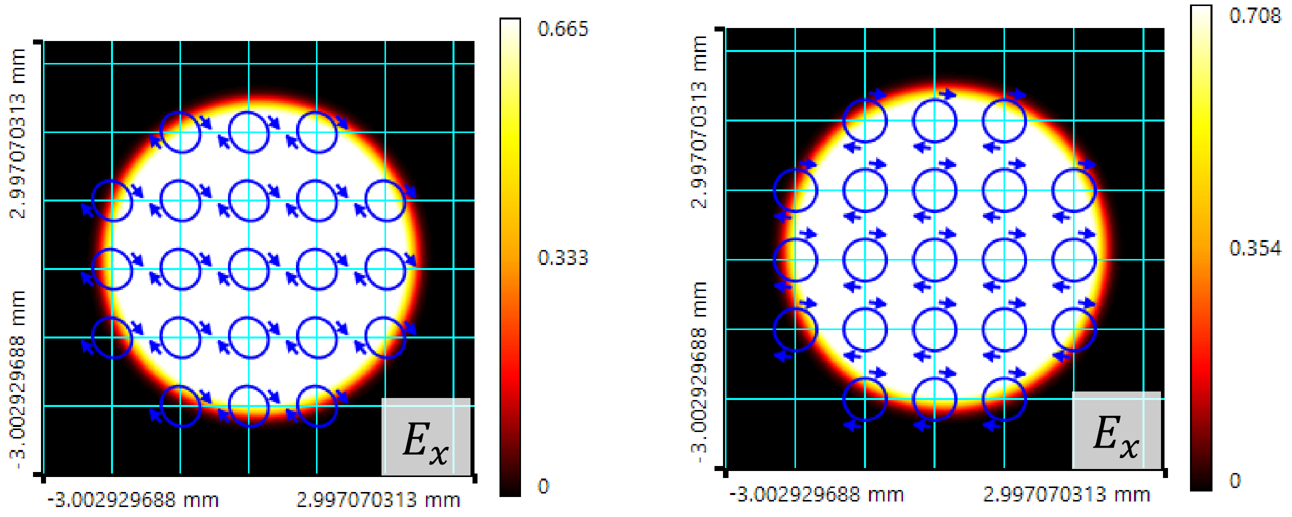




combination of isotropic AR coating and anisotropic layer

- However, when a real quarter-wave coating is configured, the two divided electric field components will face different refraction indices inside the crystal.
- Hence, the Fresnel effect when leaving the crystal will differ for the two electromagnetic field components as well, and the polarization state of the transmitted light will form an ellipse instead of a perfect circle.
- In order to eliminate this influence, an additional anti-reflection coating is applied together with the crystal coating. Then the perfect circularly polarized light is observed.

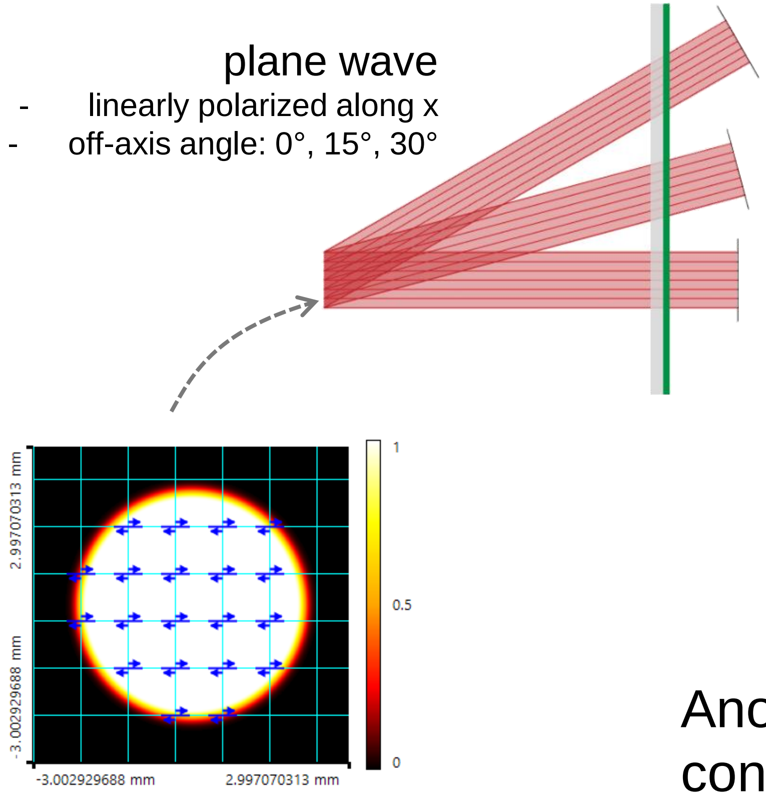
E_x after real structured quarter-wave plate with & without AR coating



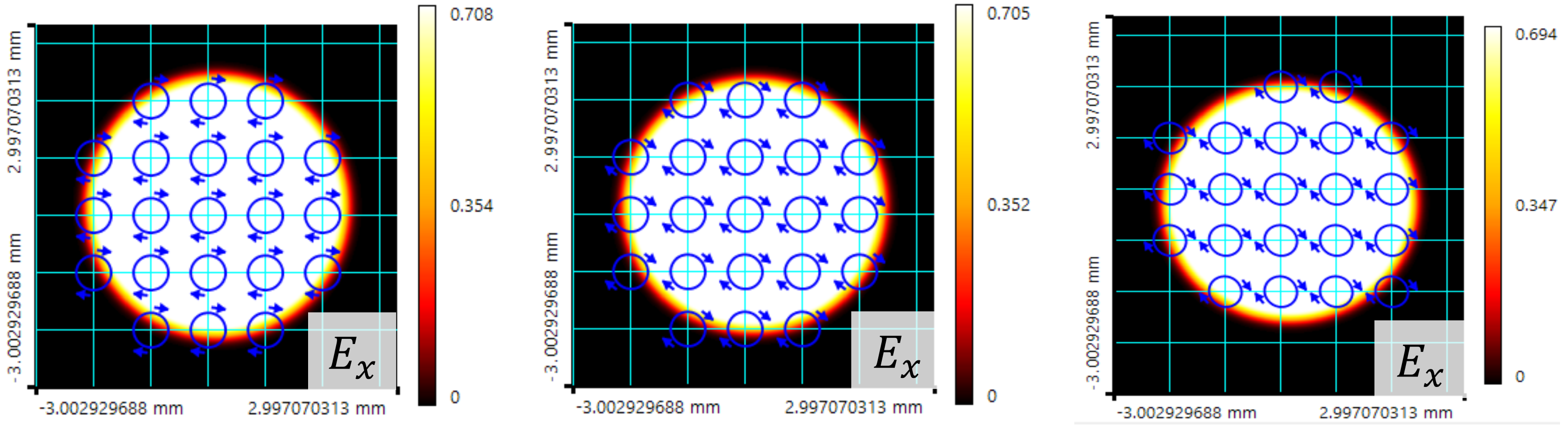
Quarter-Wave Plate Coating on Plane Surface

plane wave

- linearly polarized along x
- off-axis angle: 0°, 15°, 30°

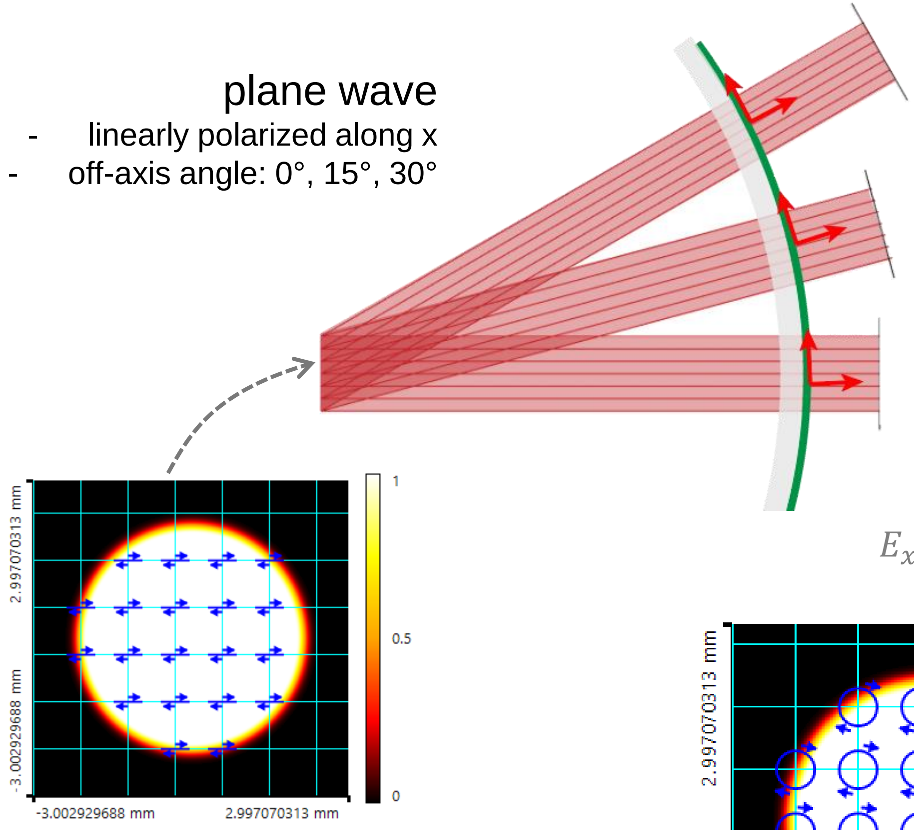


E_x after real structured quarter-wave plate with 0°, 15° and 30° of incidence



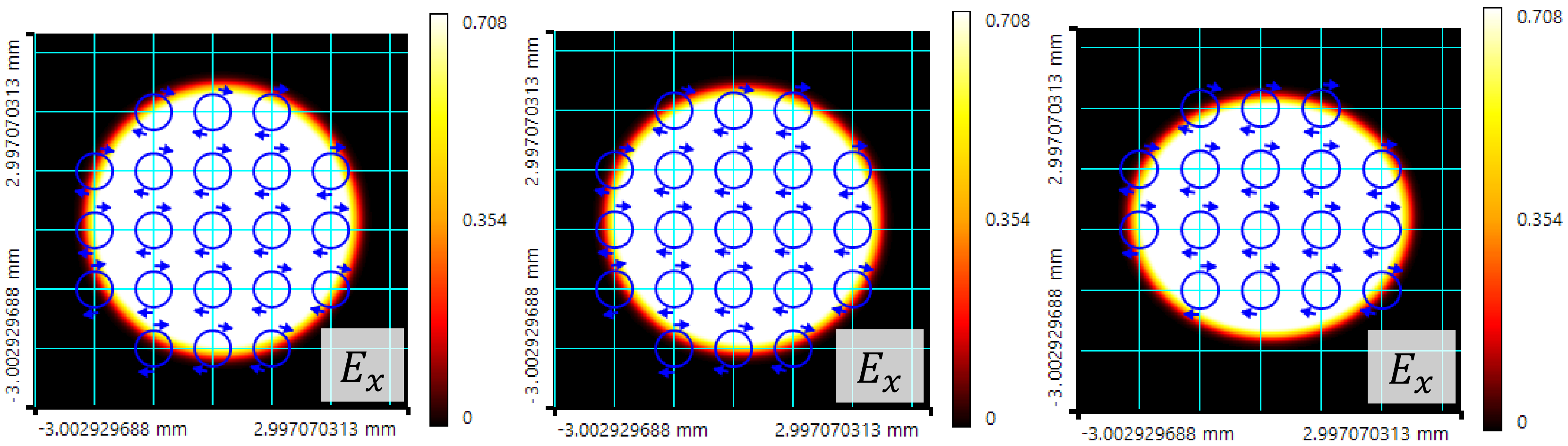
Another additional effect that might influence the polarization conversion is the angle of incidence. Due to the projection of the components of the field on the plane of the plate, the resulting polarization state will become more elliptical with increasing angle.

Quarter-Wave Plate Coating on Curved Surface



If a quarter-wavelength coating is applied to a curved surface instead, which curvature allows the light to propagate along the normal vector of the surface, the effect of different projections of the field components can be avoided. This results in perfect circular polarization for all angles of incidence.

E_x after real quarter-wave coating on curved surface with 0°, 15° and 30° of incidence



Document Information

title	Simulation and Analysis of Anisotropic Coating on Plane and Curved Surface
document code	CRO.0006
version	1.0
edition	VirtualLab Fusion Basic
software version	2021.1 (Build 1.180)
category	Feature Use Case
further reading	- Optically Anisotropic Media in VirtualLab Fusion - Conical Refraction in Biaxial Crystals - Polarization Conversion in Uniaxial Crystals