Full-wave Simulation of Light Propagation through Quarter-wave Plate

C. S. Lin (Jason)
Pitotech. CO Ltd, Changhua City, Changhua County 50053, Taiwan

The Advanced knowledge Provider
皮托科技股份有限公司
PITOTECH CO.,LTD.

Introduction: Advances in 3D display technology relies heavily on the birefringence of light as it propagates through various optical components such as the quarter-wave plate. While the Jones matrix formulation is commonly employed as a convenient means to study optical systems involving such optical components [1], full-wave simulation provides an alternative theoretical approach which could offer more insight and intuitive understanding to the behavior of light through such components. In this paper, we study the behavior of monochromatic visible light as it propagates through a birefringent quarter-wave plate based on full-wave simulation.

Computational Methods: The problem was modelled using the wave optics module. COMSOL Multiphysics software solves the time-harmonic Maxwell's equations for electric field distribution $\vec{E}$ over the defined domains at the frequency ω.

$$\nabla \times \left(\mu_0 {\mu_r}^{-1} \nabla \times \vec{E}\right) - k_0^2 \left(\varepsilon_r - \frac{j\sigma}{\omega \varepsilon_0}\right) \vec{E} = 0$$

Cases for both linearly and circularly polarized incident wave were studied as shown in Figure 1.

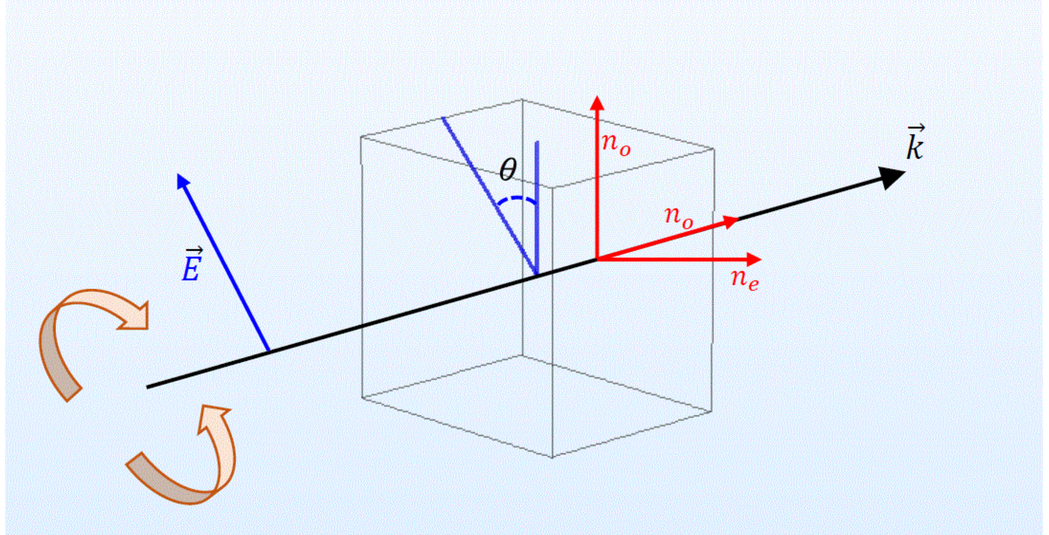

Figure 2. Light propagation through a birefringent quarter-wave plate.

Results:

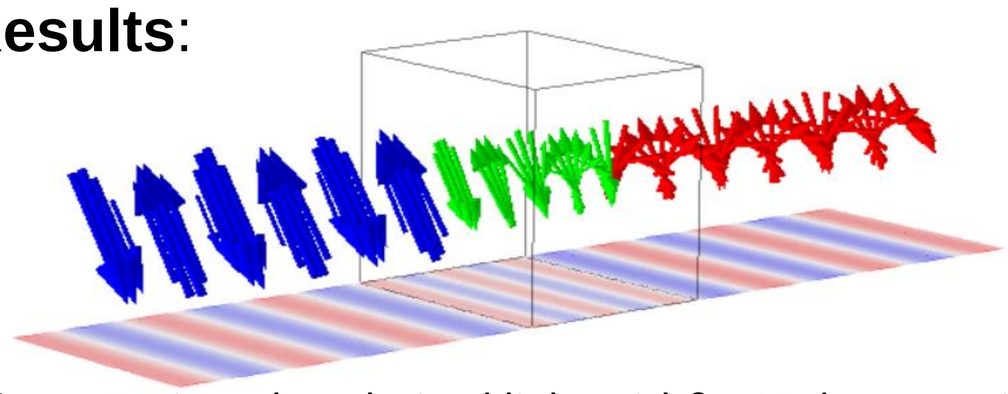

Figure 2. Linearly polarized light withθ= 45 deg turns into left-hand circularly polarized light. See [2] for animation.

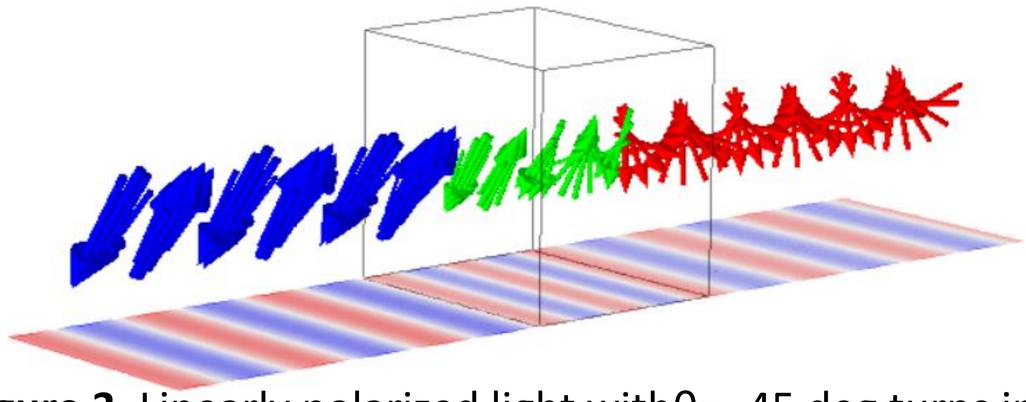

Figure 3. Linearly polarized light withθ= -45 deg turns into right-hand circularly polarized light. See [3] for animation.

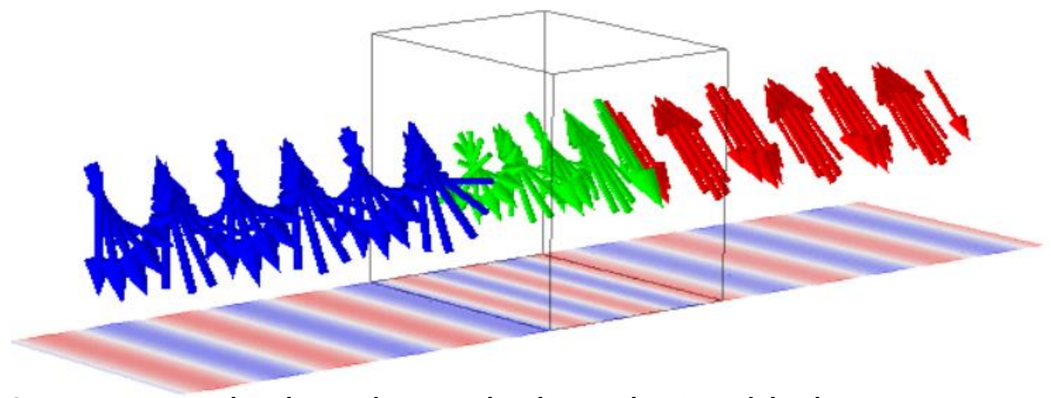

Figure 4. Right-hand circularly polarized light turns into linearly polarized light withθ= 45 deg. See [4] for animation.

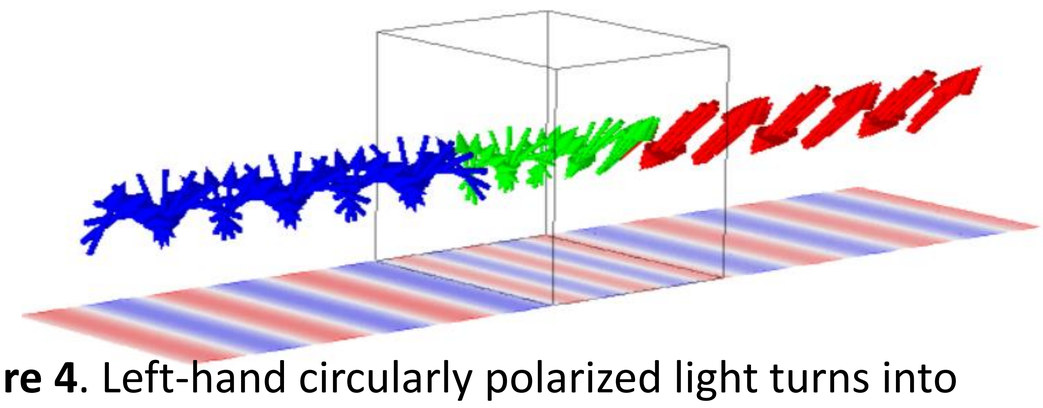

Figure 4. Left-hand circularly polarized light turns into linearly polarized light withθ= -45 deg. See [5] for animation.

Conclusions: Full-wave simulation used to study light propagation through birefringent quarter-wave plate. simulation offers an intuitive visualization of details in light behavior at the submicron scale.

References:

1. Y. Kim et al., Opt. Express, **20**, 20130 (2013)
2. http://www.pitotech.com.tw/[3]%2045deg_linear_to_LH_circularly_polarized.gif
3. http://www.pitotech.com.tw/[4]%20neagativ45deg_linear_to_RH_circularly_polarized.gif
4. http://www.pitotech.com.tw/[1]%20RH_circularly_polarized_to_45deg_linear.gif
5. http://www.pitotech.com.tw/[2]%20LH_circularly_polarized_to_nagative45deg_linear.gif