

## Investigation of Idealized Vectorial Focusing Situation Using Debye-Wolf Integral

#### Abstract



Knowing the vectorial electric field distribution near the focus of a high-NA objective lens is of great importance for applications e.g. microscopy, optical tweezer, laser machining, etc. Debye-Wolf integral provides the semi-analytical solution of the vectorial field near the focal plane, and it is widely used in the community. We demonstrate how to use the Debye-Wolf integral calculator in VirtualLab Fusion to investigate focal field properties with respect to different parameters.

# **Modeling Task**



#### input plane wave

 wavelength: 532nm, 632.8nm
 polarization: linearly polarized in *y* direction and in *x-y* diagonal direction

## **Influence from Wavelength**





#### parameters

- varying wavelength: 532nm or 632.8nm
- fixed lens NA 0.9 -
- fixed linear polarization in y
- no defocus \_





38.7

19.35

0.5

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6.86

3.43

## **Influence from NA of Objective**





#### parameters

- fixed wavelength
   532nm
- varying lens NA:
   0.5 or 0.9
- fixed linear polarization in y
- no defocus





38.7

19.35

## **Influence from Polarization**



#### $|E||^{2}$ $|E_y|$ $E_z$ $|E_x|$ 🛃 48: Debye-Wolf Integral Calculator: Harmonic ... 🗖 🔍 🎫 🛃 48: Debye-Wolf Integral Calculator: Harmonic ... 📃 💷 🎫 🛃 48: Debye-Wolf Integral Calculator: Harmonic ... 🗖 💷 🎫 🛃 49: Debye-Wolf Integral Calculator: Electric Ene... 💼 💷 🛋 Electric Field Electric Field Electric Field Numerical Data Array Diagram Table Value at (x,y) Amplitude of "Ey" [kV/m] Amplitude of "Ex" [kV/m] Amplitude of "Ez" [kV/m] Electric Energy Density [1E9 A.U.] direction 6.85 38.7 98.5 0.5 0.5 0.5 0.5 0 0 0 ۰ (mul) ۲ (pm) 0 ۲ (µm] 0 ۳. o 3.425 49.25 19.35 0 0.5 0.5 0.5 0.5 > -0.5 0.5 -0.5 0 0.5 -0.5 0 0.5 -0.5 0 0 X [µm] X [µm] X [µm] X [µm]

#### parameters

- fixed wavelength 532nm
- fixed lens NA 0.9 -
- varying linear polarization: in y, or x-y diagonal
- no defocus







4.85

## **Influence from Defocus**



#### parameters

- fixed wavelength
   532nm
- fixed lens NA 0.9
- fixed linear polarization in y
- defocus with 800nm or exactly at focus









#### **Peek into VirtualLab Fusion**

13: Debye-Wolf Integral Calculator       Light Source       Optical Setup       Numerical Parameters       Wavelength       532 nm	various input parameters including polarization for the focal spot investigation
Type of Polarization Linearly Polarized	13: Debye-Wolf Integral Calculator
Angle 0°	ight Source Optical Setup Numerical Parameters Ambient Material Name Air Catalog Material
Normalized Jones Vector $ \begin{pmatrix} Jx \\ Jy \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \end{pmatrix} $	State of Matter Gas or Vacuum Numerical Aperture 1 Focal Length 10 mm
Validity: O Close Help	Distance from Focal Plane to Result Field 0 mm
	Validity: Create Results



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## **VirtualLab Fusion Technologies**





title	Investigation of Idealized Vectorial Focusing Situation Using Debye-Wolf Integral
document code	MIC.0001
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category	Application Use Case
further reading	<ul> <li><u>Usage of Debye-Wolf Integral Calculator</u></li> <li><u>Analyzing High-NA Objective Lens Focusing</u></li> </ul>