Diffraction Patterns behind Different Apertures
Abstract

As one of the most well-known phenomena in physical optics, diffraction plays a role in various cases. VirtualLab Fusion, with its advanced propagation technologies, can handle diffraction effects in optical systems automatically. In this example, we selected some regular apertures, such as circular (or elliptical) and square (or rectangular), as well as apertures in other shapes, like pentagon or hexagon ones. The diffraction patterns from them are calculated and the property of diffraction is studied.
Modeling Task for Symmetric Apertures

input field
- Gaussian wave
- wavelength 632.8 nm
- waist radius 2 mm
- linear polarization 0°

varying distance $z$ from 0 to 3 m

apertures

- circular
  - diameter 1 mm

- square
  - side length 1 mm

How do the diffraction patterns look like at different distances?
Fields after Symmetric Apertures

Field behind aperture

Near-field

Far-field

(far-field result images are saturated.)

The far-field pattern changes only in size, but the profile keeps.

\[
\begin{align*}
z &= 0m \\
\text{window size} &= 2\text{mm} \times 2\text{mm} \\

z &= 100m \\
\text{window size} &= 2\text{mm} \times 2\text{mm} \\

z &= 2.5m \\
\text{window size} &= 25\text{mm} \times 25\text{mm} \\

z &= 3m \\
\text{window size} &= 25\text{mm} \times 25\text{mm}
\end{align*}
\]
Modeling Task for Asymmetric Apertures

input field
- Gaussian wave
- wavelength 632.8 nm
- waist radius 2 mm
- linear polarization 0°

apertures
varying distance $z$ from 0 to 3 m

elliptical apertures
rectangular apertures

How do the diffraction patterns look like behind asymmetric apertures?
Fields after Elliptical Apertures

- Field behind aperture
- Near-field
- Far-field

Elliptical aperture compressed in $y$-direction

$z = 0 \text{ m}$
$z = 100 \text{ mm}$
$z = 3 \text{ m}$

Far-field pattern stretched in $y$-direction

(far-field result images are saturated.)
Fields after Rectangular Apertures

- **field behind aperture**
- **near-field**
- **far-field**

Far-field result images are saturated.

Rectangular aperture compressed in $x$-direction.

- $z=0\,\text{m}$
- $z=100\,\text{mm}$
- $z=3\,\text{m}$

Far-field pattern stretched in $x$-direction.
Modeling Task for Polygonal Apertures

input field
- Gaussian wave
- wavelength 632.8 nm
- waist radius 2 mm
- linear polarization 0°

z = 3 m

apertures

How do the diffraction patterns look like behind apertures with different shapes?

triangle

square

pentagon

hexagon
Fields after Polygonal Apertures

triangle

square

pentagon

hexagon

(field behind aperture)

(field behind aperture)

(far-field result images are saturated.)
Peek into VirtualLab Fusion

convenient settings for aperture parameters

far-field pattern calculation with diffraction included
Workflow in VirtualLab Fusion

- Configure the Camera Detector
  - Usage of Camera Detector [Use Case]

- Specify or customize transmission functions
  - How to Work with the Programmable Function & Example (Cylindrical Lens) [Use Case]
VirtualLab Fusion Technologies

Free space prisms, plates, cubes, ...

Lenses & freeforms

Apertures & boundaries

Gratings

Diffractive, Fresnel, meta lenses

HOE, CGH, DOE

Micro lens & adaptive arrays

SLM & adaptive components

Diffractive beam splitters

Diffusers

Scatterer

Waveguides & fibers

Crystals & anisotropic components

Nonlinear components

Free space

Field Solver

# Idealized component
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