Observation of Vortex Array Laser Beam Generation from Ince-Gaussian Beam
Abstract

Ince-Gaussian modes are the third complete family of exact and orthogonal solutions of the paraxial wave equation alongside the Hermite-Gaussian and Laguerre-Gaussian modes. Ince-Gaussian modes have a diversiform transverse pattern. In this document, following in the steps of Chu et al. [Opt. Express 16, 19934-19949 (2008)], a Dove prism-embedded unbalanced Mach-Zehnder interferometer is used to simulate the generation of vortex array laser beams based on Ince-Gaussian modes. The resulting vortex array laser beam generated by the proposed interferometric setup maintains its beam profile during propagation, also through a focus. Thus, the proposed vortex array laser beams hold great promise for application in optical tweezers and atom traps in the form of two-dimensional arrays.
Task Description

Building the System in VirtualLab Fusion
The Ince-Gaussian source can be found in *Light Sources -> Basic Source Models*, and offers the following adjustable parameters:

- Waist radius
- Ellipticity parameter
- Order of mode polynomial
- Degree of mode polynomial

A more detailed explanation of the meaning of the parameters and configuration of the source can be found here: [Ince-Gaussian Modes](#)
The flexible position and orientation settings and a flexible channel configuration for non-sequential simulations makes the construction of the system a simple and intuitive process.

Direct observation of the mode pattern
Simulation of Vortex Array Laser Beam Generation

Mode pattern rotated 90° after it propagates through the dove prism.

The resulting vortex array laser beam maintains its beam profile during both propagation and focusing.

Mode pattern after beam combiner
Window size 2mm x 2mm

Mode pattern at focus
Window size 50um x 50um
Generated Vortex Array Using Different Mode Orders in Source

Incident Ince-Gaussian beams

Generated vortex array beams
A larger value of the ellipticity parameter $\varepsilon$ of the incident Ince-Gaussian laser beam reduces the curvature of the mode parabola, with the result that the generated vortices form a less distorted (squerer) array.
Summary – System Building Blocks...

![Diagram of optical system components]

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Workflow in VirtualLab Fusion

• Set up input field
  - Basic Source Models [Tutorial Video]
  - Ince-Gaussian Modes [Use Case]

• Construct real components using surfaces

• Define position and orientation of components
  - LPD II: Position and Orientation [Tutorial Video]

• Set channels properly for non-sequential tracing
  - Channel Setting for Non-Sequential Tracing [Use Case]
VirtualLab Fusion Technologies

- prisms, plates, cubes, ...
- lenses & freeforms
- apertures & boundaries
- gratings
- diffractive, Fresnel, meta lenses
- HOE, CGH, DOE
- waveguides & fibers
- scatterer
- diffusers
- diffractive beam splitters
- SLM & adaptive components
- micro lens & freeform arrays
- nonlinear components
- free space
- crystals & anisotropic components

Field Solver

# idealized component
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