Accelerating Your LightTools Design Projects when Specialized Optical Properties Are Needed

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Introduction

Your illumination product design may require specialized optical properties such as:

- Birefringent materials that have crystal axis directions that need to curve
- Generalized polarizing elements
- Volume holographic materials
- Custom diffractive optical elements (DOEs)
- Surface scattering models (based on surface roughness or micro-optics)
- Custom volume material scattering models

The User-Defined Optical Property (UDOP) capability in LightTools provides a powerful mechanism for implementing highly customized surface and volume optical properties to solve specific physics challenges and accelerate LightTools-based product development. You can choose from a library of pre-built functions to jumpstart UDOP development. Or, if you face time and resource constraints, our Optical and Illumination Engineering Services team can help accelerate your design project by writing custom UDOP code for your specialized optical property needs.

This paper outlines how your project can benefit from LightTools UDOPs and describes resources to help you get started.

How UDOPs Can Help Solve Your Design Needs

LightTools UDOPs provide tremendous flexibility to define specialized optical properties that go beyond standard built-in optical properties. You can use UDOPs to create customized polarizers, waveplates, gratings and crystals, and non-standard optical functions such as arrays of light sources, idealized lenses and unusual light scattering elements. Today's leading-edge illumination optics increasingly require teams to model complex physics against scheduling and staffing pressures. UDOPs can often provide the solution to these challenges.

UDOP Applications

The UDOP feature is a part of the LightTools Advanced Physics Module. It allows you to define any optical characteristic for any given surface. The optical characteristics are specified using a compiled dynamic link library (DLL). The UDOP feature can also be used for purposes other than defining optical characteristics, such as defining your own sources or receivers.

For a ray hitting a given surface, the following operations are possible with UDOPs:

- Obtaining incoming ray information (position, direction, wavelength, surface normal, material index)
- Specifying exiting ray direction
- Changing amplitude and polarization state
- Splitting rays
- Laterally shifting the exiting ray position

It is possible to use a UDOP to create an array of sources from a single source, create a customized receiver, and implement ideal lens, grating, or scatter properties.

The UDOP framework provides a very general toolset for modeling a variety of optical effects. UDOPs have been employed to simulate the following types of devices:

- Polarizers and waveplates
- Diffraction gratings
- Anisotropic crystals
- Arrays of light sources
- Light scattering elements
- Idealized lenses
- Customized receivers

Figure 1 shows an anisotropic crystal (calcite) that was simulated using a UDOP. The figure shows the color fringes that are created when converging light is passed through a calcite crystal placed between crossed polarizers.
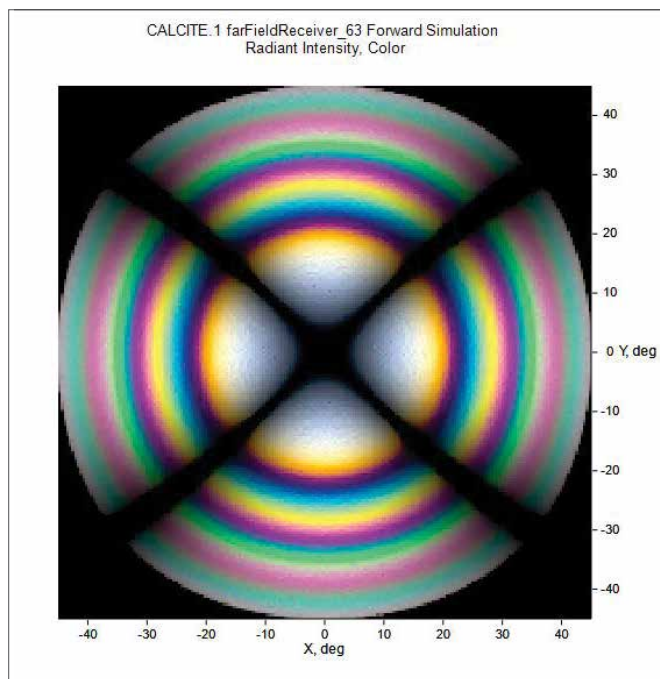

Figure 1: Calcite conoscopic image

Pre-Built UDOPs and Code Samples Provided in LightTools

LightTools includes an extensive collection of UDOP code samples. Although you need the Advanced Physics Module to create a custom UDOP, you do not need this module to apply any precompiled UDOP supplied with LightTools to your design.
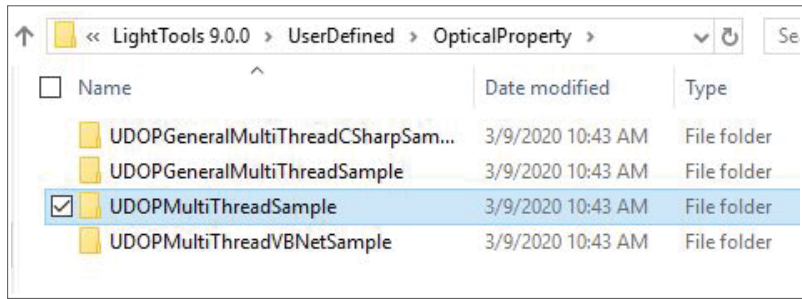
Figure 2: UDOPs provided with LightTools

The LightTools UDOP code samples provide a complete set of directories and files needed to create and compile a UDOP. This is very helpful for learning how to develop your own, customized UDOP. These samples provide only a simple reflect and transmit capability. Their main purpose is to show how to implement the UDOP framework in different code languages and how to implement multi-threading.

In addition, there are several prebuilt UDOPs available in LightTools. These UDOPs are ready to apply to your design. Only the DLL files are provided, so they are not code examples.

Figure 3 shows the prebuilt UDOP named LTUDX.dll, which contains five ready-to-use property classes.
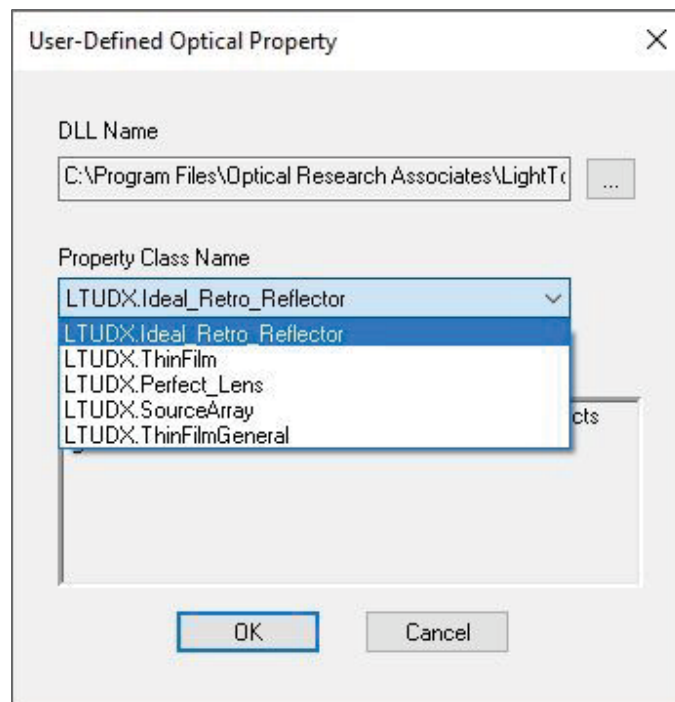

Figure 3: Property Classes in LTUDX.dll

The Perfect Lens UDOP, shown in Figures 4 and 5, provides an optical property that simulates an idealized thin lens. It includes four optional mappings: Tan-Theta, Sin-Theta, F-Theta and Abbe.
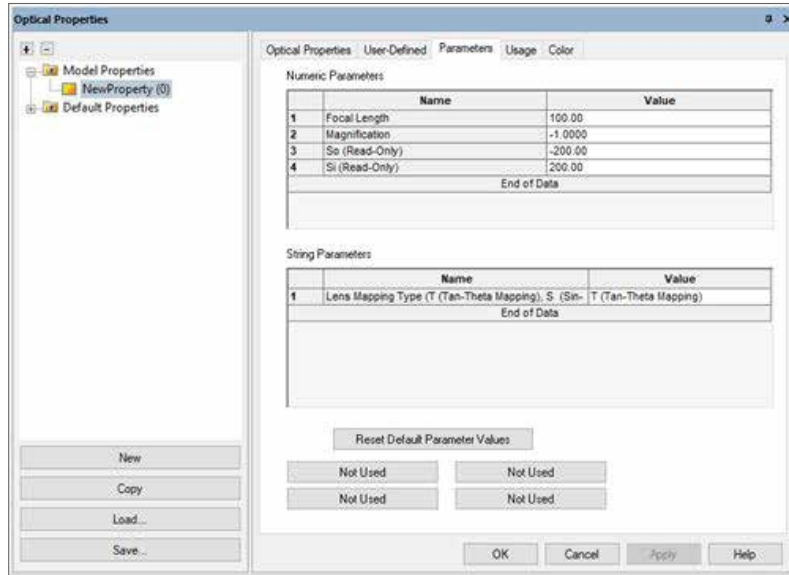

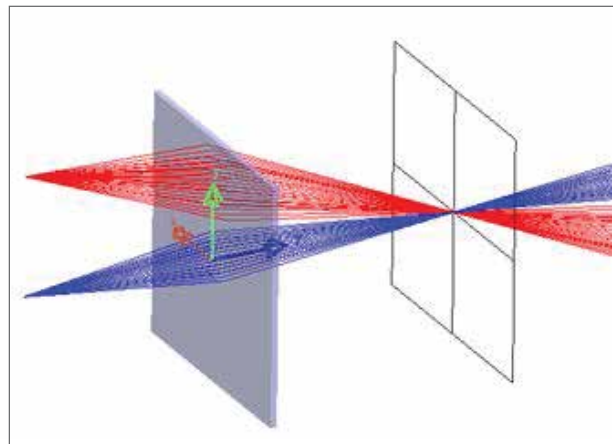Figure 4: Perfect lens UDOP control

Figure 5: Perfect lens UDOP applied to a surface

The Source Array UDOP uses the lateral shifting of rays to transform a single light source into an array of light sources. This is particularly useful for modeling arrays of laser diodes or LEDs. In Figure 6, a single bundle of rays is transformed into a 3x3 grid of bundles using the Source Array UDOP.
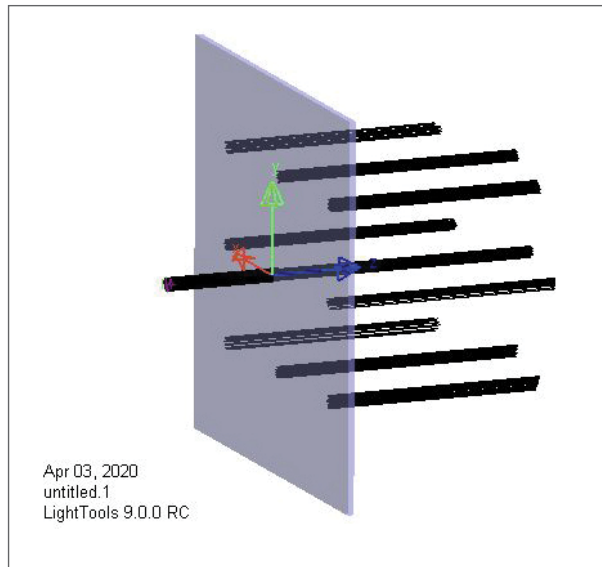
Figure 6: Source Array UDOP making a 3x3 grid of ray bundles

Need Help Creating a UDOP? Our Expert Engineers Can Develop One for You

If your team is strapped for time, our expert illumination engineers can develop UDOPs tailored to your project requirements. The development of any UDOP requires a certain base level of effort to implement the framework. Beyond that, the effort required depends on the complexity of the physics that are to be modeled. Implementing a simple scattering UDOP, for example, might only require minimal effort. More complicated physics problems, such as modeling birefringent materials or holograms, will typically require much more effort. Our Engineering Services team has substantial experience developing UDOPs to support advanced physics models.

Example Custom UDOP: Laser Diode Light Source

The Laser Diode UDOP was developed by our Engineering Services team and is available for download from the Optical Solutions Customer Support Portal:

https://opticsportal.synopsys.com/LightTools/LightTools Technical Papers/LTUDOP_LaserDiode.zip

The Laser Diode UDOP provides two approximations to the output of a laser diode:

- Point source mode, with two divergence angles
- Parallel beam mode, with two beam "diameters"

The divergence angles (or diameters) are specified using the two numeric parameters (shown in Figure 7). The string parameter can be set to either "angular" or "spatial" to set the operating mode.

A Monte Carlo process is used to adjust the direction or positions of rays through the UDOP surface to create the required Gaussian distributions, without altering the power of any of the rays. The code assumes that all the input rays have the same power. This is consistent with the use of a simple point source to generate the input rays.

In the angular mode, the ray directions are set by the UDOP (to create a Gaussian angular distribution) but the ray positions are not altered. In the spatial mode, all output ray directions are set parallel to the surface normal. The ray output positions are adjusted to maintain a Gaussian spatial distribution. Figure 7 shows the parameters that can be set for this UDOP.
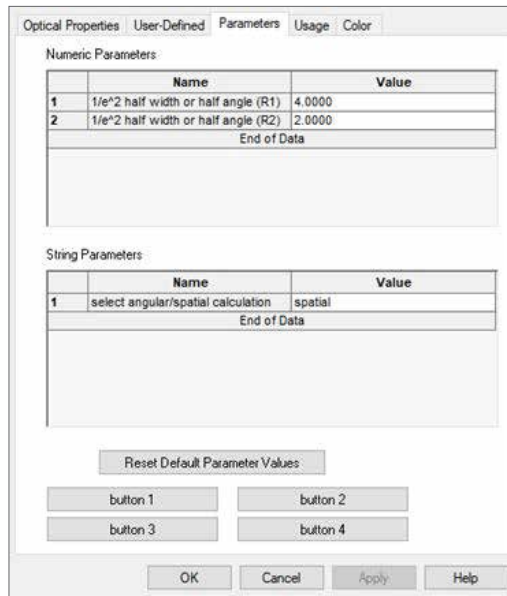
Figure 7: Laser diode UDOP parameters

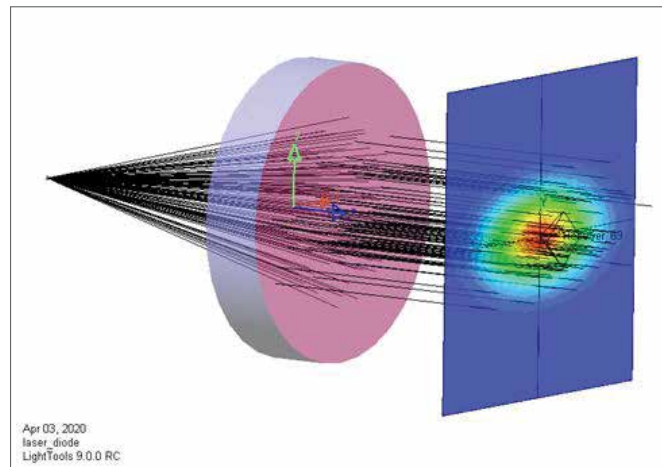Figure 8 shows an example distribution using the spatial mode.

Figure 8: Laser diode UDOP Gaussian spatial distribution

To Learn More

Would you like to learn more about our custom UDOP programming capabilities? Contact our Optical Engineering Services team by sending an email to optics@synopsys.com.

You can also find UDOP educational resources by visiting our Customer Support Portal at opticsportal.synopsys.com.