Update Guide
Release 2023.4

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Contents

INTRODUCTION

This document serves as a guide for new features, changes, and updates in TracePro 2023.3. This release has several new features to make TracePro more convenient to use and expand its capabilities. This release also fixes several problems reported by TracePro users.

WHAT'S NEW IN TRACEPRO 2023.4?

Changes in TracePro 2023.4 consist of new types of surface properties to support Diffractive Optical Elements (DOE) as well as fixes to issues reported by our customers and found by our staff. New features include:

- New surface property types to model Diffractive Optical Elements.
    - Holographic Optical Element (HOE)
    - Computer-Generated Hologram (CGH)
        - Radially symmetric
        - Asymmetric x-y
        - Asymmetric x-y (absolute value)
    - Zernike phase
- Updates to Stray Light Analyzer

For more details, please refer to the Revision History on the Current Release page in the TracePro Support section at www.lambdares.com.

SURFACE PROPERTIES FOR DIFFRACTIVE OPTICAL ELEMENTS

New surface property types are now available for modeling Diffractive Optical Elements (DOEs). All of the surface property types are modeled like gratings. The types available are:

- Holographic Optical Element (HOE)
- Computer-Generated Hologram (CGH)
    - Radially symmetric
    - Asymmetric x-y
    - Asymmetric x-y (absolute value)
- Zernike phase

Each property type requires its own input when defining the property and when applying it.

Holographic Optical Element

A Holographic Optical Element (HOE) surface behaves like a hologram formed by the interference of two spherical waves. The property is like a grating; you can add diffraction orders as you wish.

To make a HOE type Surface Property, choose type HOE from the **Type** list in the **Surface Property Editor** (**Define|Edit Property Data>Surface Properties**) and set the **Construction Wavelength** of the laser used to make the hologram.

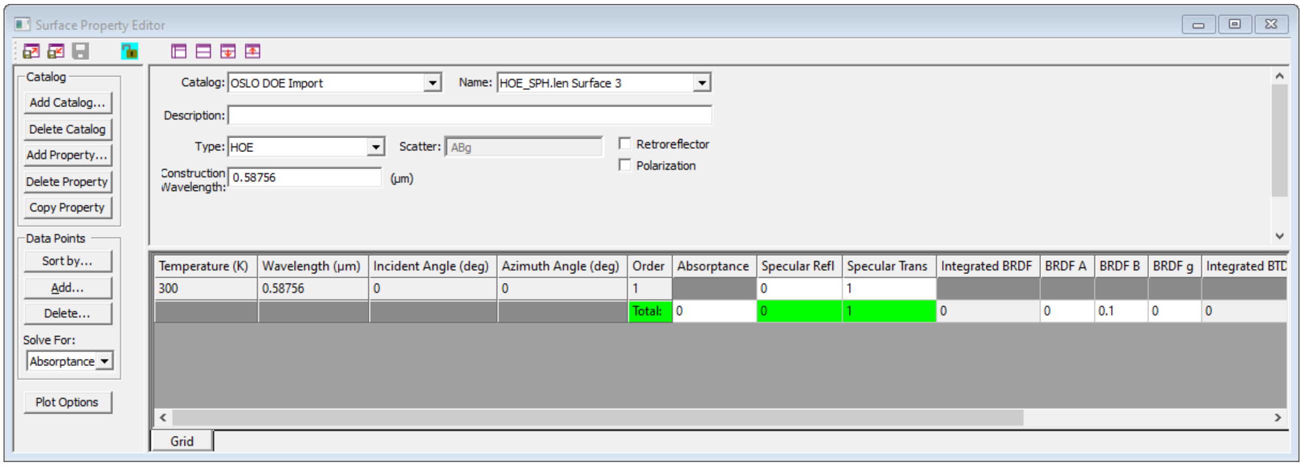


Figure 1. Surface Property Editor with an example HOE property.

To apply a HOE surface property, select the surface in the **Model Window** and select **Define|Apply Properties>Surface**. Select the **Catalog** and **Name** of the property, and the HOE tab in the lower box will provide inputs for the locations of the point sources used to form the hologram. These locations are offsets from the local vertex of the surface, with the optical axis as the local z axis.

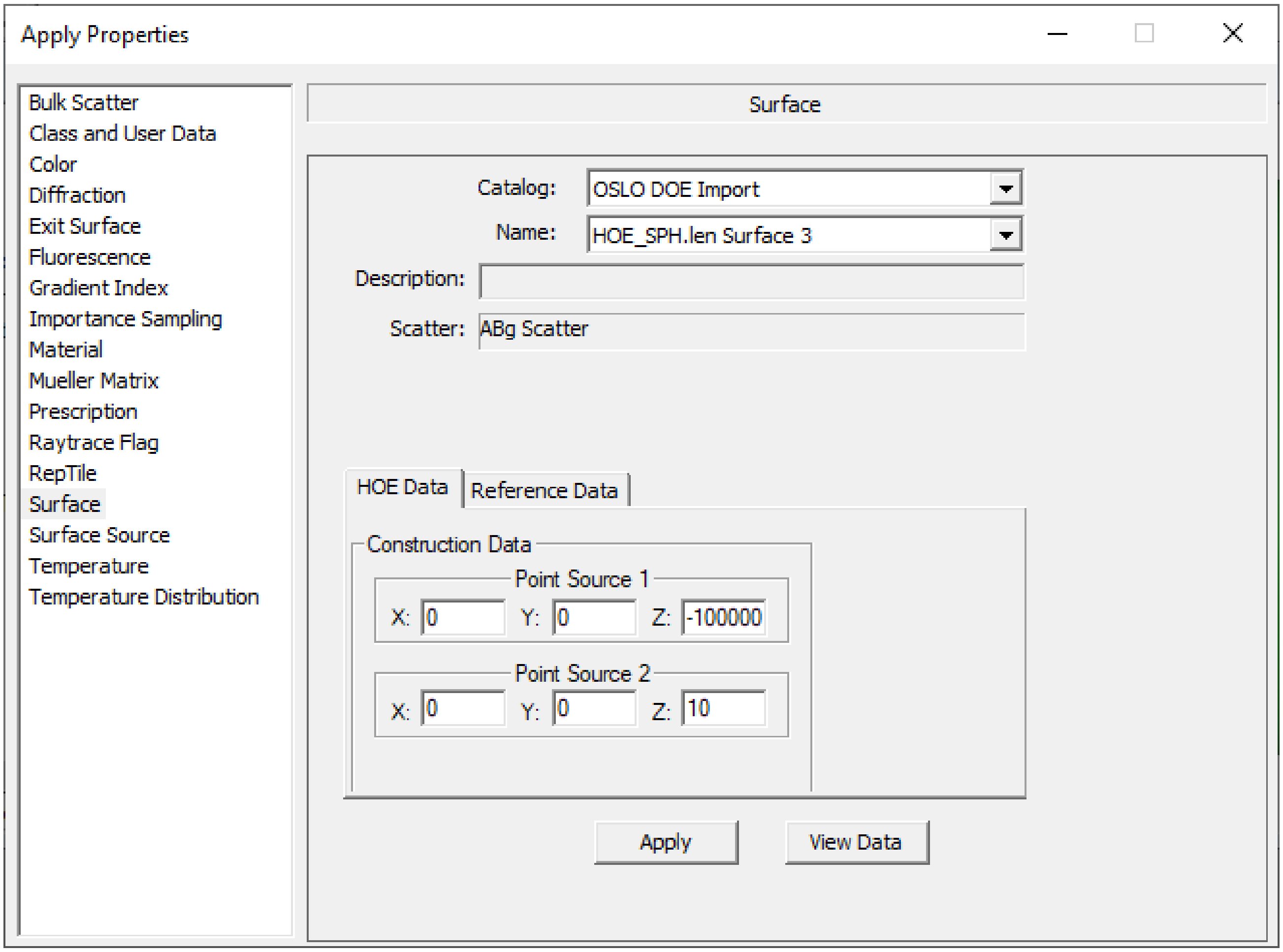


Figure 2. Apply Properties dialog box with inputs for locations of point sources used to form the hologram for the HOE surface.

Computer-Generated Hologram

A computer-generated hologram (CGH) is a hologram created from a specific phase distribution. The phase distribution is represented by a polynomial. The surface is modeled as a grating, so you can add grating orders as you wish. Three polynomial types are available:

- Radially Symmetric
- Asymmetric x-y
- Asymmetric x-y (absolute value)

A CGH surface property requires data for the **Design Wavelength**, the number of polynomial terms, and the coefficients of the polynomial terms. Figure 3 and Figure 4 show the input for the Symmetric type.

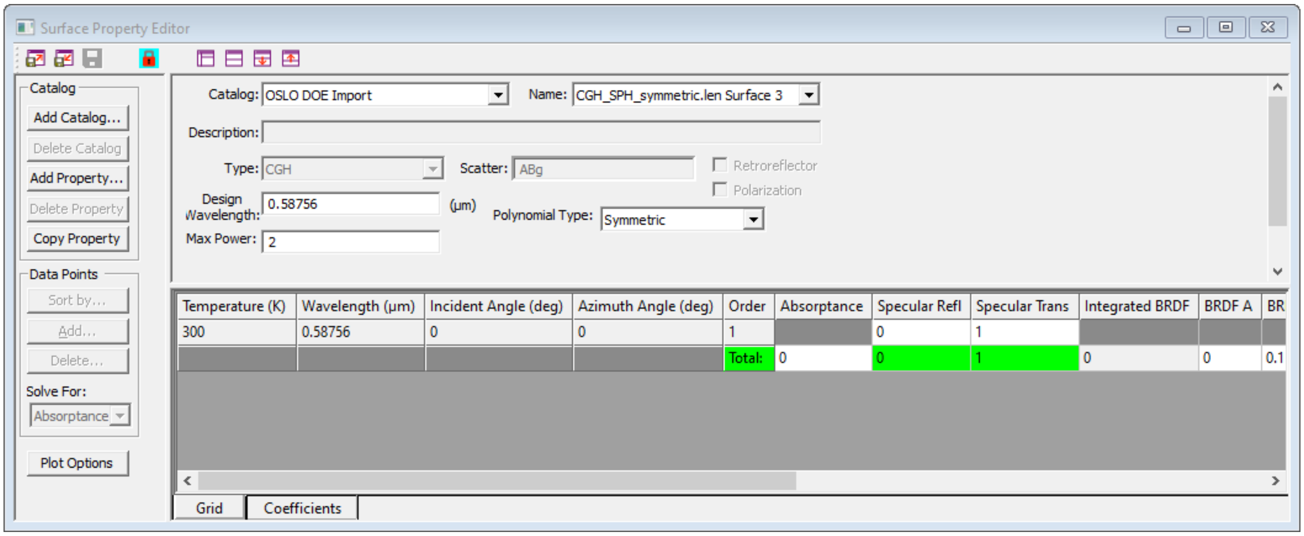


Figure 3. Surface Property data for a Symmetric CGH, Grid tab.

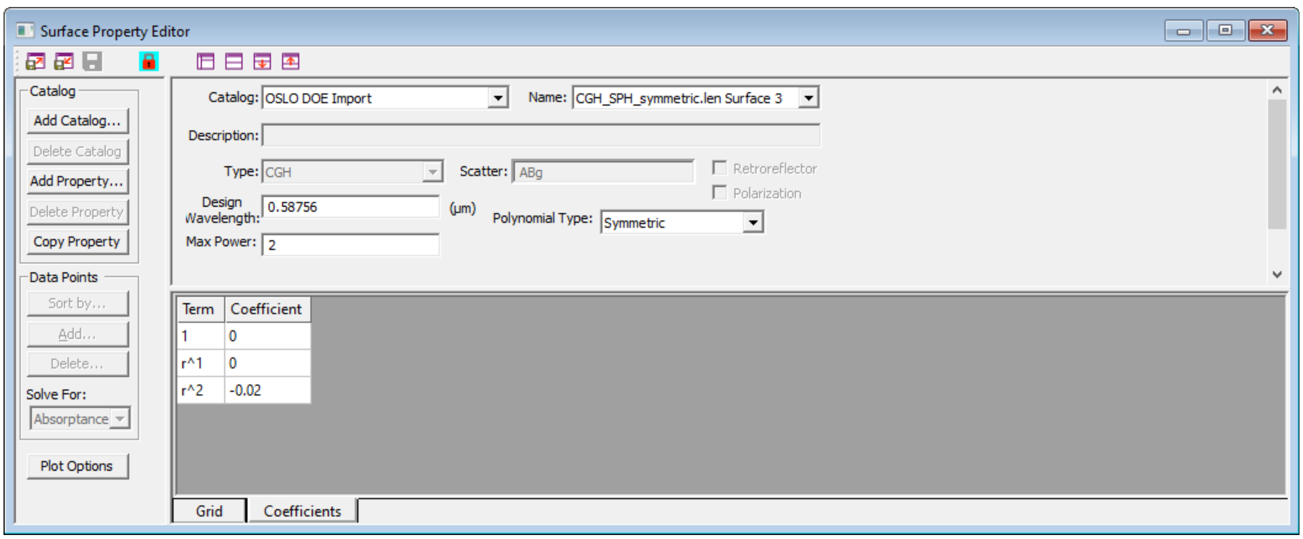


Figure 4. Surface Property data for a Symmetric CGH, Coefficients tab.

When applying a CGH surface property, you must specify the **Construction data** for the CGH, namely the **Center** of the polynomial (i.e., the vertex of the surface), the **Optical axis vector** (local z axis of the surface) and the **Up Vector** to orient the local y axis for asymmetric polynomials. You can also check the **Automatically calculate** checkbox and if the surface is an optical surface, i.e., created by the **Geometry|Lens Element** dialog box, TracePro will set the values from the lens creation. The **Apply Properties** dialog box input for an example CGH property is shown in Figure 5.

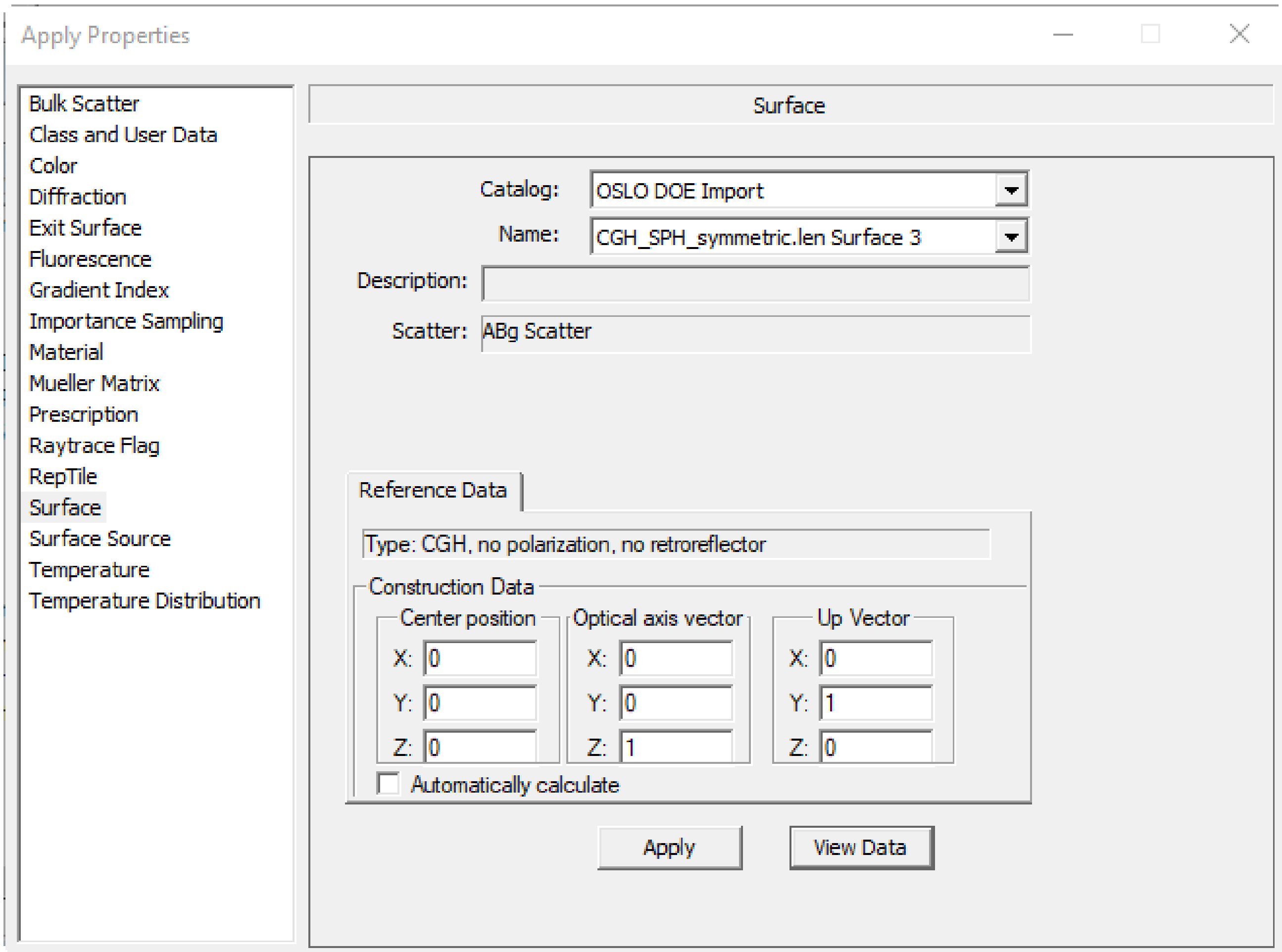


Figure 5. Apply Properties dialog box for applying a CGH surface property.

Zernike Phase

The Zernike Phase type of DOE is like the CGH type, except the phase is represented by a sum of Zernike polynomials. Again, it is modeled as a grating, so you can add whatever diffraction orders you wish.

A Zernike phase surface property has the option of specifying phase in units of waves or millimeters. The highest order of the terms, and the coefficients of the polynomial terms are also required. The highest order of the terms is the highest power of ρ. The inputs for a Zernike Phase property with units of mm is shown in Figure 6 and Figure 7.

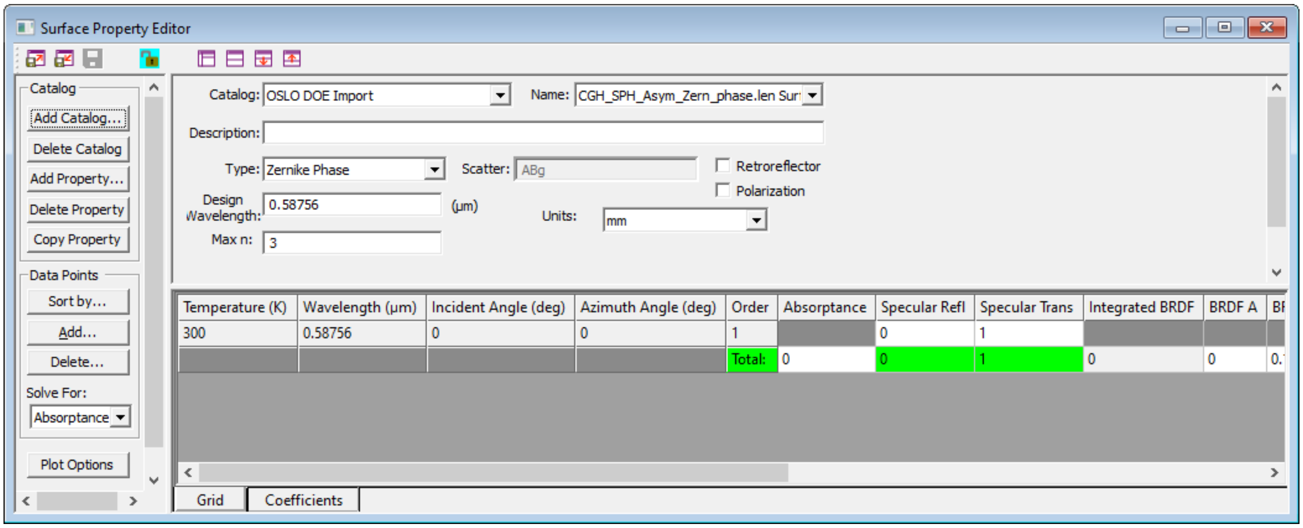


Figure 6. Surface Property Editor with example Zernike Phase type DOE, Grid tab, with units of mm.

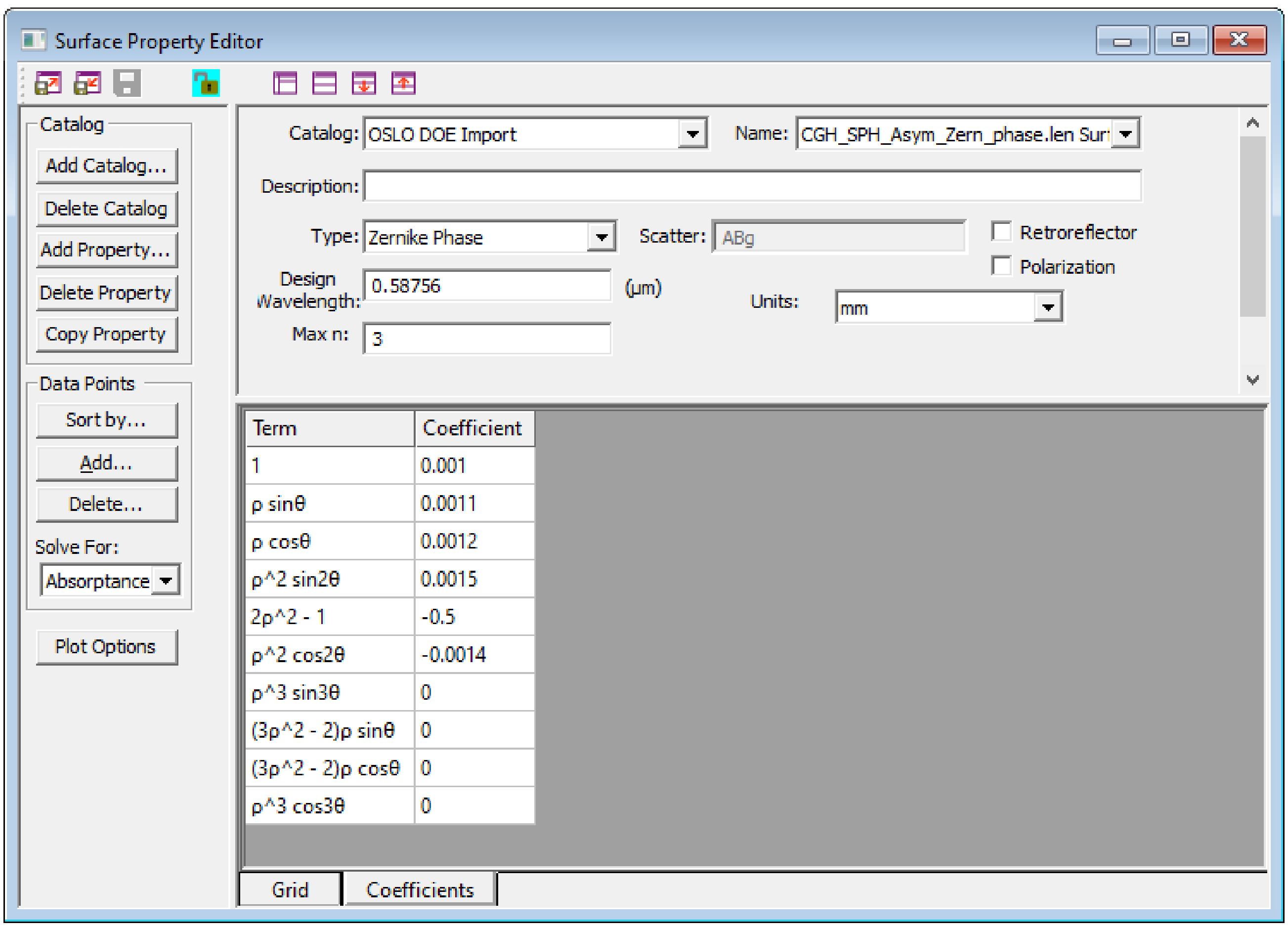


Figure 7. Surface Property Editor with example Zernike Phase type DOE, Coefficients tab, with units of mm.

Importing an OSLO file with DOE surfaces

If you design an optical system in OSLO with one or more DOE surfaces, you can open the .len or .osl file in TracePro. Doing so will create a new Surface Property for each DOE surface, in a catalog named *OSLO DOE Import*, and assign the property to the surface in TracePro. The property will have one diffraction order, corresponding to the DOR value in OSLO, with a transmittance value of 1.0 and all others property values zero. If you wish to model stray light from unwanted diffraction orders or scattering, you can edit the property as you wish.

Examples

The following sections provide examples of making various types of DOEs “from scratch,” i.e., by making a property using the Surface Property Editor, then applying the property to an optical surface of a lens element.

HOE

The following is a recipe for making an example Holographic Optical Element.

1. In a new document, make a Lens Element using **Geometry|Lens Element**. Use all default input values, except on the **Position** tab, set the *First Surface Center* to x=0, y=0, z=10.
2. Open the Surface Property Editor (**Define|Edit Property Data>Surface Properties…**). Make a new catalog or select an existing catalog.
3. Make a new property by clicking **Add Property…** and entering a name, then selecting **ABg** for the *Scatter Model*, and finally clicking **OK**.
4. Change the **Type** of the property to *HOE*.
5. The property has diffracted orders like a grating. In the *Data Points* box, click the **Add…** button and add a diffraction order equal to 1.
6. In the *Data Points* box, click the **Delete…** button and delete the grating order 0.
7. In the data grid, set the *Specular Trans* value for Order 1 to 1.0 and the absorptance to zero. All of the flux incident on the surface will be directed into the Order 1 transmitted beam. The completed property should appear as in Figure 8. Save the property and close the **Surface Property Editor** window.
8. In the **System Tree**, select *Surface 0* of the Lens Element you created earlier. Open the **Apply Properties** dialog box (**Define|Apply Properties…**), and select the **Catalog** and **Name** of the property you created. In the *Construction Data* box in the **HOE Data** tab, set *Point Source 1* to x=0, y=0, z=-1e8, and *Point Source 2* to x=0, y=0, z=10, as shown in Figure 9. Click **Apply**. This will create a HOE that will focus collimated light at 10 mm beyond the Lens Element This focal length is for light at the **Construction Wavelength** entered in the property. (Actually, not quite, because of the finite thickness of the plate.)
9. In the **Source Tree**, enable **Grid Source 1**. Open the Grid Source and set the **Grid Pattern** to *Cross*. On the Wavelengths tab, add wavelength 0.633 to match the **Construction Wavelength** of the property. Click Modify and close the **Grid Source** dialog box.
10. Trace rays and observe that the two wavelengths focus at different distances from the Lens Element as shown in Figure 10.

You can adjust the HOE surface property if you wish to see the effects of unwanted diffracted orders, reflected orders, or scattered light.

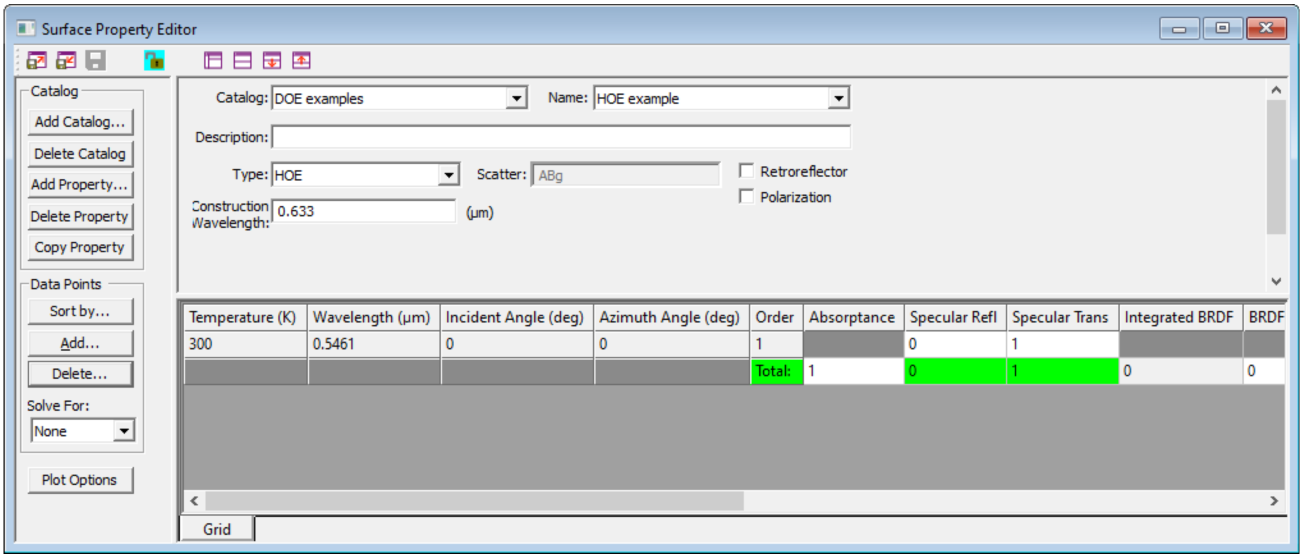


Figure 8. Surface Property Editor showing the completed HOE type surface property.

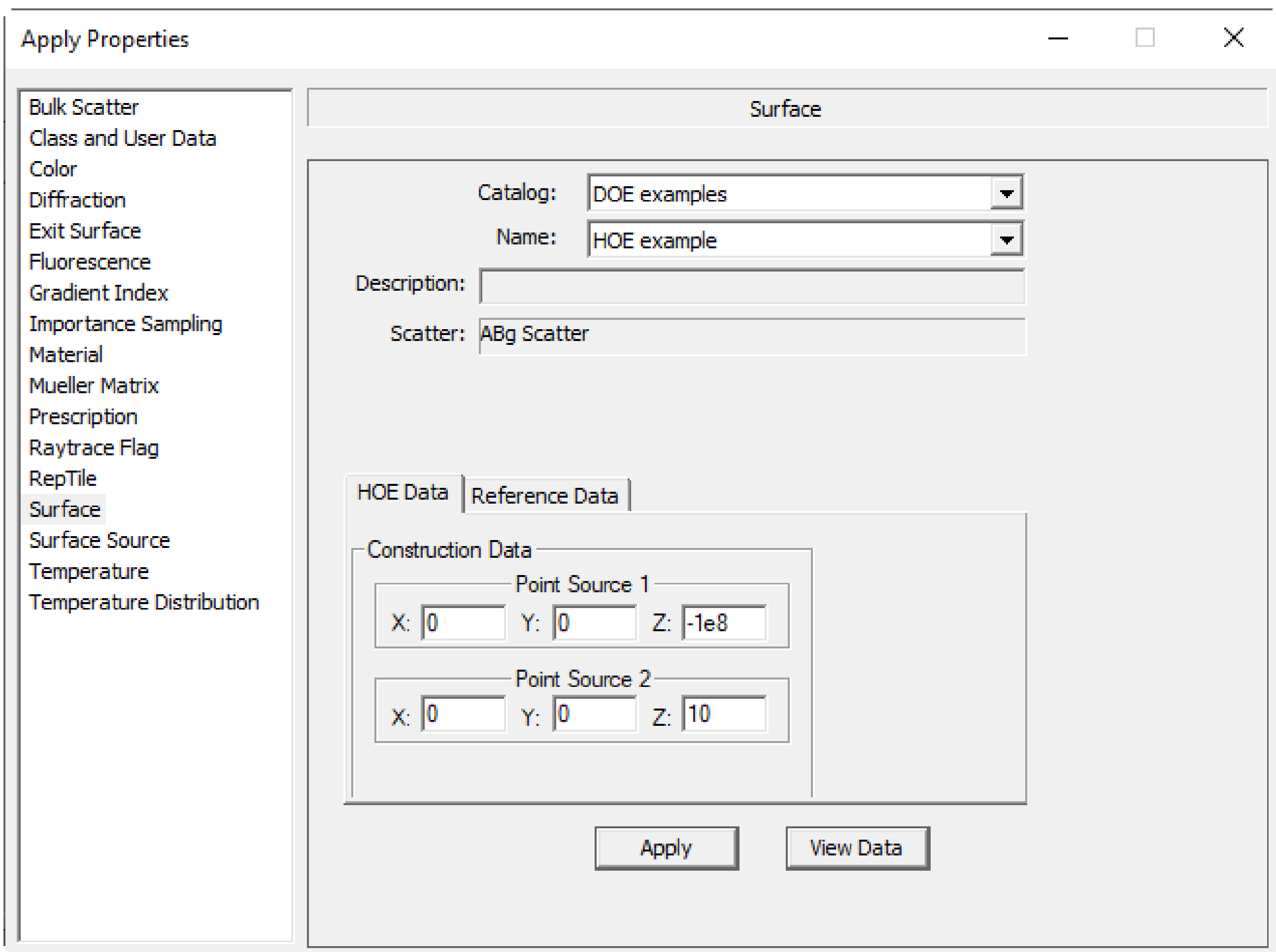


Figure 9. Apply Properties dialog box, showing the construction points for a HOE type surface property.

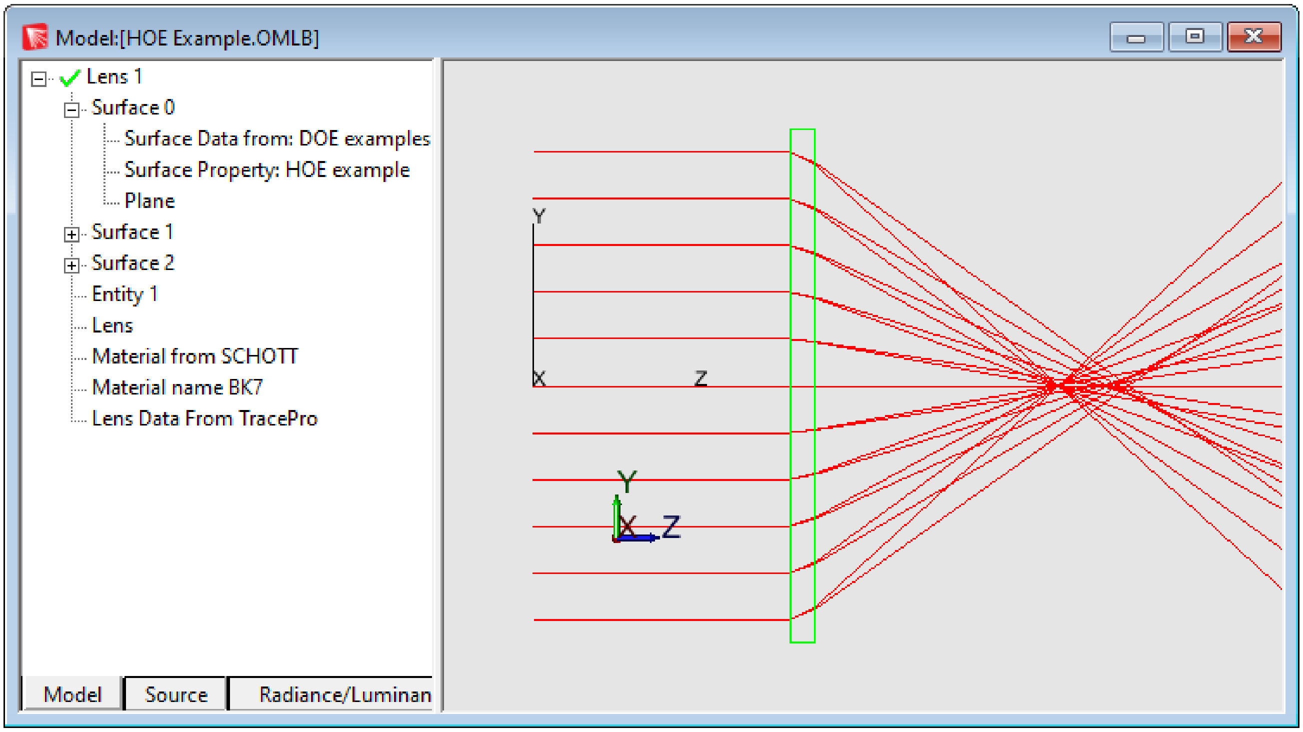


Figure 10. HOE ray-trace with wavelengths 0.5461 and 0.633 µm converging at different distances behind the glass plate.

CGH

The following is a recipe for making an example Computer-Generated Hologram.

1. In a new document, make a Lens Element using **Geometry|Lens Element**. Use all default input values, except on the **Position** tab, set the *First Surface Center* to x=0, y=0, z=10.
2. Open the Surface Property Editor (**Define|Edit Property Data>Surface Properties…**). Make a new catalog or select an existing catalog.
3. Make a new property by clicking **Add Property…** and entering a name, then selecting **ABg** for the *Scatter Model*, and finally clicking **OK**.
4. Change the **Type** of the property to *CGH*.
5. The property has diffracted orders like a grating. In the *Data Points* box, click the **Add…** button and add a diffraction order equal to 1.
6. In the *Data Points* box, click the **Delete…** button and delete the grating order 0.
7. In the data grid, set the *Specular Trans* value for Order 1 to 1.0 and the absorptance to zero. All of the flux incident on the surface will be directed into the Order 1 transmitted beam.
8. Select the **Coefficients** tab and enter -0.02 for the r^2 term. The completed property should appear as in Figure 11. Save the property and close the **Surface Property Editor** window.
9. In the **System Tree**, select *Surface 0* of the Lens Element you created earlier. Open the **Apply Properties** dialog box (**Define|Apply Properties…**), and select the **Catalog** and **Name** of the property you created. In the *Construction Data* box in the **Reference Data** tab, note that *Automatically calculate* is checked and calculated values are entered, as shown in Figure 12. Click **Apply**.
10. In the **Source Tree**, enable **Grid Source 1**. Open the Grid Source and set the **Grid Pattern** to *Cross*. Click Modify and close the **Grid Source** dialog box.
11. Trace rays and observe that the diffracted rays converge behind the Lens Element as shown in Figure 13.

You can adjust the CGH surface property if you wish to see the effects of unwanted diffracted orders, reflected orders, or scattered light.

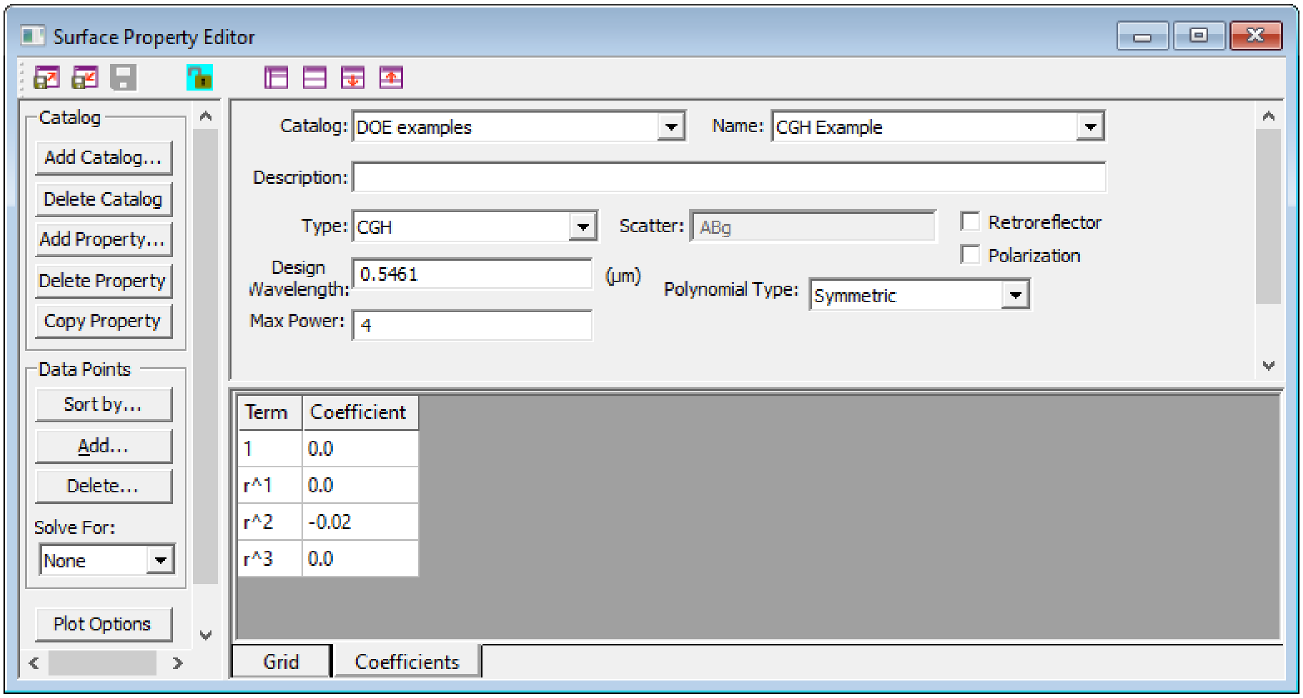


Figure 11. Example CGH surface property.

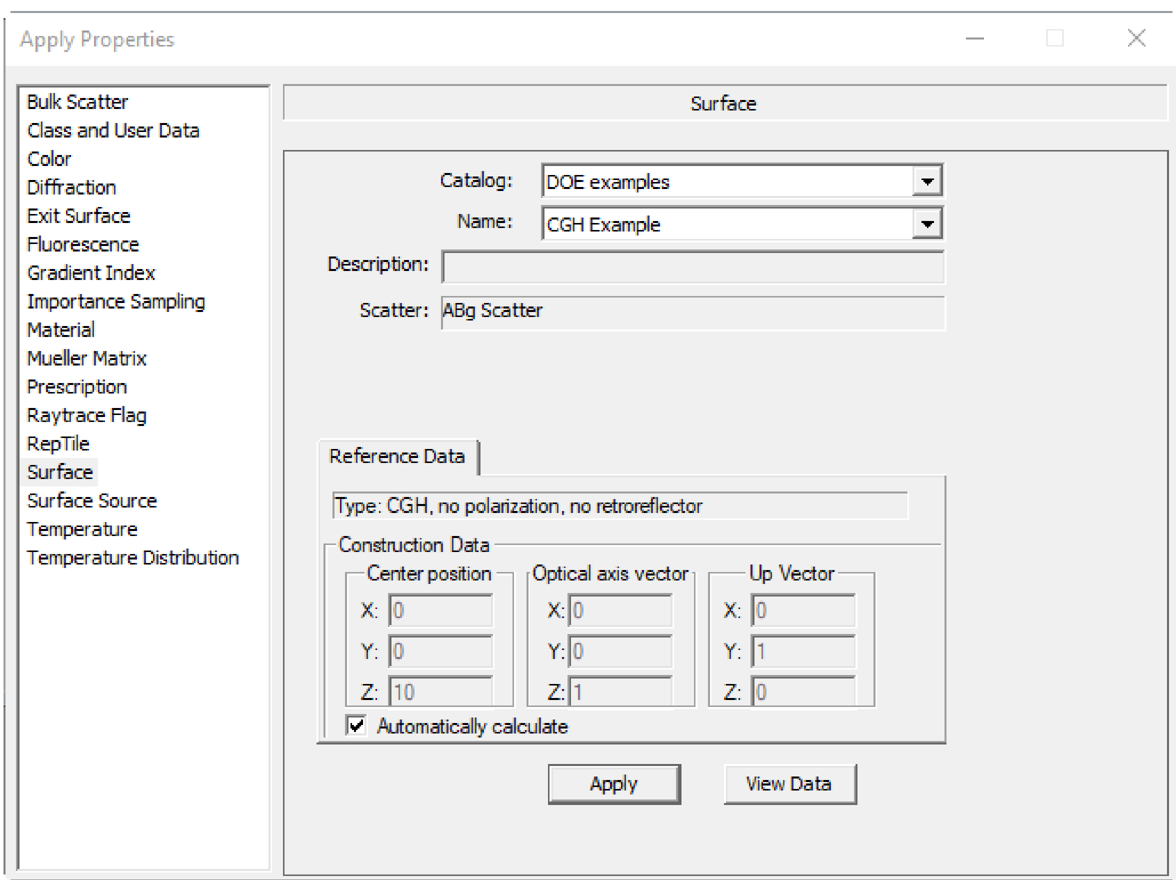


Figure 12. Applying the example CGH surface property with *Automatically calculate* checked for the Construction Data.

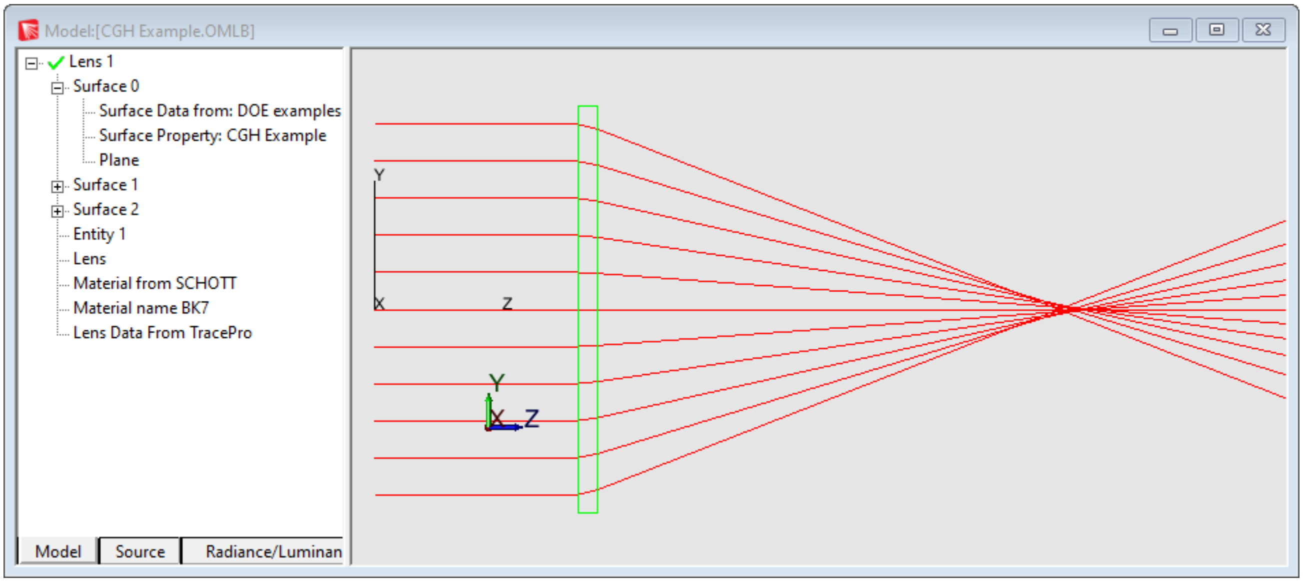


Figure 13. Rays traced through the Lens Element with example CGH surface property applied.

Zernike Phase

The following is a recipe for making an example Zernike Phase surface property.

1. In a new document, make a Lens Element using **Geometry|Lens Element**. Use all default input values, except on the **Position** tab, set the *First Surface Center* to x=0, y=0, z=10.
2. Open the Surface Property Editor (**Define|Edit Property Data>Surface Properties…**). Make a new catalog or select an existing catalog.
3. Make a new property by clicking **Add Property…** and entering a name, then selecting **ABg** for the *Scatter Model*, and finally clicking **OK**.
4. Change the **Type** of the property to *Zernike Phase*.
5. The property has diffracted orders like a grating. In the *Data Points* box, click the **Add…** button and add a diffraction order equal to 1.
6. In the *Data Points* box, click the **Delete…** button and delete the grating order 0.
7. In the data grid, set the *Specular Trans* value for Order 1 to 1.0 and the absorptance to zero. All of the flux incident on the surface will be directed into the Order 1 transmitted beam.
8. Select the **Coefficients** tab and enter -1.0 for the 2ρ^2 - 1 term. The completed property should appear as in Figure 14. Save the property and close the **Surface Property Editor** window.
9. In the **System Tree**, select *Surface 0* of the Lens Element you created earlier. Open the **Apply Properties** dialog box (**Define|Apply Properties…**), and select the **Catalog** and **Name** of the property you created. In the *Construction Data* box in the **Reference Data** tab, note that *Automatically calculate* is checked and calculated values for *Center position*, *Optical axis vector* and *Up Vector* are entered, as shown in Figure 15. Set the *Normalization Radius* to 10 to match the aperture radius of the surface. Click **Apply**.
10. In the **Source Tree**, enable **Grid Source 1**. Open the Grid Source and set the **Grid Pattern** to *Cross*. Click Modify and close the **Grid Source** dialog box.
11. Trace rays and observe that the diffracted rays converge behind the Lens Element as shown in Figure 16.

You can adjust the Zernike Phase surface property if you wish to see the effects of unwanted diffracted orders, reflected orders, or scattered light.

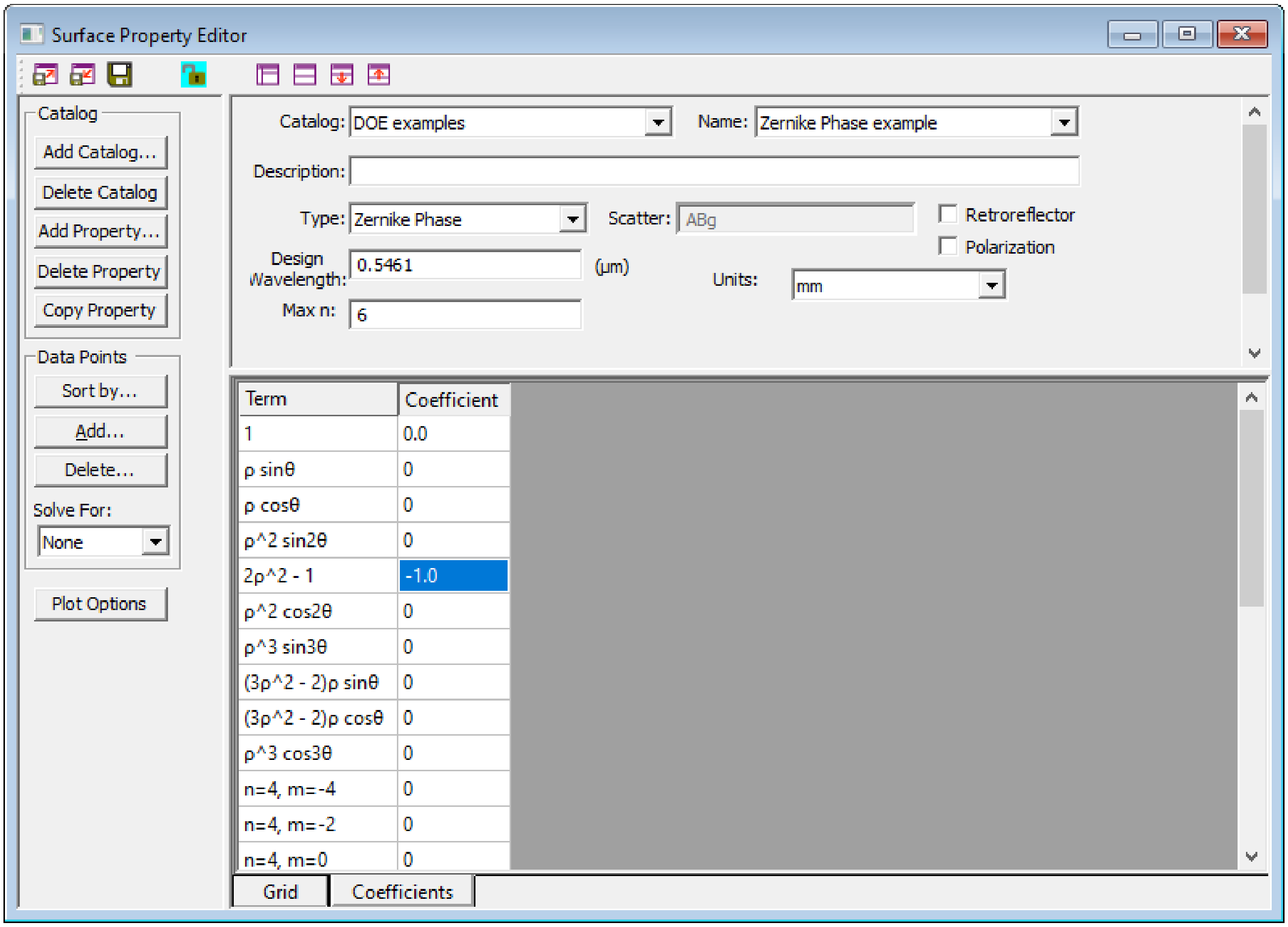


Figure 14. Example Zernike Phase surface property.

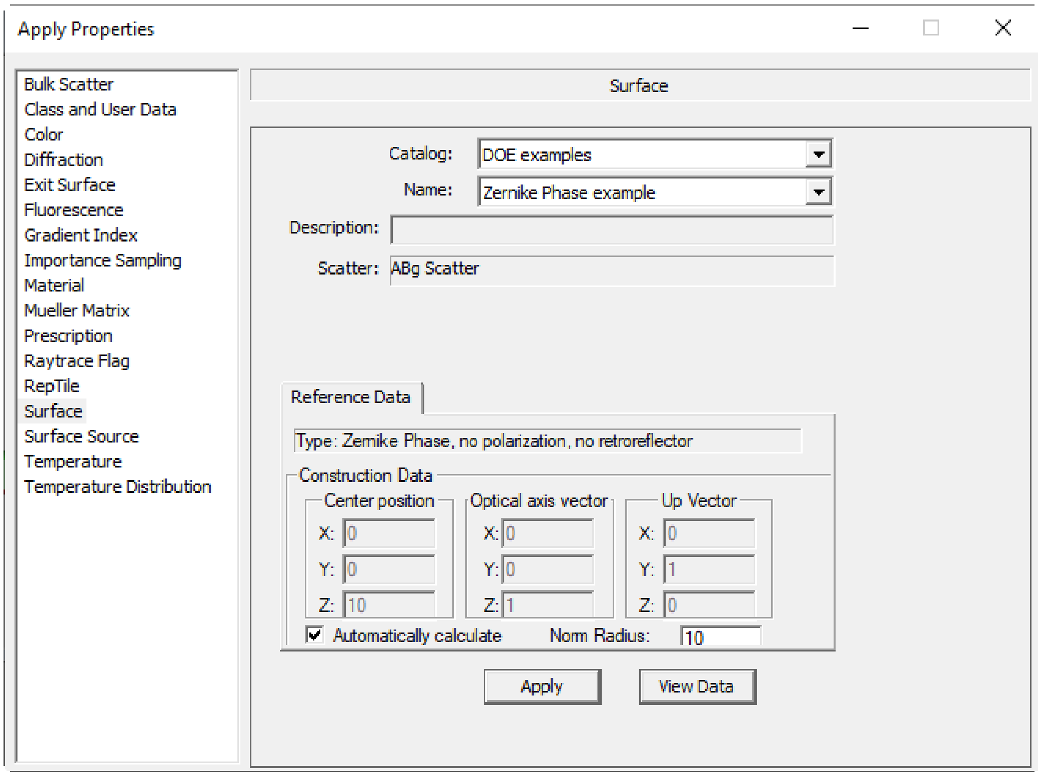


Figure 15. Applying the example Zernike Phase surface property with *Automatically calculate* checked for the Construction Data.

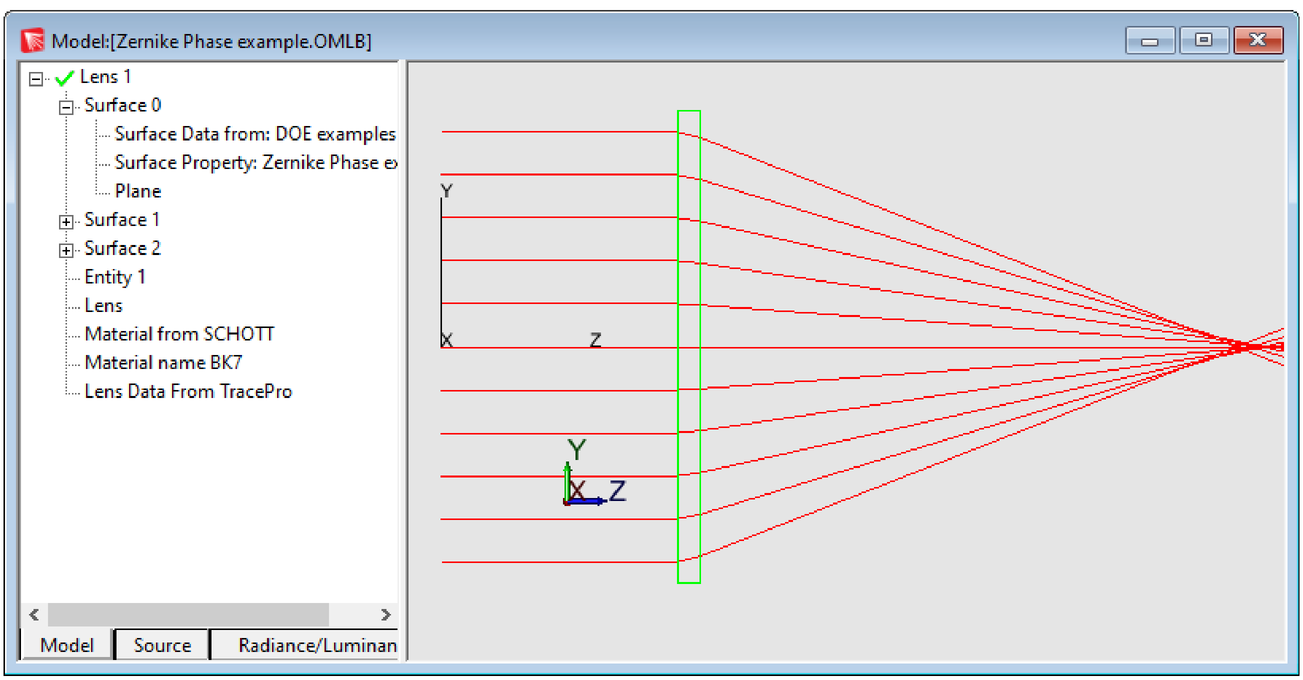


Figure 16. Rays traced through the Lens Element with example Zernike Phase surface property applied.

STRAY LIGHT ANALYZER

The Stray Light Analyzer automates many of the tasks involved in the stray light analysis of an optical system including defining multiple light sources positions and rotations as well as populating the Path Sort Analysis Table. This feature is available in TracePro Standard and Expert.

The Stray Light Analyzer Lens System View window allows a user to load a lens model from TracePro and automatically assign unique names to the lens elements and surfaces.

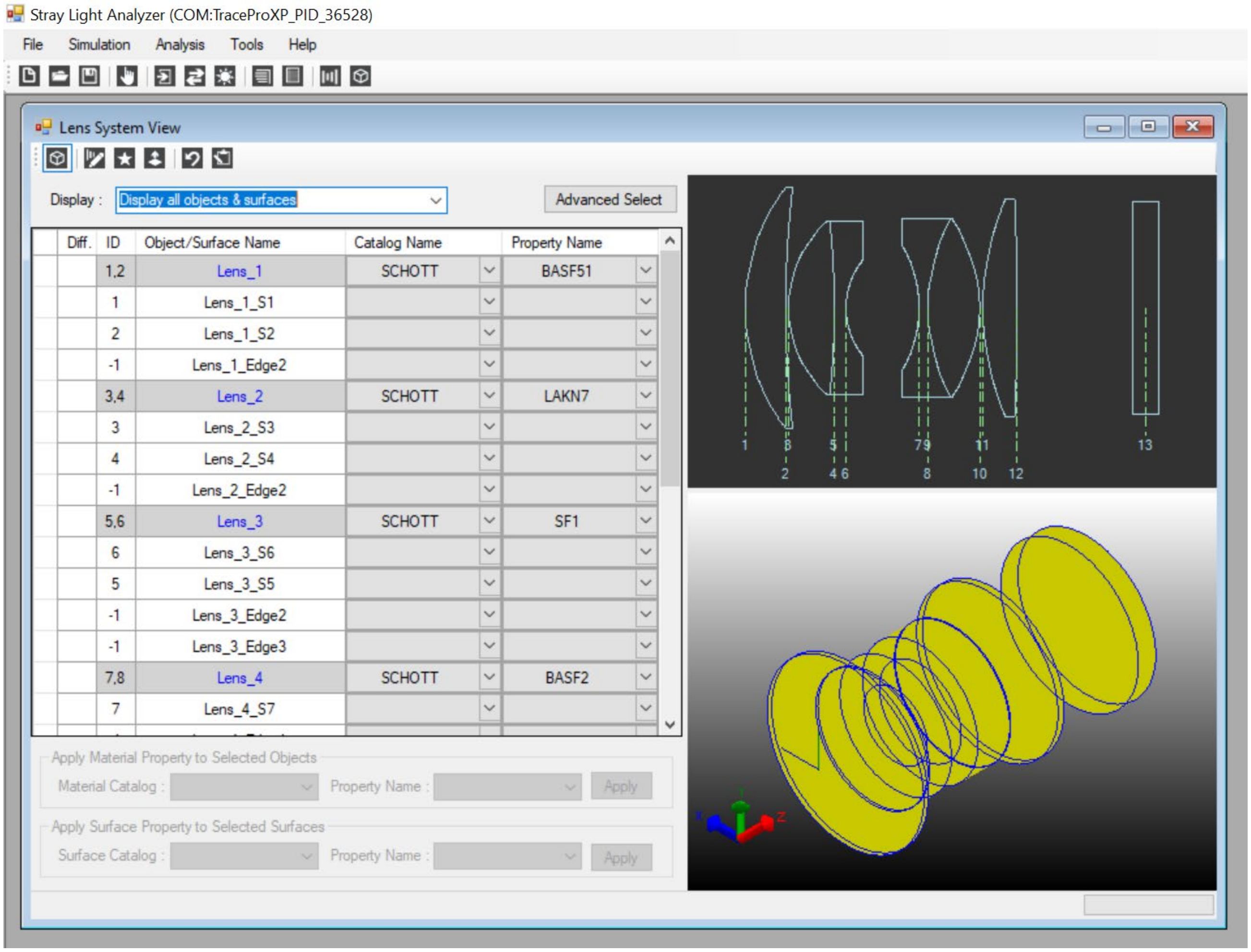
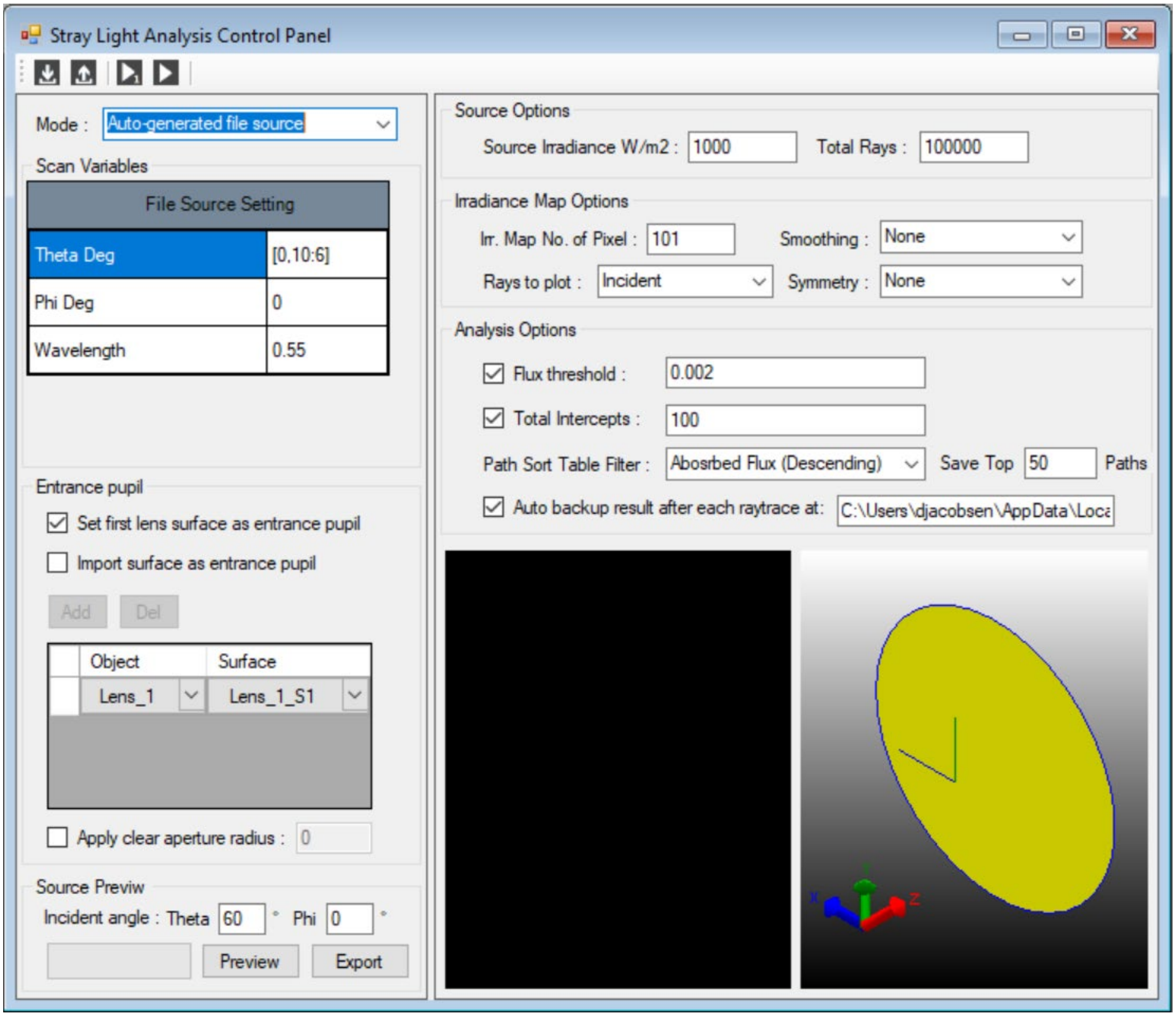
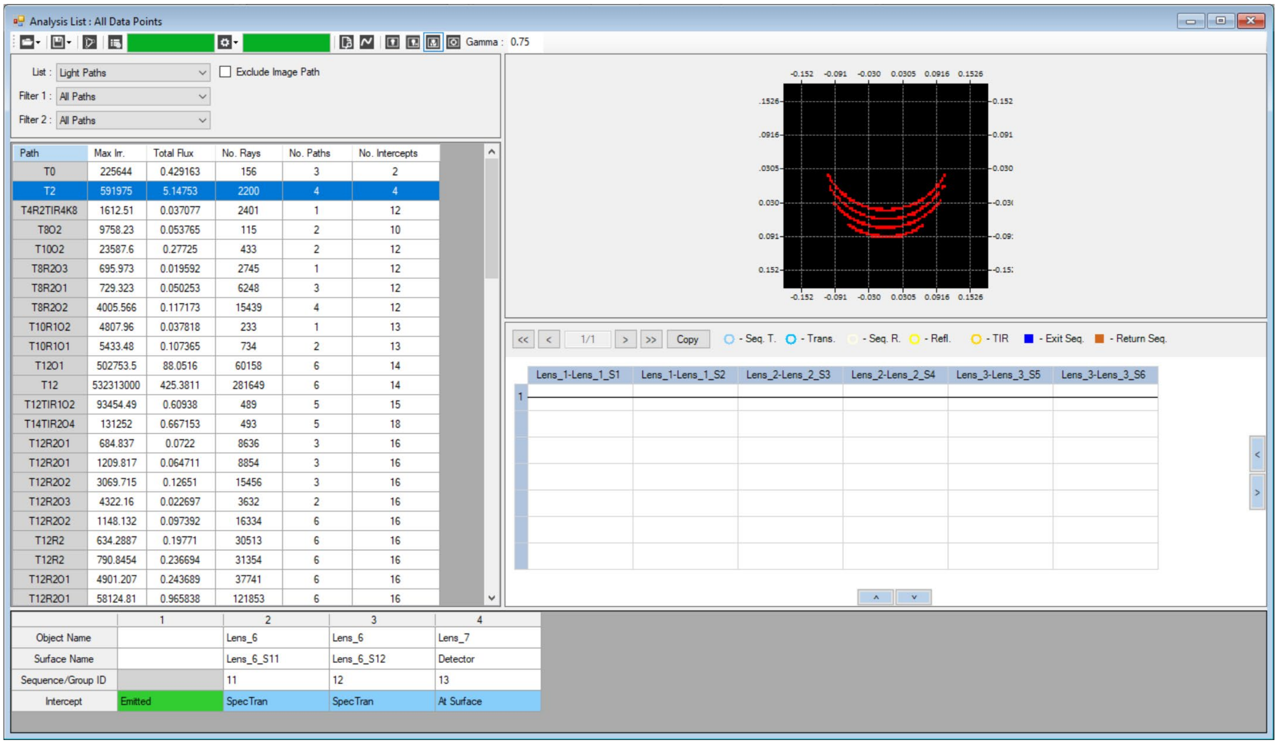


Figure 17. Lens System View window

The Stray Light Analysis Control Panel gives users the option to use either an auto-generated file source or a TracePro Grid Source in the stray light analysis. Additional options are source irradiance, total rays, theta and phi angles, entrance pupil, Irradiance Map settings, Flux Threshold and Total Intercepts, and Path Sort table options.



The Stray Light Analyzer will automatically define the sources, trace the rays, and populate the analysis table. At that point the individual paths can be sorted and analyzed.


Analysis List : All Data Points
Gamma : 0.75
List : Light Paths
Exclude Image Path
Filter 1 : All Paths
Filter 2 : All Paths
Path Max Irr. Total Flux No. Rays No. Paths No. Intercepts
T0 225644 0.429163 156 3 2
T2 591975 5.14753 2200 4 4
T4R2TIR4K8 1612.51 0.037077 2401 1 12
T8O2 9758.23 0.053765 115 2 10
T10O2 23587.6 0.27725 433 2 12
T8R2O3 695.973 0.019592 2745 1 12
T8R2O1 729.323 0.050253 6248 3 12
T8R2O2 4005.566 0.117173 15439 4 12
T10R1O2 4807.96 0.037818 233 1 13
T10R1O1 5433.48 0.107365 734 2 13
T12O1 502753.5 88.0516 60158 6 14
T12 532313000 425.3811 281649 6 14
T12TIR1O2 93454.49 0.60938 489 5 15
T14TIR2O4 131252 0.667153 493 5 18
T12R2O1 684.837 0.0722 8636 3 16
T12R2O1 1209.817 0.064711 8854 3 16
T12R2O2 3069.715 0.12651 15456 3 16
T12R2O3 4322.16 0.022697 3632 2 16
T12R2O2 1148.132 0.097392 16334 6 16
T12R2 634.2887 0.19771 30513 6 16
T12R2 790.8454 0.236694 31354 6 16
T12R2O1 4901.207 0.243689 37741 6 16
T12R2O1 58124.81 0.965838 121853 6 16
1/1 Copy
- Seq. T. - Trans. - Seq. R. - Refl. - TIR - Exit Seq. - Return Seq.
Lens_1-Lens_1_S1 Lens_1-Lens_1_S2 Lens_2-Lens_2_S3 Lens_2-Lens_2_S4 Lens_3-Lens_3_S5 Lens_3-Lens_3_S6
1 2 3 4
Object Name Lens_6 Lens_6 Lens_7
Surface Name Lens_6_S11 Lens_6_S12 Detector
Sequence/Group ID 11 12 13
Intercept Emitted SpecTran SpecTran At Surface