Diffraction Gratings

Requirements

Models: None

Properties: None

Editions: TracePro Standard or Expert

Introduction

To model a diffraction grating in TracePro, you must create a surface property of type Grating to specify the diffraction efficiency of each grating order, then apply the property to a surface in the model.

TracePro models linear gratings, which are gratings that have grating grooves along the intersections of equally spaced parallel planes with a substrate surface. The substrate surface may be a plane, in which case the grating grooves are equally spaced and straight. If the substrate is curved, the grating grooves are defined by the intersection of equally spaced parallel planes with the substrate.

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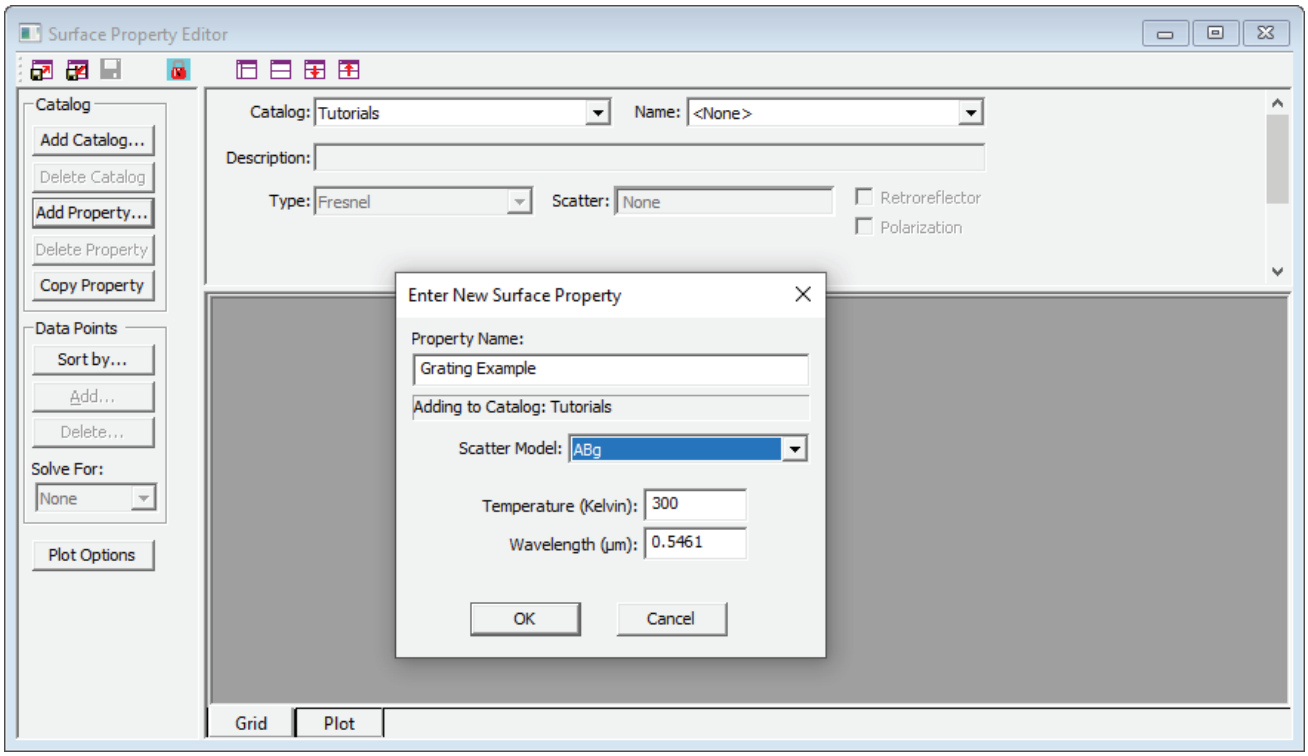
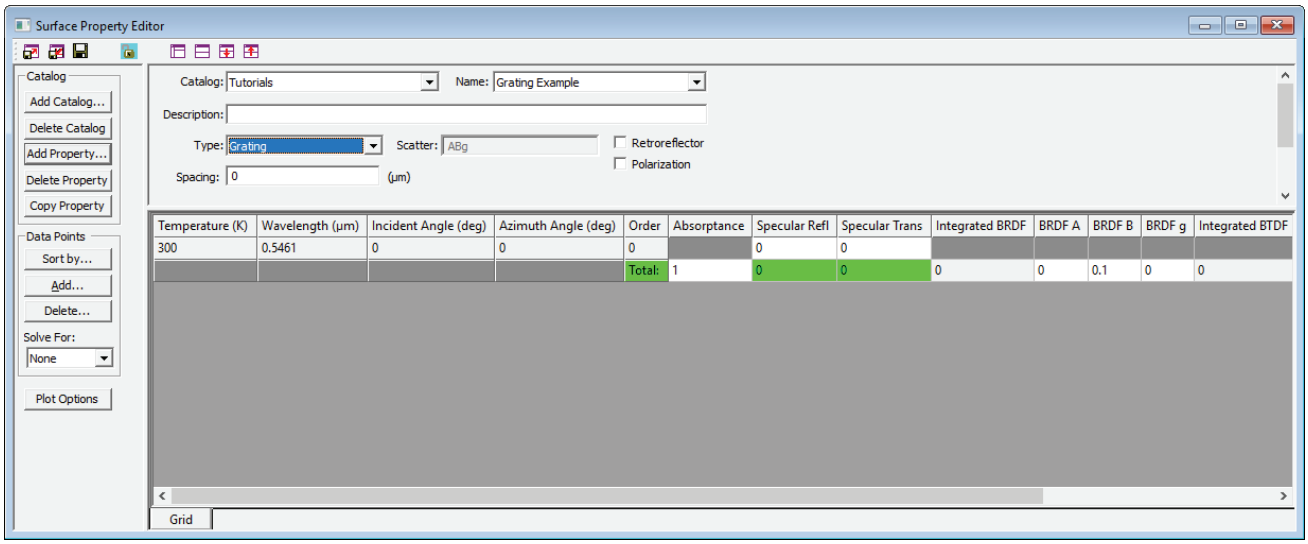
Creating a Grating-Type Surface Property

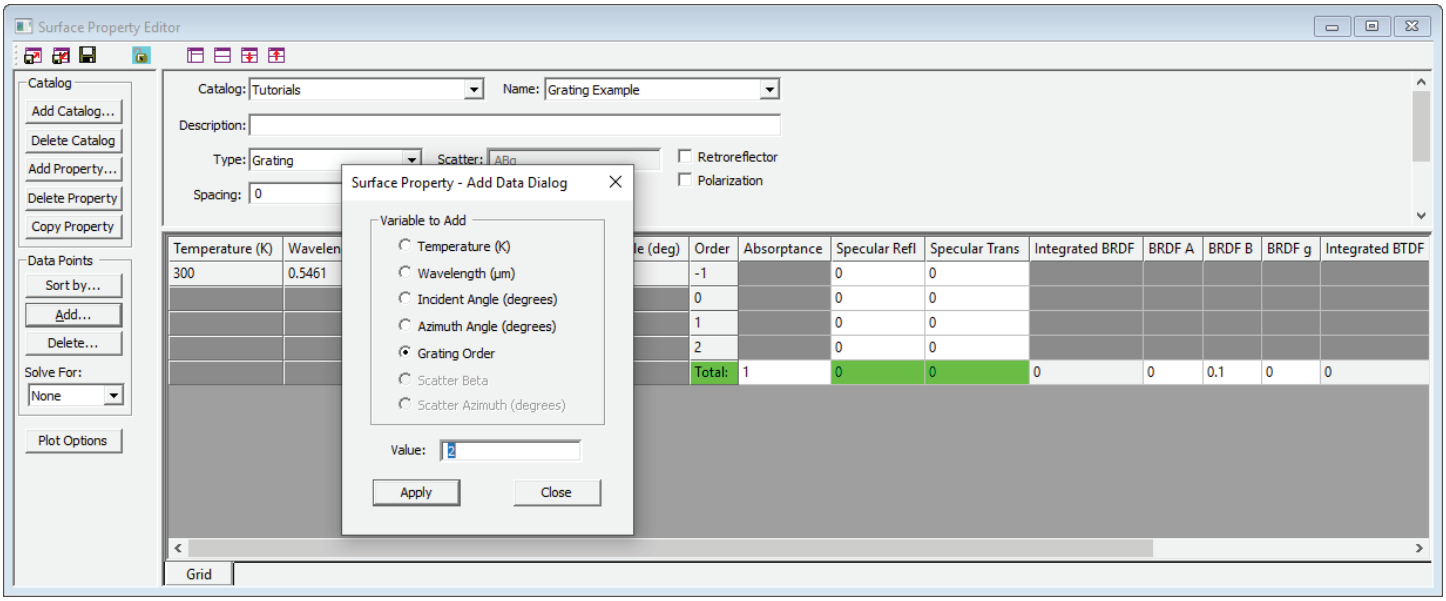
1. Select **Define|Edit Property Data>Surface Properties** to open the *Surface Property Editor*.
2. Select an existing catalog or create a new catalog (Add Catalog) for this new property.
3. Select Add Property, give the property a name, and select the Scatter Model as ABg.
4. In the *Surface Property Editor*, select the property type to be Grating.





Add Grating Orders to the Property

Add grating orders to the surface property by clicking Add in the Data Points section. Add the orders -1, 1, 2 by typing each new order in the Add dialog box and clicking Apply after each one as shown below. Alternateively, you can press the Enter key instead of clicking Apply.

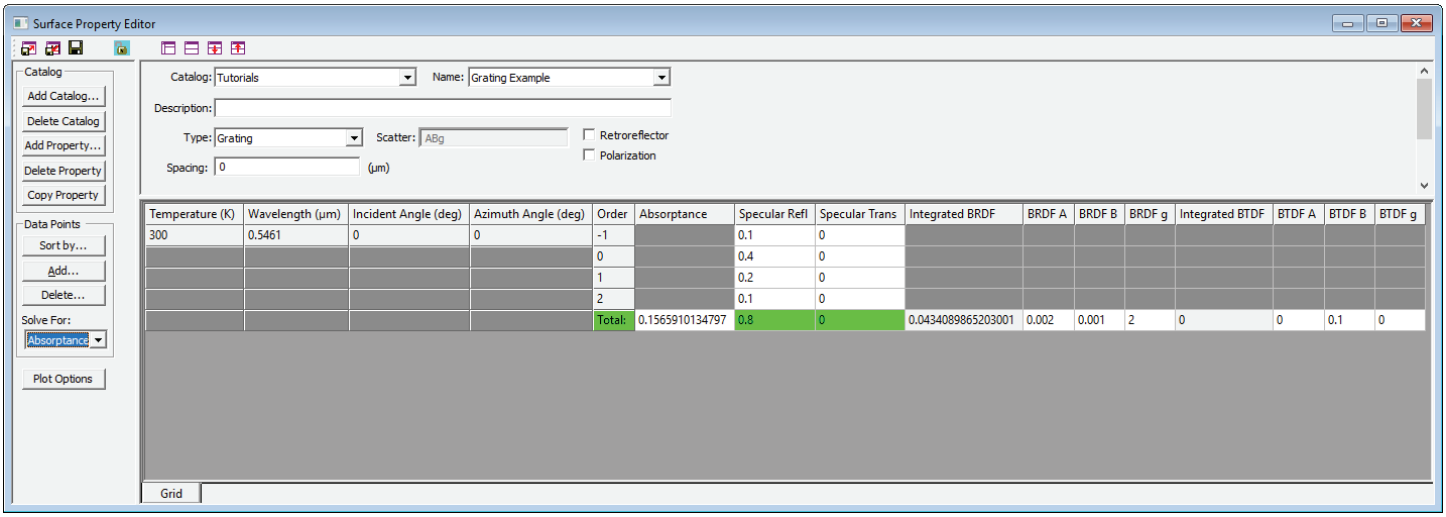


Entering Data in the Grating Surface Property

The efficiency of an order is the fraction of the incident flux that is diffracted into that order. TracePro computes the sum of all the reflection efficiencies and puts that value in the Total row on the on the bottom of the input for the current data subset, and likewise for the transmission efficiencies. For a grating surface property, then, the specular reflectance and transmittance cannot be entered directly as in other Surface Properties. However, the absorptance, BRDF, and BTDF are entered in the usual way, and you may solve for the absorptance, BRDF, or BTDF. You may also enter as many angles of incidence as you wish, the same as for a Table type surface property. Finally, you must enter a value for the grating spacing. This is the distance between the parallel planes used to form the grating.

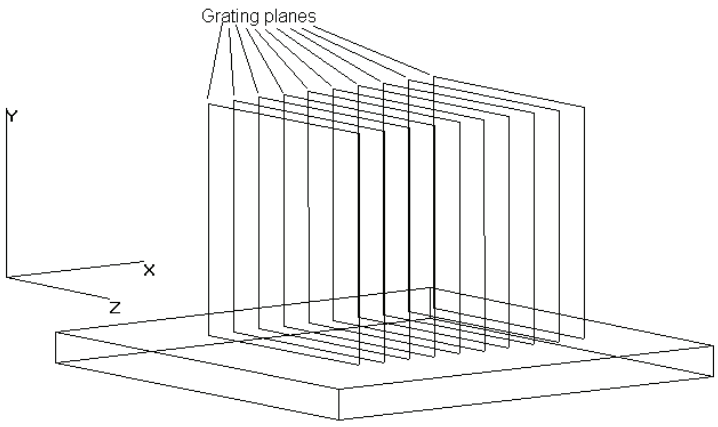
For this example grating surface property, with just one angle of incidence, enter the Grating Spacing as 1, the efficiency for each of the four reflected grating orders as 0.1, 0.4, 0.2, 0.1, define the BRDF with A = 0.002, B = 0.001, and g = 2, then solve for Absorptance.

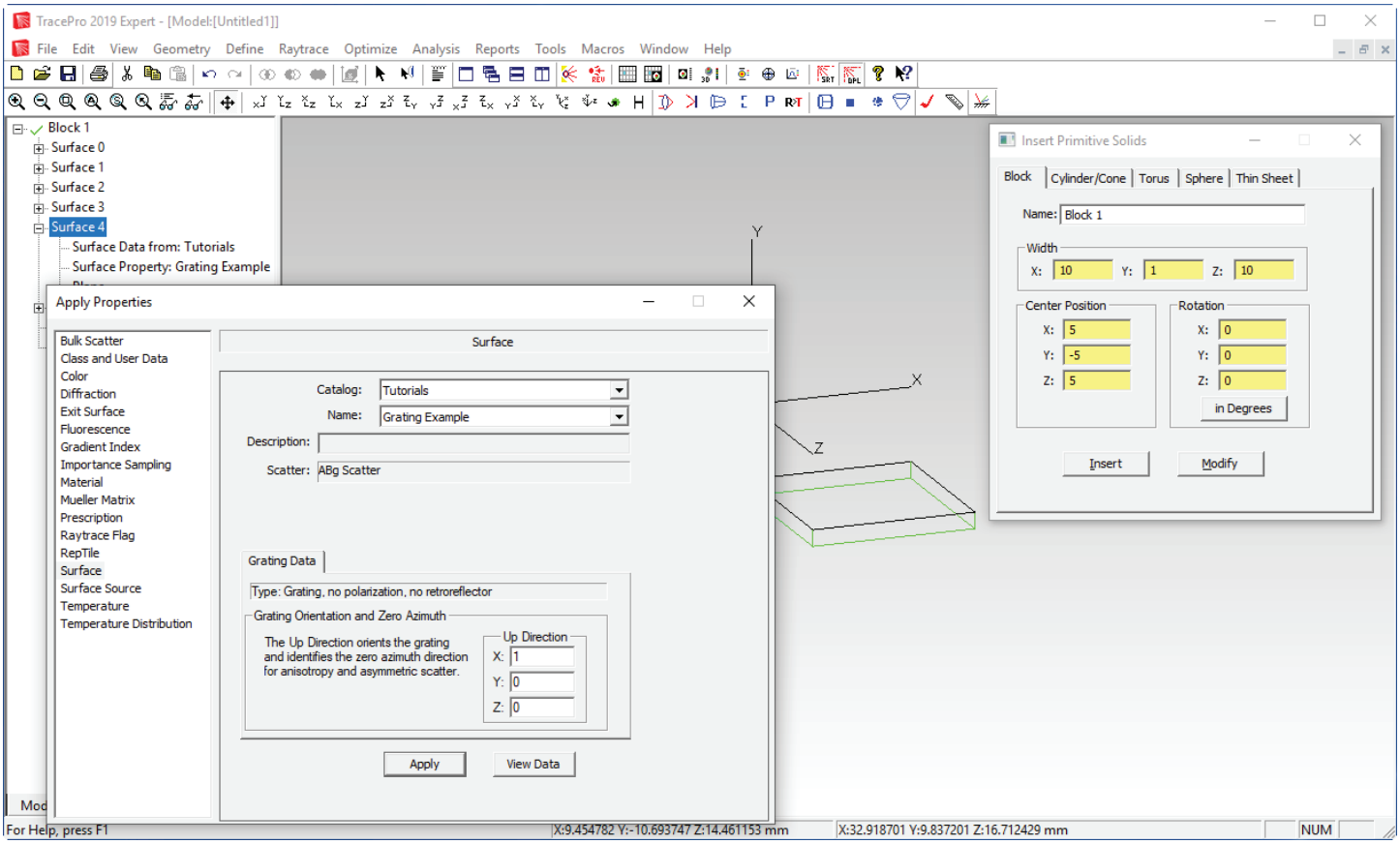
This surface property is a reflection grating, and we have added a BRDF to model scattering as well. When you specify a BRDF, the Integrated BRDF or Total Scatter (TS) will be split up between the diffracted orders, in proportion to the diffraction efficiency. The property is nearly complete. Save the surface property and close the Surface Property Editor.



Applying the Grating Surface Property

1. Select **File|New** to open a new TracePro model, and select **Geometry|Primitive Solids|Block**. Enter the block dimensions shown in the figure below. We will apply the grating property to the +y surface of the block.
2. Select Surface 4 in the system tree and select **Define|Apply Properties|Surface** to open the *Apply Properties* dialog suface page. When you select the grating property from the Surface Property drop-down list, a field appears for an Up Direction to be entered.
3. The Up Direction is a unit vector that is perpendicular tc the grating planes, and points in the direction of positive diffracted orders. The diagram to the right shows a Rectangular substrate with grating formation planes. In this illustration, the grating Up Direction could be along the +x or -x axis.
4. For our model, enter (1,0,0) for the Up Vector, and click Apply. This orientation makes the positive diffracted orders go towards the +x direction, while the negative orders will go toward the -x direction.



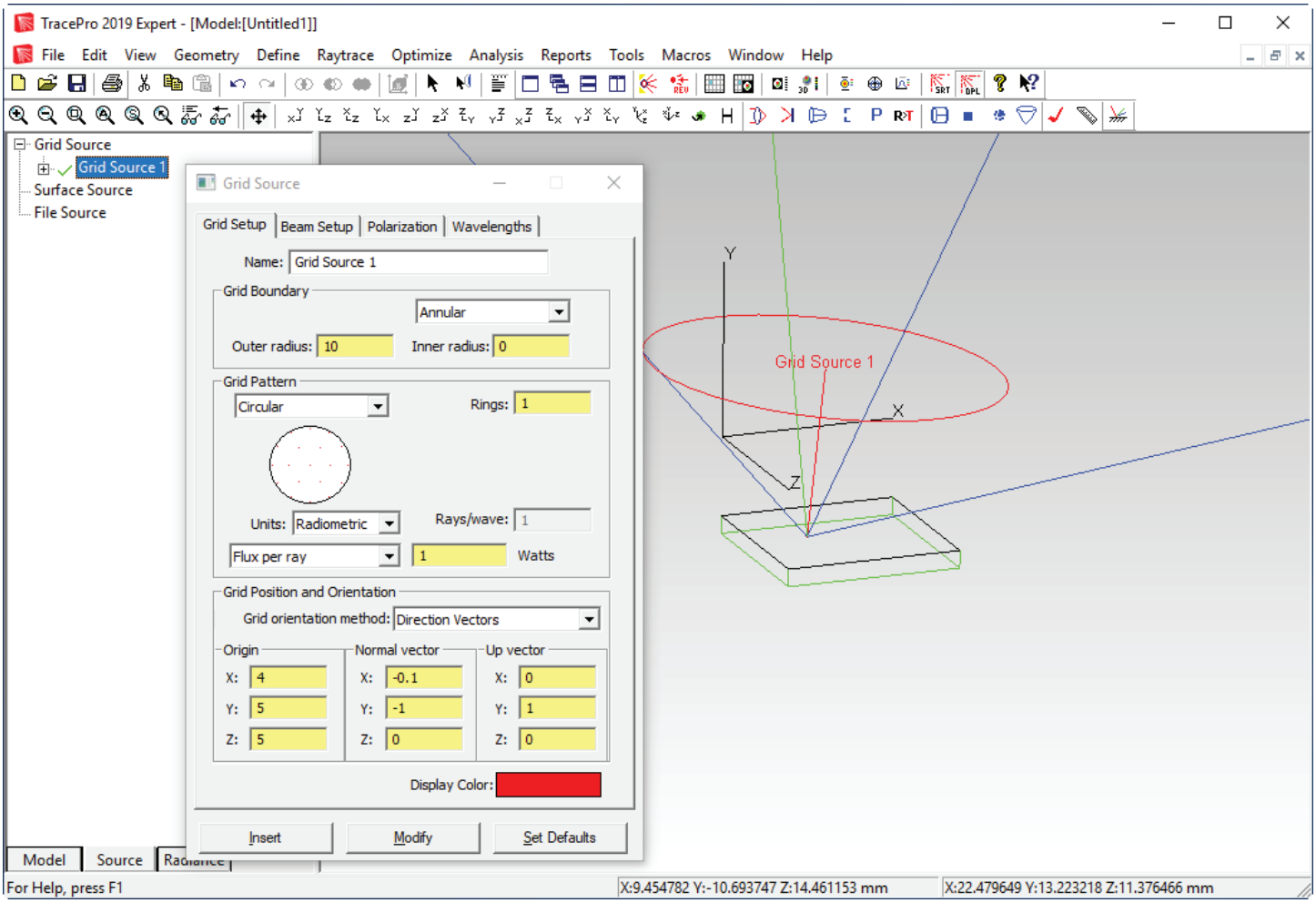


Ray-tracing a Grating Surface Property

When a ray intersects a surface with a grating surface property applied, TracePro will interpolate the efficiency data for the given angle of incidence. If the direction of incidence is such that one or more orders cannot exist, the flux from those orders will be allocated to the remaining orders, in proportion to their efficiencies.

To trace rays in our model, select the Source tab of the System Tree, and turn on Grid Source 1 by changing the red x to a green check. Double-click on Grid Source 1 and enter the values shown below, then select **Raytrace|Trace Rays** to begin the raytrace.

In our grating property, the grating has reflected orders only, and a BRDF is defined. The scattered rays have flux below the default flux threshold of 0.05, so they are not traced.



2nd Raytrace with lower Flux Threshold

Select **Raytrace|Raytrace Options|Thresholds** and set the flux threshold to 0.001, then repeat the raytrace. Now the lower-flux scattered rays are traced, and there is one scattered ray for each diffracted order.