

Diffraction Gratings

Requirements

Models: None

Properties: None

Editions: TracePro Standard or Expert

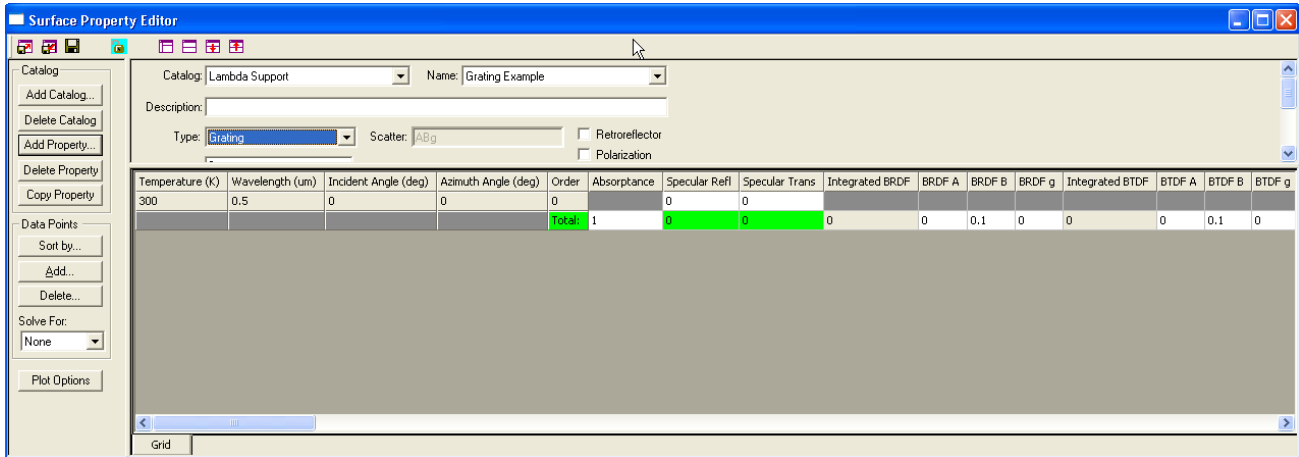
Introduction

To model a diffraction grating in TracePro, a surface property of type “Grating” must be created to specify the diffraction efficiency of each grating order, then the property must be applied to a surface in the model.

TracePro handles 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.

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, 0, 1, 2 by typing each new order in the Add dialog box and clicking Apply after each one as shown below.

The screenshot shows the TracePro Expert - [Surface Property Editor] window. The main window displays the Surface Property dialog for a 'Grating Example' with the following data table:

Temperature (K)	Wavelength (um)	Incident Angle (deg)	Azimuth Angle (deg)	Order	Absorbance	Specular Refl	Specular Trans	Integrated BRDF	BRDF A	BRDF B	BRDF g	Integrated BTDF	BTDF A	BTDF B	BTDF g
300	0.5	0	0	-1		0	0								
				0		0	0								
				1		0	0								
				2		0	0								
				Total	1	0	0	0	0	0.1	0	0	0	0.1	0

The 'Surface Property - Add Data Dialog' is open, showing the 'Variable to Add' section with the following options:

- Temperature (K)
- Wavelength (microns)
- Incident Angle (degrees)
- Azimuth Angle (degrees)
- Grating Order
- Scatter Beta
- Scatter Azimuth (degrees)

The 'Value' field is set to 2. The 'Apply' button is highlighted.

For Help, press F1

Entering Data in the Grating Surface Property

The efficiency 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 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, a value must be entered for the grating spacing. This is the distance between the parallel planes used to form the grating.

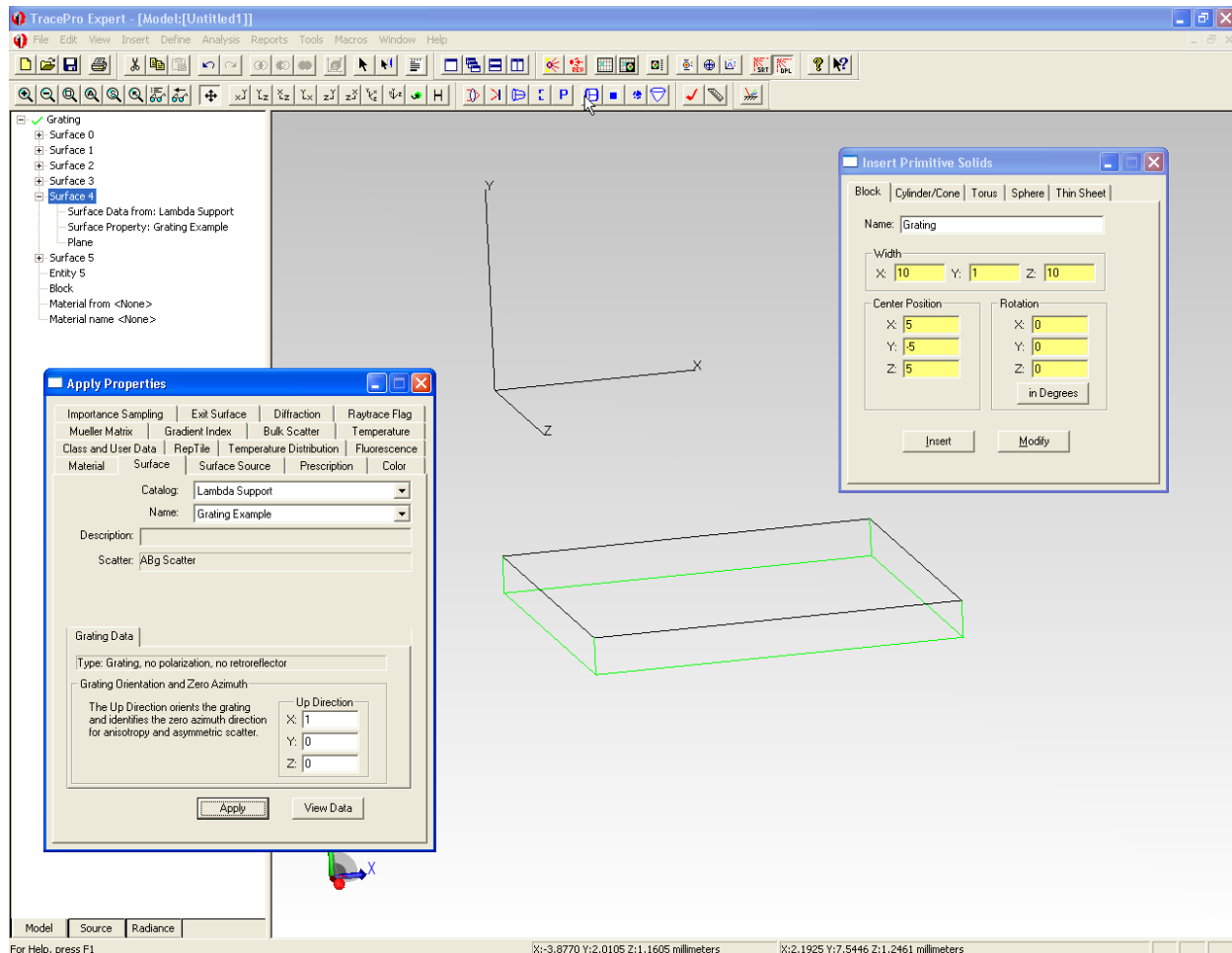
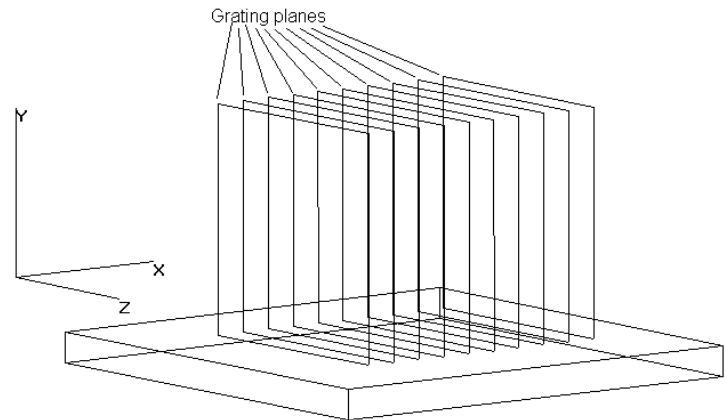
For this example grating surface property, with just one angle of incidence, enter the efficiency for each of the 4 grating orders, define the BRDF with $A = 0.002$, $B = 0.001$, and $g = 2$, then solved for Absorptance.

This surface property is a reflection grating, and we have added a BRDF 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 efficiency.

Temperature (K)	Wavelength (um)	Incident Angle (deg)	Azimuth Angle (deg)	Order	Absorptance	Specular Refl	Specular Trans	Integrated BRDF	BRDF A	BRDF B	BRDF g	Integrated BTDF	BTDF A	BTDF E
300	0.5	0	0	-1		0.1	0							
				0		0.4	0							
				1		0.2	0							
				2		0.1	0							
				Total	0.1565910134797	0.8	0	0.0434089865203001	0.002	0.001	2	0	0	0.1

Applying the Grating Surface Property

1. Select File/New to open a new TracePro Model, and select Insert/Primitive Solids/Block to create an object for the Grating Surface Property to be applied to.
2. Select Surface 4 in the System Tree and select Define|Apply Properties|Surfacet to open the Apply Properties dialog. 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 to 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 example, 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.

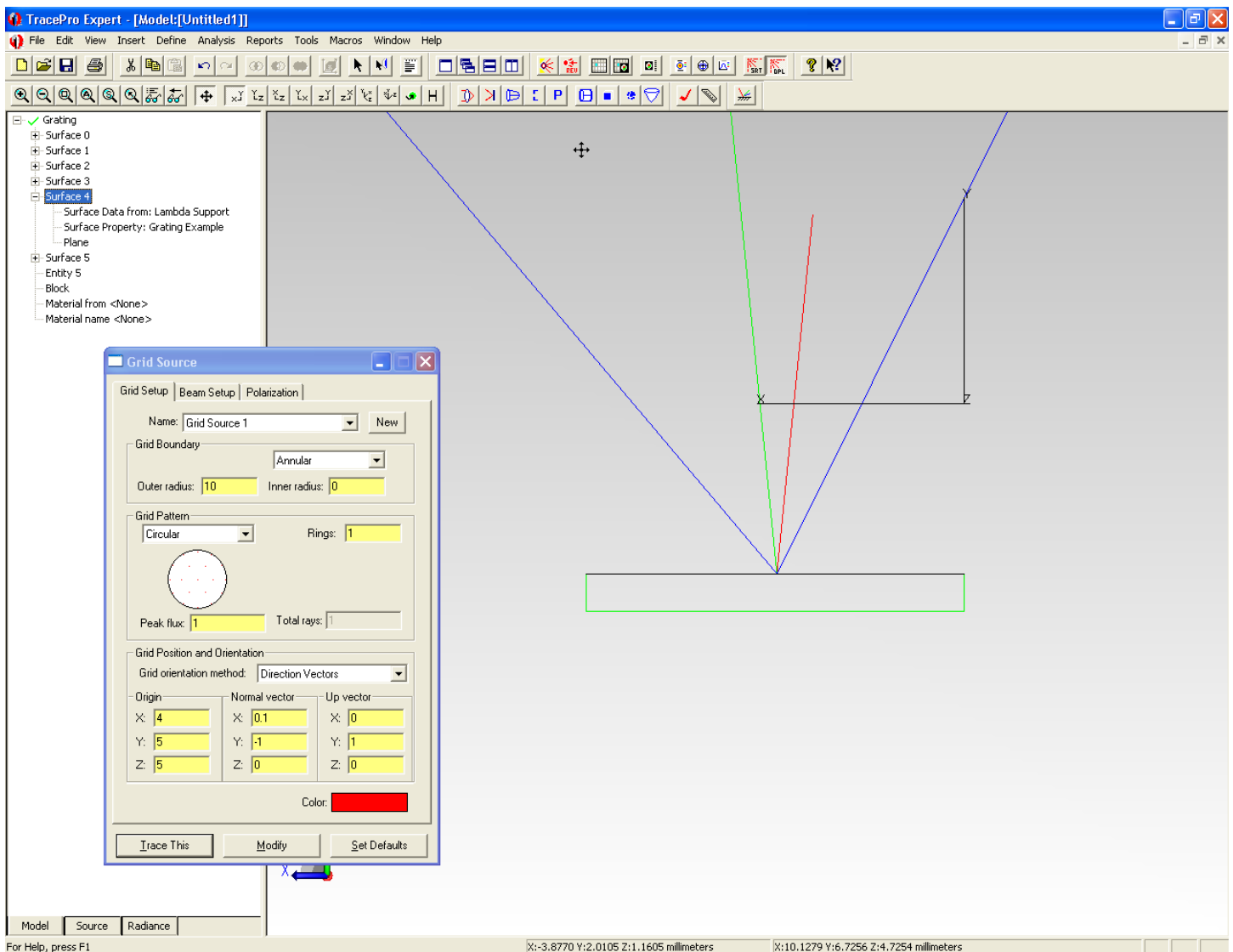


Raytracing a Grating Surface Property

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 given to the remaining orders, in proportion to their efficiencies.

To trace rays in our model, select Define/Grid Source, enter the values shown below, then click “Trace This”

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 Analysis/raytrace options/Thresholds and decrease 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.

