Grating Examples

Grating structure examples for MC Grating codes package

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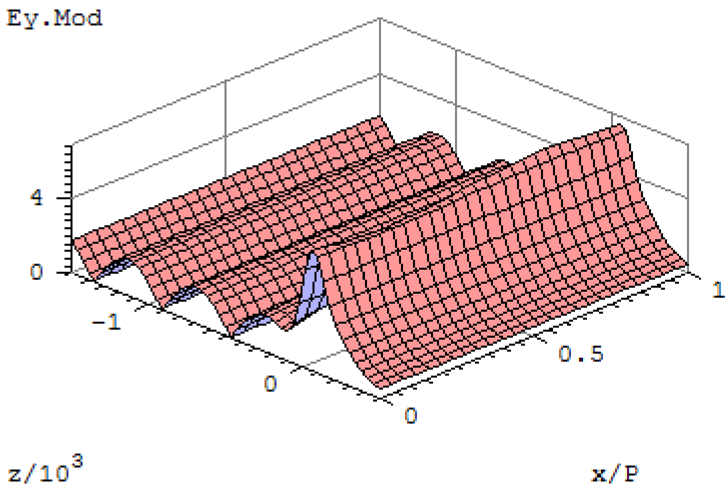
1 Chandezon collinear

1.1 Classic

1.1.1 The example of a single resonance excitation in a corrugated waveguide by a plane wave having the TE polarization under 45 degrees incidence.

Settings are arranged for the **E**-field modulus scanning inside the structure and in ambient media.

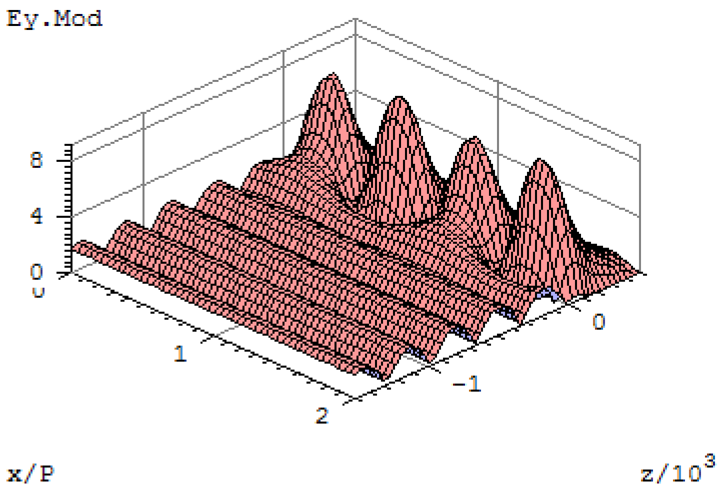
Open the source file **Single_TE_Res_45deg.cha** and press the ***Run*** button and then press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Front***.



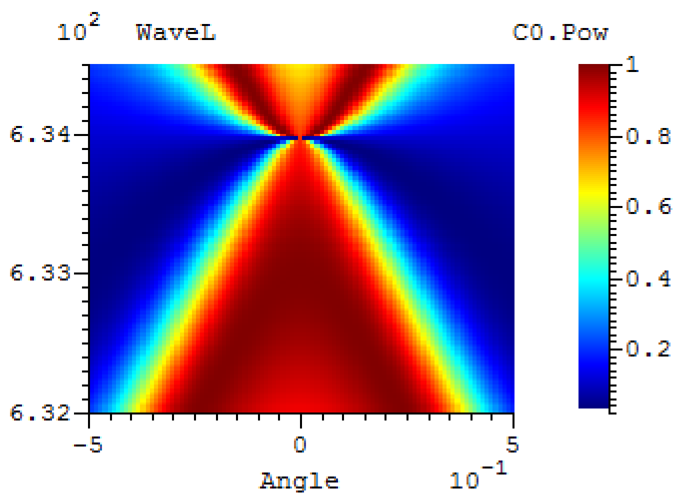
1.1.2 The example of a double resonance excitation in a corrugated waveguide by a plane wave having the TE polarization under normal incidence.

Settings are arranged for:

a) The **E** field modulus scanning inside the structure and in ambient media.
Open the source file **Doub_TE_Res_Refl_Field.cha** and press the ***Run*** button and then press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Front***.

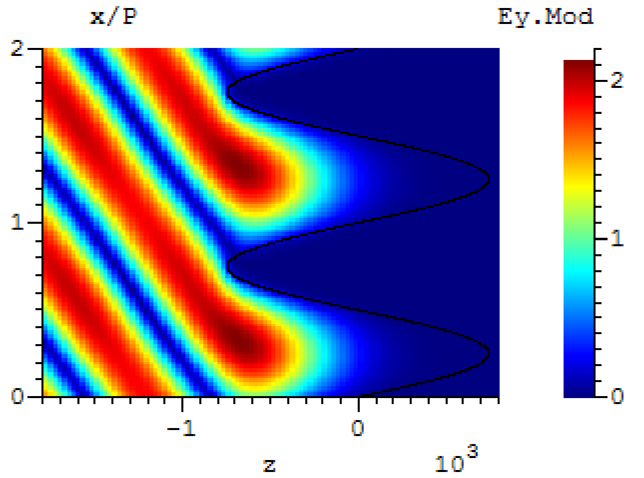


b) Reflection scanning versus angle and wavelength both close to the resonance values.
Go to ***Settings*** -> ***Scanning*** and enable page ***Scanning***.
Press the ***Run*** button and wait for result and then press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.



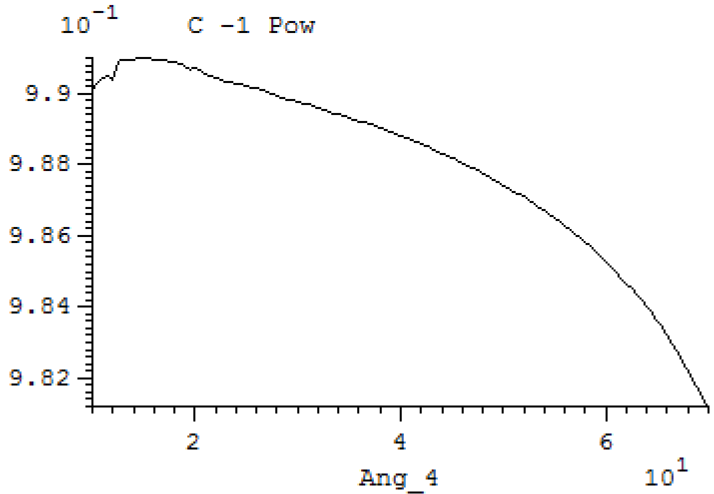
1.1.3 The example demonstrates high efficient metal sinusoidal grating in Littrow condition for the TE polarization. A substrate refractive index is close to the Aluminum real value refractive index at the 1000 nm wavelength.

Open the source file **Littrow.cha** and press the ***Run*** button for evaluating diffraction efficiencies. Press the ***Run*** button again and then press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.



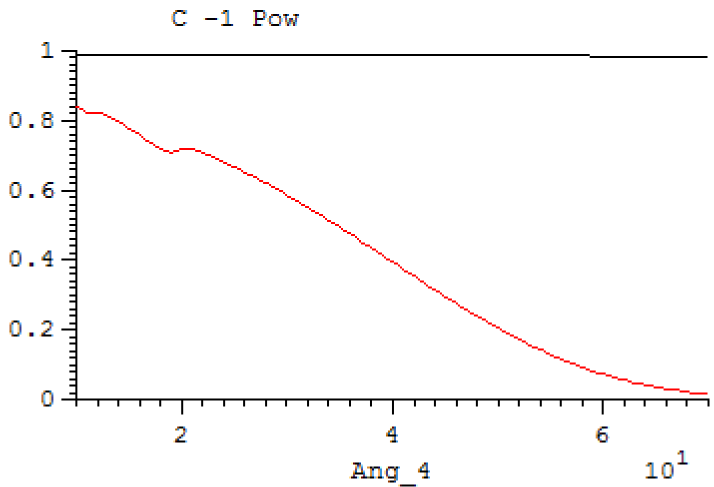
1.1.4 The example of a Littrow reflection versus incident angle of a plane wave having the TM polarization from a triangular cupper grating for rear copper mirror CO2 laser of radial polarization. Advanced scanning was used with the expectation that the incident radiation was normal for a leg of the triangle. There are two variants: first - the scan data were prepared outside the MC Grating code in form of the built-in table and second – the incident conditions are provided by the built-in equations.

This example was designed to investigate of a Littrow reflection versus incident angle of a plane wave having the **TM** polarization from a triangular cupper grating. This calculation is due to the further application of optimal parameters for the design of a concentric diffraction grating on the surface of the copper cone rear mirror for the radial polarization selection of CO_2 laser.

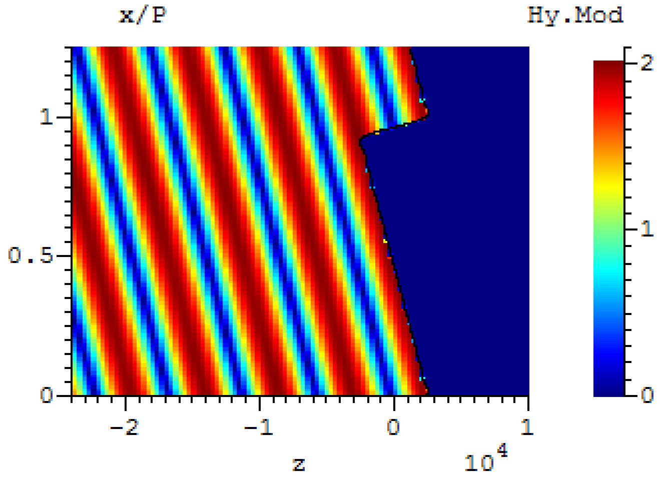


Open the source file **Littrow_CO2_Table.cha** or. **Littrow_CO2_Equations.cha.**

a) Press the ***Run*** button and then press the ***Graph*** button, select **ANG_4** as a ***X*** column and press ***OK*** button.
b) To see the **TE** - **TM** reflection contrast. Go to ***General***, change ***Polarization*** to **TE** and repeat the previous instructions (with red curve color).



To see reflection coefficient and field distribution open the source file **Littrow_CO2_Fld.cha**. Press ***Run***, then once again the key and button ***Graph.*** If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale*.**

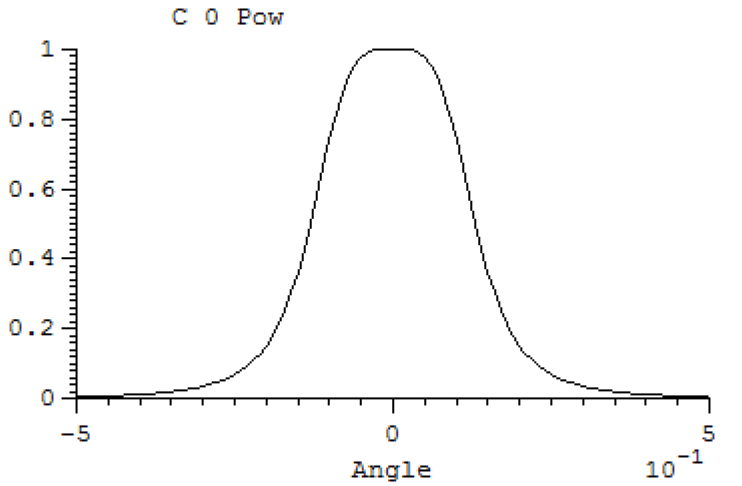


1.1.5 The example of abnormal mirror for laser diode array synchronization

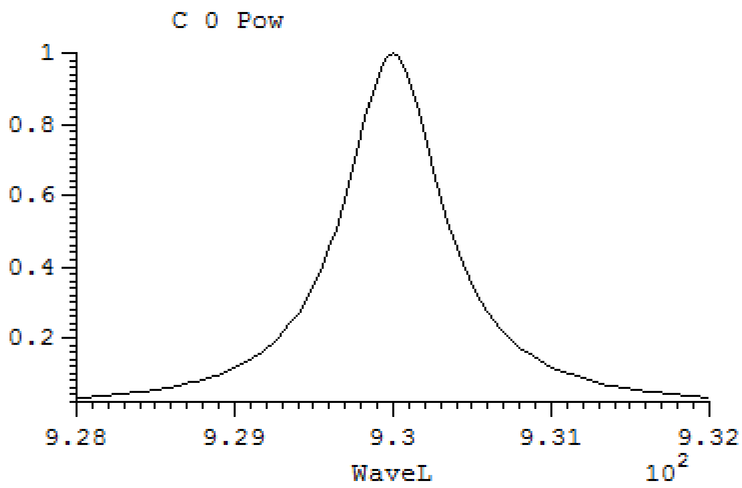
The example is taken from the paper [Quantum Electronics 42(6) 561-564(2012)] and is adapted for demo version.

Open the source file **Abnormal_Mirror.cha**.

a) For evaluating angular reflection spectrum press the ***Run*** and the ***Graph*** button**.**



b) For evaluating wavelength reflection spectrum go to ***Settings*** -> ***Scanning*** select ***Wavelength*** as ***Scanning of***, press the ***Run*** and the ***Graph*** button.



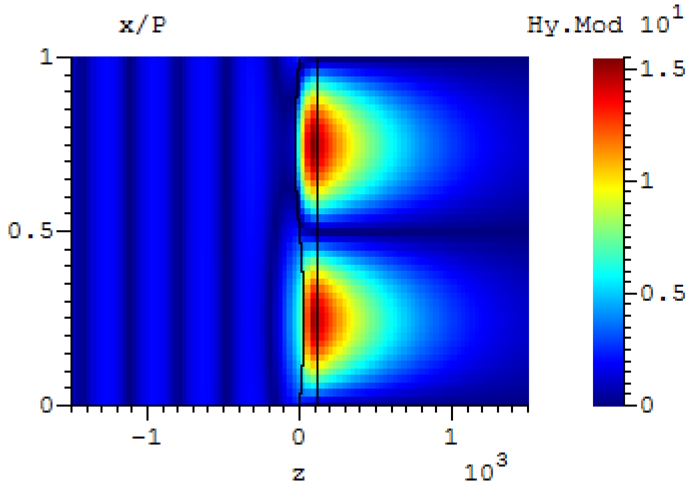
c) Press the ***Optimize*** button to evaluate optimization functionality.

1.2 Extended

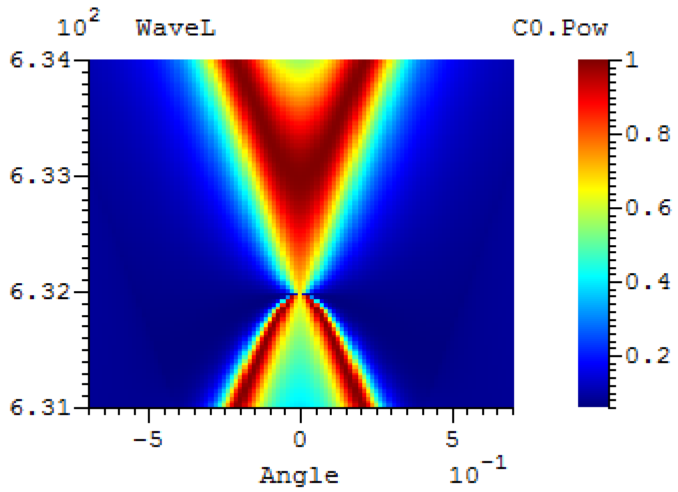
1.2.1 The example of a double resonance excitation in a corrugated waveguide by a plane wave having the TM polarization under normal incidence.

Settings are arranged for:

a) Magnetic field modulus scanning inside the structure and in ambient media.
Open the source file **Doub_TM_Res_Refl_Field.cha** and press the ***Run*** button and then press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.



b) Reflection scanning versus angle and wavelength both close to the resonance values.
Go to ***Settings*** -> ***Scanning*** and enable page ***Scanning***.
Press the ***Run*** button and wait for result then press the ***Graph*** button.

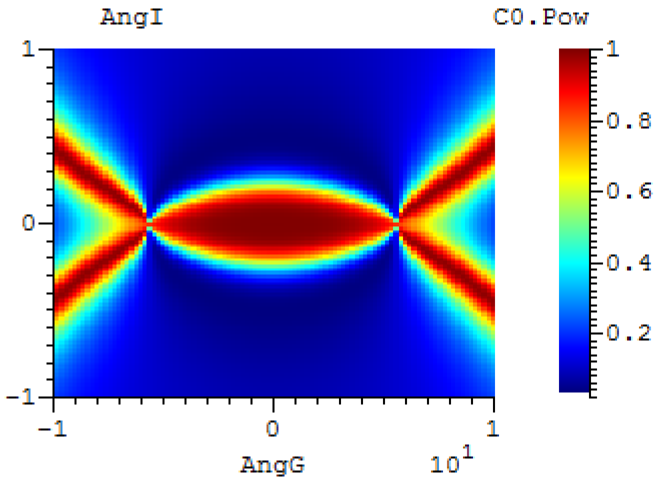


2 Chandezon conical

2.1 Classic

2.1.1 The example of a double resonance excitation in a corrugated waveguide by a plane wave having the TE polarization under normal incidence. The example also demonstrates the *Grating based* coordinate system use.

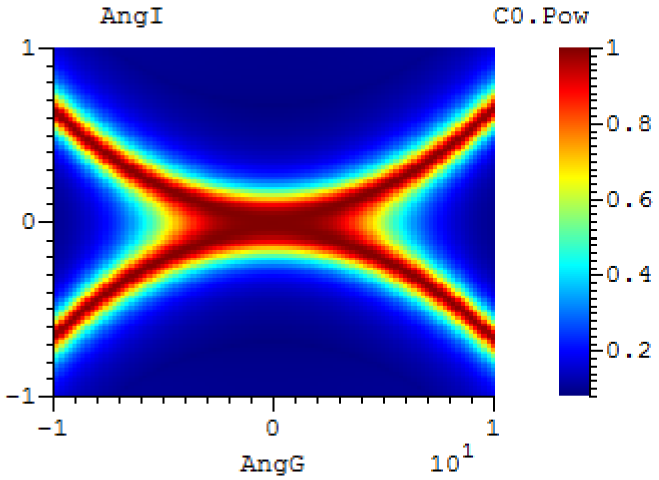
Settings are arranged for reflection scanning versus two angles close to the normal. The incidence wave **E** field projection on a structure plane remains parallel to the grating grooves. Open the source file **Doub_TE_Res_AngI_AngG.cha** and press the ***Run*** button and wait for result then press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.



2.2 Extended

2.2.1 The example of a double resonance excitation in a corrugated waveguide by a plane wave having the TM polarization under normal incidence.

Settings are arranged for the reflection scanning versus two angles close to the normal. Incidence wave **H** field projection on structure plane remains parallel to the grating grooves.
Open the source file **Doub_TM_Res_AngI_AngG.cha** and press the ***Run*** button and wait for result then press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.



3 Chandezon crossed

3.1 Classic

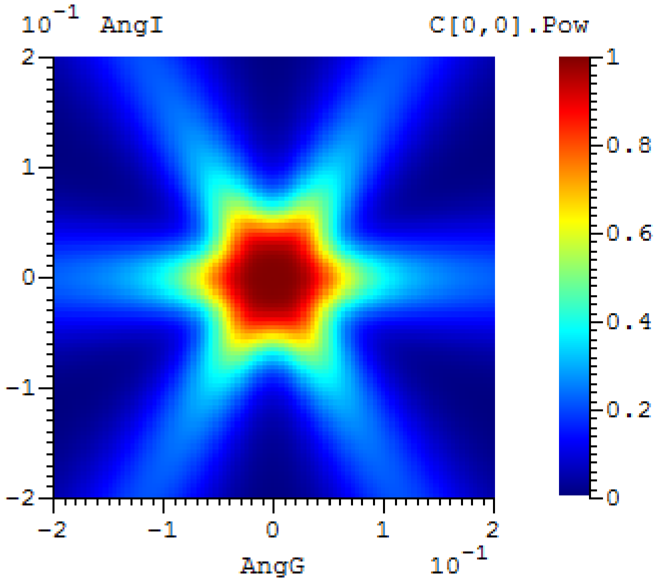
3.1.1 The example of a hexagonal grating of high period resonance excitation in all interfaces corrugated waveguide by a plane wave near normal incidence.

The example also demonstrates the Grating based coordinate system use.

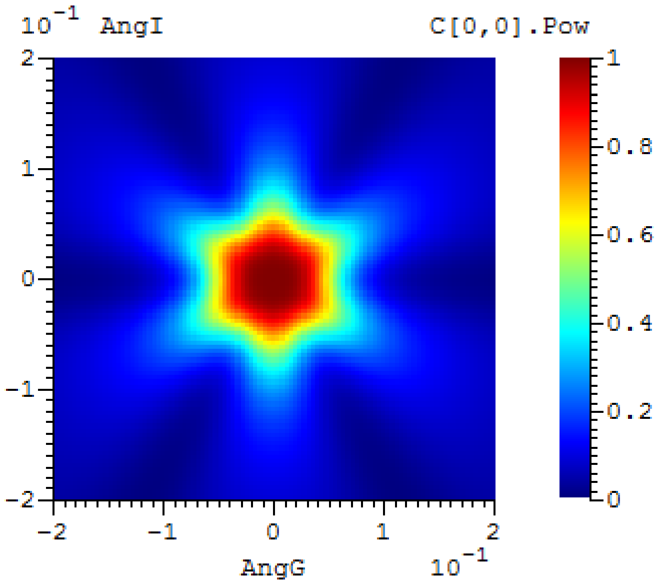
a) Settings are arranged for reflection scanning versus two angles close to the normal.

The incidence wave has the **TE** polarization state (***State*** angle equals to zero).

To see a **TE** polarization incidence open the source file **Classic_High_Per.cha** press the ***Run*** button and wait for several hours. Software will calculate a reflection for positive angles quarter. When calculation will be finished position mouse to result area, press the right mouse button and select ***Symmetrize Data*** option to extend results for negative angles (instead of all the previous open file **Classic_High_Per_TE.dat**) and press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.



b) To see a **TM** polarization incidence wave reflections go to ***Settings*** -> ***General*** and change the ***State*** angle to 90 degrees, press the ***Run*** button, ***Symmetrize Data*** (instead of all the previous open file **Classic_High_Per_TM.dat**) and press the ***Graph*** button.

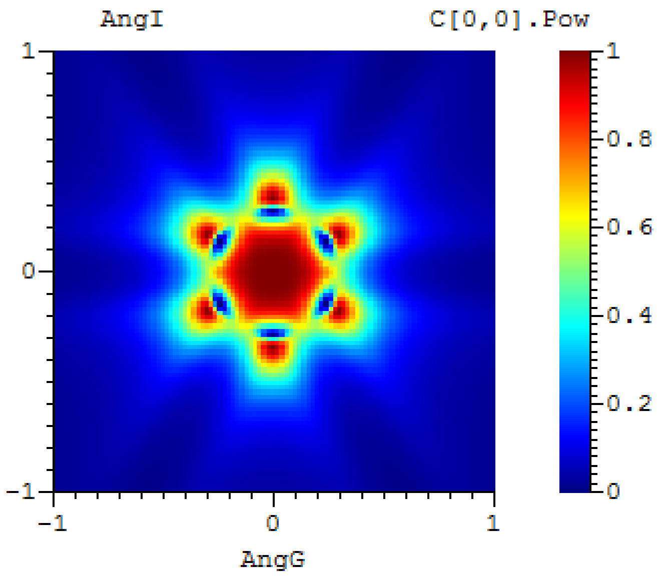


3.1.2 The example of a hexagonal grating of low period resonance excitation in all interfaces corrugated waveguide by a plane wave near normal incidence.

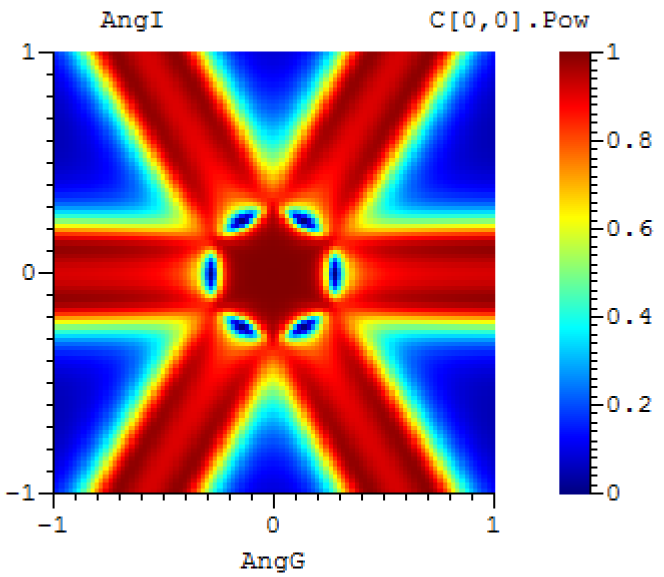
The example also demonstrates the Grating based coordinate system use.

a) Settings are arranged for reflection scanning versus two angles close to the normal. The incidence wave has the **TE** polarization state (***State*** angle equals to zero).

To see a **TE** polarization incidence open the source file **Classic_Low_Per.cha** press the ***Run*** button and wait for several hours. Software will calculate a reflection for positive angles quarter. When calculation will be finished position mouse to result area, press the right mouse button and select ***Symmetrize Data*** option to extend results for negative angles (instead of all the previous open file **Classic_Low_Per_TE.dat**) and press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.



b) To see a **TM** polarization incidence wave reflections go to ***Settings*** -> ***General*** and change the ***State*** angle to 90 degrees, press the ***Run*** button, ***Symmetrize Data*** (instead of all the previous open file **Classic_Low_Per_TM.dat**) and press the ***Graph*** button.



3.2 Extended

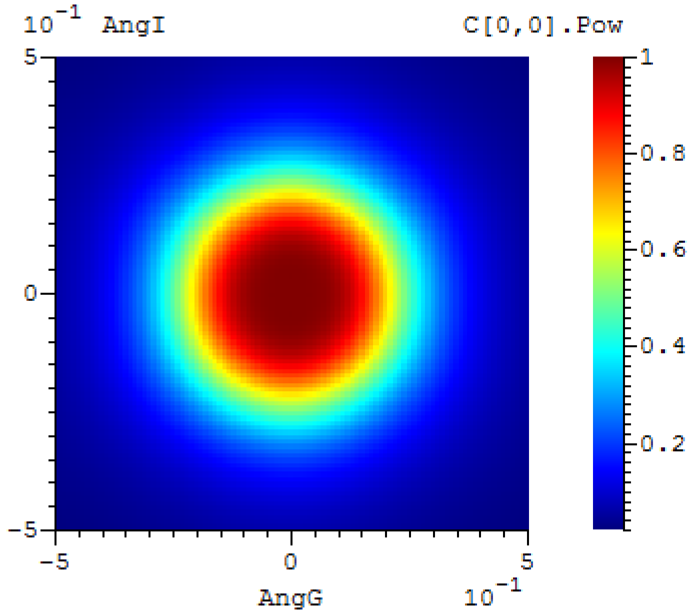
3.2.1 The extended method example of a hexagonal grating of high period resonance excitation in a cover interface corrugated waveguide by a plane wave near normal incidence.

The example also demonstrates the Grating based coordinate system use.

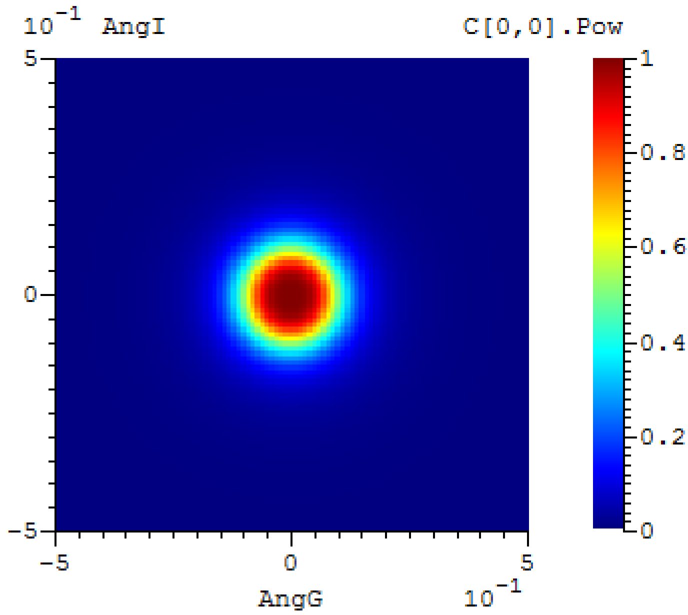
a) Settings are arranged for reflection scanning versus two angles close to the normal.

The incidence wave has the **TE** polarization state (***State*** angle equals to zero).

To see a **TE** polarization incidence open the source file **Extended_High_Per.cha** press the ***Run*** button and wait for several hours. Software will calculate a reflection for positive angles quarter. When calculation will be finished position mouse to result area, press the right mouse button and select ***Symmetrize Data*** option to extend results for negative angles (instead of all the previous open file **Extended_High_Per_TE.dat**) and press the ***Graph*** button.
If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.



b) To see a **TM** polarization incidence wave reflections go to ***Settings*** -> ***General*** and change the ***State*** angle to 90 degrees, press the ***Run*** button, ***Symmetrize Data*** (instead of all the previous open file **Extended_High _Per_TM.dat**) and press the ***Graph*** button.



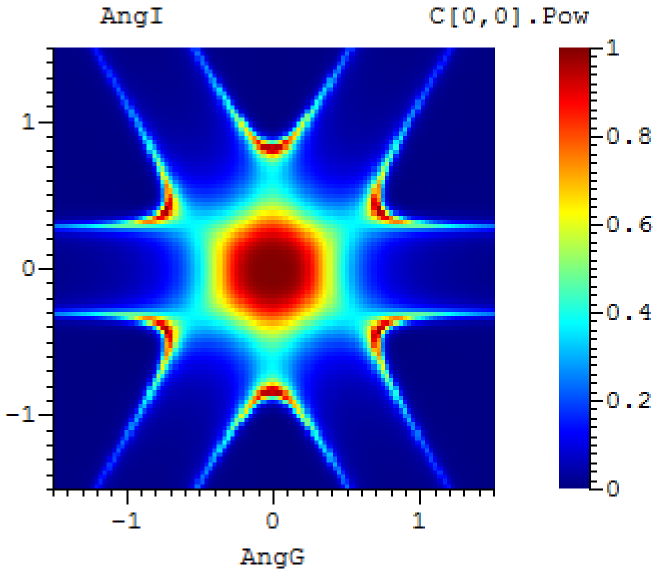
3.2.2 The extended method example of a hexagonal grating of low period resonance excitation in a cover interface corrugated waveguide by a plane wave near normal incidence.

The example also demonstrates the Grating based coordinate system use.

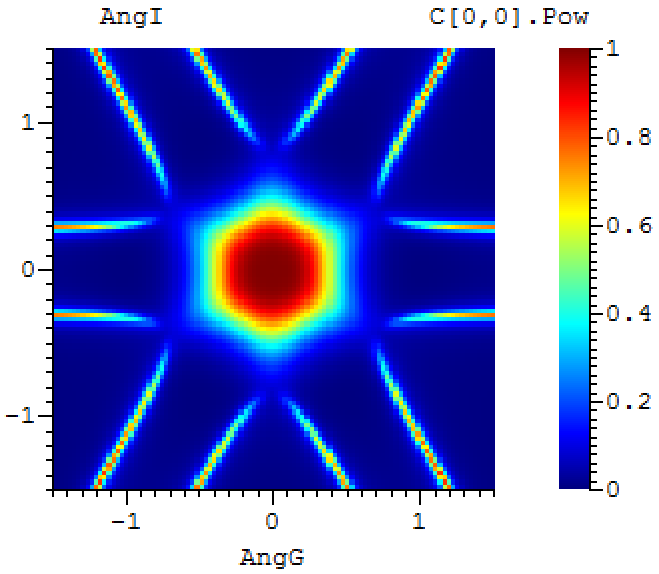
a) Settings are arranged for reflection scanning versus two angles close to the normal.

The incidence wave has the **TE** polarization state (***State*** angle equals to zero).

To see a ***TE*** polarization incidence open the source file **Extended_Low_Per.cha** press the ***Run*** button and wait for several hours. Software will calculate a reflection for positive angles quarter. When calculation will be finished position mouse to result area, press the right mouse button and select ***Symmetrize Data*** option to extend results for negative angles (instead of all the previous open file **Extended_Low_Per_TE.dat**) and press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.



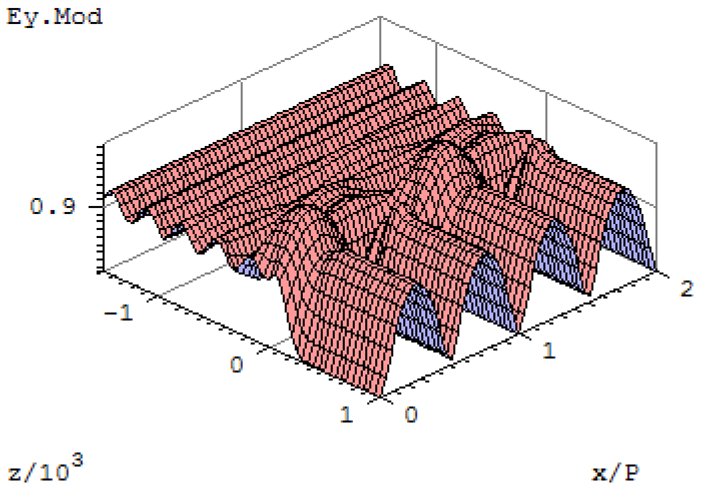
b) To see a **TM** polarization incidence wave reflections go to ***Settings*** -> ***General*** and change the ***State*** angle to 90 degrees, press the ***Run*** button, ***Symmetrize Data*** (instead of all the previous open file **Extended_Low_Per_TM.dat**) and press the ***Graph*** button.



4 Modal collinear

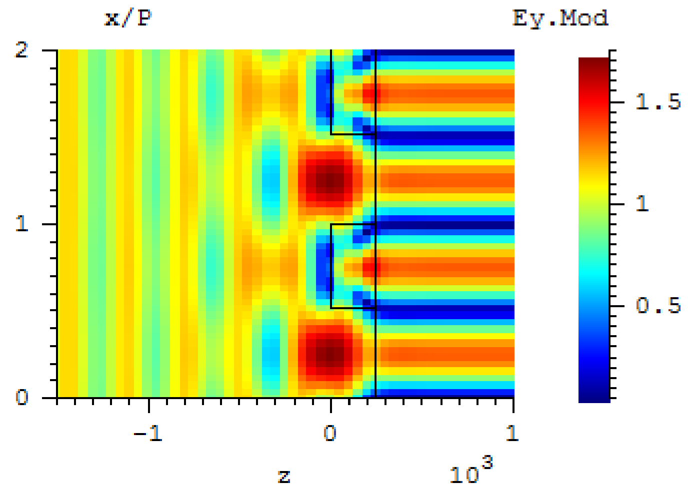
4.1 The example demonstrates the grating having zero transmission in zero order for the TE polarization.

Open the source file **ZeroTransm_0-order.mdl**. There are several successive options:



a) Press the ***Run*** button to evaluate diffraction efficiencies.

b) Press the ***Run*** button again and then press the ***Graph*** button for the field distribution. If necessary, in the ***Graph*** window go to ***View*** and select ***Back***.

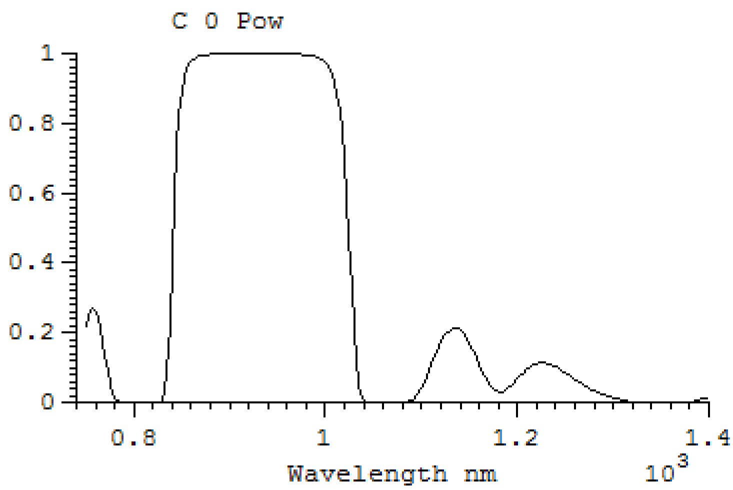


c) In the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.

d) Press the ***Optimize*** button to evaluate optimization functionality.

4.2 The example of a multilayer mirror design using an optimization.

The example is taken from the paper [Quantum Electronics 30(1) 13-14(2000)] and is adapted for demo version.



Open the source file **MLMirror.mdl**. There are several options:
a) Press the ***Run*** button and then press the ***Graph*** button to see a Mirror wavelength reflection graph.

b) Press the ***Optimize*** button to evaluate the optimization functionality.

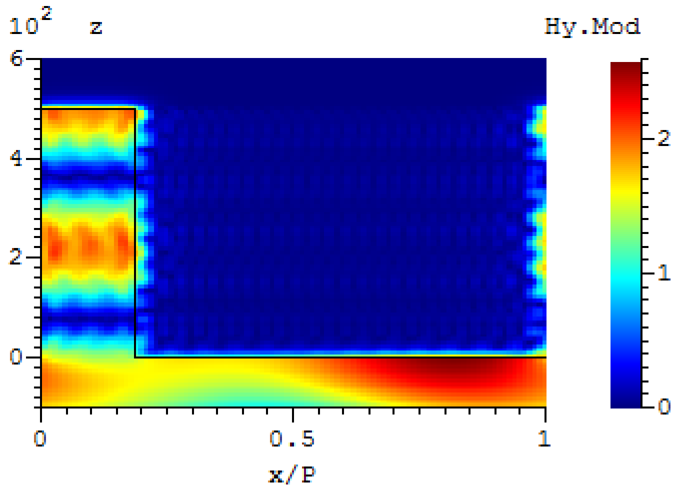
4.3 The example of modes filtering effect for high refractive index contrast ideal metal grating.

The example is taken from the paper J. Opt. Soc. Am. A, Vol. 24, pp. 3781-3788 (2007) and is adapted for demo version.

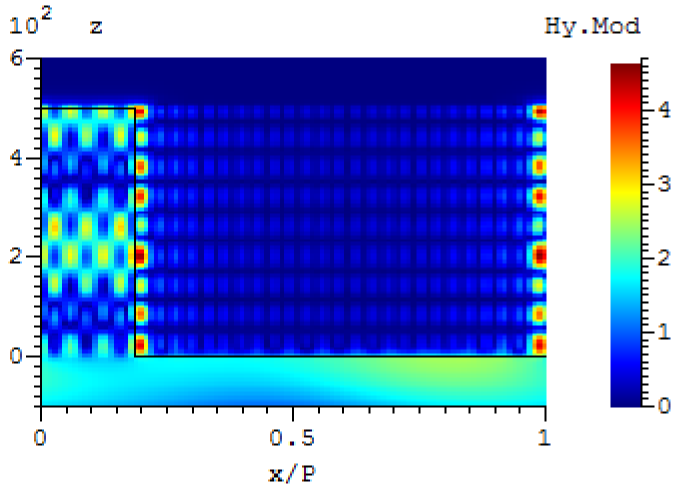
Settings are arranged for the field calculation and for the diffraction efficiency scan versus groove width.

Open the source file **RCWA.mdl**. There are several successive options.

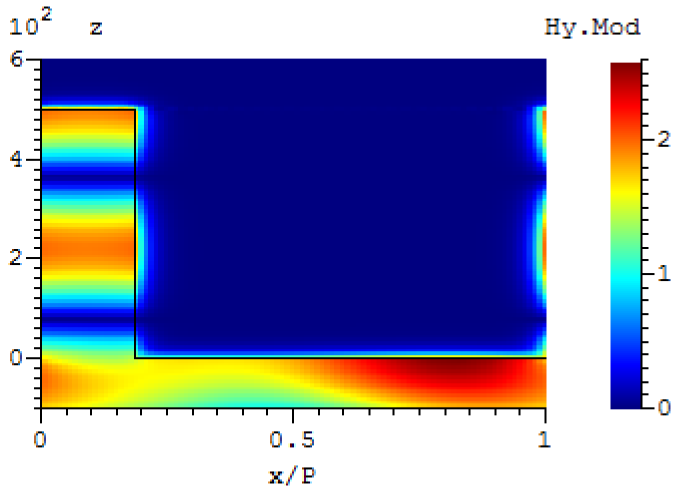
a) For the **FMM** field calculation with modes filtering press the ***Run*** button. When the calculation is finished press the ***Graph*** button.



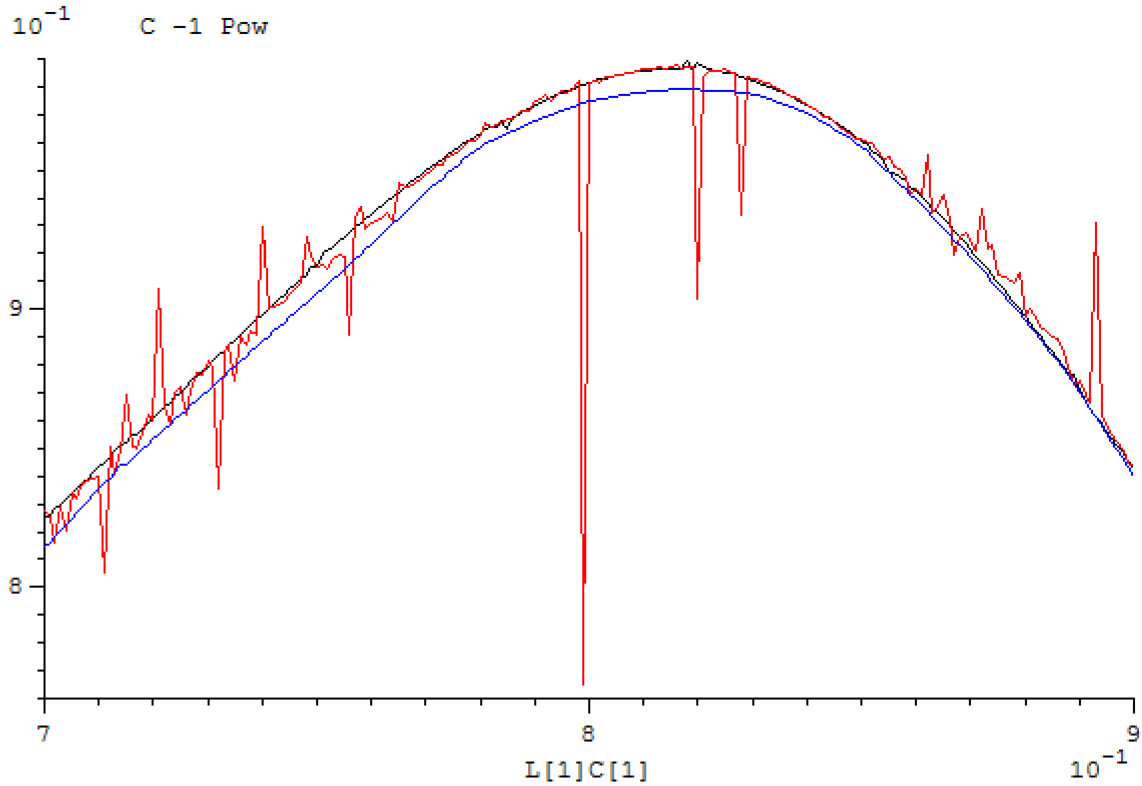
b) For the **FMM** field calculation without modes filtering go to ***Setting*** -> ***Options*** uncheck ***Neff Filter Level*** box. Press the ***Run*** button. When the calculation is finished press the ***Graph*** button.



c) For the **TMM** field calculation go to ***Setting*** -> ***General*** select ***True Modes***. Press the ***Run*** button. When the calculation is finished press the ***Graph*** button.

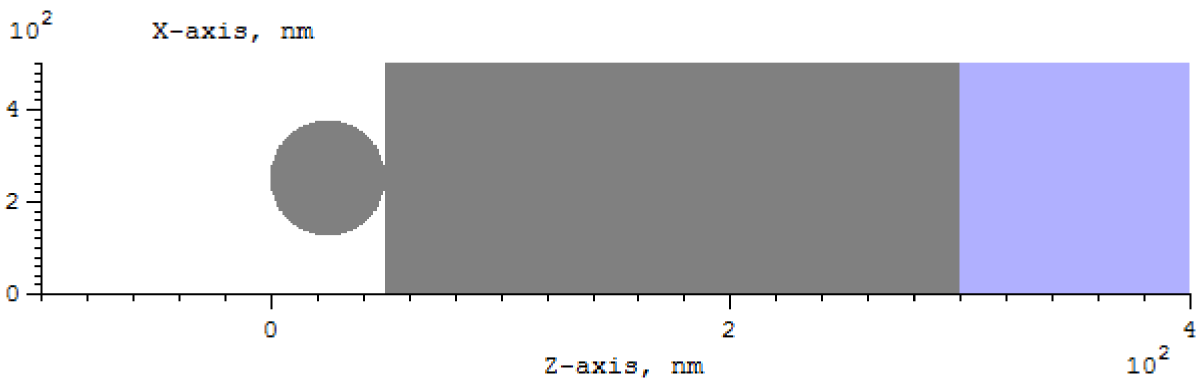


d) For the **TMM** diffraction efficiency scan go to ***Setting*** -> ***Options*** uncheck ***Field Calculation*** box. Press the ***Run*** button. When the calculation is finished press the ***Graph*** button.
e) For the **FMM** diffraction efficiency scan without modes filtering go to ***Setting*** -> ***General*** select ***Fourier Modes***. Press the ***Run*** button. When the calculation is finished press the ***Graph*** button and select red color.
f) For the **FMM** diffraction efficiency scan with modes filtering go to ***Setting*** -> ***Options***. check ***Neff Filter Level*** box. Press the ***Run*** button. When the calculation is finished press the ***Graph*** button and select blue color.



4.4 The example of a grating profile generation from a data file.

Open any sample from the ***File*** -> ***Samples*** menu. Go to ***Settings*** -> ***Layers*** and press the ***Convert*** button to open ***Layer Conversion*** window. For example type 100 in the field ***Number of Sub Layers***. In ***Conversion Type*** combo box select the ***Profile From File*** item and then from the **Profile files -> Modal 1D** folder select ***ProfileCylinder 1*** data file and press ***OK*** button. Close the ***Settings*** window and go to the ***Service Window*** -> ***Grating Profile*** menu to evaluate the grating profile.

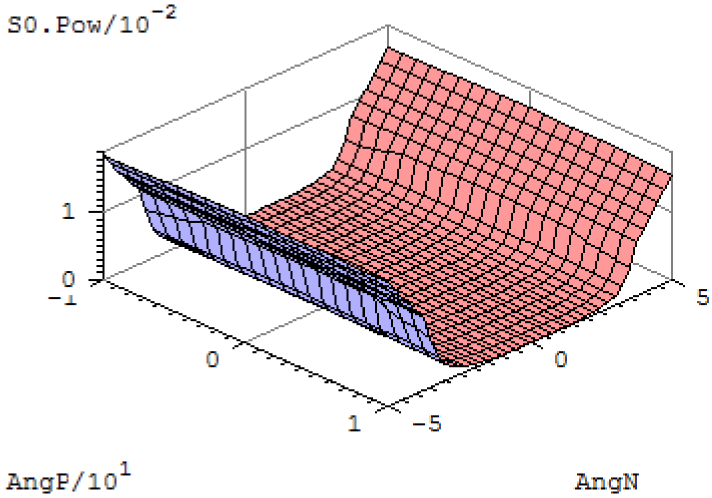


5 Modal conical

5.1 The example demonstrates the grating having zero transmission in zero order under normal incidence. The example also demonstrates the *Grating based* coordinate system use.

Settings are arranged for evaluating the zero order transmission versus two angles around normal preserving the vector **E** projection on the structure plane parallel to the grating grooves.

Open the source file **ZeroTransm_AngN_AngP.mdl** and press the ***Run*** button and wait for result, then press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Front***.



5.2 The example demonstrates the Slider functionality.

Open the source file **Slider.mdl**. Press the ***Run*** button.
In a few seconds the angular reflection from a corrugated waveguide will be calculated.
Press the ***Slider*** menu item and evaluate the reflection behavior versus incident wave polarization state and the output polarizer orientation.

6 Modal crossed

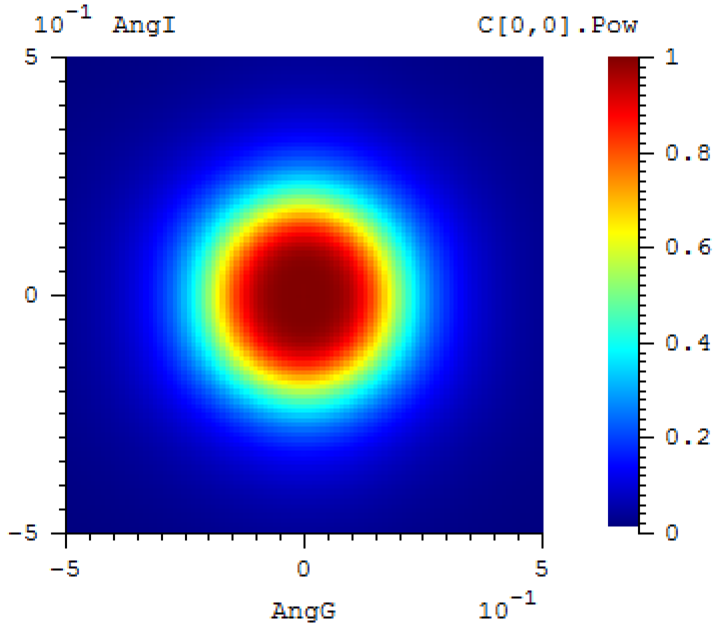
6.1 The modal method example of a hexagonal grating of high period resonance excitation in a cover interface corrugated waveguide by a plane wave near normal incidence.

The example also demonstrates the Grating based coordinate system use.

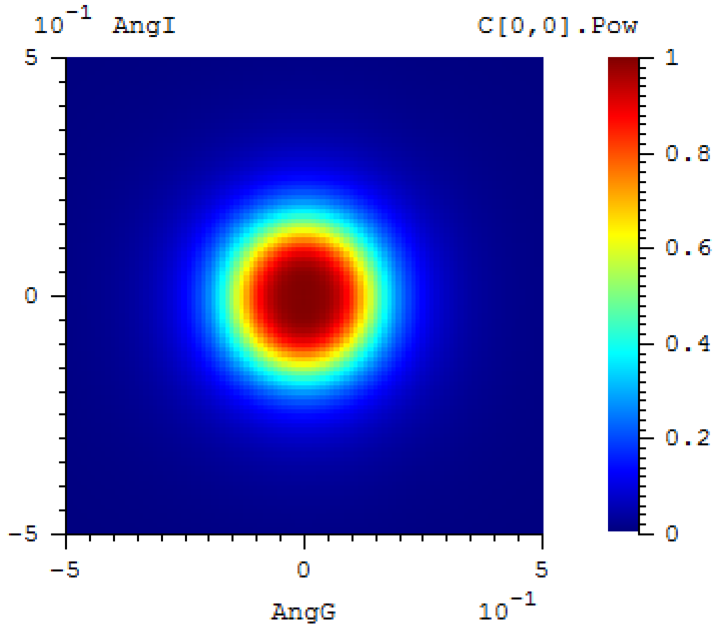
a) Settings are arranged for reflection scanning versus two angles close to the normal.

The incidence wave has the **TE** polarization state (***State*** angle equals to zero).

Open the source file **High_Period.mdl** press the ***Run*** button and wait for several hours. Software will calculate a reflection for positive angles quarter. When calculation will be finished position mouse to result area, press the right mouse button and select ***Symmetrize Data*** option to extend results for negative angles (instead of all the previous open file **High_Period _TE.dat**) and press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.



b) To see a **TM** polarization incidence wave reflections go to ***Settings*** -> ***General*** and change the ***State*** angle to 90 degrees, press the ***Run*** button, ***Symmetrize Data*** (instead of all the previous open file **High_Period _TM.dat**) and press the ***Graph*** button.

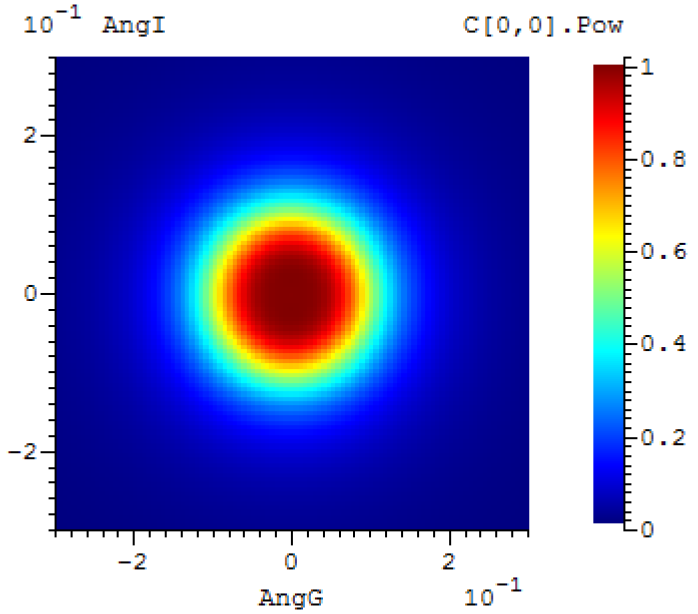


6.2 The modal method example of a hexagonal grating of low period resonance excitation in a cover interface corrugated waveguide by a TE plane wave near normal incidence.

The example also demonstrates the Grating based coordinate system use.

a) Settings are arranged for reflection scanning versus two angles close to the normal. The incidence wave has the **TE** polarization state (***State*** angle equals to zero).

Open the source file **Low_Period_TE.mdl** press the ***Run*** button and wait for several hours. Software will calculate a reflection for positive angles quarter. When calculation will be finished position mouse to result area, press the right mouse button and select ***Symmetrize Data*** option to extend results for negative angles (instead of all the previous open file **Low_Period_TE.dat**) and press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.

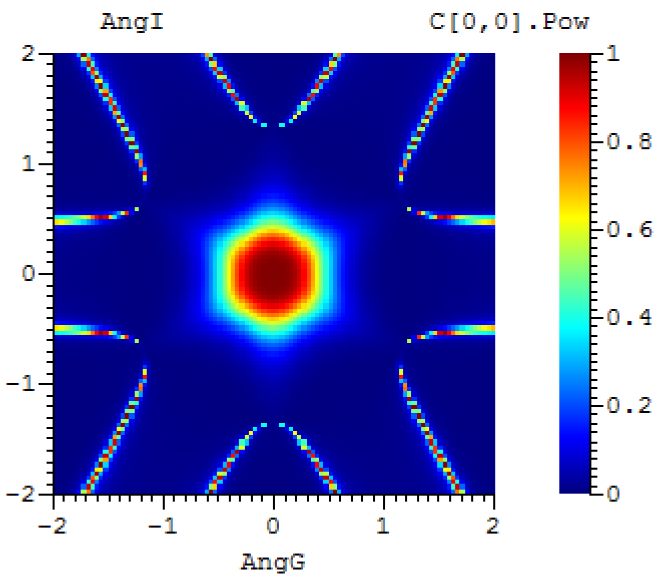


6.3 The modal method example of a hexagonal grating of low period resonance excitation in a cover interface corrugated waveguide by a TM plane wave near normal incidence.

The example also demonstrates the Grating based coordinate system use.

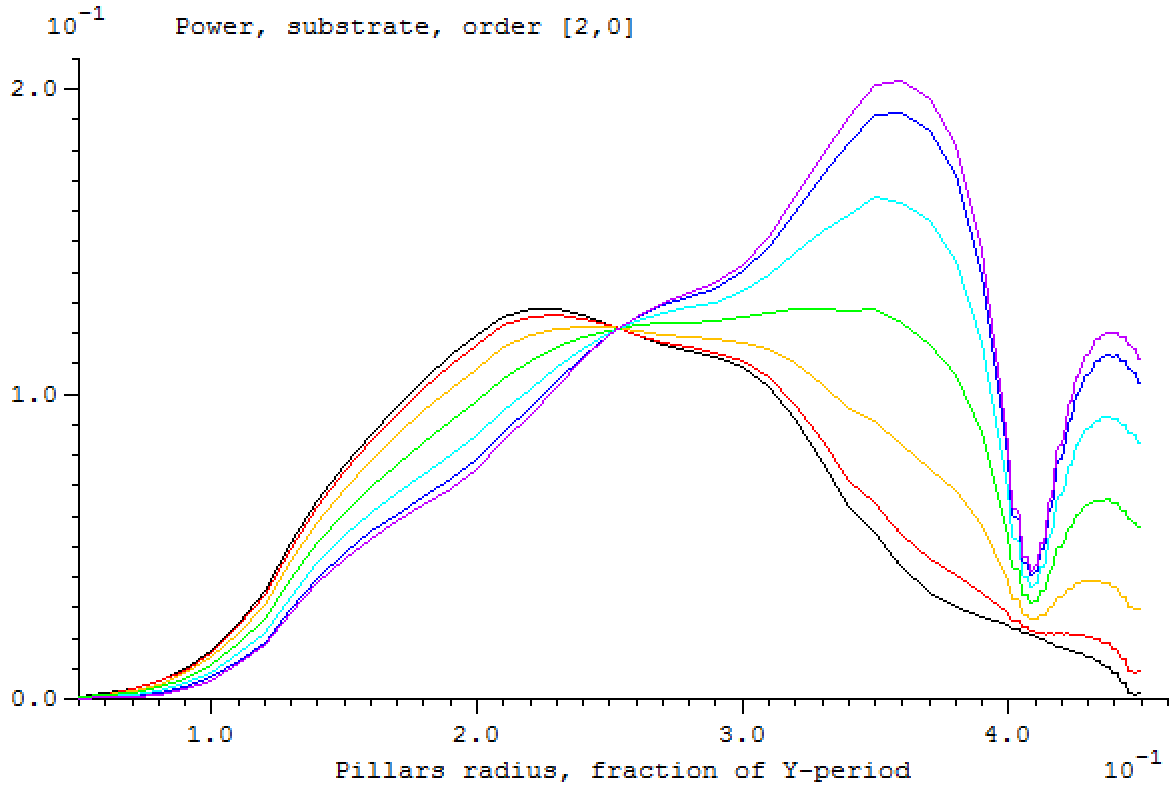
a) Settings are arranged for reflection scanning versus two angles close to the normal. The incidence wave has the **TM** polarization state (***State*** angle equals to 90 degrees)

Open the source file **LowPeriodTM.mdl** press the *Run* button and wait for several hours. Software will calculate a reflection for positive angles quarter. When calculation will be finished position mouse to result area, press the right mouse button and select ***Symmetrize Data*** option to extend results for negative angles and (instead of all the previous open file **Low_Period _TM.dat**) press the ***Graph*** button. If necessary, in the ***Graph*** window go to ***View*** and select ***Top Color Image*** and ***Color Scale***.



6.4 Advanced scanning and advanced output. There are two variants: first - the scan data were prepared outside the MC Grating code in form of the built-in table and second - the structure parameters are provided by the built-in equations

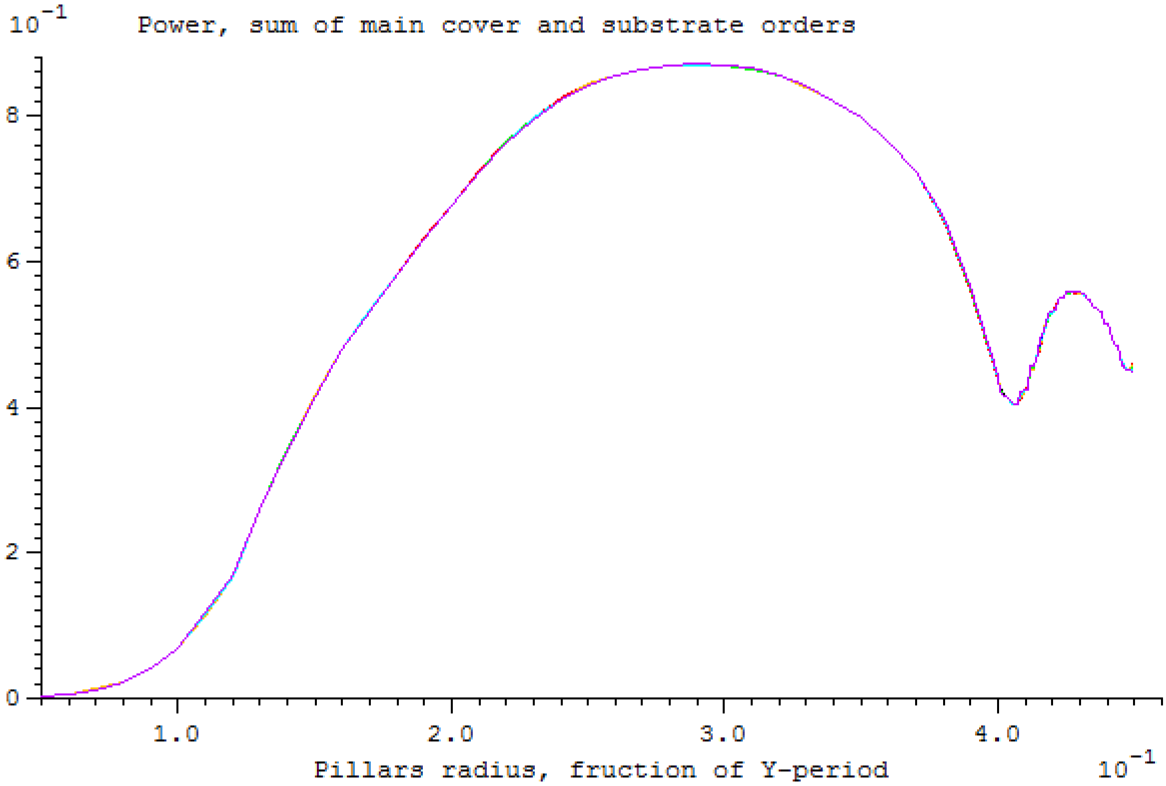
This example was designed to investigate hexagonal binary grating of circular pillars for diffraction efficiency versus radius of pillars as a fraction of a smallest dimension of elementary grating cell. For this purpose the purely theoretical grating model was used. Pillars of refractive index 2 is "free suspended" in media of refractive index 1. The scanning data was prepared outside the **MC Grating** software and has two parts: first part with radius step of 0.01 and second part around peculiarity with step of value 0.001. In the figure there are presented graph of diffraction efficiency curves for the substrate (2,0) order. Curves correspond to different polarization states of incident wave from the **TE** (black) to the **TM** (violet) with respect to the diffracted wave (angular step is 15 degrees). Diffraction orders (2,0), (1,1), (1,-1), (-1,1), (-1,-1), (-2,0) are physically equivalent owing to the grating symmetry and have the same dependence versus the polarization state of incident wave.



Open the source file **Efficiency_Pilllar_Radius_Table.mdl** or **Efficiency_Pilllar_Radius_Equations.mdl** press the ***Run*** button and wait for quarter of an hour. Software will calculate a reflection scan for the **TE** polarization. Draw this scan curve end goes back to ***Scanning*** -> ***General*** and increase the polarization state by 15 degrees. Press the ***Run*** button. Recalculation will take a couple of seconds. Repeat these steps up to the **TM** polarization (90 degrees of polarization state).

After finishing scanning by source file it is also possible to analyze the polarization behavior by ***Slider*** option.

Advanced output adds an additional column for the output with a power sum of all main diffracted orders (six transmitted and six reflected). A series of seven plots, under the same conditions as a graphic in the previous figure, is set out below.



This figure allows us to conclude that the total diffraction efficiency of a hexagonal grating in the basic order does not depend on the orientation of the electric vector of the incident wave at normal incidence.