MO.002 Import of and simulation of diffraction at user defined phase plates.

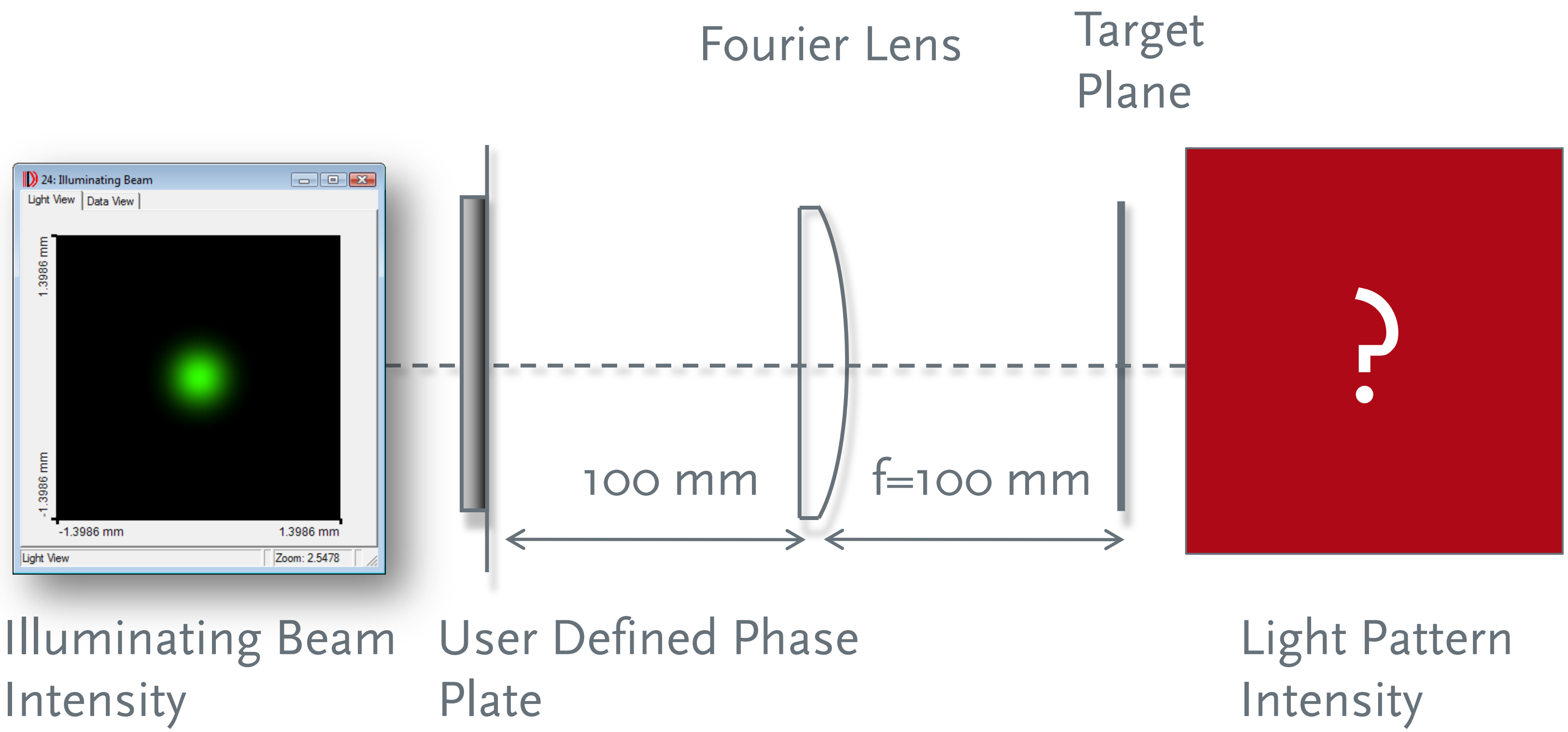
Example for the import of a user defined phase plate from ASCII or bitmap data and the simulation of the diffraction at this plate.

Keywords: Diffractive Optics, Diffractive Optical Elements, Diffusers, Beam Splitters, Beam Shapers, Phase Plates, Kinoforms, Computer Generated Hologram (CGH)

Required Toolboxes: Starter Toolbox; Diffractive Optics Toolbox

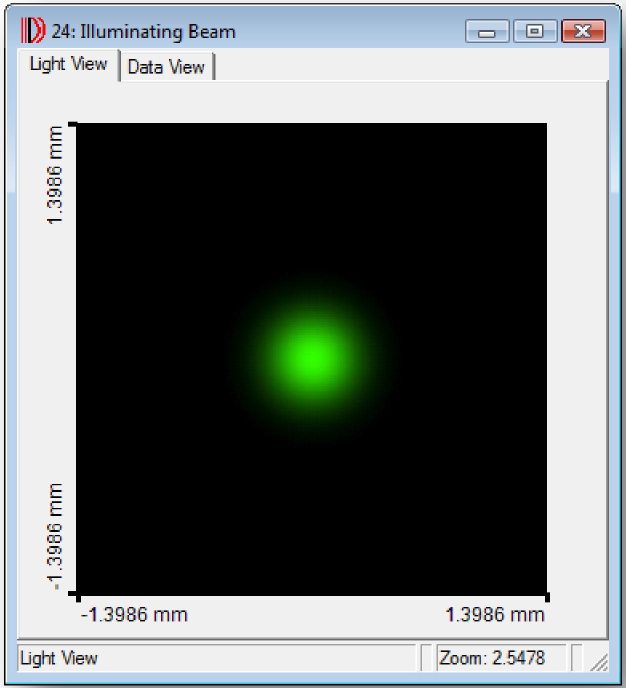
Related Tutorials: -

Modeling Task



Modeling Task

Illuminating Beam Parameters



Wavelength: 532 nm
Laser Beam
Diameter ($1/e^2$): 500 µm

Modeling Task

User Defined Phase Plate

Phase Modulation stored in MO.002_Diffraction_At_User_Defined_Phase_Plates_01.bmp and MO.002_Diffraction_At_User_Defined_Phase_Plates_02.txt files

Sampling Distance: 5 µm

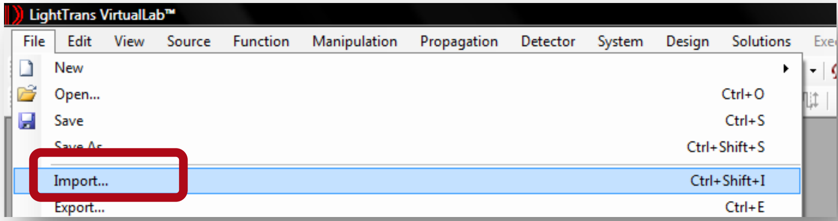
Period: 160 x 160 µm

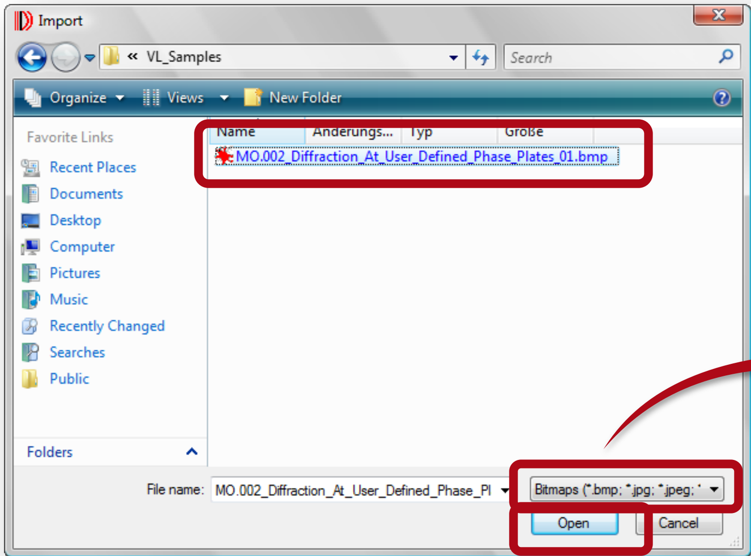
Import of Used Defined Phase Plate

- Used defined phase plates can be imported from ASCII or bitmap files (.bmp, .jpg, .png formats are supported).

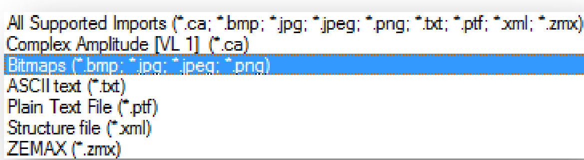
- Both Imports will be shown on the following transparencies.

Import from Bitmap File



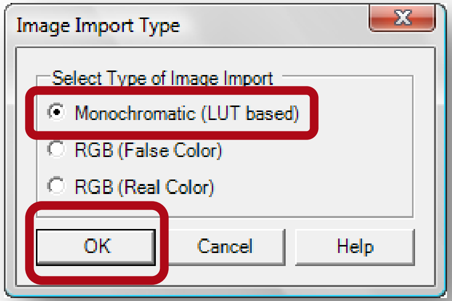


- Click *Import* in main menu.
- Select import filter *Bitmaps (*.bmp; *.jpg; *.jpeg; *png)*
- Select file MO.002_Diffraction_At_User_Defined_Phase_Plates_01.bmp.
- Click *Open* button.



Results in

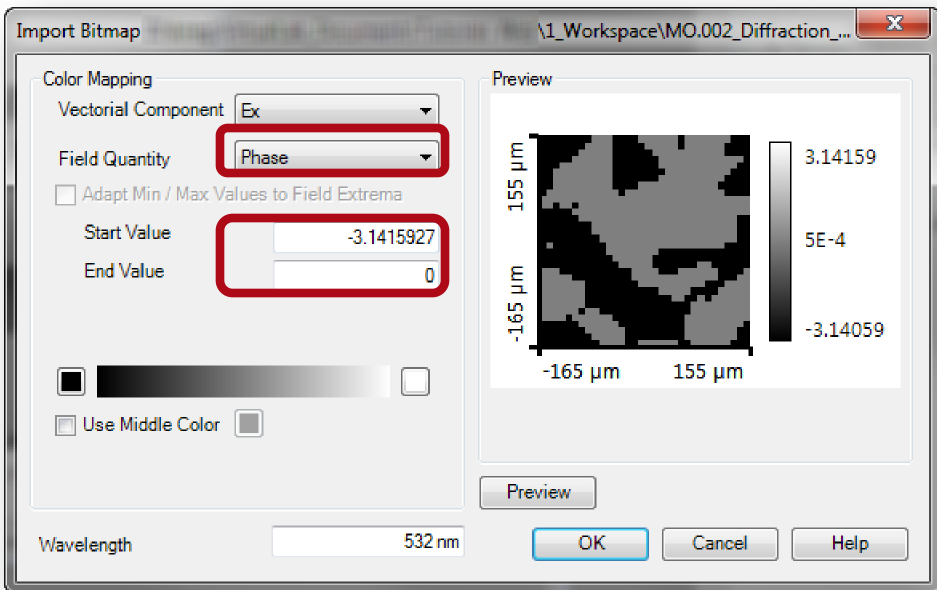
Import of Bitmap File



- Depending on the physical meaning of the data stored in the bitmap different interpretations are supported.
- For the import of amplitude and phase masks select *Monochromatic (LUT based)*.
- It is recommended to use grey scale bitmaps.
- Click *OK* button.

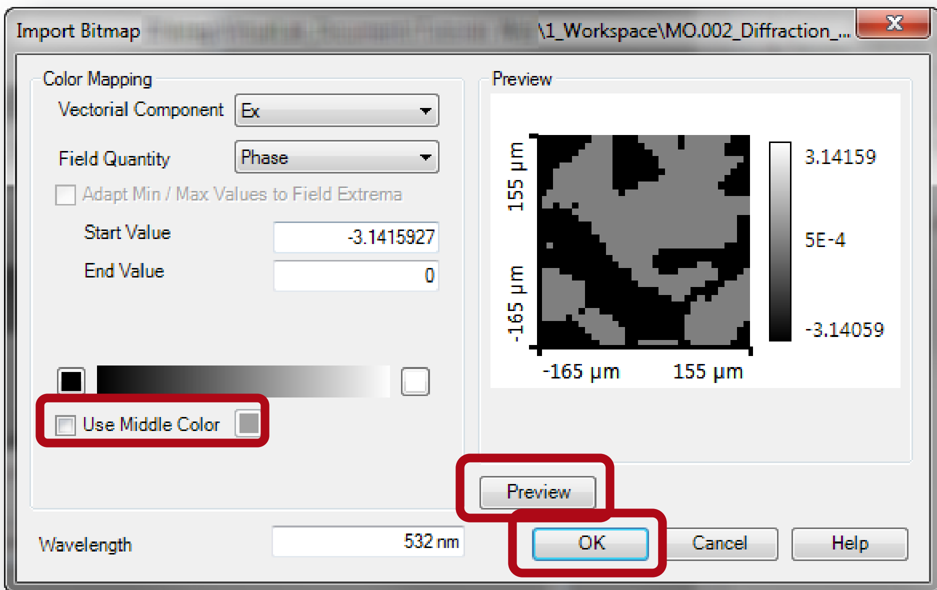
Results in

Import of Bitmap File



- This dialog is responsible for the interpretation of the colors in the bitmap.
- Select *Field Quantity Phase* to indicate that an import of a phase plate should be done.
- Select the value range of the phase corresponding with the minimum and maximum color of the color scale. Since this is a binary phase plate the value range will be from $-\pi \ldots 0$

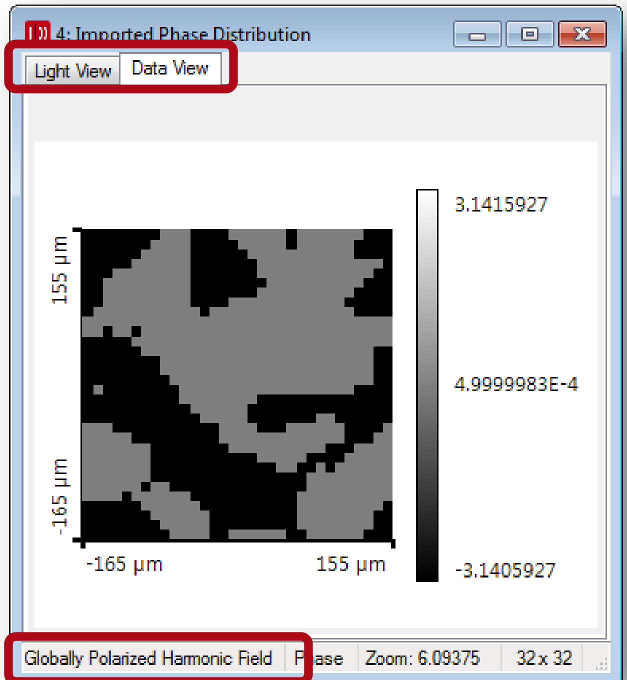
Import of Bitmap File



Results in

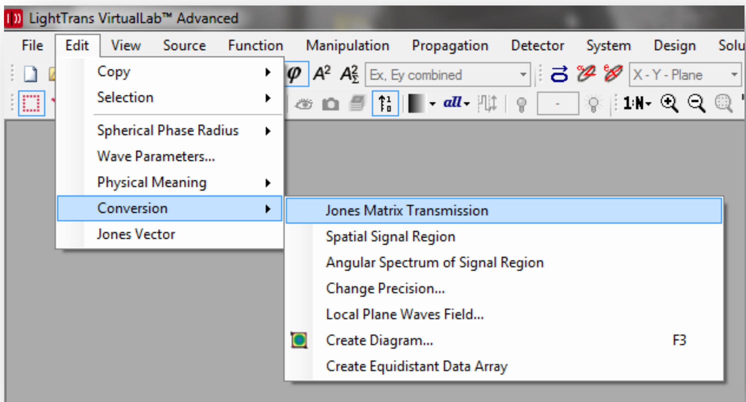
- The bitmap import requires the specification of a color scale defining the colors used in the bitmap. The color scale is a linear color change between two or three user defined colors. To use a color scale of three user defined colors the option *Use Middle Color* must be selected.
- Click the *Preview* button to get a preview of the imported bitmap.
- Click *OK* button to import.

Creation of Transmission



- The screen shot shows the imported phase distribution.
- The result of the import is a complex amplitude of a light distribution. This is visible in the status bar (*Globally Polarized Harmonic Field*) and in the appearance of the *Light View*.
- To use the imported phase distribution as the phase modulation of a phase plate a *Jones Matrix Transmission* must be created.

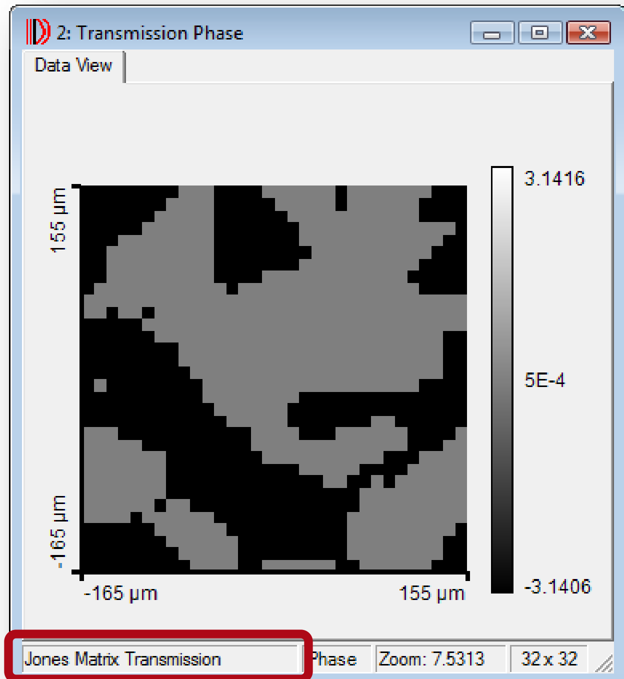
Creation of Transmission



- To convert into a Jones Matrix Transmission click in the main menu Edit→Conversion→Jones Matrix Transmission.

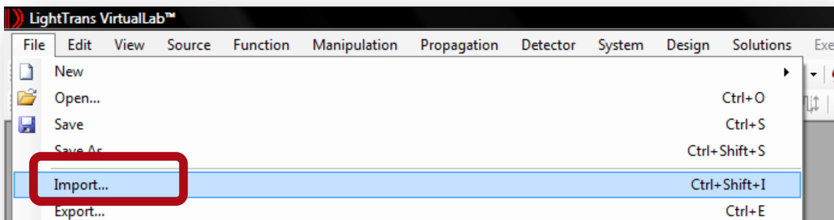
Results in

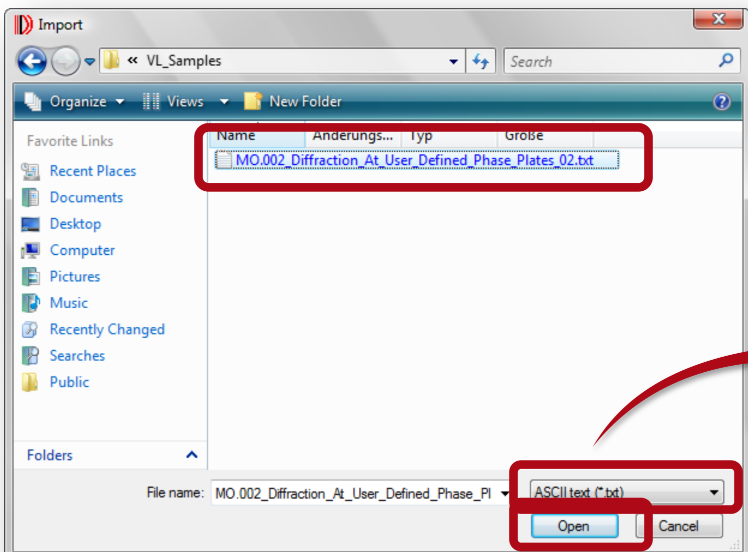
Creation of Transmission



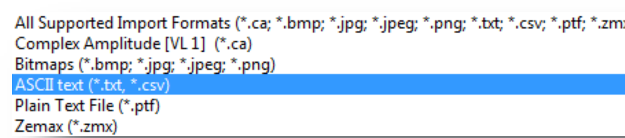
- The screen shot shows the converted *Jones Matrix Transmission*.
- This is visible in the status bar.

Import from ASCII File



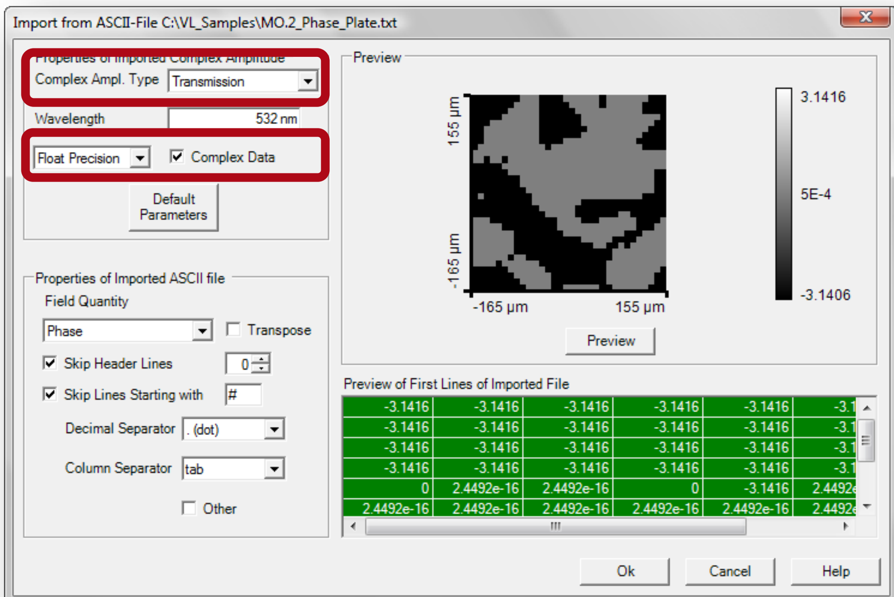


- Click *Import* in main menu.
- Select import filter *ASCII text (*.txt, *.csv)*
- Select file MO.002_Diffraction_At_User_Defined_Phase_Plates_02.txt.
- Click *Open* button.



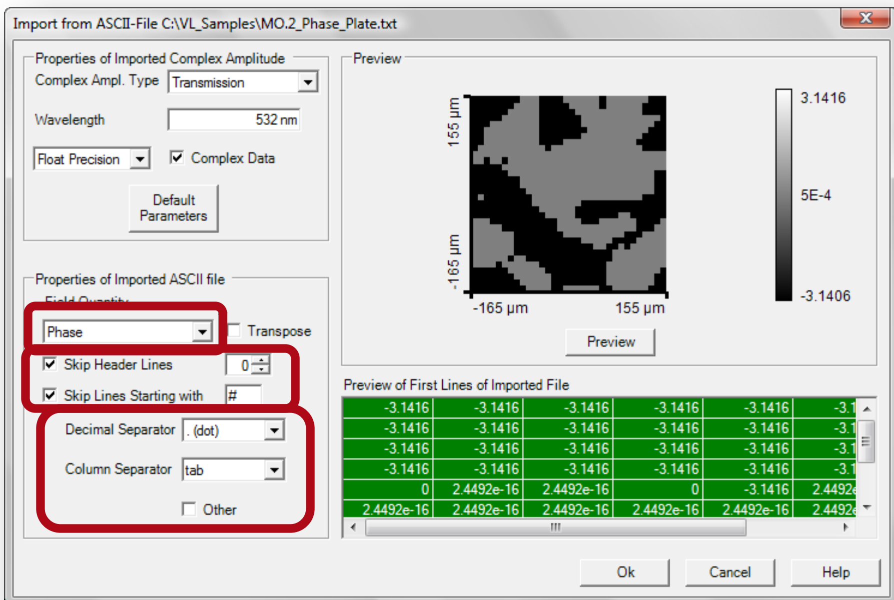
Results in

Import from ASCII File



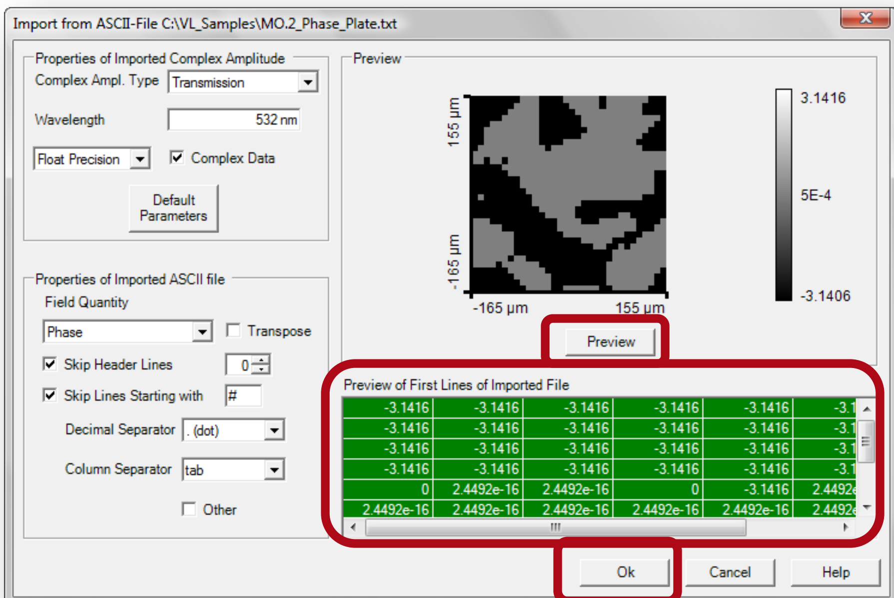
- Select the physical interpretation of the ASCII data to import (*Complex Amplitude Type: Transmission*).
- The data can be stored in VirtualLab™ in double, float or integer precision. The user can select if *Complex Data* or just real part should be stored. Use these settings to save RAM memory. Depending on these settings probably not all data can be stored in the computer with sufficient accuracy.

Import from ASCII File



- The *Field Quantity* allows to select if the data should be imported as squared amplitude, amplitude, phase, real part or imaginary part.
- VirtualLab™ can't interpret header lines. You can skip a defined number of header lines or all header lines starting with a special character.
- Select the character that separates the columns. All data lines have to end with carriage return.

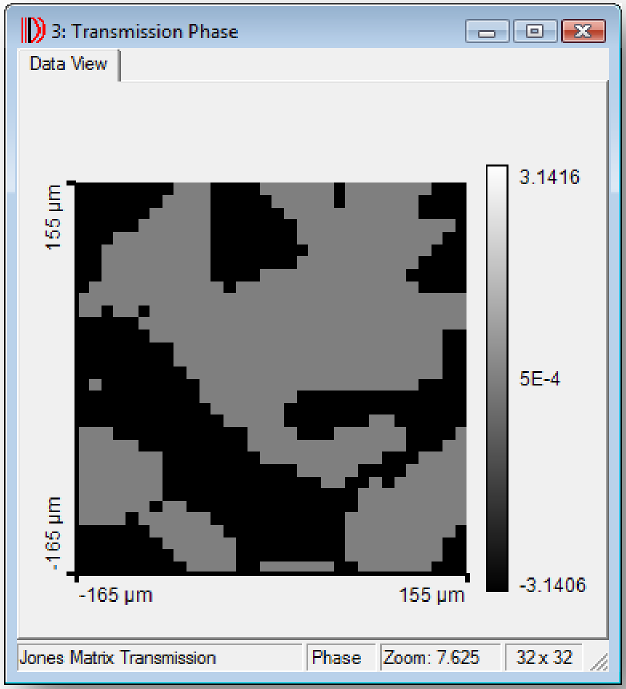
Import from ASCII File



Results in

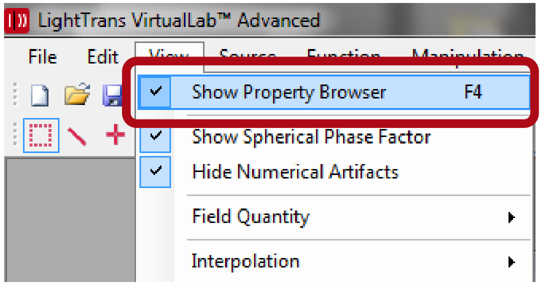
- The table in the right lower corner gives you an preview of the imported numbers at the beginning of the ASCII file. Numbers that can't be interpreted are marked red. Additionally a warning message will appear.
- If an interpretation of the ASCII file is possible, a preview of the imported data can be displayed by clicking the *Preview* button.
- Click the *Ok* button to start the import.

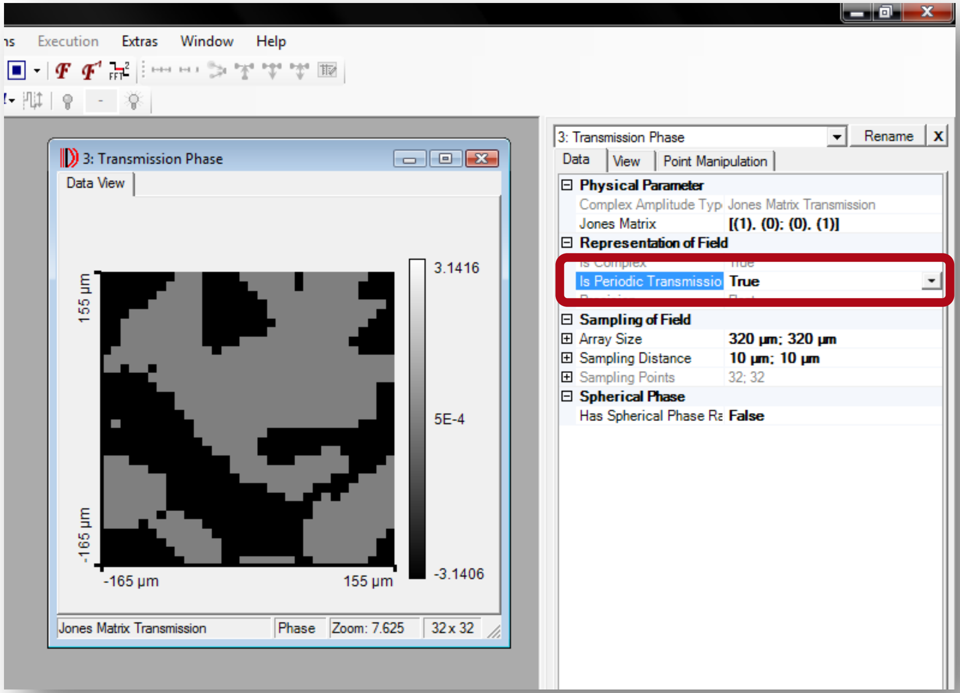
Import of ASCII File



- The screen shot shows the phase of the imported transmission.

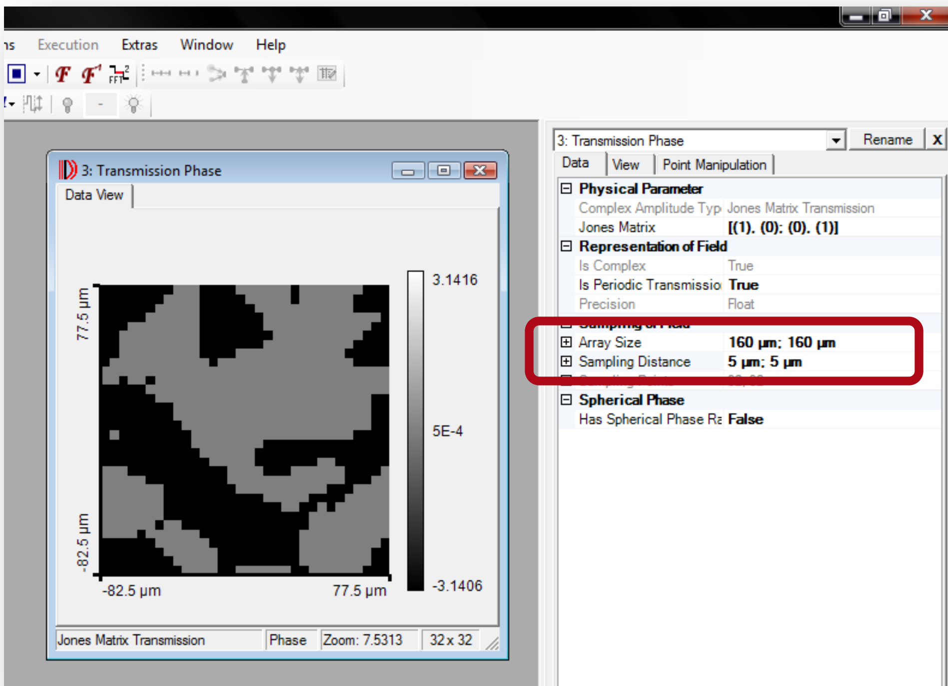
Periodic Phase Plate Transmission





- Phase plates can be periodic or non periodic.
- In case of periodic phase plates only one period must be imported.
- Activate the *Property Browser*.
- Activate the window containing the imported transmission and set the switch *Is Periodic Transmission* inside the *Property Browser* to “True”.

Adjustment of Phase Plate Diameter



- The *Sampling Distance* of the phase plate transmission will be set to the default sampling distance after import (typically 10 x 10 µm).
- Change the *Sampling Distance* or the *Array Size* in the *Property Browser* to the desired values.
- The *Array Size* is equal to the period in case of periodic phase plates.
- Set the *Array Size* to 160 x 160 µm.

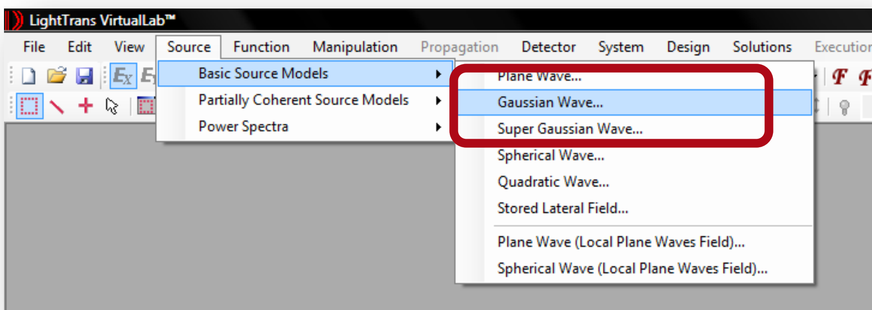
Simulation of Diffraction at Phase Plate

- The diffraction at the phase plate can be simulated by a light path diagram or by simple Fourier optics models located in main menu.

- Both methods will be explained in the following.

- The simulation using the light path diagram requires the Starter Toolbox.

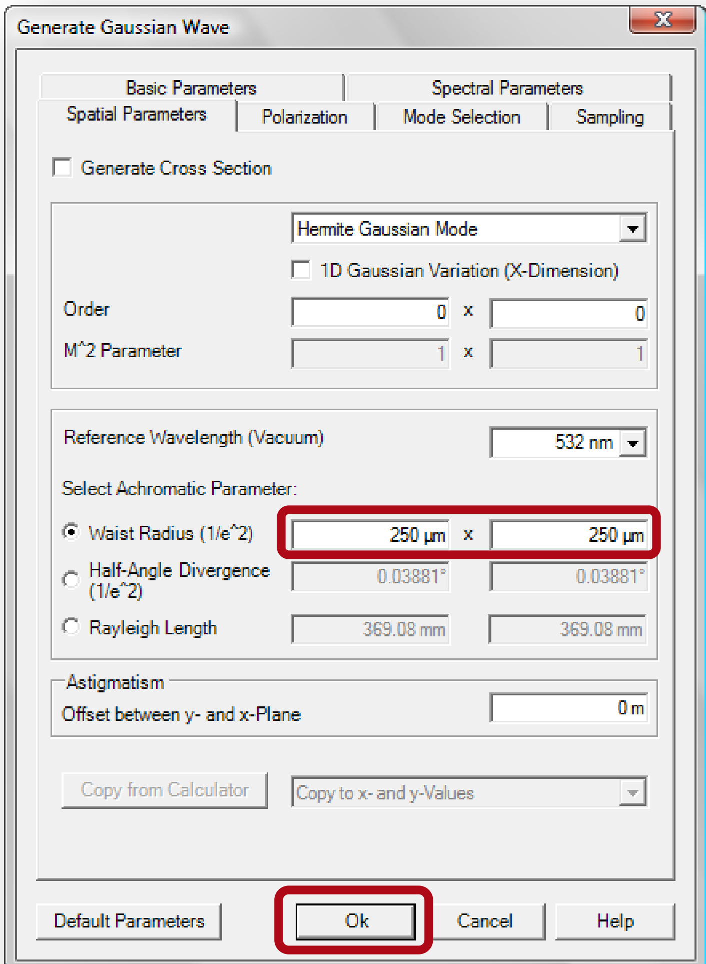
Simulation of Diffraction at Phase Plate



- The simulation of the diffraction at the phase plate can be done using Fourier optics models located in main menu.
- Click *Gaussian Wave* source in main menu to generate the illuminating beam.

Results in

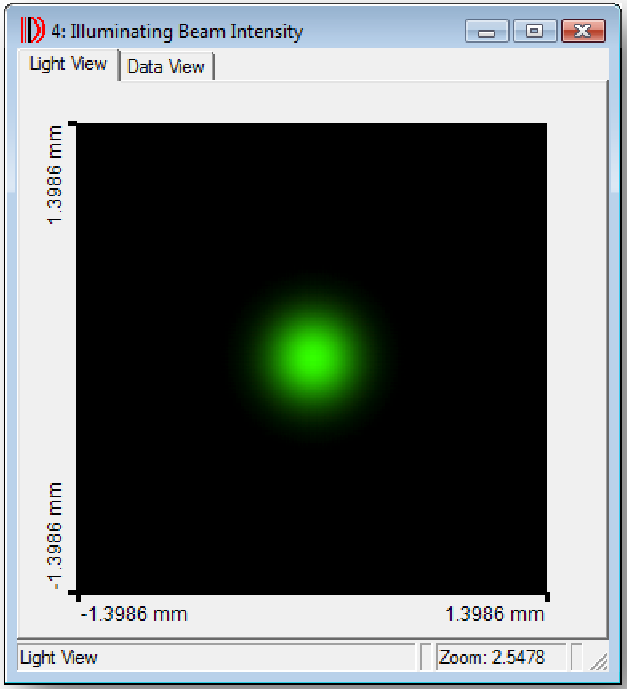
Simulation of Diffraction at Phase Plate



- The illuminating beam has an $1/e^2$ diameter of 500 x 500 µm.
- The *Gaussian Wave* dialog allows to enter the *Waist Radius*. So enter a radius of 250 x 250 µm.
- Click *Ok* to generate the harmonic field that represents the illuminating beam.

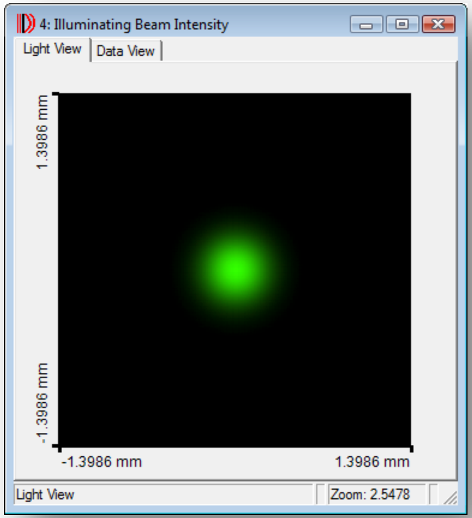
Results in

Simulation of Diffraction at Phase Plate

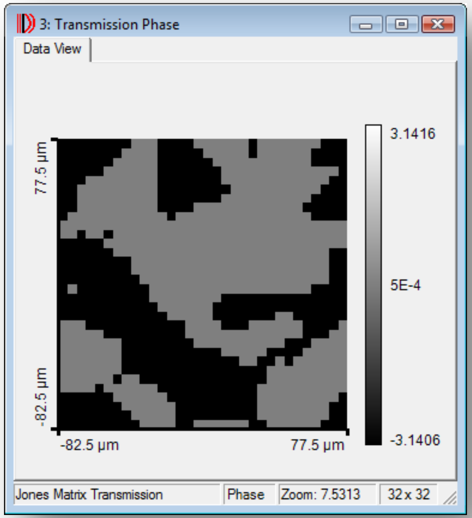


- This is the intensity distribution of the illuminating beam.

Simulation of Diffraction at Phase Plate



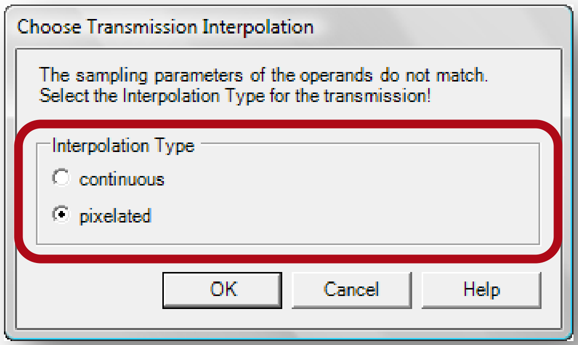
*



- The simulation of light propagation through the phase plate can be modeled by multiplying the illuminating beam field and the phase plate transmission.
- The multiplication can be done by activating the windows containing the illuminating beam field and the phase plate transmission one after another, followed by pressing the '*' key.

Results in

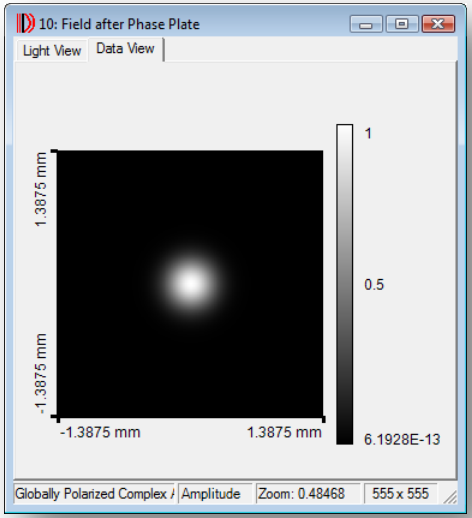
Simulation of Diffraction at Phase Plate

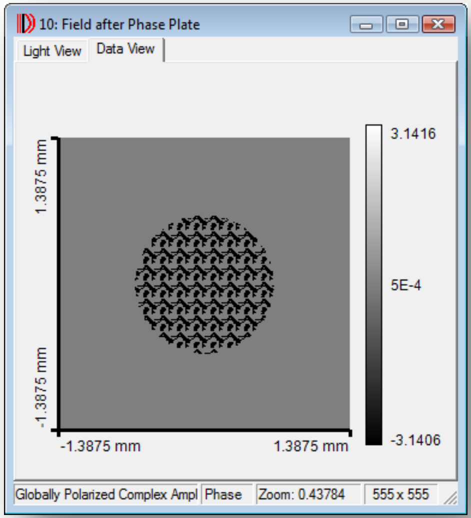


- An interpolation of the transmission could be necessary.
- VirtualLab™ will ask which *Interpolation Type* should be used. Use *continuous* for transmission with smooth phase and amplitude modulation and *pixelated* for transmissions consisting of rectangular pixels.
- Select *pixelated* in this example, then press *OK*.

Results in

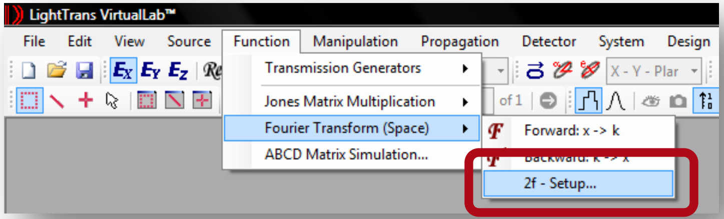
Simulation of Diffraction at Phase Plate





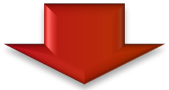
- The left screen shot shows the amplitude and the right screen shot shows the phase of the field behind the phase plate, i.e. after multiplication with the phase plate transmission.
- The phase view shows that the phase plate transmission was replicated periodically during multiplication.

Simulation of Diffraction at Phase Plate



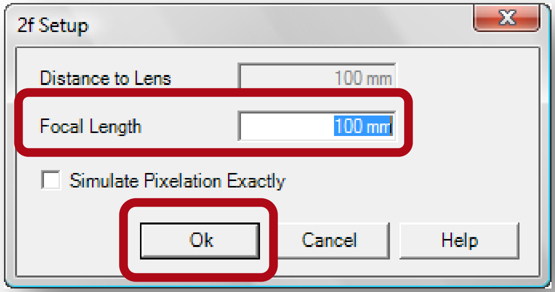
- The next step is the propagation of the field behind the phase plate into the target plane.
- The simulation can be done by the 2f-Setup function in the main menu.

Results in



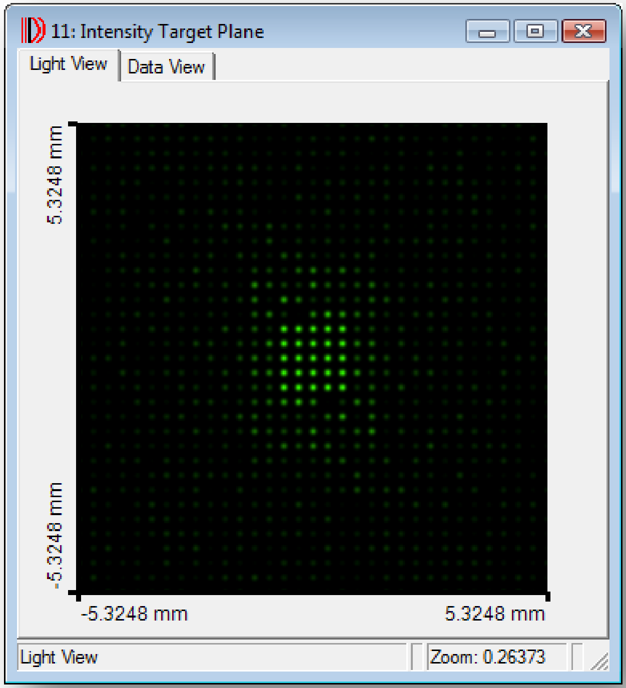
Simulation of Diffraction at Phase Plate

- Set a *Focal Length* of 100 mm.
- Click the *Ok* button.



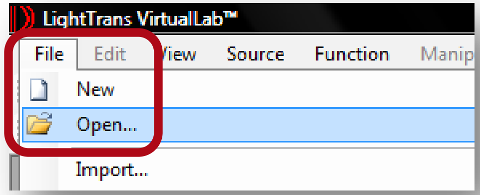
Results in

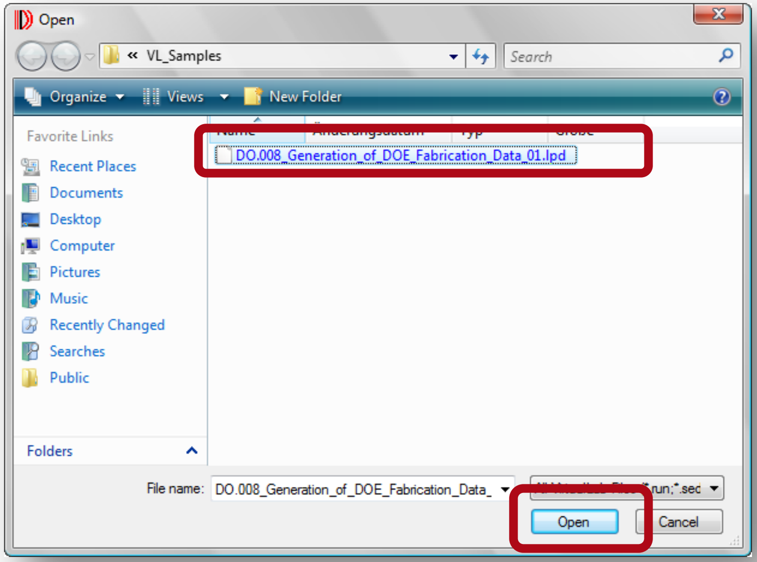
Simulation of Diffraction at Phase Plate



- Simulated intensity in target plane (focal plane of 2f-setup).

Simulation of Diffraction at Phase Plate

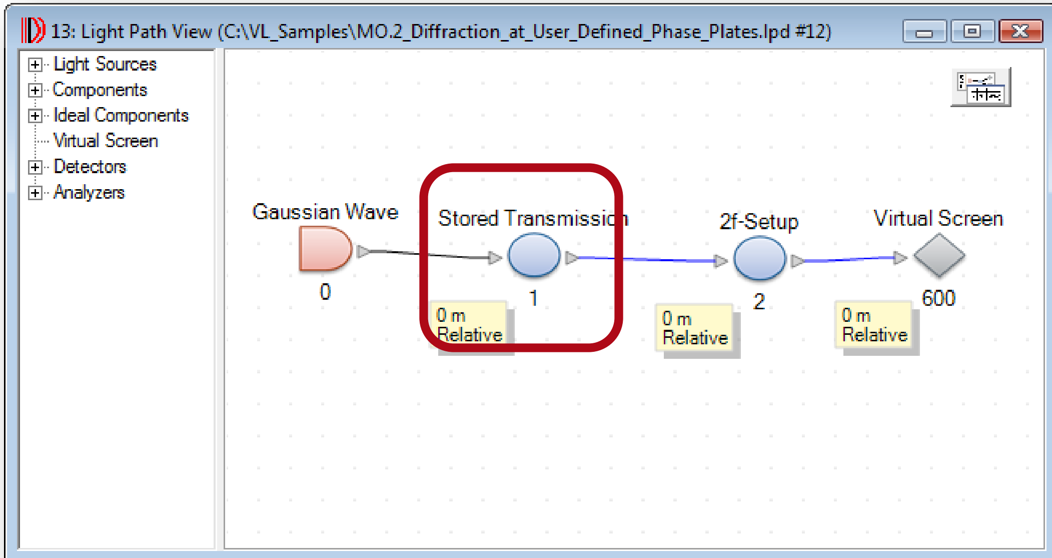




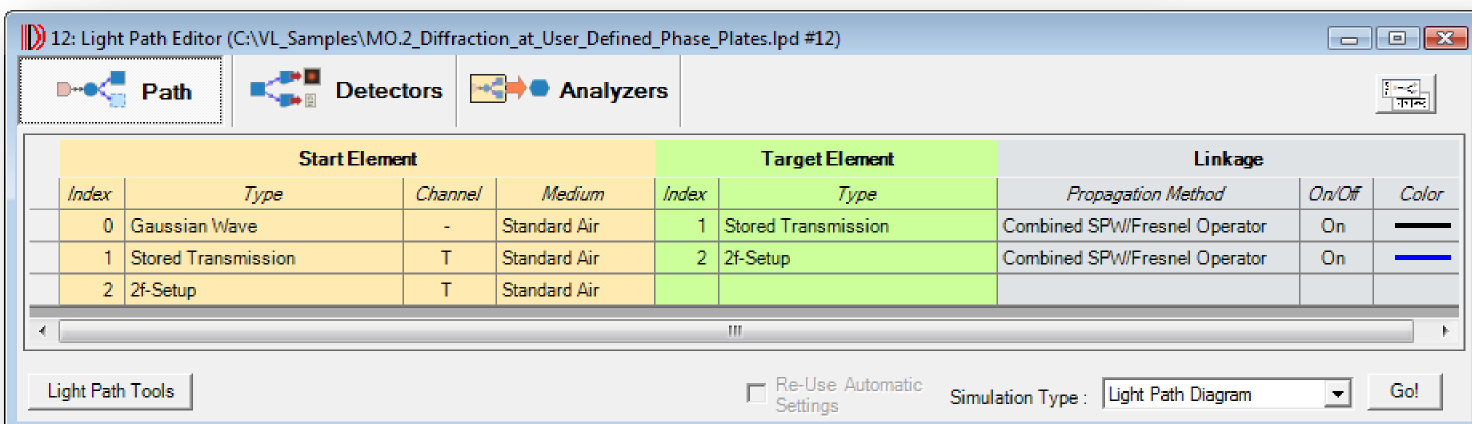
- The simulation can be also done using a light path diagram.
- The following simulation requires the Starter Toolbox.
- Load the file MO.002_Diffraction_At_User_Defined_Phase_Plates_03.lpd.
- The file can be found in the VL_Samples folder of this tutorial.

Results in

Simulation of Diffraction at Phase Plate



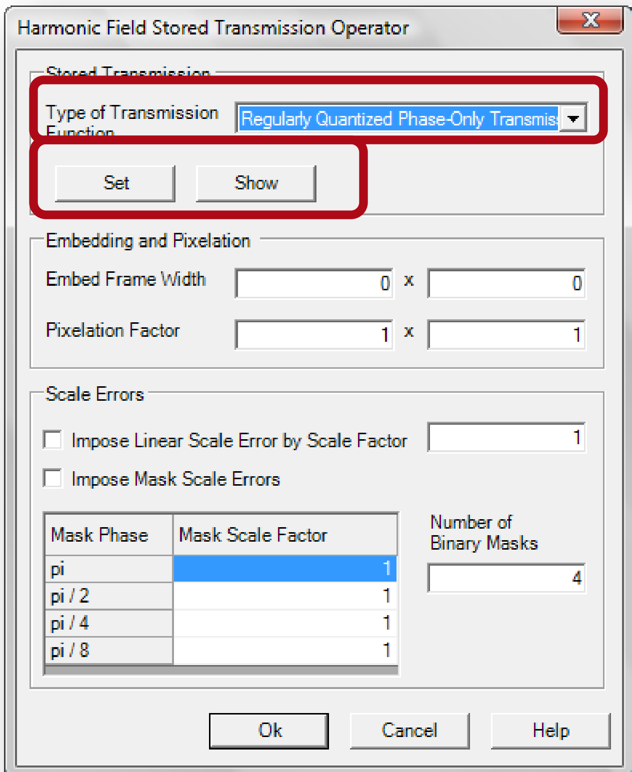
- A stored transmission is used in the light path diagram for the simulation of the imported phase plate.
- Double click on "Stored Transmission".



Start Element				Target Element		Linkage		
Index	Type	Channel	Medium	Index	Type	Propagation Method	On/Off	Color
0	Gaussian Wave	-	Standard Air	1	Stored Transmission	Combined SPW/Fresnel Operator	On	
1	Stored Transmission	T	Standard Air	2	2f-Setup	Combined SPW/Fresnel Operator	On	
2	2f-Setup	T	Standard Air					

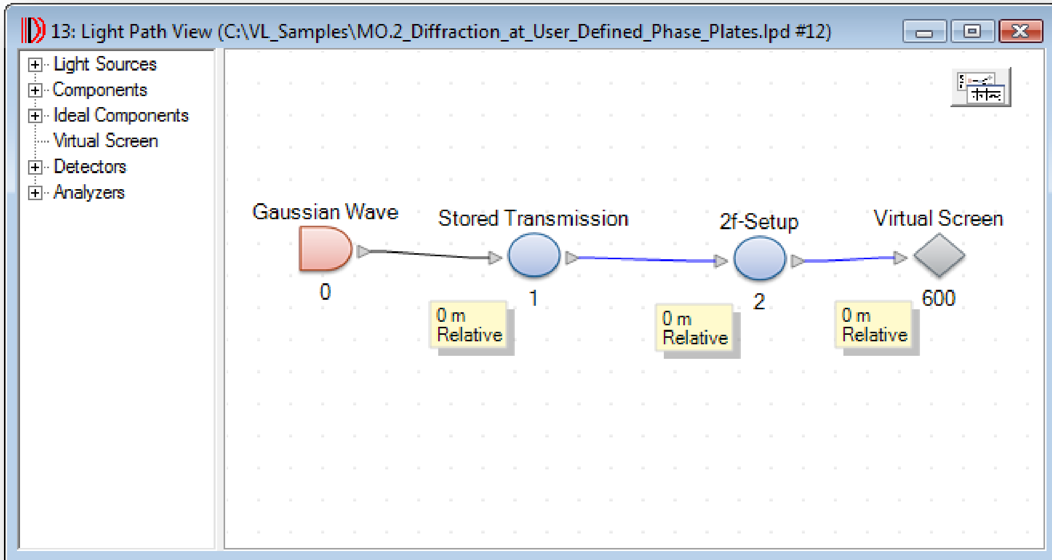
Results in

Simulation of Diffraction at Phase Plate

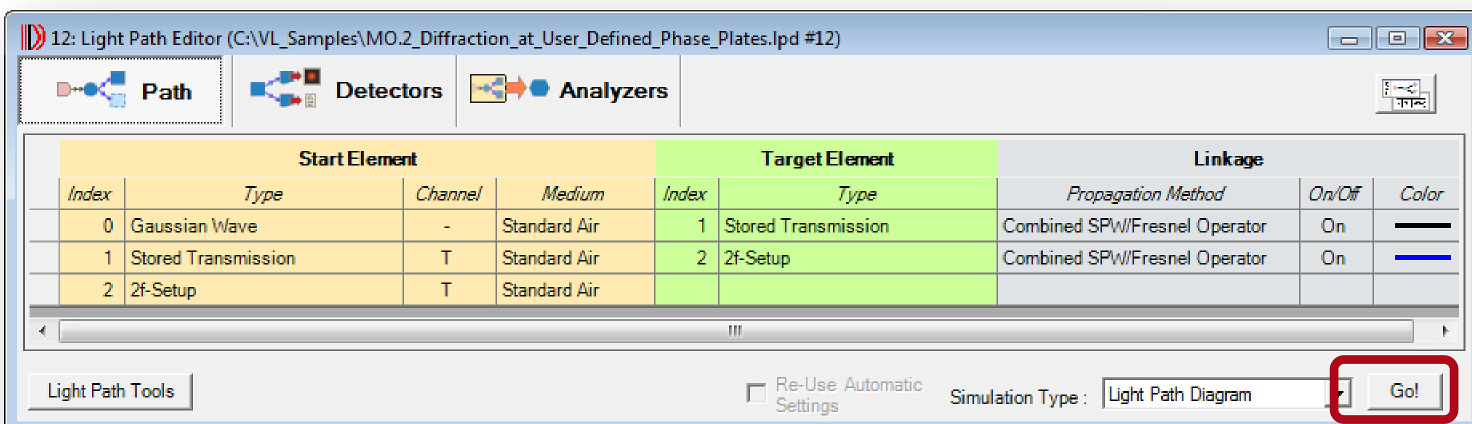


- The *Type of Transmission Function* is used to distinguish between transmission with continuous amplitude and phase modulation and transmissions containing rectangular pixels and discrete amplitude and phase levels.
- The *Set* and *Show* buttons allow to set and display the transmission used for simulation.

Simulation of Diffraction at Phase Plate

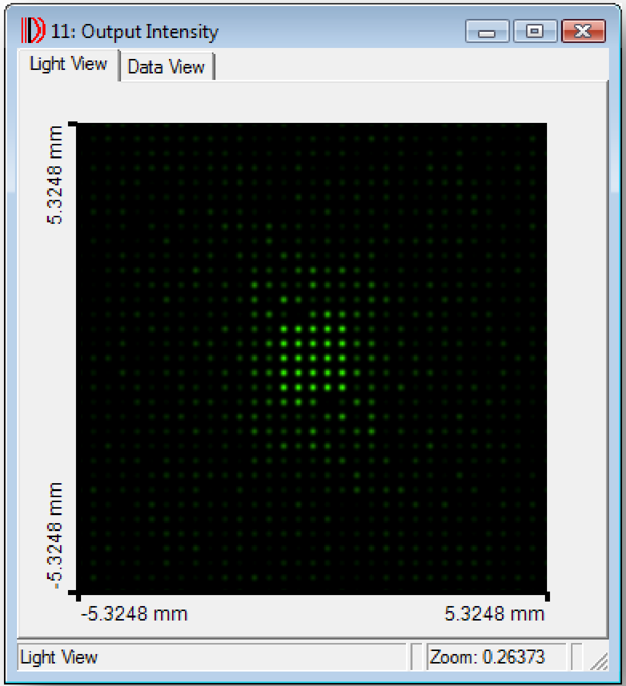


- Click *Go!* to start the simulation of the system.

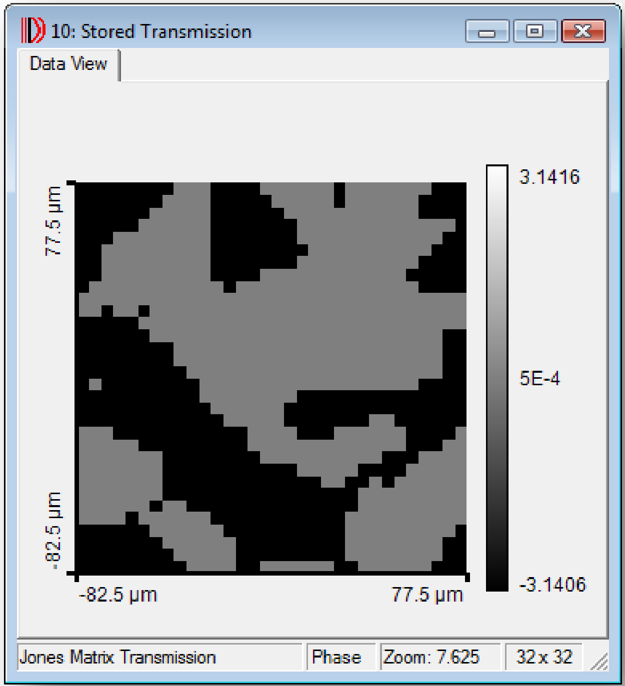


Results in

Simulation Results



Intensity in Target Plane Generated by Phase Plate



Imported Phase Plate

Conclusion

- VirtualLab™ supports the import of a user defined phase plate from bitmap or ASCII files.
- A stored transmission component can be used to model a phase plate.
- The light path diagram allows the user to simulate the diffraction at a phase plate.