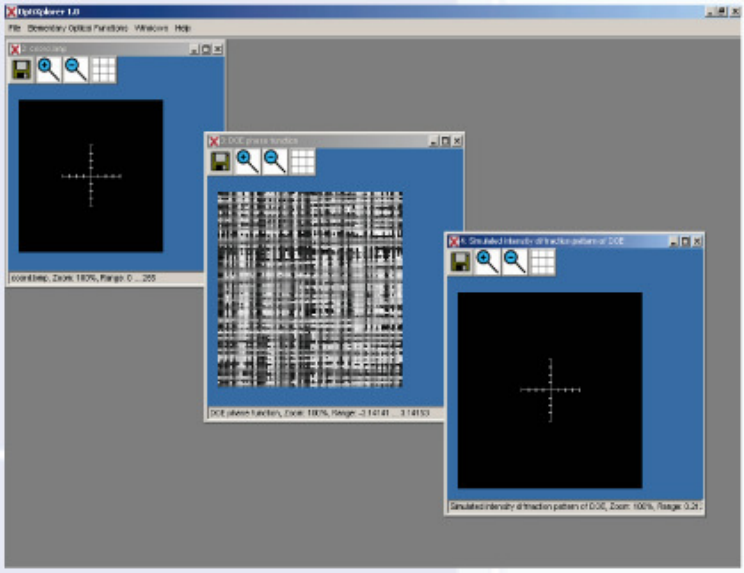
>>HOLOEYE

Application Software



Manual

HOLOEYE Pioneers in Photonic Technology

TABLE OF CONTENTS

SLM Application Software

Application software manual

1 Installation

In order make a successful installation, you should make sure that you have sufficient privileges in the computer's operating system. You should be permitted to create a directory in the directory that contains programs and copy files into that directory, and to write into the 'all users' section of the start menu of your operating system. Of course administrator privileges will be sufficient for all these operations.

Start the executable file "HoloeyeSLMAppSoft_*_installer.exe" (the asterisk is replaced with the SLM device name and the software version number in the actual file name) and follow the instructions of the installation menu.

Please accept the license agreement before choosing the required program components. Mark all checkboxes to install the complete version. Choose the destination folder as well as the start menu folder. Select "Install" to start the installation procedure and finally "Close" to finish the installation.

2 Starting the software

Start the program using the start menu entry "SLM Application Software". Upon start-up, the software will determine the number of attached screens. Note that if available multiple screens are operated in a 'display clone mode' so that all attached screens display the same information, the software will recognize only *one* screen.

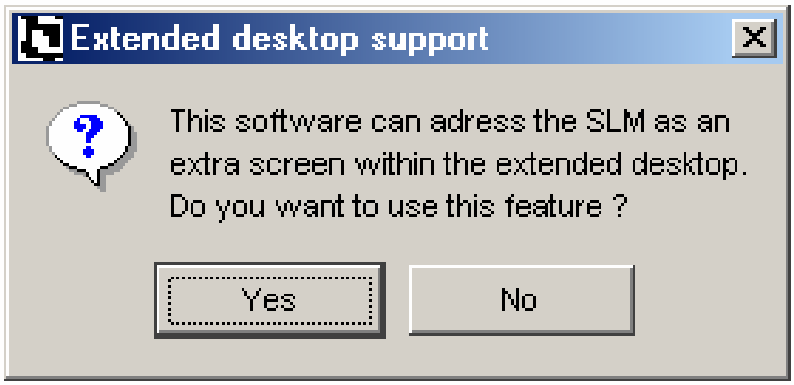


Figure 1 Choice for multiple attached screens

If the software detects more than one screen operated in an 'Extended desktop' configuration, it will determine whether *exactly one* of the non-primary screens has the pixel resolution of the SLM. If this is the case, it will display the message shown in Figure 1

If 'Yes' is selected, the program will display the content of full-screen windows to the SLM with the correct resolution and display a monitor window on the primary screen for a convenient supervision of what is being displayed. Please see section 4 for details. If 'No' is selected, the user has to make sure that the signals are display on the SLM by e.g. dragging the windows to the part of the external desktop that corresponds to the SLM.

The operation of the SLM as an external monitor in a 'Display clone mode' of the operating system is of course the most straightforward option. However, there are a few disadvantages of the 'Display clone mode' which make using an 'Extended desktop' configuration attractive.

Firstly, the full-screen window has a boundary (and potentially a button toolbar) which somewhat distort the transmission function of the SLM. Secondly, the operation in 'clone mode' is only easy if the primary display and the SLM are operated at the same pixel resolution, which may not be desirable. Third, if the PC that controls the SLM should be used for other tasks in parallel, the 'extended desktop mode' permits to do so without interrupting the operation of the SLM.

The use of the software with the ‘extended desktop mode’ can be tested most conveniently with the SLM in amplitude modulation (using a suitable polarizer configuration) – or with an additional computer display operated at the SLM’s pixel number.

3 Opening an image file

Choose from the *File* menu the point „Open Image File“. The supported image formats are BMP, PNG, JPEG, GIF, XBM, XPM, MNG and the different PNM formats: PBM (P1 or P4), PGM (P2 or P5), and PPM (P3 or P6). The loaded picture will be transformed to a picture with 256 gray-scale values. In order to display all 256 gray-scale values a monitor setting of minimum 16 Mio. colors (24bit) is required.

It is also possible to open an image by copying it to the clipboard with another application and inserting it into the application with the key combination CTRL-V.

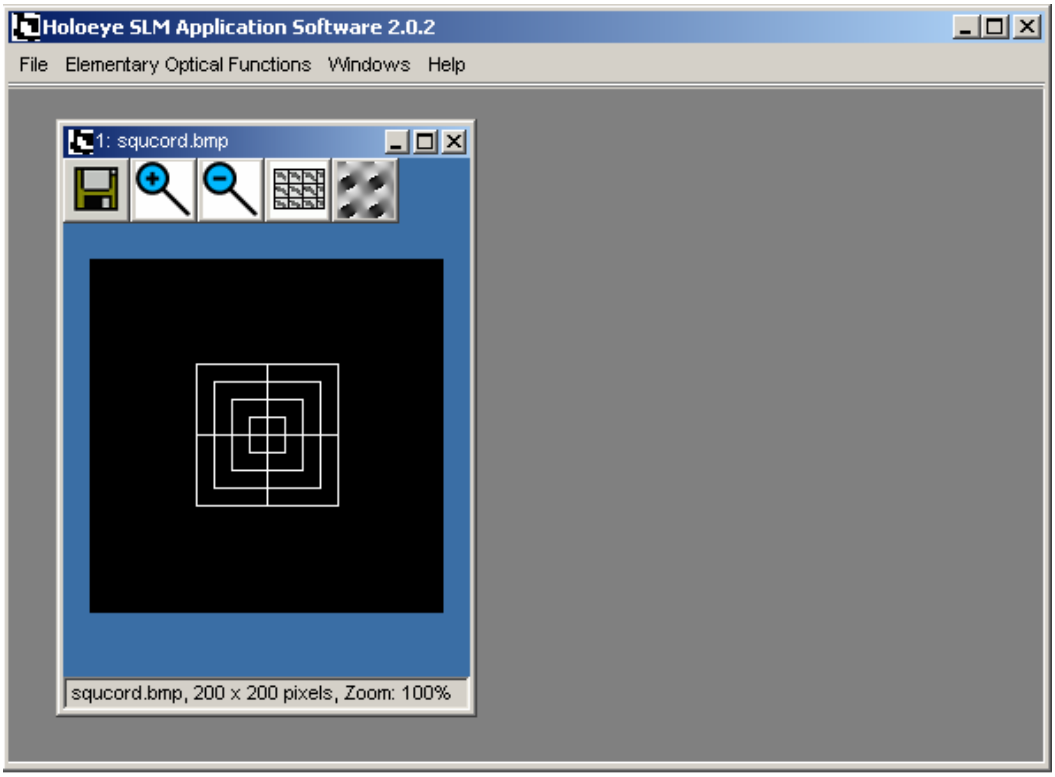


Figure 2 Image window of the application software

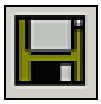
The image window will have the following buttons:

'Zoom In' Button

Pushing this button will perform a fast 'zoom in' operation on the image.

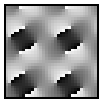
'Zoom Out' Button

Pushing this button will perform a fast 'zoom out' operation on the image.



'Save' Button

Pushing this button will open a dialog in which a file name can be specified for saving the image in one of the supported formats (PNG or BMP Image, ASCII textfile matrix of integer values representing the grayscale values).

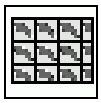


'Compute DOE' Button

This button will only appear if the displayed image (taking zoom operations into account) is no larger than 200x200 pixels.

Pushing this button will start a computation of a Computer-generated hologram (CGH) phase function for the signal displayed in the image window. Please see section 5 for more information.

The result of the computation will be displayed in a full-screen window where it can be manipulated as explained in section 4.



‘Replicate to full screen size’ Button

Pushing this button will open a full-screen window in which the shown image is used as a single tile which is replicated until the whole screen is covered.

4 Full-Screen window functions

This full-screen image will display a task-bar immediately after its appearance. This taskbar will disappear but emerge again when the position of the mouse pointer of the PC is moved towards the right edge of the window.

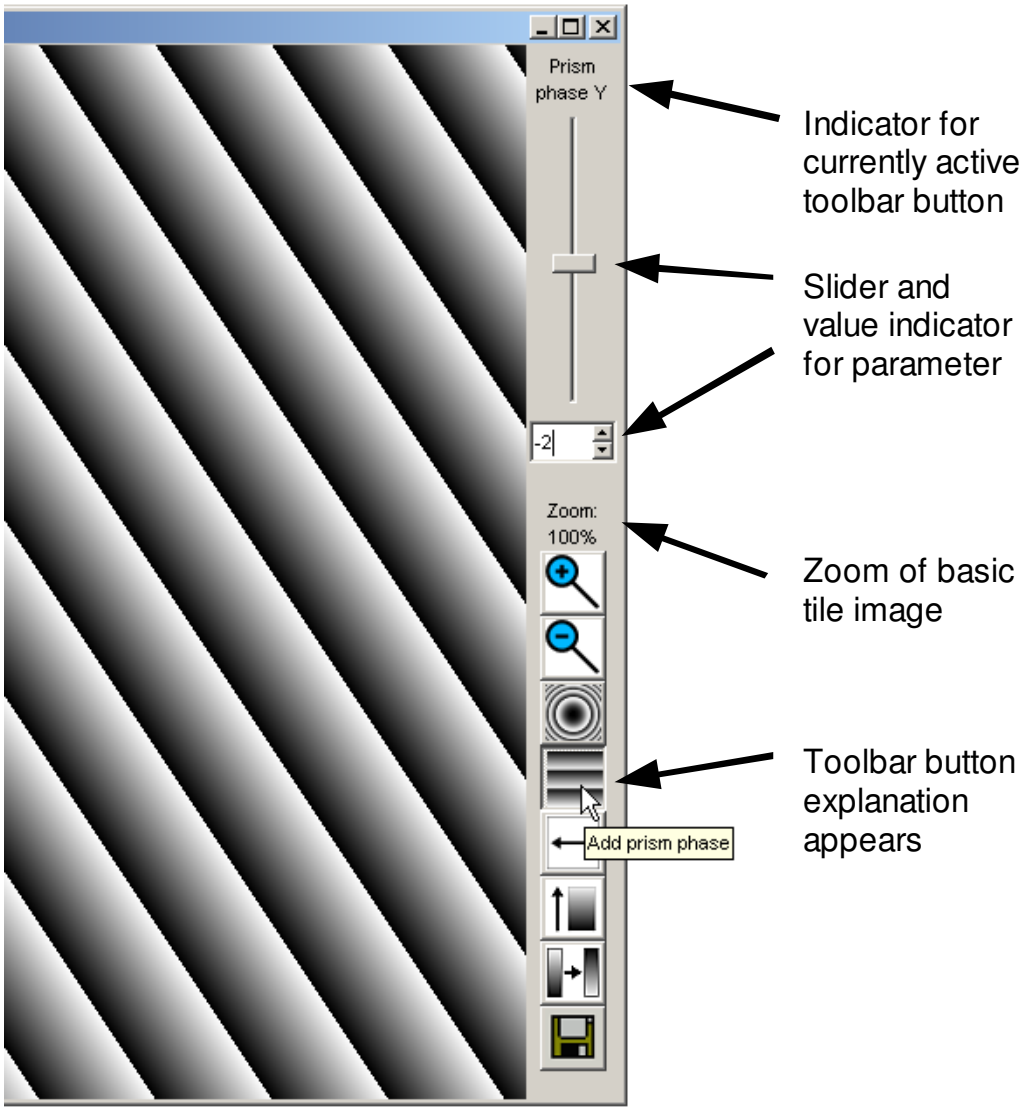
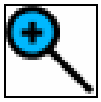


Figure 3 Toolbar of the full-screen window

The functions accessibly by the taskbar buttons offer the possibility to manipulate the ‘basic tile’ image by superposition of signals that represent optical elements (lens, prisms), by zooming and translating the image and by changing its grayscale values.

Some of the functions can be activated by pressing the buttons or by using a pressing a certain key combination on the keyboard, referred to as hotkeys in the forthcoming list.

The taskbar will have the following buttons:



‘Zoom In’ Button

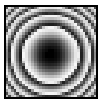
Pushing this button will perform a fast ‘zoom in’ operation on the image that is the basic tile of the displayed image composition. Note that the zoom does **not** change superimposed optical functions, it will only be applied to the ‘basic tile’.

‘Zoom Out’ Button

Pushing this button will perform a fast ‘zoom out’ operation on the image that is the basic tile of the displayed image composition. Note that the zoom does **not** change superimposed optical functions, it will only be applied to the ‘basic tile’.

‘Save’ Button (Hotkey: CTRL+S)

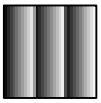
Pushing this button will open a dialog in which a file name can be specified for saving the full-screen image image in one of the supported formats (PNG or BMP Image, ASCII textfile matrix of integer values representing the grayscale values). The image will be saved as displayed, i.e. including effects by superposition of optical functions etc.



‘Superimpose lens’ Button (Hotkey: CTRL+L)

This button will superimpose the displayed image with a XY grayscale signal that resembles the optical phase function of a lens. This means that the focal plane of the light source incident on the LC Display is changed when such function is superimposed.

The focussing/defocussing strength of the optical lens function can be changed by adjusting the value given on the task bar by moving the slider or by directly entering a value.



‘Superimpose prism in *X* direction’ Button (Hotkey: CTRL+P)

Pushing this button will superimpose the displayed image with a grayscale signal that resembles the optical phase function of a prism in X direction. This means that all diffraction angles created by the signal on the LC Display are changed when such function is superimposed.

The strength of the optical prism function can be changed by adjusting the value given on the task bar by moving the slider or by directly entering a value.

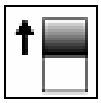
In order to switch to a prism superposition in Y direction, click on the button again.

‘Superimpose prism in *Y* direction’ Button (Hotkey: CTRL+P)

Pushing this button will superimpose the displayed image with a grayscale signal that resembles the optical phase function of a prism in Y direction. This means that all diffraction angles created by the signal on the LC Display are changed when such function is superimposed.

The strength of the optical prism function can be changed by adjusting the value given on the task bar by moving the slider or by directly entering a value.

In order to switch back to a prism superposition in X direction, click on the button again.

 **‘Adjust Graylevel 1’ Button (Hotkey: CTRL+G)**

This button will only be accessible if the ‘basic tile’ image is binary, i.e. consists of only two different graylevel values.

Pushing this button will than permit a change of one of the two grayscale values by moving the slider or by directly entering a value.

 **‘Adjust Graylevel 2’ Button (Hotkey: CTRL+G)**

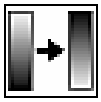
This button will only be accessible if the ‘basic tile’ image is binary, i.e. consists of only two different graylevel values.

Pushing this button will than permit a change of the second of the two grayscale values by moving the slider or by directly entering a value.

 **‘Adjust Gamma curve’ Button (Hotkey: CTRL+G)**

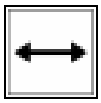
This button will be accessible if either the ‘basic tile’ image is binary and a lens and/or prism functions are superimposed, or if the ‘basic tile’ image is not binary.

Pushing this button will than permit a simultaneous change of all grayscale values by moving the slider or by directly entering a value. The gamma curve is linear if the entered value is 0, and can be changed to concave and convex nonlinear curves by entering positive and negative values, respectively.

 **‘Invert displayed bitmap’ Button (Hotkey: CTRL+I)**

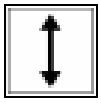
This toggle button will invert the grayscale value of the displayed full-screen image. This includes any superimposed lens and or prism functions. This inversion can be reversed

simply by clicking the button again, which will cause the button to be no longer toggled.

 **'Translate in *X* direction' Button (Hotkey: CTRL+M)**

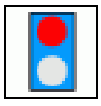
Pushing this button will move the shown image with respect to the X direction. This function can be used to align the displayed functions with respect to the incident beam. Note that the translation does change the 'basic tile' **and** any superimposed optical functions (if present) simultaneously.

In order to switch to a translation in Y direction, click on the button again.

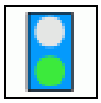
 **'Translate in *Y* direction' Button (Hotkey: CTRL+M)**

Pushing this button will move the shown image with respect to the X direction. This function can be used to align the displayed functions with respect to the incident beam. Note that the translation does change the 'basic tile' **and** any superimposed optical functions (if present) simultaneously.

In order to switch back to a translation in X direction, click on the button again.

 **'Connect to SLM' Button – Disconnected state**

This button is only visible if the software is operated in the 'extended desktop support mode' (see section 2 for details how to achieve this). Toggling this button will change the button to a green traffic light button, and the displayed bitmap of the full-screen window will be displayed as a frameless window on the SLM. If another full-screen window is already 'connected' to the SLM in this way when the button is toggled, it gets automatically disconnected.



'Connect to SLM' Button – Connected state

This button is only visible if the software is operated in the 'extended desktop support mode' (see section 2 for details how to achieve this) and the button has been toggled before. In this case the 'bitmap content' of the window is currently displayed at the connected SLM. Toggling this button will change the button to a red traffic light button, and the SLM screen will be erased and reveal whatever is displayed underneath (other windows or the desktop background).

5 Calculating a diffractive optical element (DOE)

To compute a DOE, the signal image size needs to be smaller than 200x200 pixels. In the software versions for the LC-R 1080 and the HEO 1080P images with up to 400x400 pixels are supported for DOE computations DOE computation for larger pictures is not supported by this software.

Load the image as described in section 3. If the image is not larger than the supported size pixels the **'Compute DOE' Button** will appear with the option to calculate a diffractive optical element (DOE) for this image..

Press this button to start the iterative Fourier Transformation Algorithm (IFTA). Note that the process of computing may take a while, depending strongly on the signal picture size.

When the process is finished, two windows will appear. They show the DOE phase function (in a full-screen window) and the calculated intensity of the diffraction pattern. This calculated intensity should look quite similar to the image in the original window, if the DOE calculation algorithm has properly converged.

6 Creating elementary optical functions

All optical functions from the menu point *Elementary Optical Functions* appear in a new window after input of the required parameters. Depending on the optical function, binary or

multilevel, the task bar of the full-screen window will be slightly different (compare section 4).

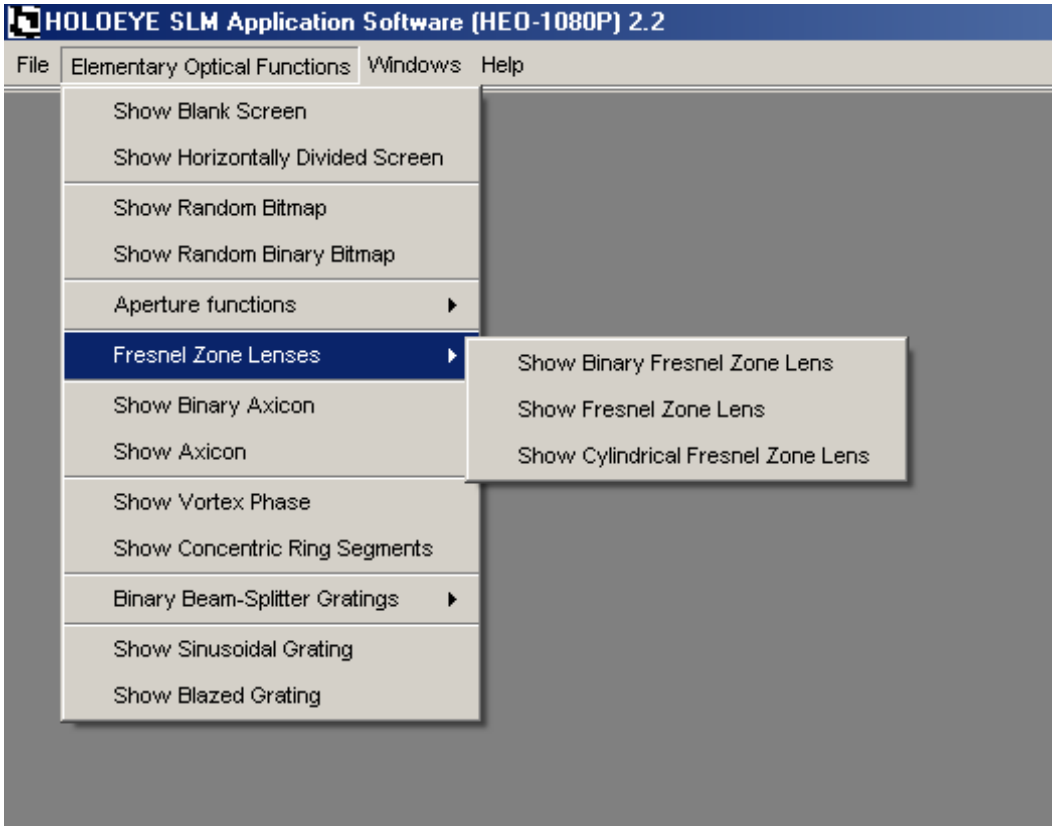


Figure 4 Menu entries for optical functions

6.1 Blank Screen

With this function you can create a homogeneous gray level screen. If the mouse pointer is moved to the right edge of the window a taskbar for changing the addressed gray level occurs.

6.2 Horizontally Divided Screen

With this function you will create a horizontally divided screen, constitng of two homogeneous graylevel partial screens. If the mouse pointer is moved to the right right edge of the window a taskbar for changing the addressed gray levels occurs.

6.3 Random Bitmap

With this function you will create a random pixel distribution using 256 grayscale values. This function can be used to realize the optical function of a random phase plate.

6.4 Random Binary Bitmap

With this function you will create a random pixel distribution using only two grayscale values. This function can be used to realize the optical function of a random binary phase plate.

6.5 Aperture Functions

6.5.1 Rectangular Aperture

Use this function to create a rectangular aperture. The size of the aperture can be defined by specifying the aperture width and aperture height. With the sliders on the taskbar one can change the gray levels of the background and of the aperture.

6.5.2 Circular Aperture

Use this function to create a circular aperture. The radius of the aperture can be defined by specifying a numbers of pixels. With the sliders on the taskbar one can change the graylevels of the background and of the aperture.

6.5.3 Single Slit and Double Slit

To create a single slit choose the point „Show Single Slit“ from the menu point *Aperture Functions.* The slit width can be defined by the number of pixels in the dialog window.

To create a double slit choose the point „Show Double Slit“ from the menu point *Aperture Functions.* Moreover the slit distance can also be defined. This refers to the gap between both slits.

6.6 Fresnel Zone Lenses

6.6.1 Binary Fresnel Zone Lens

Use this function to create a Binary Fresnel Zone Lens graylevel image representation. In the dialogue field the lens function can be characterized by the radius of the smallest ring, which is defined by a number of pixels.

6.6.2 Fresnel Zone Lens

Use this function to create a 256-level Fresnel Zone Lens graylevel image representation. In the dialogue field the lens function can be characterized by the radius of the smallest ring, which is defined by a number of pixels. It can be specified whether the image representing the lens should be positive or negative.

6.6.3 Cylindrical Fresnel Zone Lens

Use this function to create a 256-graylevel image representation of a Cylindrical Fresnel Zone Lens. In the dialogue field the lens function can be characterized by the width of the central zone, which is defined by a number of pixels. The angular orientation of the cylindrical lens can be entered in degrees (integer values only).

6.7 Binary Axicon

Use this function to create a Binary Axicon graylevel image representation. In the dialogue field the lens function can be characterized by the radius of the smallest ring, which is defined by a number of pixels.

6.8 Axicon

Use this function to create a 256-level Axicon graylevel image representation. In the dialogue field the axicon function can be characterized by the radius of the smallest ring, which is

defined by a number of pixels. It can be specified whether the image representing the lens should be positive or negative.

6.9 Vortex Phase

Use this function to create a 256-graylevel image representation of a vortex phase. In the dialogue field the radius a central zone with constant phase can be specified as a number of pixels. The angular orientation of the line where the phase changes from 0 to 2π can be entered in degrees (integer values only).

6.10 Concentric ring segments

Use this function to create binary images consisting of concentric ring segments. In the dialogue field the image function can be characterized by the radius of the smallest ring, which is defined by a number of pixels, and the desired number of segments, which can be varied from two to 20 (even numbers only).

6.11 Binary beam-splitter gratings

6.11.1 Linear Gratings and Crossed Linear gratings

Choose from the menu *Binary beam-splitter gratings* the item „Show Binary Linear Grating“ to create a grating. The grating period can be defined by the number of pixel. By selecting the boxes the grating direction can be chosen horizontal and/or vertical. Check both boxes to overlap a horizontal with a vertical grating.

6.11.2 Exemplary binary beam-splitter designs

Choose from the menu *Exemplary binary beam-splitter designs* one of the menu items

- Show Binary Linear 1-to-5 Linear Beamsplitter Grating (Grating period 26 Pixels)

- Show Binary 1-to-(2x2) Separable Array Beamsplitter Grating (Grating period 18x18 Pixels)
- Show Binary Array 1-to-(5x5) Separable Array Beamsplitter Grating (Grating period 26x26 Pixels)
- Show Binary Array 1-to-(5x5) Non-separable Array Beamsplitter Grating (Grating period 26x26 Pixels)

to obtain a full-screen window with one of the mentioned diffractive elements.

The basic tiles of these gratings are fixed and usable as examples for separable and non-separable binary DOEs.

6.12 Sinusoidal Grating

Choose from the menu point *Elementary Optical Functions* „Show Sinusoidal Grating“ to create a sinusoidal grating. The size of the grating period can be specified by the number of pixels.

6.13 Blazed Grating

Choose from the menu point *Elementary Optical Functions* „Show Blazed Grating“ to create a blazed grating. The size of the grating period can be specified by the number of pixels.

7 The ‘Window’ Menu

The Menu ‘Windows’ contains the usual options for tiling, cascading and closing windows that are opened inside the main window.

When full-screen windows are open outside the main window, they can be closed via a separate menu point ‘Close all windows outside the main window’. Of course the menu item ‘Close all windows inside the main window’ does not affect full-screen windows outside and vice versa.