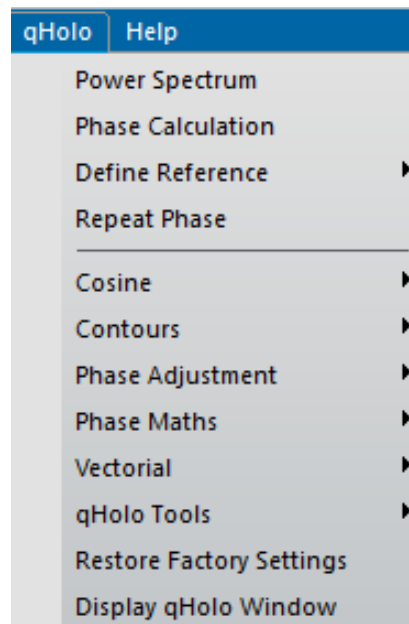


Quick Reference Guide

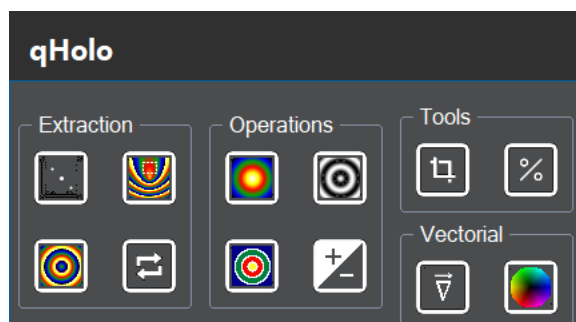
The qHolo Menu and Windows

The qHolo Menu







The qHolo Window

The qHolo menu is not the only way to access the commands in qHolo. Open the qHolo Window with **Window...Floating Windows...Technique Manager** (GMS 3.x). The window can also be accessed through **qHolo...Display qHolo Window** (Before GMS 3.x).



Commands can be activated by clicking on the buttons. In fact, this is the way we usually use qHolo.

The commands in the qHolo menu are described below.

Command	Description
Power Spectrum 	Calculates and displays the Fourier transform of the front most hologram (or stack of holograms). The side-band is then selected in the image of the Fourier transform (called Power Spectrum) using the DM rectangular ROI tool. Button is identical to selecting the menu.
Phase calculation ... 	Calculates phase from front most hologram (or stack of holograms). The Power Spectrum is displayed with an automatically selected side-band circled in red. A dialog appears with the choice of options (see Phase calculation dialog below). When a Power Spectrum was front most, Phase Calculation will continue using the Power Spectrum. Button is identical to selecting the menu.
Define Reference  (see sub menus)	Define Reference submenu of this command defines the area to be used as reference in the hologram phase image (see other sub-menus below). Button is identical to selecting the Define Reference submenu.
Repeat Phase 	Repeats phase calculation on the front most hologram using the previously defined options. Nevertheless, the Phase Calculation dialog will appear, allowing options to be changed. Button is identical to selecting the menu.
Cosine (see sub menus)	Menu for creating a cosine image of the phase amplified by a specified factor.
Contours (see sub menus)	Menu to add contours to the phase image.
Phase Adjustment (see sub menus)	Menu to make adjustments to the calculated phase image, for example to use the same q-vector as another phase image, or to rotate the phase image.
Vectorial (see sub menus)	Menu to calculate derivatives of phase images (Gradient and Laplacian) including smoothing options.
qHolo Tools (see sub menus)	Menu of useful operations, like extracting image areas, not necessarily restricted to phase images.
Restore Factory Settings	Resets all defaults and options to the initial values for qHolo.
Display qHolo Window	Makes the floating qHolo Window appear (before GMS 3.x).

Phase Extraction

Phase Calculation Command

Phase Calculation Dialog

Phase Calculation

Project Name: Nanowire - holo 1

Mask: Large, 0.08242 1/pixel, Swap, 3.033 nm

Display: Binning 4, P (checked), A (unchecked), Side (radio selected)

Reference: W: Nanowire - holo 1 - ref, Apply Correction (checked), Keep same q (checked), Fit (unchecked), Order 6, Show (unchecked)

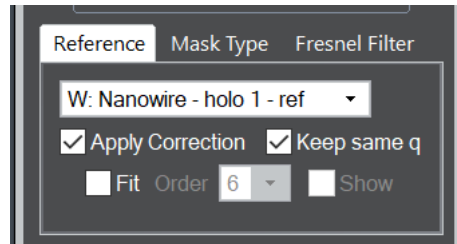
OK Cancel

The components of the dialog are described below.

Component	Description
Project Name	Name given to the group of images and results. By default, this is the same as the front most hologram.
Mask Box	
Size selection	Large ($q/2$), Medium ($q/3$), Small ($q/4$) and Custom. Mask size in 1/pixel in Fourier space and nm in real-space (if calibrated).
Swap	allows the opposite side-band to be chosen. The q -vector should point towards the reference wave.
Display Box	
Binning	Binning means the phase image will be smaller (in pixels) than the original hologram, the number of rows and columns being divided by the binning factor. This speeds up the calculation and saves space without loss of information. The binning factor can be selected from 1,2,3,4,5,6,7,8. Default is 4.
P and A	When checked, Phase (P) and/or Amplitude (A) will be displayed.
Mask selection	Radio buttons to select Central or Side band.
Reference Tab	For information about the components of the Reference tab, see Display Tab below.

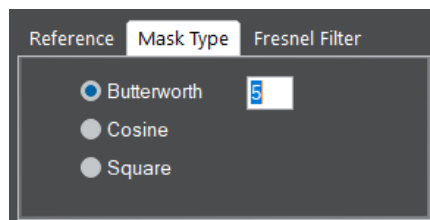
Mask Type Tab	For information about the components of the Mask Type tab, see Mask Type Tab below.
Fresnel Filter Tab	For information about the components of the Fresnel Filter tab, see Fresnel Filter Tab below.
OK	Closes the dialog and starts the image calculation according to the specified parameters.
Cancel	Closes the dialog without executing the command.

Reference Tab



Component	Description
Reference hologram selection	Pulldown menu to choose a <i>reference</i> hologram from the list of opened images.
Apply Correction	When checked, the hologram phase will be corrected using a selected reference hologram image.
Keep same q	When checked, the q-vector will be made identical for the object and reference holograms.
Fit	When checked, the phase of the reference hologram is smoothed by performing a polynomial fit before subtraction. Only the low-frequency artefacts in the phase, from dust on the biprism for example, are removed without adding the high-frequency noise present in the reference hologram. Unfortunately, the camera may have fixed pattern high-frequency components that will no longer be removed.
Order	Order of polynomial.
Show	When checked, polynomial fit image will be displayed in a separate window.

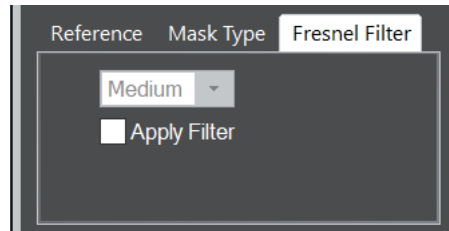
Mask Type Tab



Component	Description
Butterworth	Butterworth shape for the mask.
Order	Order of Butterworth filter

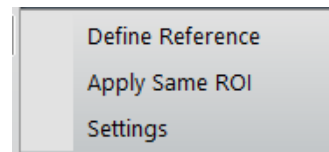
Cosine	Half-cosine mask with hard-cut off given by Mask Size.
Square	Square mask with hard edges. The edge of square is two times of the Mask Size.


Fresnel Filter Tab



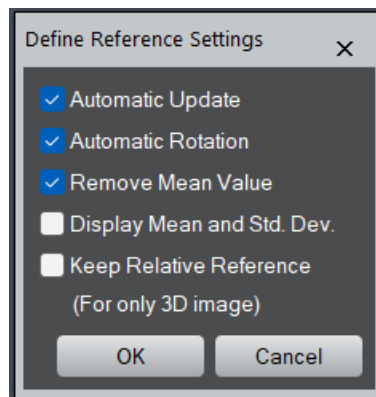
Component	Description
Fresnel Filter Strength	Strength of Fresnel filter: Weak, Medium, Strong.
Apply Filter	When checked, Fresnel filter is applied

Define Reference Submenu



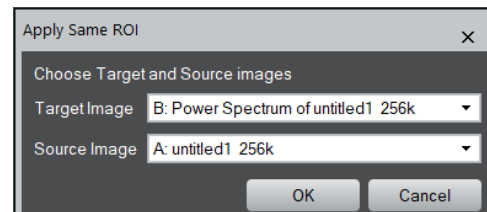
Command	Description
	<p>If a DM rectangular ROI is present in the phase image, the command defines this region as the internal reference area for the hologram fringes. The corresponding carrier frequency q is recalculated and the phase image adjusted accordingly (see Settings).</p> <p>If no ROI is present, a rectangular ROI is created by default at the center of the phase image. You may have to move the ROI, and change its size.</p> <p>Button is identical to selecting the menu.</p>
Apply Same ROI	<p>The ROI in the Source Image is copied to the Target Image, and then Define Reference is applied on the Target Phase Image using the new ROI.</p> <p>See Apply ROI dialog (see below).</p>
Settings	Opens Settings dialog (see Setting dialog below).

Settings Dialog



Component	Description
Automatic Update	Moving the reference area updates the phase images automatically. If the Mean and Std. Dev. values have been displayed, they are also automatically updated.
Automatic Rotation	The ROI is rotated automatically parallel to the hologram fringes.
Remove Mean Value	The average phase in the reference area is subtracted from the whole phase image.
Display Mean and Std. Dev.	The Mean and Standard Deviation of the phase in the reference area is displayed above the ROI.
Keep Relative Reference	This option is relevant only for a stack of holograms. When checked, Slice 0 is used for the calculation for all slices. Otherwise, the reference is calculated and corrected for each slice independently.

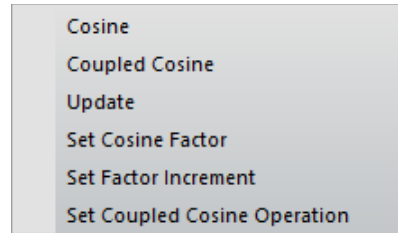
Apply Same ROI Dialog




Component	Description
Target Image	Phase image to be adjusted using the same ROI.
Source Image	Phase image with ROI.
OK	The ROI in the Source Image is copied to the Target Image. If there is a ROI in the Target Phase Image, the ROI in the Source Image will replace it. Then, Define Reference is applied on the Target Phase Image using the new ROI.
Cancel	Operation is abandoned.

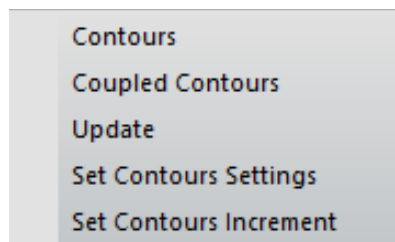
Phase Operations


Cosine submenu



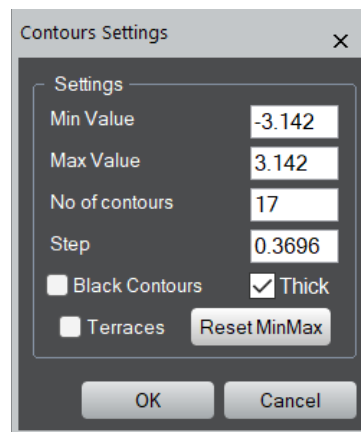
Component	Description
Cosine 	<p>Creates an image that is equal to the cosine of the frontmost <i>phase image</i> multiplied by a user-definable Factor.</p> <p>If a Cosine image of the frontmost <i>phase image</i> is already present, the existing Cosine image will be updated.</p> <p>Button is identical to selecting the menu.</p>
Coupled Cosine	<p>Creates a cosine image that is superimposed on a “Background” image selected via a dialog. In the same dialog, you can define whether Background image is Multiplied or Replaced by the Cosine Image. It does not matter if the phase image has a different size to the Background image.</p> <p>NOTE: Replacement option is useful, when the original hologram is chosen as Background image, but the phase image has a different size to the original hologram owing to binning.</p>
Update	Ensures that the Cosine Image is updated using the current Cosine Factor.
Set Cosine Factor	Allows the user to change the Cosine factor, when the cosine image is frontmost.
Set Factor Increment	<p>Defines the increment of the Factor for Cosine image.</p> <p>NOTE: When the Cosine image is frontmost, by using the keyboard Arrow keys, the Cosine image is automatically updated by increasing/decreasing the Cosine Factor with this increment.</p>

Contours submenu



Command	Description
Contours 	Creates an image that has contours superimposed according to the Settings (see Contours Settings below). Button is identical to selecting the menu.
Coupled Contours	Creates a Contours image that is superimposed on a "Background" image selected by the user.
Update	Ensures that the Contours Image is updated using the current Step size.
Set Contours Settings	Allows contour options to be defined (see Set Contours Settings dialog below).
Set Contours Increment	Defines an increment of the number of contours. NOTE: When the Contour image is front most, by using the keyboard Arrow keys, the Contour image is automatically updated by increasing/decreasing the number of contours with this increment.

Contours Settings Dialog




Component	Description
Min Value	Minimum contour value. The minimum value of the target image is shown as a default. If the frontmost is the phase image, this will be -Pi.
Max Value	Maximum contour value. The maximum value of the target image is shown as a default. If the frontmost is the phase image, this will be +Pi.

No of contours	Number of contours to be created (excluding maximum contour). Automatically adjusts the Step accordingly if modified.
Step	Step between contours. Automatically adjusts the number of contours to nearest integer value.
Black Contours	By default, the contours are white. When checked, the contours are shown in black.
Thick	When checked, the width of the contour lines is made thicker to be more visible.
Terraces	When checked, the resulting image has the values flattened between each contour, creating a terraced image. Note that on terraced images, no contours are superimposed.
Reset MinMax	Resets the minimum and maximum values to the default setting.
OK	Creates the Contour image.
Cancel	Abandons the operation.

Phase Adjustment submenu


Unwrap Phase
 Normalize Phase
 Align Two Phase Images...
 Rotate Phase
 Restore Initial q Vector
 Apply Same q Vector between 2 Images
 Apply Same q Vector for 3D Image
 Apply Same Phase Offset between 2 images
 Apply Same Phase Offset for 3D image
 Reset Phase Offset

Command	Description
Unwrap Phase 	Unwraps the phase using the Goldstein algorithm. Button is identical to selecting the menu.
Normalize Phase	Resets the phase to between $-\pi$ and $+\pi$ (i.e. rewrapping after and unwrap).
Align Two Phase Images...	Allows two phase images from different Holograms to be aligned. Corresponding amplitude images will be used to find alignment conditions.
Rotate Phase	Rotates the phase image whilst correctly dealing

	with phase jumps.
Restore Initial q Vector	Resets the current q-vector equal to the initial q-vector obtained with Phase Calculation command. Phase image is automatically updated.
Apply Same q Vector between 2 Images	The q-vector of the Source phase image will be applied to a Target phase image. The Target phase image is automatically adjusted and renormalized. The target image can be 2D or 3D. When both the Target and Source images are 3D, the q-vector of the Source image will be applied to a Target image slice by slice.
Apply Same q Vector for 3D Image	For phase image stacks, the q-vector of the slice specified via a dialog is applied to all the images in the stack.
Apply Same Phase Offset between 2 images	The mean phase of the Target image is set to that of the Source image. When there is a ROI on the Source image, the mean phase within the same area of the Target image is set to that within the ROI on the Source image. The target image can be 2D or 3D. When both the Target and Source images are 3D, the mean phase of the Target image is set to that of the Source image slice by slice.
Apply Same Phase Offset for 3D Image.	For phase image stacks, the mean phase of the whole stack is set to that of the slice specified via a dialog. When there is a rectangular ROI on the Source image, the mean phase within the same area of other slices is set to that within the ROI.
Reset Phase Offset	The mean of the whole phase image is set to zero. When there is a ROI on the phase image, the mean phase within the rectangular ROI is set to zero. This command works for both 2D and 3D images.

Phase Maths submenu



Add Constant to Phase
Invert Phase
Add/Subtract Phase Images
Average Stack

Command	Description
Add Constant to Phase	Adds a constant phase in radian or in Pi to the whole phase image. The constant value will be specified via a dialog. As might be expected, a negative value results in subtracting a phase.
Invert Phase	Calculates the negative of the phase (and simultaneously inverts the q-vector).
Add/Subtract Phases 	Adds/Subtracts two phase images chosen via a dialog. Add or Subtract can be chosen with the radio buttons in the dialog. The new phase image is rewrapped automatically. Button do the same thing with the menu.
Average Stack	Averages the phase images in a stack, correctly dealing with the phase jumps.

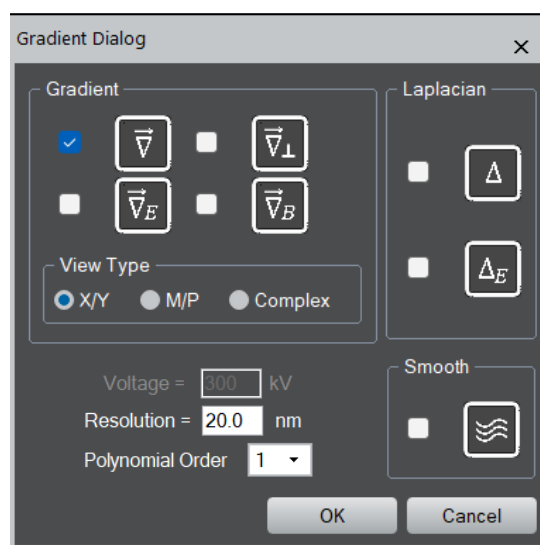
Tools and Vectors

Vectorial submenu

Gradient
Generate ColorMap
Change View Type
Display Color Wheel

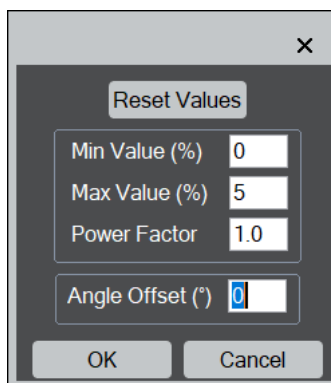
Command	Description
Gradient 	Opens a dialog to calculate different image gradients (see Gradient Dialog below). The x/y components will be displayed in different two windows. Button is identical to selecting the menu.
Generate ColorMap 	Generates a color map to display the gradient in a single image: the modulus and direction of the gradient are given by the intensity and by the color, respectively. Options can be defined by dialog window (see Generate ColorMap Dialog below). Button is identical to selecting the menu.
Change View Type	Changes display type of gradients among x/y components, Modulus/Phase and Complex selected via a dialog.
Display Color Wheel	Creates an image of the Color wheel, useful as figure legend to go with the ColorMap. The size of color wheel can be specified.

Gradient Dialog



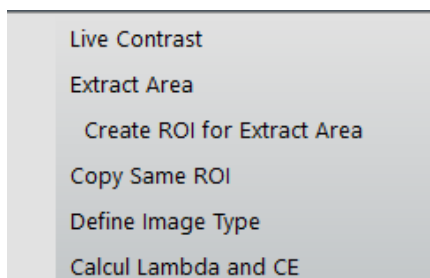
Component	Description
$\vec{\nabla}$	Calculates the gradient in x (horizontal) and y (vertical) directions $\vec{\nabla} = \vec{\nabla}_{xy} = (\nabla_x, \nabla_y)$ at the requested spatial resolution (see Resolution below) and displays them as separate images.
$\vec{\nabla}_E$	<p>Calculates the gradient in x and y directions in units of electric potential, assuming that the phase is purely electrical in origin (i.e., no magnetic contribution).</p> $\phi^E = c_E \int V dz$ $\vec{\nabla}_E = \frac{1}{c_E} \vec{\nabla} \phi^E = \int \vec{\nabla} V dz = - \int \vec{E}_{xy} dz$
$\vec{\nabla}_\perp$	Calculates the vector perpendicular to the gradient $\vec{\nabla}_{xy}$, i.e., $\vec{\nabla}_\perp = \hat{z} \wedge \vec{\nabla}_{xy} = (-\nabla_y, \nabla_x)$
$\vec{\nabla}_B$	<p>Calculates the perpendicular gradient in x and y directions in units of magnetic potential, assuming that the phase is purely magnetic in origin:</p> $\phi^M = \frac{e}{\hbar} \int A_z dz$ <p>Now:</p> $\mathbf{B} = \nabla \wedge \mathbf{A}$ <p>Therefore:</p> $\vec{\nabla}_B = \int \mathbf{B}_{xy} dz = \frac{e}{\hbar} (\hat{z} \wedge \vec{\nabla}_{xy} \phi^M)$ <p>The result is the integrated in-plane magnetic field in units of T.nm.</p>
Voltage	Accelerating voltage, necessary for the calculation of the in-plane electric field. Greyed out if not necessary.
Resolution	Spatial resolution for the calculation of the gradient. It is usually necessary to choose a lower spatial resolution than that of the phase image, because taking gradients amplifies noise.
Polynomial Order	<p>The gradient is calculated using the Savitzky–Golay algorithm in 2-dimensions by locally fitting a polynomial to the phase image (in a square region of dimensions given by the resolution). The maximum order of the polynomial is 4.</p> <p>The gradient is given by the first order of the resulting polynomial function in the x and y directions.</p>
Smooth	This option shows the phase image smoothed by the spatial resolution chosen for the gradient calculation.



Generate ColorMap Dialog



Component	Description
Reset Values	Resets all the values back to the default values, namely 0 and 100 %.
Min Value (%)	Outliers below this percentage of the maximum gradient present in the image will be removed.
Max Value (%)	Outliers above this percentage of the maximum gradient present in the image will be removed.
Power Factor	Allows a stretching of the intensity values in the ColorMap (non-linear LUT for the grey scale). By default, the value is 1 and no stretching is applied. A value of 0.5 (square root) means the variations are damped, and a value of 2.0 (square) means the variations are accentuated.
Angle Offset (°)	Sets the zero angle for the color wheel (blue color direction).
OK	Calculates and displays the ColorMap from the Gradient X and Gradient Y images.
Cancel	Cancels the operation.

qHolo Tools submenu



Command	Description
Live Contrast 	<p>Displays the fringe contrast, the fringe spacing (in pixels and calibrated units) and mean intensity above a rectangular ROI in the hologram image. These values are updated as the ROI is moved.</p> <p>If no ROI is present, a rectangular ROI will be automatically created. Then, you may have to move the ROI, and change its size.</p> <p>Button is identical to selecting the menu.</p>
Extract Area 	<p>Creates a new image corresponding to a <i>rotatable</i> ROI on front most image.</p> <p>Button is identical to selecting the menu.</p>
Create ROI for Extract Area	Creates a <i>rotatable</i> ROI on front most image from a Rectangular ROI placed in advance.
Copy Same ROI	Copies an ROI from the “Source” image to a “Target” image selected via a dialog.
Define Image Type	Allows the image type to be changed, changing the tag of the image “Type”. Useful for images calculated outside qHolo.
Calculate Lambda and CE	<p>Calculates the value of the electron wavelength λ and the hologram constant c_E from a given accelerating voltage, and outputs their values in the DM Output window.</p> <p>NOTE: $c_E = \frac{\pi}{\lambda E}$ where E is the total energy of the fast electron.</p>