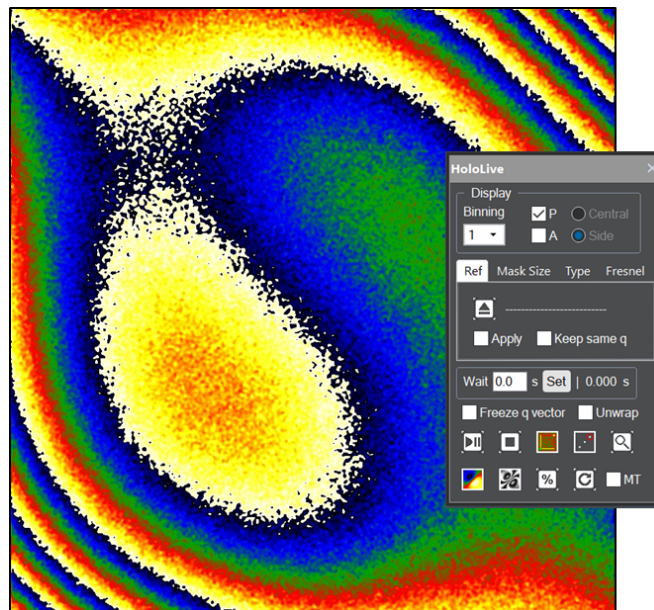


June, 2024

# *HoloLive!* *for DigitalMicrograph*

*Live phase images for  
off-axis electron holography*



HoloLive Manual 1.5

HREM Research Inc

## Conventions

The typographic conventions used in this help are described below.

Convention	Description
<b>Bold</b>	Used to denote components of the user interface such as buttons, field names, menus, and menu options. For example, the <b>New</b> button.
<b>Menu...MenuOption</b>	Select the menu from the menu bar then select the menu option from the menu. For example, <b>File...Open</b> would mean to select the <b>File</b> menu and then the <b>Open</b> option.
<b>CAPS</b>	Used to denote the name of a key on the keyboard. For example, the ENTER key.
<i>Italics</i>	Used to denote emphasis, captions and the result of an action in a procedure.

## Contact Us

**General enquiries on the HoloLive! for DigitalMicrograph should be sent to:**

HREM Research Inc.  
14-48 Matsukazedai  
Higashimatsuyama  
Saitama 355-0055  
Japan  
email: support@hremresearch.com  
Website: www.hremresearch.com

**Enquiries on HoloLive! of a technical nature should be directed to:**

Dr. Christophe Gatel  
CEMES-CNRS, Toulouse, France  
email: christophe.gatel@cemes.fr

## Copyright Statements

© Copyright 2019-24 HREM Research Inc. and CEMES-CNRS

All rights reserved. This manual is protected by international copyright laws and treaties. Unauthorized reproduction and distribution of this manual, or any portion of it, will be prosecuted to the maximum extent possible and may result in severe civil and criminal penalties.

Portions of this document were prepared by HREM Research Inc. by editing the materials supplied by Drs Martin Hytch and Christophe Gatel.

DigitalMicrograph is a trade mark of Gatan Inc.

# Introduction to HoloLive!

Welcome to the HoloLive! plug-in for DigitalMicrograph (Gatan Inc.). This software is designed to provide live phase images during off-axis electron holography experiments, hence the exclamation mark. The software was developed because electron holograms are almost impossible to interpret directly by the human eye: the important information is contained in the phase, which requires reconstruction. We have found that being able to see the phase during holography experiments changes the experience completely, particularly for in-situ work.

The main requirement is that the live holograms at the microscope are displayed within DigitalMicrograph, in the usual viewing mode for Gatan cameras. As the hologram changes over time, HoloLive! automatically recalculates and displays the corresponding phase image. Using current computing power, a speed of 3 phase images per second can be obtained for a 4K by 4K digital hologram, with even higher speeds for smaller-sized holograms. Live features include:

- Automatic detection and tracking of side band (via live FFT)
- Carrier frequency refinement (via user-defined reference area)
- Distortion correction (via a reference hologram)
- Phase unwrapping
- Fresnel fringe filtering
- Amplitude and Cosine visualisation

*HoloLive!* has been briefly described in the following publication:

- [1] C. Gatel, J. Dupuy, F. Houdellier, M.J. Hÿtch, **Appl. Phys. Lett.** 113, 133102 (2018). *Unlimited acquisition time in electron holography by automated feedback control of transmission electron microscope.* [10.1063/1.5050906](https://doi.org/10.1063/1.5050906)

Development versions of HoloLive! were used extensively in the following in-situ electron holography work:

- [2] C. Gatel, B. Warot-Fonrose, N. Bizi re, L. A. Rodriguez, D. Reyes, R. Cours, M. Castiella, M.-J. Casanove, **Nature Communications** 8, 15703 (2017). *Inhomogeneous spatial distribution of the magnetic transition in an iron-rhodium thin film.* [10.1038/ncomms15703](https://doi.org/10.1038/ncomms15703)
- [3] C. Gatel, X. Fu, V. Serin, M. Eddrief, V. Etgens, B. Warot-Fonrose, **Nano Letters** 17, 2460–2466 (2017). *In Depth Spatially Inhomogeneous Phase Transition in Epitaxial MnAs Film on GaAs(001).* [10.1021/acs.nanolett.7b00144](https://doi.org/10.1021/acs.nanolett.7b00144)

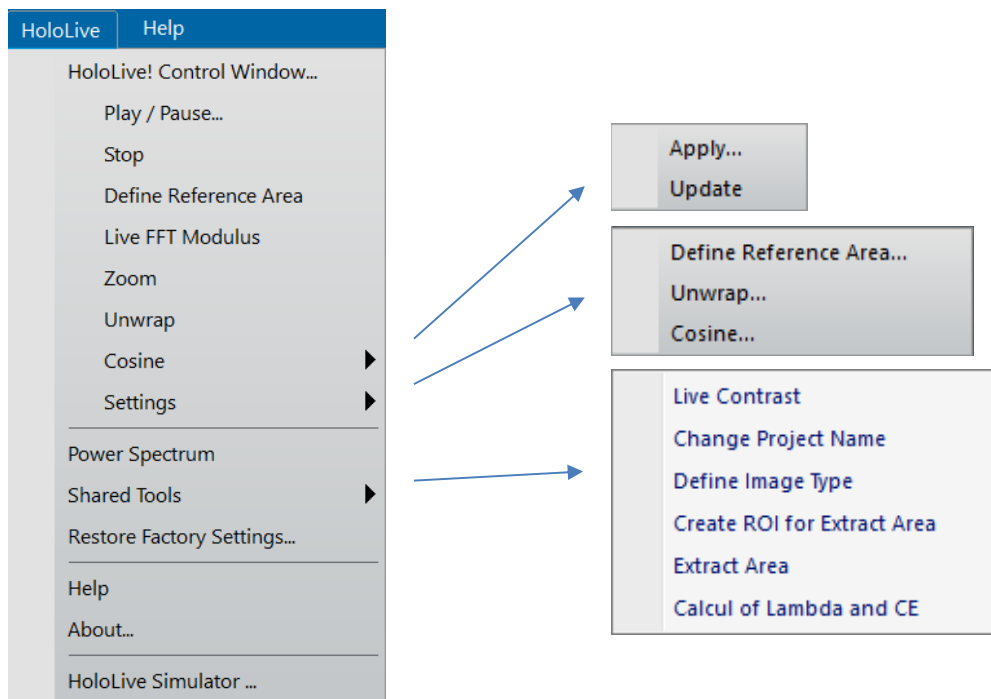
Without phase visualisation during experiments, how can you tell if the data being collected is valuable? And during in-situ work, how could you tell if the applied stimuli are indeed changing the fields? HoloLive! has been designed to help you during experiments, to make them more productive and more interactive.

In this manual, we will dive straight into the use of the HoloLive! package with a prepared example. Indeed, we have provided a stack of holograms, acquired experimentally, to simulate work at the microscope. A simple script refreshes the hologram in a viewing window by cycling through the data stack.

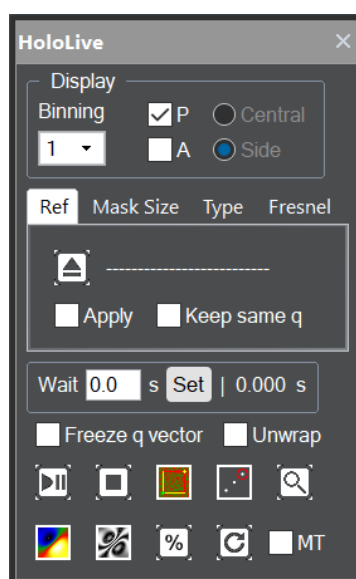


But before starting, there are a few important points to remember:

1. *HoloLive! is a plug-in for DigitalMicrograph (Gatan Inc.).* This means that results are fully compatible with the other functions present in DM. For example, profiles drawn across the live phase images using the **DM line profile tool** will be automatically updated. Similarly, any calibration of the images within DM will be transferred to the phase images.
2. *The complete list of commands related to HoloLive! are located in the menu:*



3. *However, it is more fun to access command using the **HoloLive! Control window** below. You have direct access to it via the **Technique Manager**.*

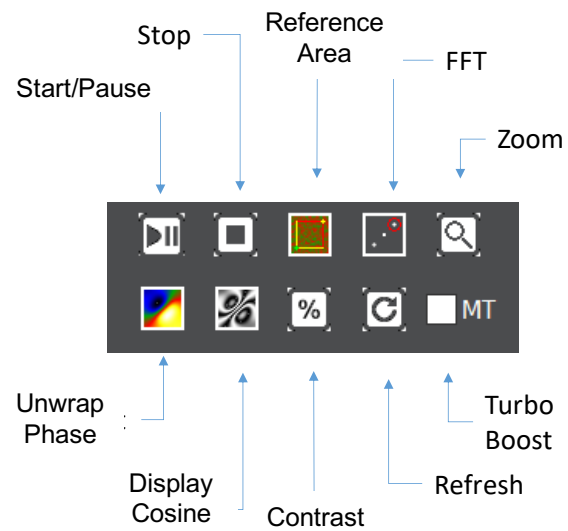


**Technical note:** When the Technique Manager is not displayed, you can open it through Window -> Floating windows -> Technique Manager.

**Technical note:** For GMS 2.x, the window can be opened from the first item menu of the HoloLive menu: HoloLive! Control Window...

**Note:** Clicking on a button with **CTRL** key down will reveal the Settings (if present).  
In the following, we will assume use of the HoloLive control window, but all commands can be accessed via **HoloLive** menu.

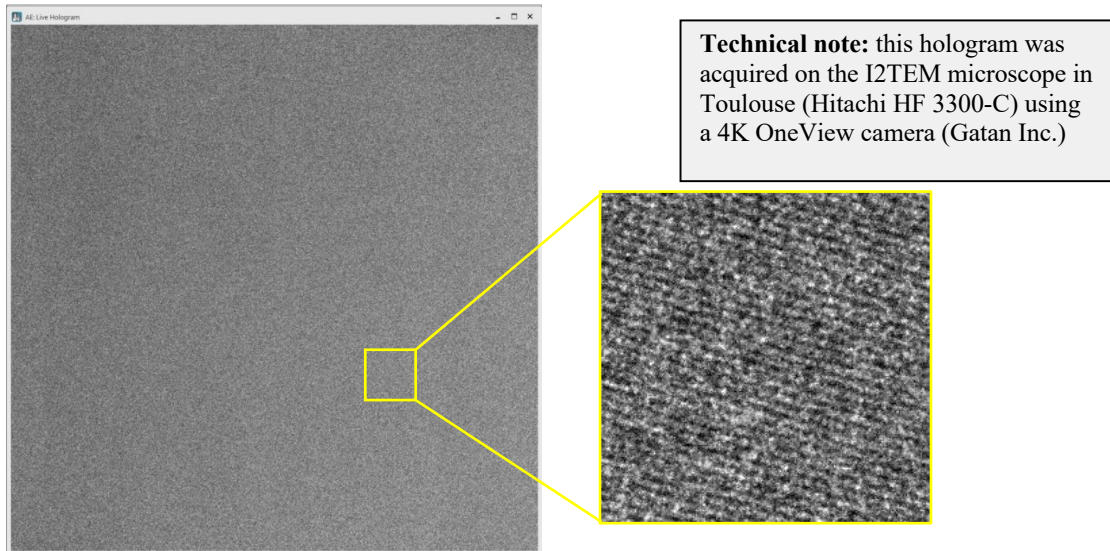
Like a TV remote controller, check out the overall features below:




# HoloLive! Tutorial

## Getting Started

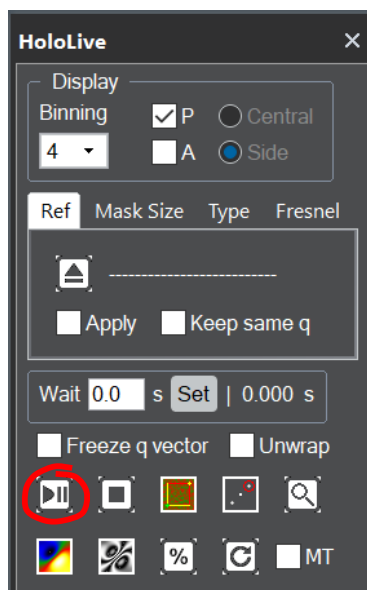
Open the image “Live Hologram” using the DM command **File...Open** from the HoloLive Manual folder:



It does not look like much for the moment but it is a real hologram. Use the **DM magnifying glass tool**  to zoom in to see the narrow hologram fringes. Hint: if you are new to GMS 3, remember you need to right-click on the image for the tools to appear.

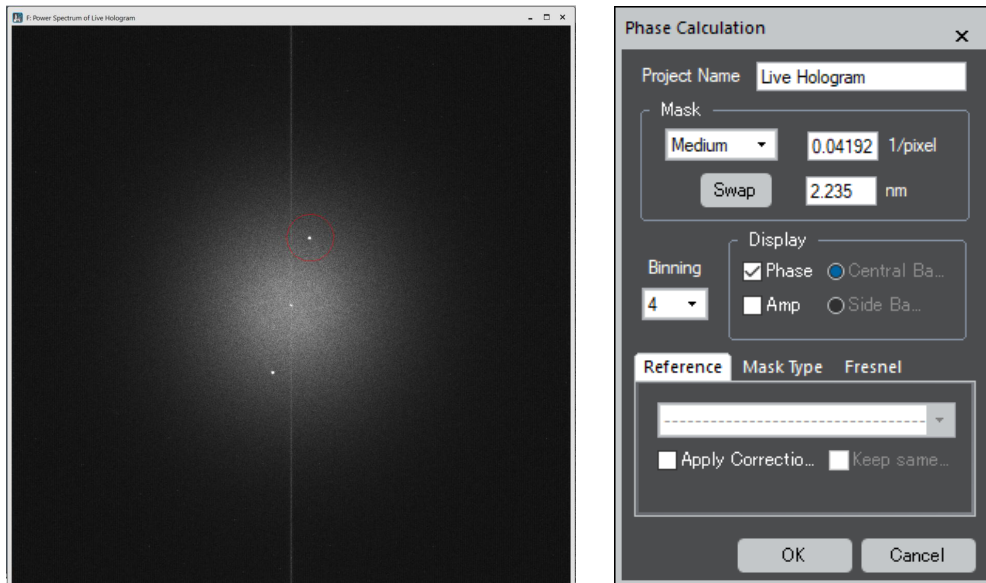
## HoloLive...Start/Pause (Button)

Now let's use HoloLive! to calculate the phase image from this static hologram. Later on, we will make this image move to simulate a microscope session. Select the “Live Hologram” image by clicking on it somewhere (as usual in DM) and then just click on the **Start/Pause** button in the **HoloLive! control window**:




**Hint:** if someone else has been playing the HoloLive! before you, check that the options in the control window look like this and change values if necessary. You can also use **Restore Factory Settings**.

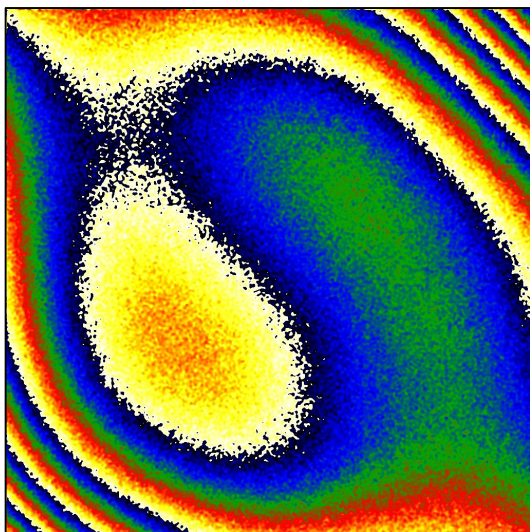
Since this is the first time **HoloLive** operates on this particular image, the **Power Spectrum** of the hologram will be calculated, and the Phase Calculation dialog shown below will be displayed. It should look something like this:



**Technical note:** the power spectrum is the modulus squared of the Fourier transform of the image. To avoid streaking from edge effects, the image was prefiltered. Any remaining vertical streaking is due to the camera (in this case) or the finite width of the hologram.

Notice that the side band (at carrier frequency  $q$ ) has been automatically detected and a red circle has been placed around it with a radius indicative of the mask size. If for some inexplicable reason (this is a worked example!) there is no circle or the circle is in the wrong place, press **Cancel**. The Phase Calculation Window will disappear allowing you place a **DM Rectangular ROI tool**  around the side band. Press again on **Start/Pause** for HoloLive! to find the side band position within the ROI. Just make sure the ROI encloses the side band spot.

We will look at the other features later, but for now just click on **OK**, and you should see your first phase image, called “Live Hologram P”:

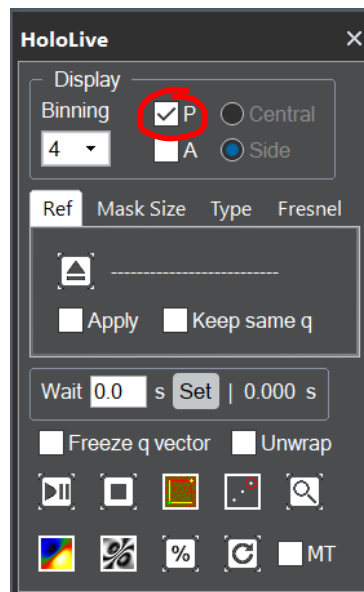


**Technical note:** we like displaying phase images using the “Temperature” colour scale in DM but you can use grey scales if you really want, just use the DM menu **Object...Image Display...Color**. The actual values in the phase image will not be changed, only its appearance.

**Technical note:** in HoloLive!, every image has a “type”, used in the titles and in the image tags. For example, a phase image is type P.

Now, HoloLive! is running. However, the phase image is not changing, because the hologram is static. We will see moving phase images and the use of this **Start/Pause** button later.

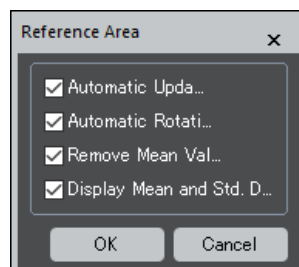
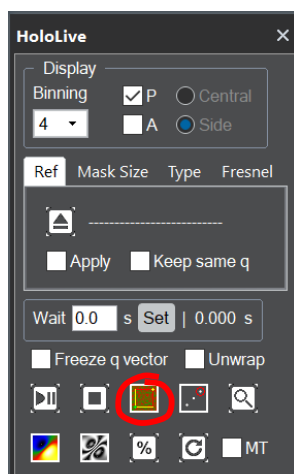
**Hint:** if you close the phase image, by mistake or by intention, you may notice that the **P** box becomes unticked. HoloLive will continue working in the background. To make the phase image reappear, just click the **P** box.



**NOTE:** The **Start/Pause** button can be distinguished by looking at the phase image. If the phase image is continuously updated, the status is ON, so you stop updating by pressing the **Start/Pause** button. Contrary, the image is not updated or you cannot find the phase image, the state is OFF, and you can start phase calculation by pressing the **Start/Pause** button.

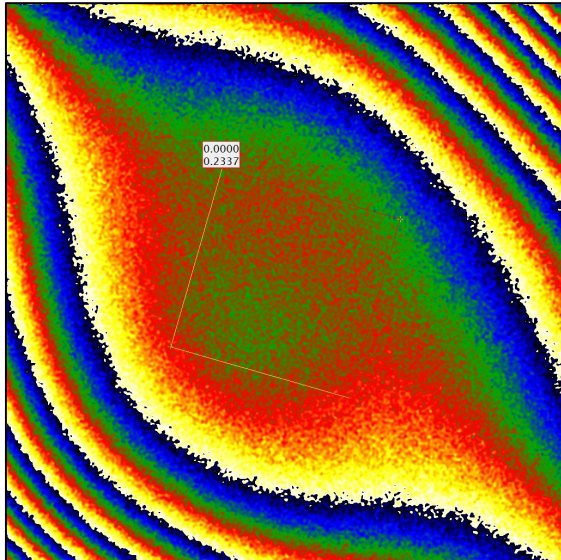
## HoloLive...Reference Area (Button)

When analysing phase images, it is customary to define a reference area. Usually, a region of vacuum is chosen where the hologram is undisturbed by any stray fields. In this example, the whole hologram was taken in empty vacuum so you can choose anywhere using the **DM Rectangular ROI tool**. Alternatively, you can just click on the **Reference Area** button to use the default settings of HoloLive!:

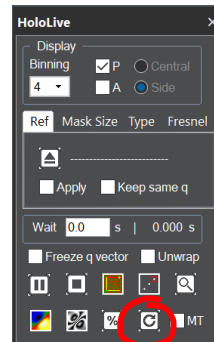


**Technical note:** the default settings is a reference area at the centre of the image, rotated parallel to the hologram fringes. These settings can be modified in the **Reference Area** dialog that will be accessed via the **Settings->Reference Area...** menu or by pressing **CTRL** while clicking on the **Reference Area** button.

HoloLive! will determine the average phase gradient in the reference area and subtract the corresponding phase ramp from the whole image. This is equivalent to ensuring that the carrier frequency  $q$  corresponds exactly to that of the chosen reference area of the hologram. The result should look something like this:



**Hint:** if nothing happened, use the **Refresh** button to make sure HoloLive! updates the phase image (this is a static hologram after all).



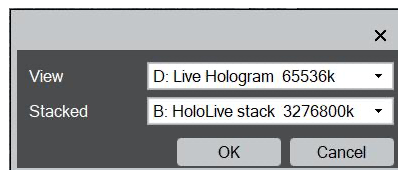
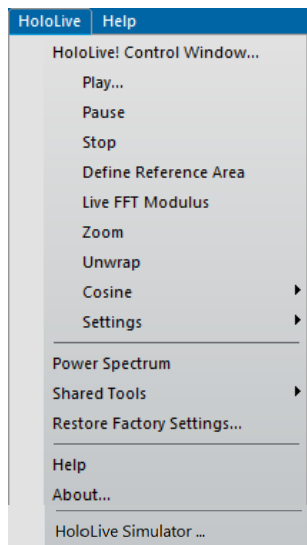
The mean phase and standard deviation of the phase in the reference area are displayed on the top left of the reference ROI. Feel free to move the ROI around and you will see the phase image automatically updated (if not, check that the Automatic Update box is ticked in the **Reference Area** dialog. Remember that **Settings->Reference Area...** menu or **CTRL** plus clicking on the **Reference Area** button will display the settings.) You can also change the size, shape and orientation of the ROI by grapping and dragging the different corners.



## Live Holograms Processing

We could continue explaining the other features using a static hologram but it is more fun to use a live one, just like at the microscope.

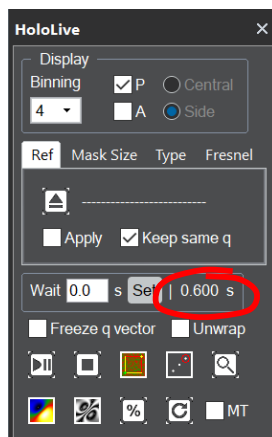
To simulate an on-line holography session off-line so to speak, we have created for you a stack of 50 holograms acquired on the I2TEM microscope in Toulouse. Open the image stack “HoloLive stack”. It is a stack of 4K by 4K holograms weighing a total of 3Gb so there might be a pause. Scroll through the holograms if you like with the **Slice** tab of the **DM Display** window (if absent use **DM Window...Floating Window...Display**). Now launch the menu command **HoloLive Simulator**. Check that the “Live Hologram” image is still open (and preferably the frontmost image). You should see the following dialog:



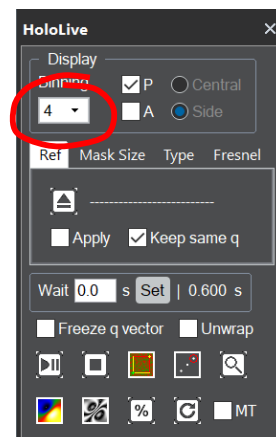
**Hint:** to stop the Simulator press on **CRTL-SHIFT**

Choose as shown the “Live Hologram” to be the equivalent of the viewing screen (View) and “HoloLive stack” to provide the images. On **OK** the script will replace the hologram in the Live Hologram window with a hologram from the stack. The frequency is determined by the number variable “wait” in the script (in seconds). Change it if you like. To halt the movie, press down **CTRL-SHIFT**.

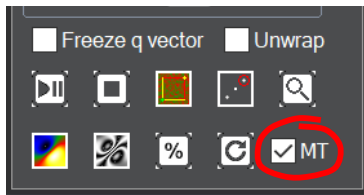
As if by magic, you should see the phase image changing as if it were live. The delay between phase images is displayed on the HoloLive! control window:



**Hint:** make sure you are on **Binning 4** (or higher) unless you want your computer to have a headache. See later for more details.



On the laptop used for writing this tutorial, the time is about 0.6s and varies depending what else is going on the computer. To speed things up use the **Turbo Boost**:



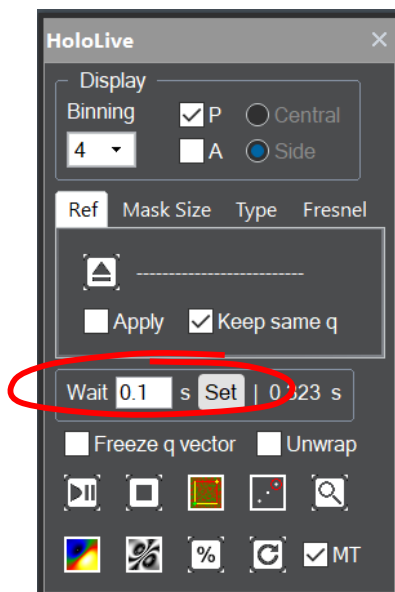
**Technical note:** In fact, MT stands for “Multi-Threading”. Without **Turbo Boost**, all operations (FFT, masks, reference, etc.) will be done in the sequence for each hologram.

Use the **Start/Pause** button to resume and suspend. Note that there is a delay between stopping and starting. This is because it takes a certain time to create the first phase image in a sequence which is longer than the delay between successive phase images using the **Turbo Boost**.

### Please be kind to HoloLive!

Your computer is having to do some pretty heavy calculations, especially with a stack of 4K holograms. Everything has been done to optimise the algorithms in order to reach these speeds but the computer is working flat out. There will always be slight delays after clicking on a button. Please be patient before clicking again.

To assuage your computer, you can always include a “Wait” time:



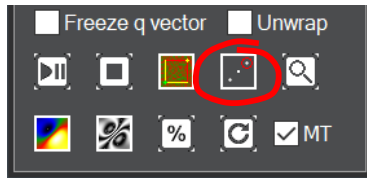
**Hint:** after putting say 1 into the **Wait** box, click the **Set** button for the new value to take effect. You should see the 1 become 1.0.

There are, however, better ways to help your computer by using Binning and ROIs, as we will see later.



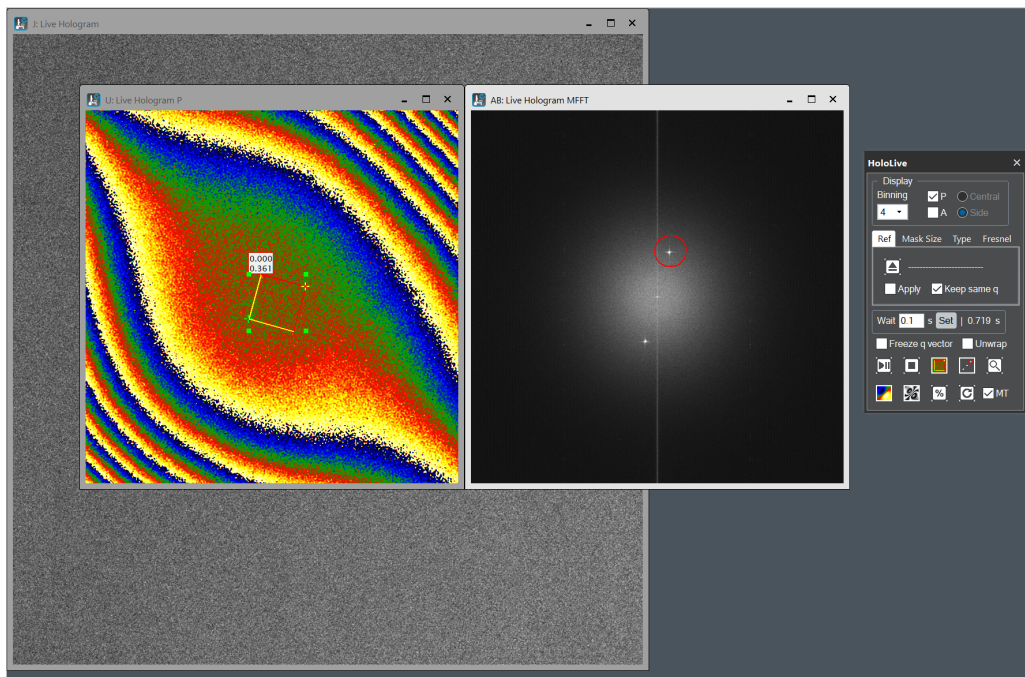
## HoloLive... Live FFT (Button)

By default, the FFT of the hologram is shown live alongside the phase image. If it is not, click on the **FFT** button in the **HoloLive Control Window**:



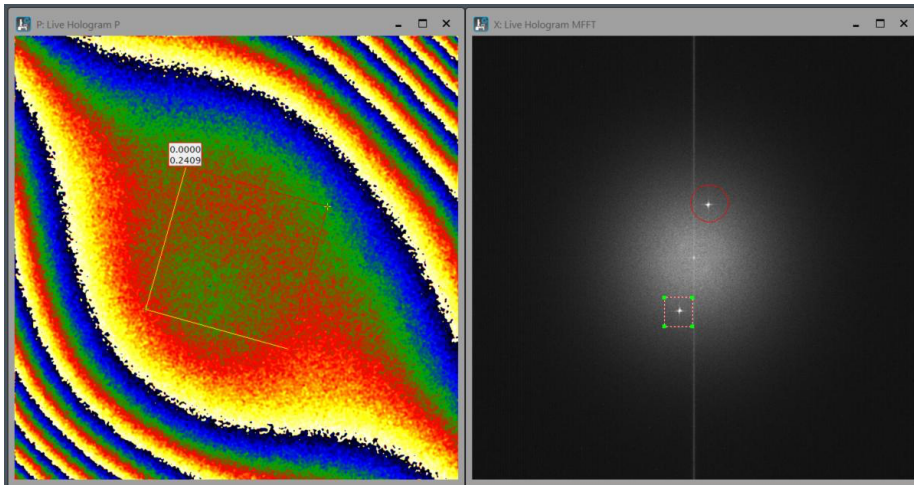
**Technical note:** it is too time consuming for HoloLive! to calculate a live Power Spectrum (which includes masking in real-space). The **FFT** button shows the modulus of the FFT of the hologram (which had to be calculated anyway for the phase image). You will therefore notice streaking of the spots. Purists can see the *static* Power Spectrum using **Power Spectrum** menu.

Now place the Live FFT next to the phase image:

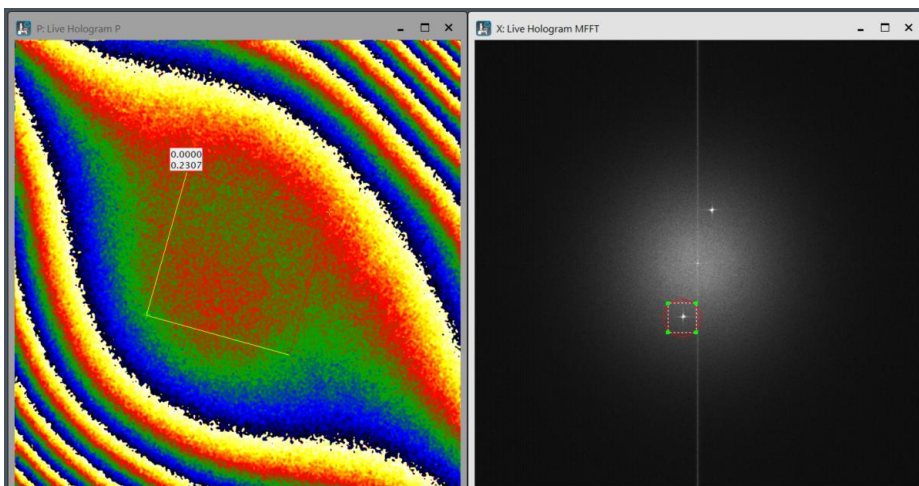


If you press on the **FFT** button again, this closes the Live FFT window. Not to worry, you can press on **FFT** button to make it reappear.

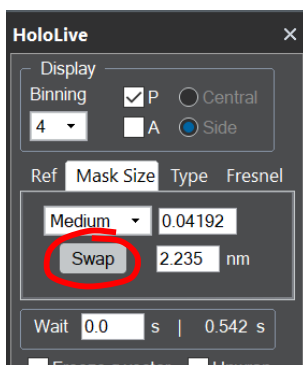
The **FFT** button does more than just displaying the FFT. It can be used to control the choice of sideband. Place a **DM Rectangular ROI** around the other sideband as shown below:



Now press down **SHIFT** key and click on the **FFT** button. This tells HoloLive! to hunt for the sideband within the ROI. You should see the red circle denoting the mask is swapped to the new position:



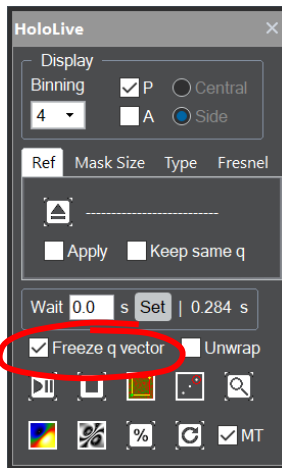
Notice that the phase has changed sign, as it should do since  $\mathbf{q}$  has changed to  $-\mathbf{q}$ . This is such a useful operation, that we have included a special **Swap** button on **Mask Size** tab of the **HoloLive Control Window** to do this:



**Technical note:** the choice of sideband is important for subsequent quantification. Our convention is that the sideband pointing towards the reference wave (usually the vacuum) should be chosen. In that case, the phase is positively proportional to the mean-inner potential of the material. A positive phase gradient means increasing sample thickness.

Have a go but remember the delay.

The main reason for including the ROI option on the FFT was for cases where HoloLive! does not find the sideband. A classic example is when a hologram becomes too noisy (for example, after jolting the microscope or biprism) and loses all contrast. The ROI guides HoloLive! to the right place. Another way to avoid such mishaps is to use **Freeze q vector**:



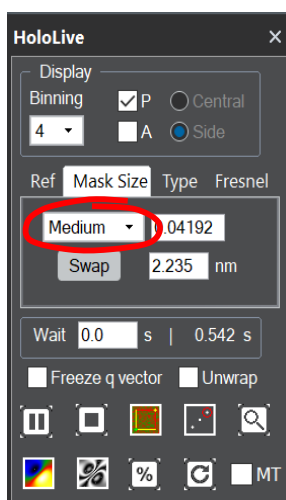
By choosing this option, HoloLive! no longer hunts for the sideband in the live FFT, it just continues to use the same carrier frequency  $q$ . There is a slight increase in speed. Unticking the option just lets HoloLive! go back to automatically detecting the sideband.

A typical experimental procedure is to change the biprism voltage and the carrier frequency changes. Untick the **Freeze q vector** and HoloLive! tracks the carrier frequency. Once the biprism voltage is stable again, **Freeze q vector** can be reselected.

Another use of freezing  $q$  is to detect electric fields during in-situ biasing experiments. The  $q$  vector can be frozen in the vacuum area, when a bias is applied, any gradient in the phase image indicates the presence of an electric field. With automatic tracking, the phase gradient would be automatically removed!

## Mask Size Tab

Since we are on the **Mask Size** tab, let us look at the effect of changing the mask size for the phase reconstruction.

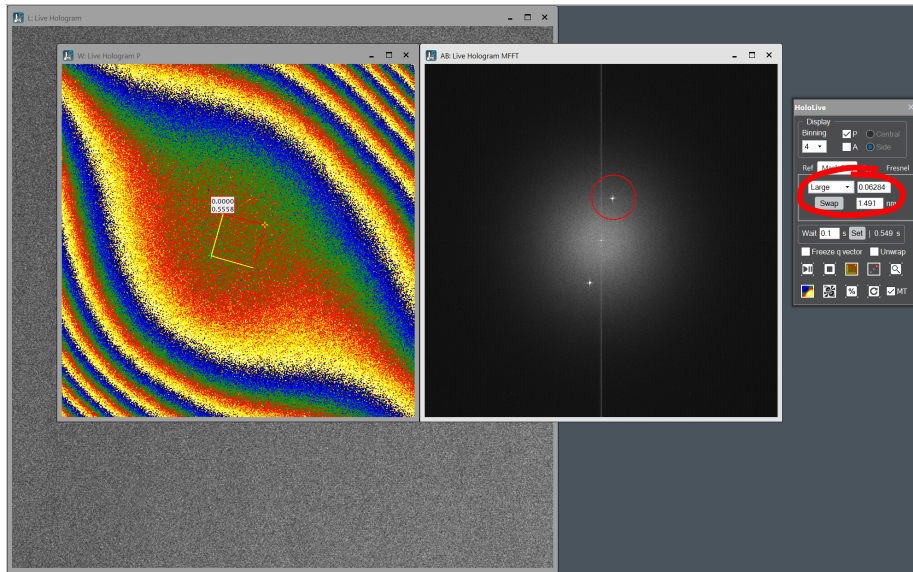


**Technical note:** the default mask radii are the following: Small  $q/4$ , Medium  $q/3$  and Large  $q/2$ .

Technically, a mask size larger than Medium lets information from the centre band leak into the masked region. Holographers argue about whether Large is acceptable or not.



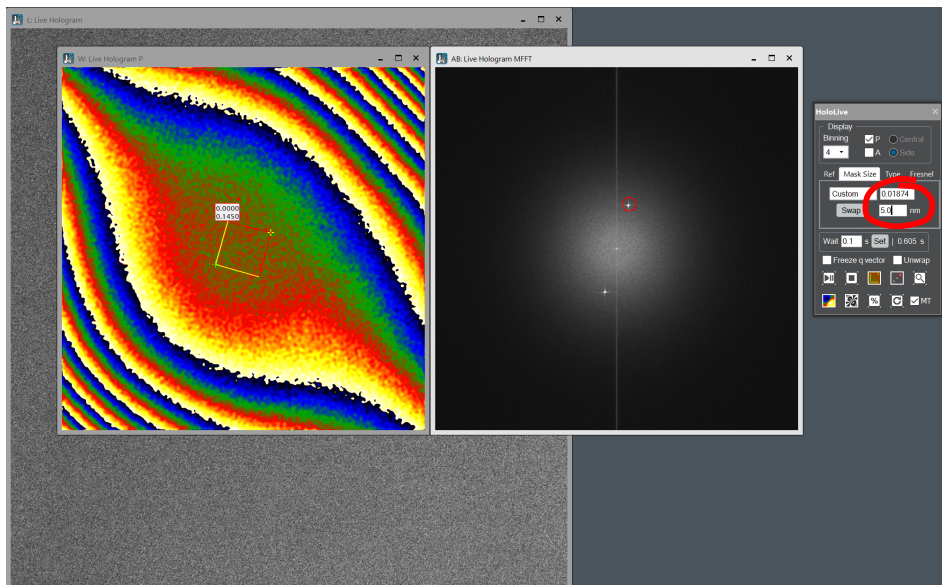
Use the scroll-down menu to choose a “Large” mask size. You should see the following result:



**Technical note:** these figures give the spatial resolution of the phase reconstruction. The upper figure is in pixels and the lower in nm. If the original hologram has not been calibrated, the nm box will be greyed out.

The red circle has a larger radius on the live FFT and the phase image should look noisier but finer grained. The standard deviation of the phase is indeed larger (see the information on the **Reference Area ROI**). The spatial resolution of the phase map is now higher (see the information on the **HoloLive Control Window**.) This is the price to pay for higher spatial resolution: a lower signal-to-noise ratio for the phase.

You can choose any mask size by filling in the spatial resolution you want into the boxes (either in 1/pixel or in nm), then the mask size name is shown as Custom. Choose 5 nm spatial resolution for the phase reconstruction:

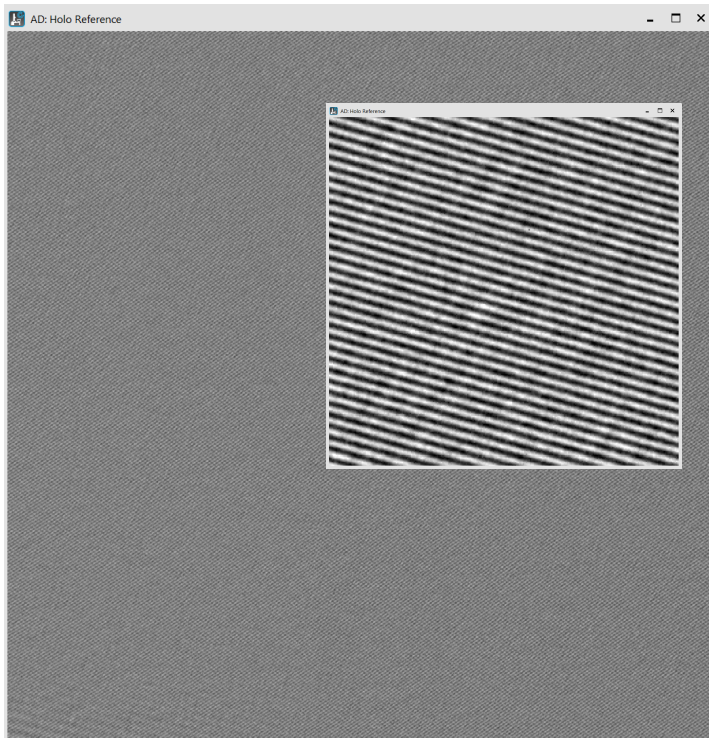


This is indeed a better way to define the mask size as it does not depend on the carrier frequency, which might change during the experiment.


Now that we have seen the FFT, let us close the FFT window. Just close as usual in DM or click on the **FFT** button. If you need it again, just click on the Live **FFT** button.

## Ref (Reference Hologram) Tab

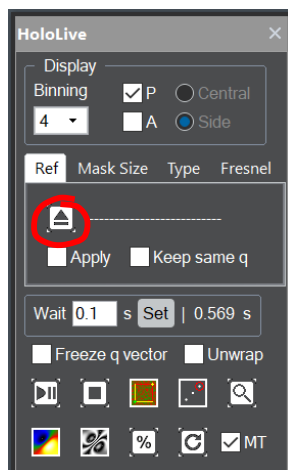
The large phase variations seen in this example are due to optical distortions of the microscope, the projector lens distortions to be exact. To remove them, the conventional procedure is to acquire a reference hologram in empty vacuum. Put HoloLive! on **Pause** state using **Start/Pause** button and open the reference hologram that we have supplied “Holo Reference”:



**Technical note:** this reference hologram has some pretty sensational contrast because we used the drift compensation, exposure time of 4 mins and  $\pi$ -shift reconstruction (see Gatel et al. APL 2018)

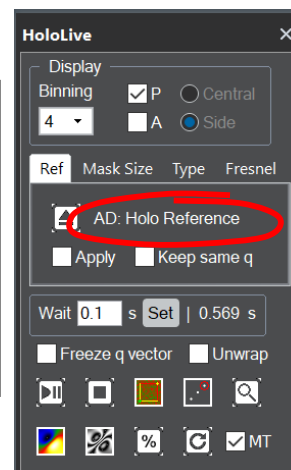
**Hint:** use the **DM magnifying glass** tool  to zoom in.

With the “Holo Reference” as the frontmost image, click on the **Load** icon on the **Ref (Reference Hologram)** tab:



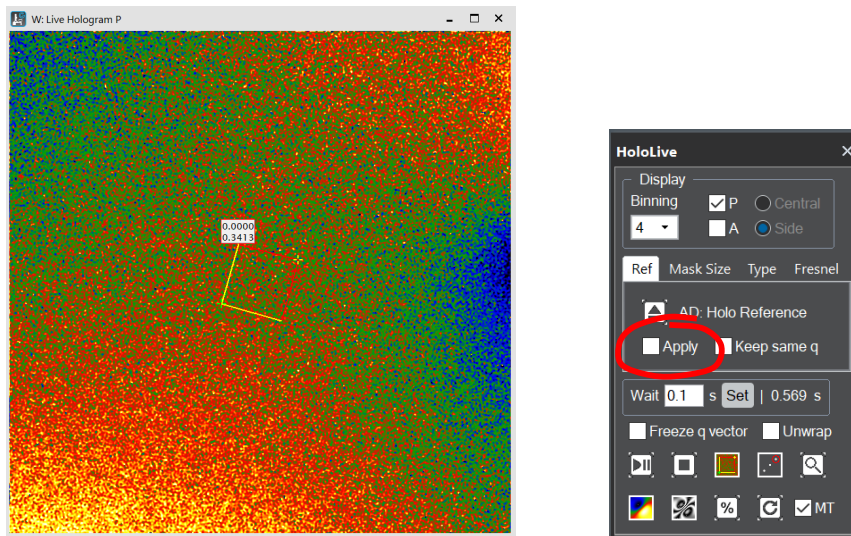
**Technical note:** as usual there will be a pause as HoloLive! calculates and stores the phase reconstructed from the Reference Hologram.

When it is over, the title of the image will appear. It will be truncated to fit into the box.



HoloLive! uses exactly the same parameters (notably the mask size and binning) to reconstruct the phase of the reference hologram. It stores the result ready for use.

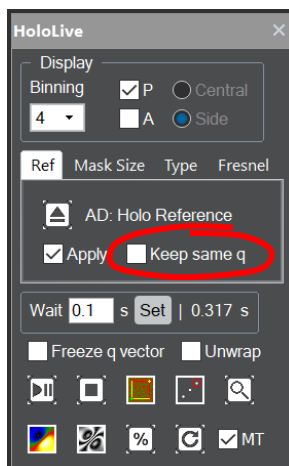
Resume the live phase image by clicking on the **Start/Pause** button, and then click on the **Apply** box to see the correction works:



The phase variation across the field of view is much smaller. Click and unclick **Apply** to see the improvement. Ideally, there should be no phase variation on correction (apart from the noise from the counting statistics). As is often the case, the reference image was acquired a bit later in the day when the imaging conditions had changed slightly.

### ***Reference hologram...Keep same $q$***

The reference phase was reconstructed using the same parameters as the live phase image, but not necessary the same carrier frequency  $q$ . Indeed, HoloLive! hunts for the sideband automatically and determines the peak position itself. This can be useful because the biprism voltage can change slightly, or wilfully, between the current conditions and the reference hologram conditions. Purists, who want exactly the same carrier frequency to be used for the current hologram and reference hologram, can use the **Keep same  $q$**  option:

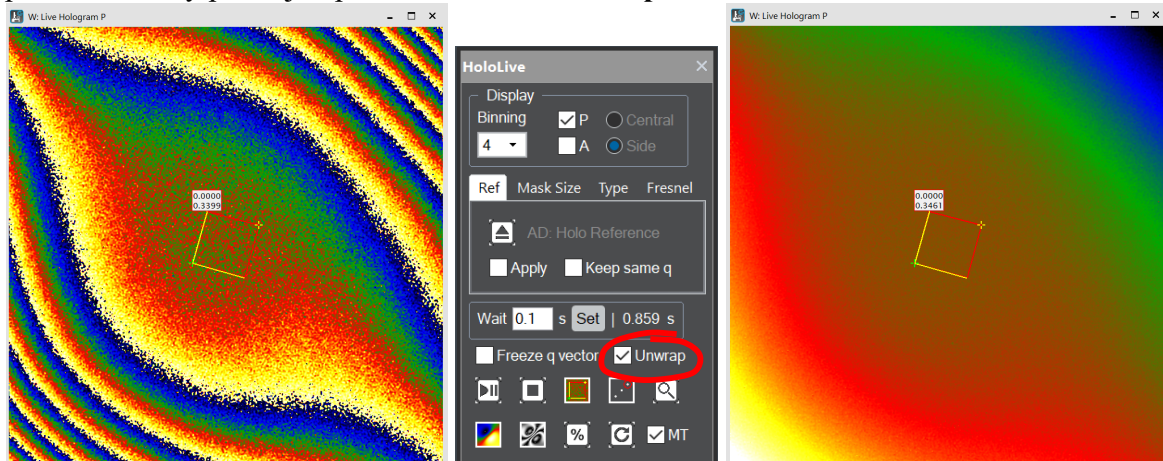




## HoloLive...Unwrap Phase (Button)

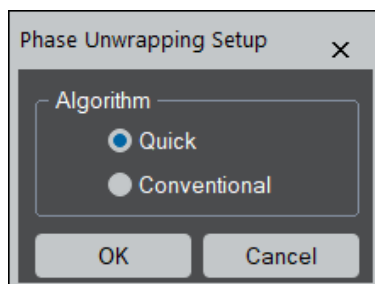
As is well known, the phase is well defined in a range of  $2\pi$ , and in our convention between  $-\pi$  and  $\pi$ . Holographers sometimes like to “unwrap” the phase. This means extending the phase continuously beyond the  $2\pi$  range. For example, if we are looking at a wedge-shaped sample, we would like to see the phase from the mean-inner potential increase continuously from the edge of the sample. We have therefore included an unwrapping capability.

To see the full effect, remove the Reference Hologram correction (untick **Apply**) so that the phase has many phase jumps. Now click on **Unwrap Phase** button to see the transformation:



**Hint:** Noisy images can cause phase unwrapping to fail or give weird results. Reduce the mask size to compensate.

There is no unique solution to phase unwrapping in two dimensions and several methods have been developed with their advantages and disadvantages<sup>1</sup>. The slower ones tend to be more robust but for live phase visualisation speed is important. We have therefore developed two algorithms (based on the Goldstein approach): one very fast and another one which is more conventional. You can choose which one in the **Settings->Phase Unwrapping...**:



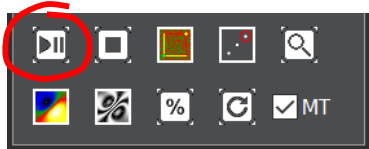
The tutorial holograms have a good signal-to-noise ratio, so the only difference you will see is probably in the speed of execution. However, for noisier images the Conventional setting will produce better results.

<sup>1</sup> See the excellent book by D.C. Ghiglia & M.D. Pritt, “Two-dimensional phase unwrapping: Theory, algorithms and software” (John Wiley & Sons, Inc., New York, 1998).

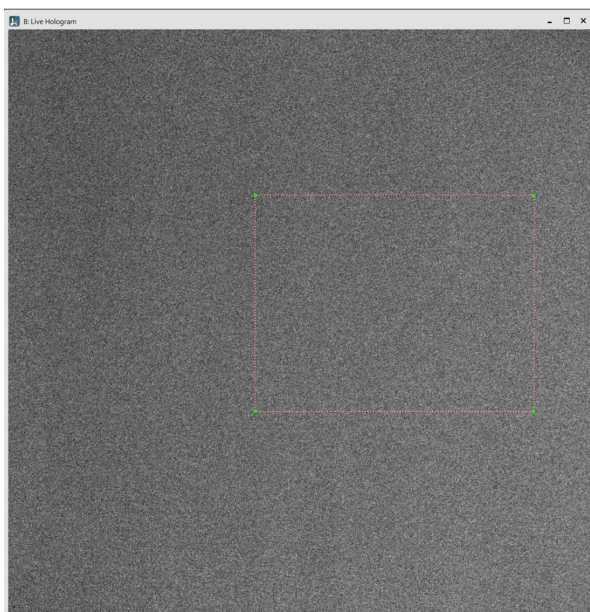
## HoloLive...Zoom (Button)

Sometimes, you do not want to see the phase image corresponding to the whole field of view. HoloLive allows you to see the phase in a smaller region.

First, put HoloLive on **Pause** using the **Start/Pause** button (this is not absolutely necessary but is politer to the computer)

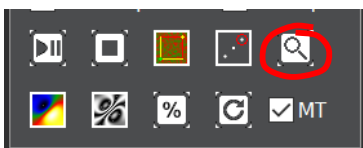


and then select the Live Hologram window by clicking on it. Then draw a region with the **DM Rectangular ROI** tool:



**Hint:** if you hold down **SHIFT** key, you force a square region, and both **ALT** and **SHIFT** keys forces sizes of powers of 2. Do not worry though, HoloLive can deal with any size or proportion.

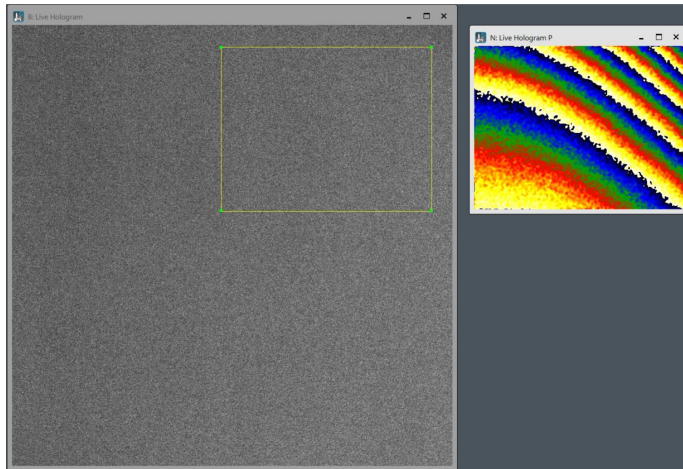
If you have stopped phase updating, restart it by clicking on the **Start/Pause** button, and then click on the **Zoom** button (Magnifying Glass):



**Technical note:** when the phase is updating, you don't need to restart it again.



HoloLive will calculate and display the phase image corresponding to only this small region of the hologram:



**Technical note:** the phase image is calculated using your current settings except **Reference Area**.

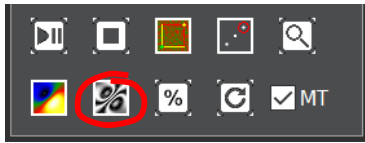
Notice that the ROI has become yellow, which indicates that it is active in HoloLive, and you will see an updating phase image corresponding to the ROI area.

You can even move the ROI around (use the **DM select/arrow** tool to click inside the ROI, then holding the left-click down, move the mouse) and the phase image is updated automatically. You can maybe see this more clearly by not applying a reference hologram correction and freezing the q vector.

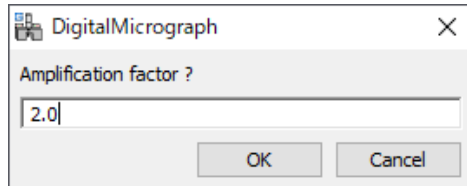
The size and shape of the ROI can also be changed. However, be careful not to grab one of the corners and change the shape too rapidly! When the size and/or shape of the ROI is changed, HoloLive has to recalculate from scratch and performance suffers. Be kind to the computer, shape changing is best done gently.

## HoloLive...Cosine (Button)

While we are in the **Zoom** mode, let us look at the **Cosine** button:



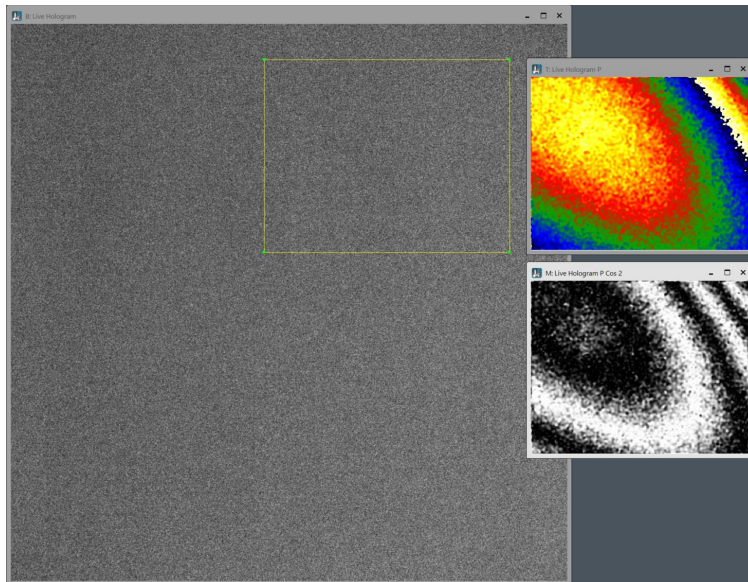
When clicking the **Cosine** button, a dialog to specify an amplification factor,  $\alpha$ , will be open.



### Technical note:

the **amplification Factor** determines the cosine phase magnification. Displayed will be the cosine of the phase times the factor.

By pressing OK, HoloLive! will display  $\cos(\alpha\phi)$  in a new window, where  $\phi$  is the phase. For the default factor of two, the result will look something like:

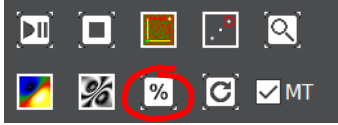


**Hint:** to change the cosine factor *en route*, click the **Cosine** button with **CTRL** down to modify the setting.

Holographers sometimes find this useful to accentuate the phase variations. In fact, the cosine function harks back to the original way of phase visualisation in the analogue days pre-digital.

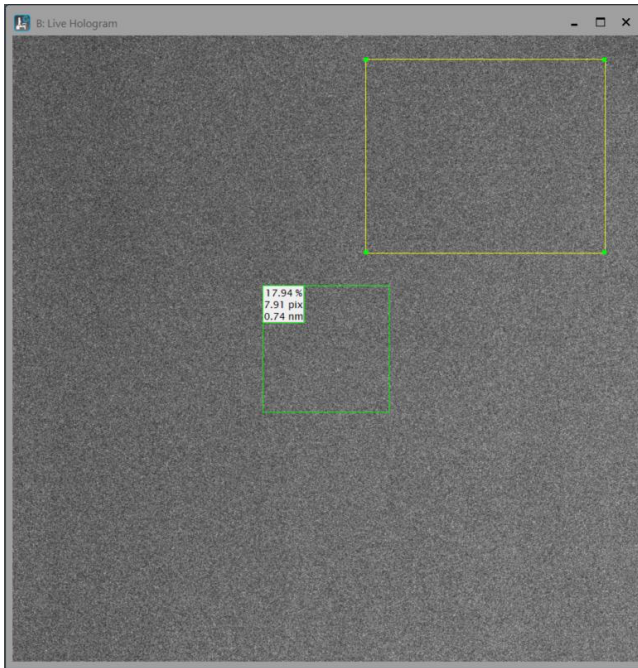
## HoloLive...Contrast (Button)

Another useful feature linked to a selected area in the hologram image is the **Live Contrast** function. Make sure that the Live Hologram is the frontmost image, and click on the **Live Contrast** button:



**Technical note:** you do not even have to have phase images running for this function to work.

If an ROI was present, HoloLive! will use it, otherwise a default ROI will be created:



**Hint:** feel free to move the ROI around or to change its shape or size.

The information provided from top to bottom is the following: hologram fringe contrast, fringe spacing in pixels, and the corresponding spacing in nm if the image has been calibrated.

The contrast uses the same definition as fringe visibility:

$$V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$

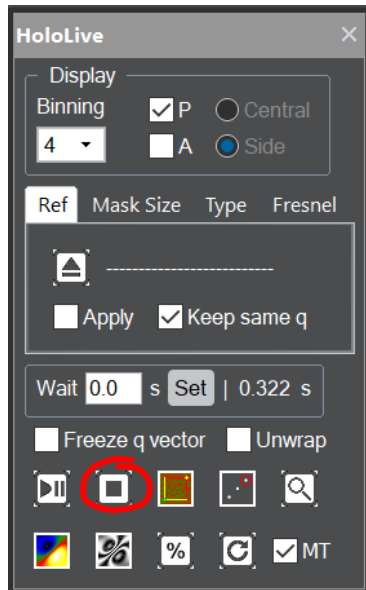
In the presence of noise, we should isolate the fringes from the background and measure their average amplitude. However, for speed, we use an approximation based on the ratio of the standard deviation of the intensity to the mean intensity:

$$V = \frac{1}{\sqrt{2}} \frac{\sigma(I)}{\langle I \rangle}$$

For pure cosine fringes, the result would be correct. However, the method breaks down for a noisy image with weak fringes. In the extreme case, in the absence of hologram fringes, we would be measuring the noise level rather than the fringe contrast. Bare this in mind.

## HoloLive...Stop (Button)

All this time you may have been wondering what the **Stop** button does and the difference with the **Pause** state. Give it a go:

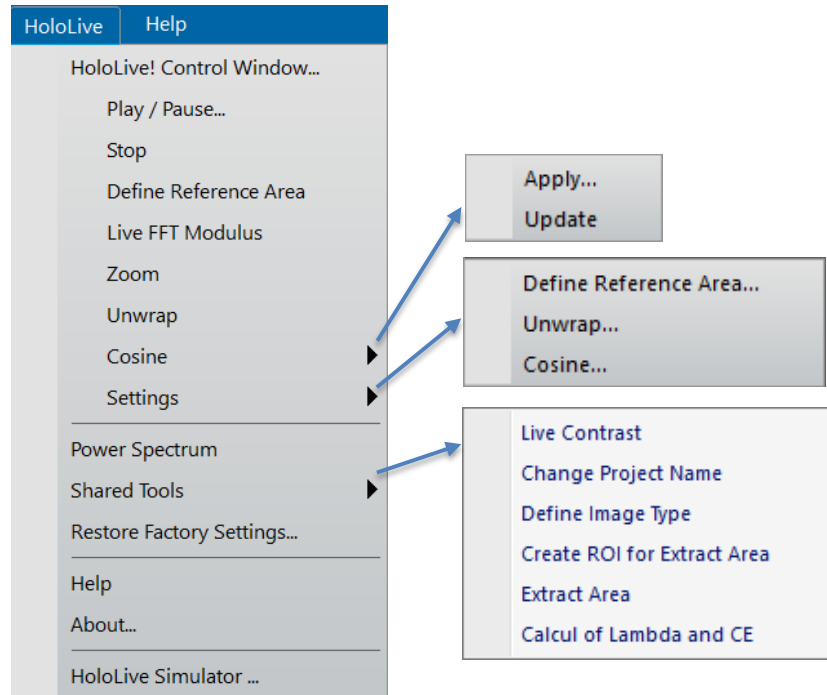


**Note:** **Stop** menu or button will terminate phase calculation, and clean-up the instances created for phase calculation. Therefore, *it is mandatory to use Stop menu or button before you leave HoloLive.*

You may not have seen everything but it is enough for now.  
**This is the end of the tutorial for HoloLive!**

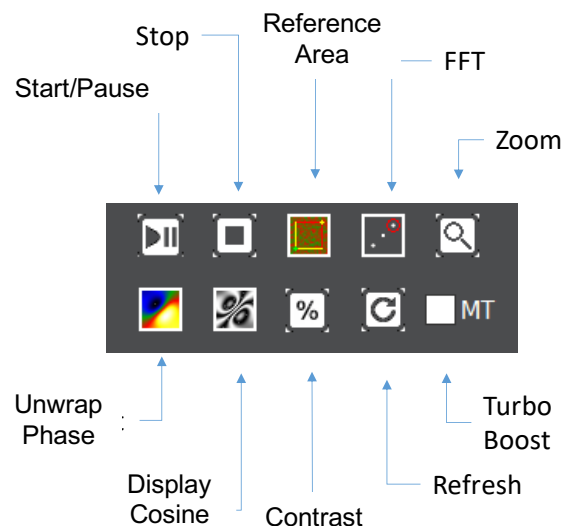
# Quick Reference Guide

## HoloLive Menu



The menu is not the only way to access the commands in HoloLive. The HoloLive Control Window can be accessed through **Technique Manager**.

## HoloLive Control Window



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

**NOTE:** When the Technique Manager is not displayed, you can open it through Window -> Floating windows -> Technique Manager.

**NOTE:** In the case of GMS 2.x, the HoloLive Control Window can be opened from the first menu of the HoloLive: HoloLive! Control Window...

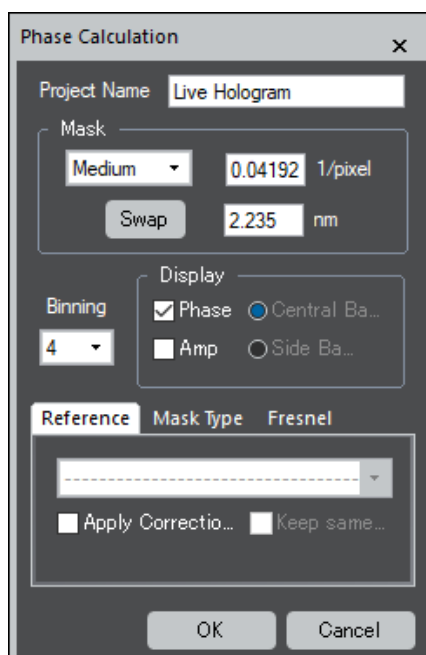
## **HoloLive Main Menu**

The commands in the HoloLive menu are described below.

<b>Command</b>	<b>Description</b>
Start/Pause (Button)	<p>When the front most image is a new hologram, this menu or button will calculate Power Spectrum with an automatically selected side-band within a red circle, and then opens a dialog with the choice of options for phase calculation (see below). When you click <b>OK</b> in the dialog, Phase will be calculated for the hologram.</p> <p>When the front most image is the Power Spectrum of a hologram, Phase will be calculated for the parent hologram.</p> <p>The Start/Pause button resumes or suspend a live phase update.</p>
Stop (Button)	<p>This menu or button will terminate phase calculation, and clean-up the instances created for phase calculation. Therefore, it is mandatory to use Stop menu or button before you leave the HoloLive.</p>
Reference Area (Button)	<p>This menu or button will define an internal reference area for the hologram fringes, when rectangular ROI is present in the phase image. The corresponding carrier frequency <math>q</math> is recalculated and the phase image adjusted accordingly. If no ROI is present, a rectangular ROI is created by default at the center of the phase image.</p> <p>Activating this command with <b>CTRL</b> key down will open the Settings dialog with the choice of options (see below).</p>

Live FFT (Button)	<p>This menu or button displays the FFT of a hologram. If you select this menu or button again, the Live FFT window will be closed. You can select this menu or button to make it reappear.</p> <p>When you use this menu or button with SHIFT key down, a new side-band center will be searched within the given ROI on the FFT.</p>
Zoom (Button)	<p>This menu or button will display a magnified phase image corresponding to the rectangular ROI on the hologram.</p> <p>When you move the ROI on the hologram or change the size and shape of the ROI, the phase image will be updated.</p>
Unwrap Phase (Button)	<p>This menu or button will unwrap a phase image, namely the phase value will be continuously extended beyond the <math>2\pi</math> range.</p> <p>Activating this command with <b>CTRL</b> key down will open the Settings dialog with the choice of options (see below).</p>
Display Cosine (Button)	<p>This menu or button will display <math>\cos(\alpha\phi)</math> in a new window, where <math>\phi</math> is the phase. An amplification factor, <math>\alpha</math>, will be specified in a popped-up dialog (see below).</p> <p>Activating this command with <b>CTRL</b> key down will open the Settings dialog with the choice of options (see below).</p>
Settings	Each submenu opens Settings dialog for corresponding commands (see below).
Restore Factory Settings	Resets all defaults and options to the initial values for HoloLive.
HoloLive Simulator	Opens HoloLive simulator dialog.

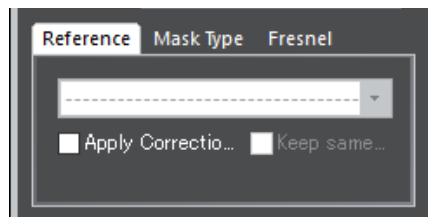
## Phase Calculation Dialog



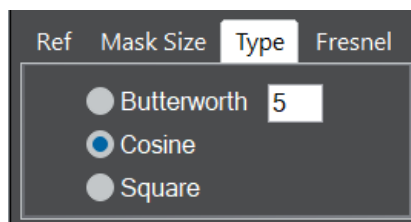
The components of the dialog are described below.

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	<b>Size:</b> Large (q/2), Medium (q/3), Small (q/4) and Custom. Mask size in 1/pixel and real-space nm (if calibrated). <b>Swap</b> allows the opposite side-band to be chosen. The q-vector should point towards the reference wave.
Binning	Selection of the binning factor from 1,2,3,4,5,6,7,8.
Display	Display controls for Phase and Amplitude (Amp). Selections for Central-band or Side-band.
Reference Tab	For information about the components of the Display tab, see <i>Reference Tab</i> below.
Mask Type Tab	For information about the components of the Mask tab, see <i>Mask Type</i> below.
Fresnel Tab	For information about the components of the Display tab, see <i>Fresnel Tab</i> below.

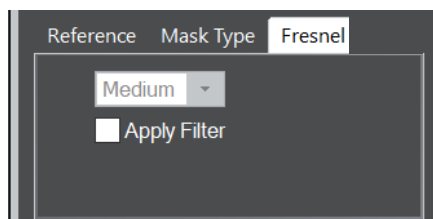


Reference Tab

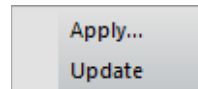
Component	Description
Reference hologram	Scrolling menu to choose the reference hologram from list of open images.
Apply Correction	Means that the hologram phase will be corrected using the above chosen reference hologram image.
Keep same q	This means that the q-vector will be identical for the object and reference holograms.

Mask Type Tab

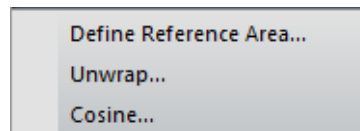
Component	Description
Butterworth Order	Butterworth shape for the mask. Order of Butterworth filter.
Cosine	Half-cosine mask with hard-cut off given by Mask Size.
Square	Square mask with hard edges. Mask size defines the half length of the square edge.

Fresnel Tab

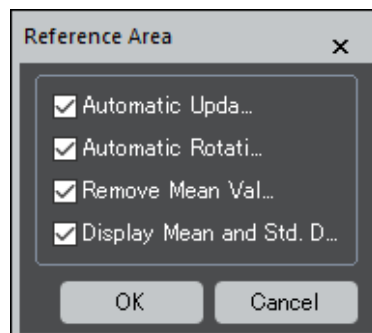
Option	Description
Fresnel Filter Strength	Strength of Fresnel filter: Weak, Medium, Strong.
Apply Filter	Defines whether Fresnel filter is applied or not.

**Cosine sub menu**

Command	Description
Apply	Creates an image that is equal to the cosine of the frontmost phase image multiplied by a user-definable Factor.
Update	Ensures that the Cosine Image is updated using the current Cosine Factor.

**Settings sub menu**

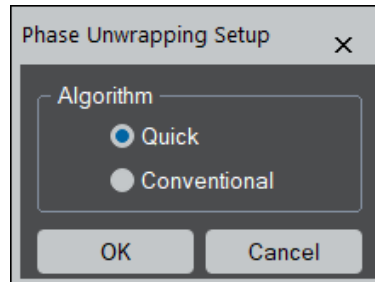
Command	Description
Define Reference Area	Opens a dialog to control Define Reference Area command.
Unwrap	Opens a dialog for selecting an unwrapping scheme.
Cosine	Opens two dialogs to set Factor and Increment that define an amplification factor.

**Define Reference Area Dialog**

Option	Description
Automatic Update	Moving the reference area automatically updates the phase images and reference values.
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.

### Unwrap Phase Dialog



Option	Description
Quick	Accelerated version of the Goldstein routine.
Conventional	Conventional Goldstein routine for phase unwrapping.

### Shared Tools sub menu



Command	Description
Live Contrast	Displays the fringe contrast, the fringe spacing (in pixels and calibrated units) and mean intensity above a rectangular ROI in the hologram image. A rectangular ROI will be automatically created if absent. Values are updated as the ROI is moved.
Change Project Name	Allows the project name to be changed.
Define Image Type	Allows the image type to be changed, changing the tag of the image "Type".
Create ROI for Extract Area	Creates a rotatable ROI on front most image.

Extract Area	Creates a new image corresponding to rotatable ROI on front most image.
Calculate of Lambda and $C_E$	Calculates and displays the value of the electron wavelength and the hologram constant $c_E$ in the DM Output window.