ĆWICZENIE 106	LIQUID CRYSTAL MODULATOR

1. Experimental set-up

1.1. Find all the elements necessary to perform the experiment: Spatial Light Modulator (SLM), two mounted polarizers (P, A), lens S, grey filter FS, CCD camera, white screen. Turn on the laser, connect the CCD camera and SLM to the computer, plug SLM power, remove camera cover. Finally, turn on the computer (it is important to turn on SLM first, otherwise the computer may not detect the modulator)

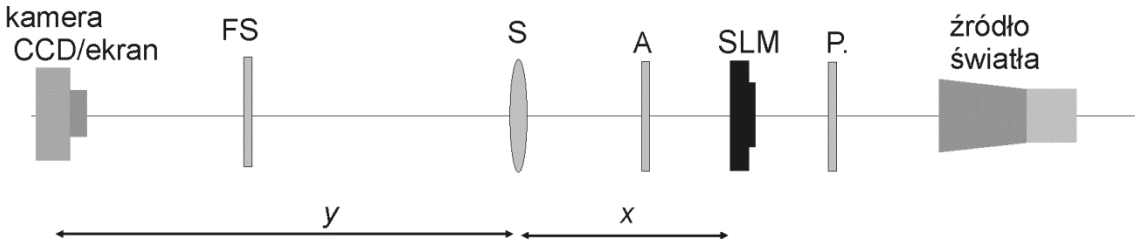


Fig. 1. Element's arrangements used in the experimental setup.

1.2. Please note that the polarization filter can be rotated in its mount without rotation of the angular scale. Therefore the polarization filter has an additional white dot for the adjustment of its position with respect to the marker on the mount. This dot should overlap with the marker on the mount (Fig. 2). Angle of the polarizer axis will be denoted as θ_P, and analyzer respectively as θ_A.

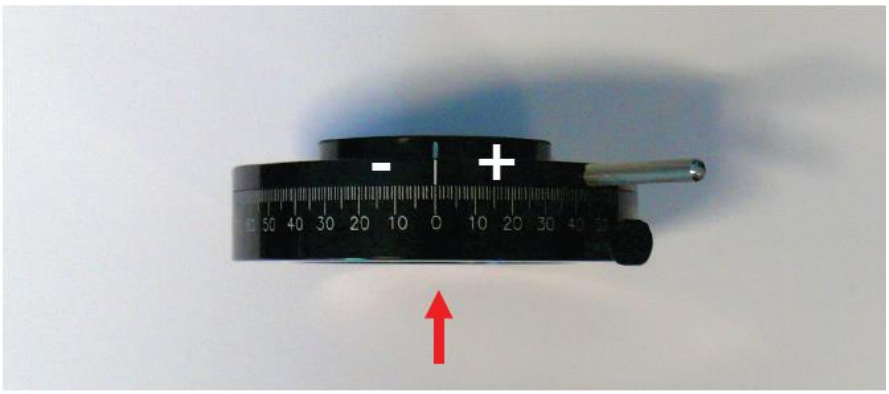


Fig. 2. Definition of the light propagation direction and of the sign of the direction of the angular scale reading used in this manual

1.3. Run the program HoloLab (HoloLab3) on the computer. This software enables to control the SLM and allows to observe the image detected on the CCD camera. When you start the program, you will see the three windows: *Video preview*, *SLM preview* and *Tools* (fig. 3). *Video preview* shows the image detected at the CCD camera, *SLM preview* shows

the image/mask displayed on the SLM. Window *Tools* enables to control/specify the image displayed on SLM. CCD camera is a 8bit camera and it detects image with the 255 grayscale level. Too high light intensity may cause the overexposure of the camera (not recommended). In the case of too much light, insert the grey filter in front of the camera. If it does not help, try to decrease the exposure time (in the *Video preview* window, click *Options* and then *Stream*-you will see the window *Właściwości* (fig. 4). Choose the bookmark *Timing*, set *Auto exposure* and *1/framerate* of and using the slider choose the correct exposure time. Click *OK* button)

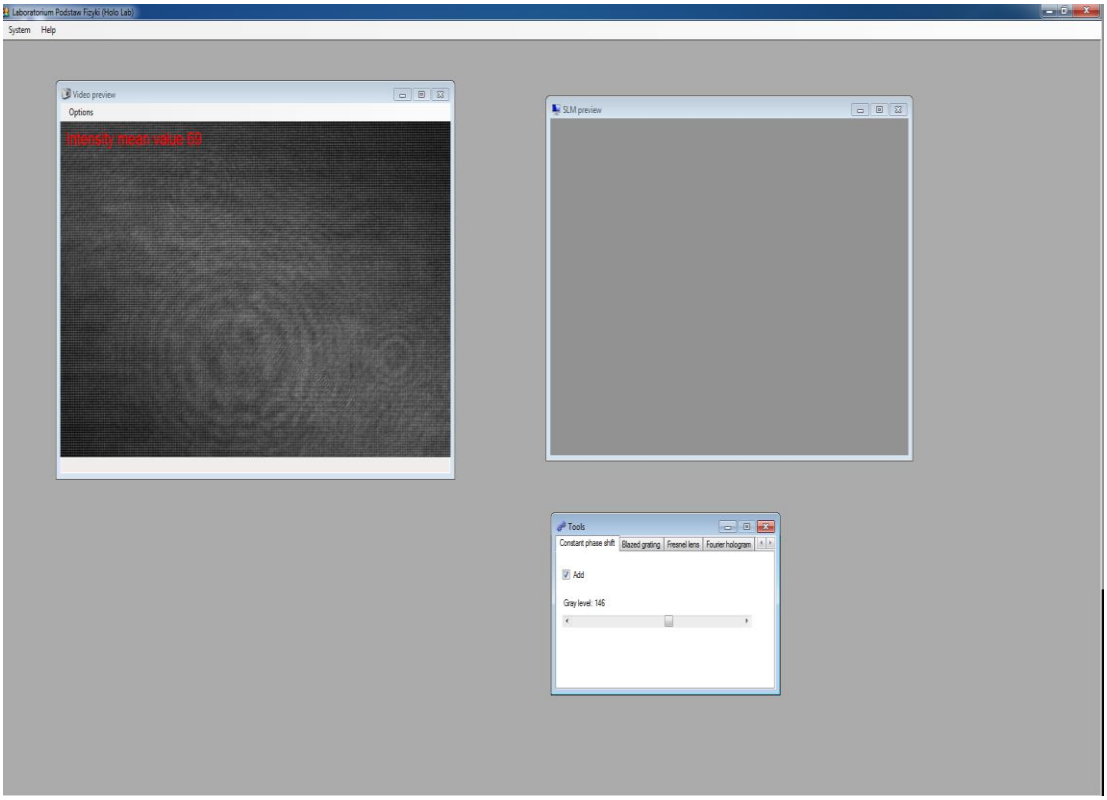


Fig. 3. Three windows of the Hololab3 program.

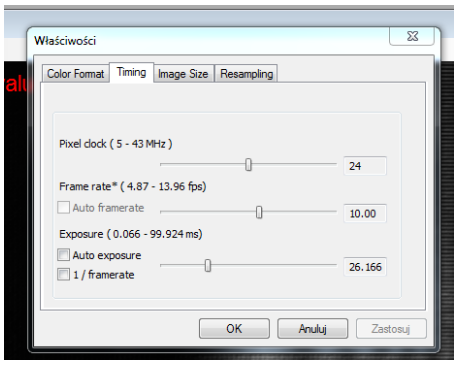


Fig.4. Camera exposure time window

2. Experiments proposals

2.1. SLM as a video display

SLM can be used as a transparency in the classical projection set-up. Setup the optical system shown in Fig. 1. Place the polarizer and analyzer crossed (θ_P=0°, θ_A=90°). Put the lens of the focal length 250mm at the distance longer than 300mm from SLM. Display some image on the SLM. To do this, from the window *Tools* choose the bookmark *Display image* and load any image. At the white screen watch the image of the object displayed on the modulator. Rotate the analyzer in the angular mount and observe what happened to the image on the screen. Note that the contrast of the image depends on the relative angle between the polarizer and analyzer axes. One can modulate the light intensity by rotating the analyzer axis. Remove the analyzer and observe the image on the screen.

NOTE: SLM itself modulates the phase of the incoming wave only. To change the phase modulation into the amplitude modulation the polariscope setup is needed (polariscope=polarizer+analyzer)

2.2. Polarization characteristics of light sources

Experimental setup used is shown in Fig. 5 (Light source, polariser, grey filer and detector). Rotate polarizer by 10° and observe the change in the light intensity. In the case of unpolarised light, the light intensity should not change. For linearly polarised light sources a sinusoidal angular dependence should be observed.

Fig. 5. Measurement of the polarisation characteristics of a light source.

2. 3. Angular distribution of linearly polarized light (Malus law)

Experimental setup is shown in Fig. 6. (light source, polarizer, detector). If the used light source is not linearly polarized, a fixed polarizer provides linearly polarized light. Set the polarizer at the position θ_P=0°. Rotate the analyzer gradually by 10° in the range from -90° to +90°. For each analyzer position θ_A write down the mean light intensity (I) as detected on CCD (red number in the upper part of the *Video preview* window). Sketch the graph showing dependence I(θ_A).

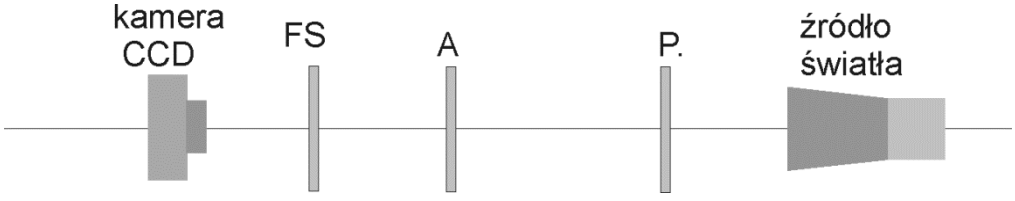


Fig.6. Polariscope set up for measuring the angular distribution of the polarized light.

2.4. Polarizing properties of the light modulator

Experimental setup is shown in Fig. 7. Set the polarizer and analyzer crossed (θ_P=0°, θ_A=90°).

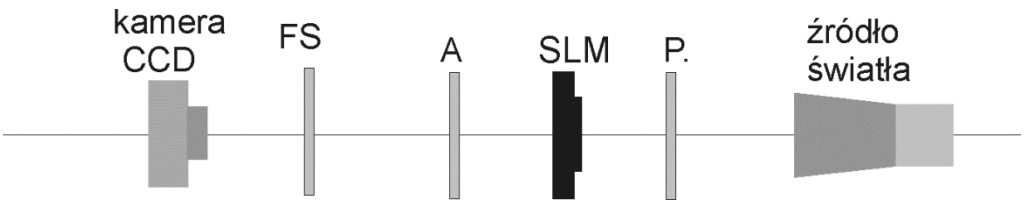


Fig.7. Measurement of the polarization characteristics of the light modulator.

- From the *Tools* window choose the bookmark *Constant phase shift* (fig. 8). This options displays on the SLM image with the constant grey level (from 0-255). Value of the grey level ascribes the appropriate value of the voltage between the marginal layer of the liquid crystal (the higher grey level value the higher voltage). The polarization state of the light passing through the SLM with the applied voltage is changed, and consequently the phase of the light is changed too. Using slider change gray-level (voltage) and watch the change in the light intensity on the screen or CCD (check the *Add* button).

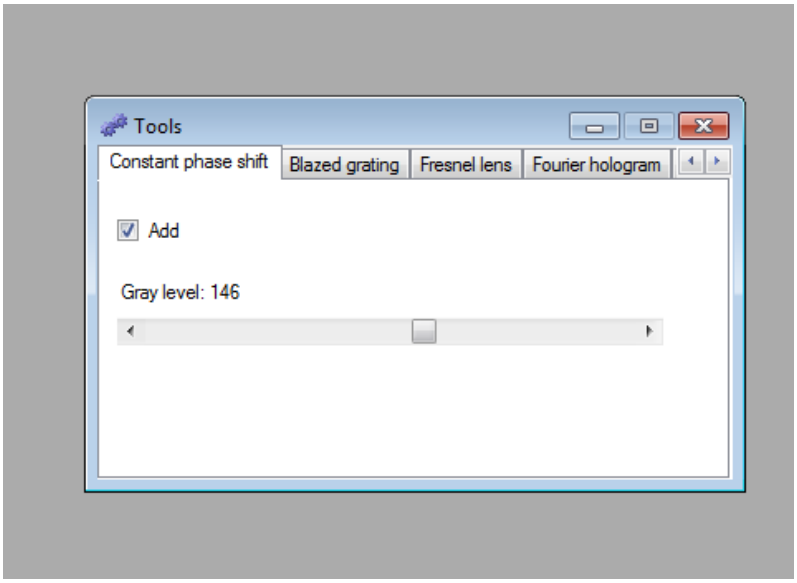


Fig. 8. Window Tools of the HoloLab3 program.
Check the Add buton to display this image on the SLM.

- Check if the same effect will be observed without the analyzer in the setup
- Remove adding the *Constant phase shift* (un-check the Add button). From the *Tools* window choose the Blazed grating bookmark (here check Add button). Using slider set the grating parameters to get the image shown in Fig. 9. Rotate the analyzer and observe the change of the image contrast

NOTE Adequate polariscope configuration may cause phase-only modulation, amplitude –only modulation or both: amplitude and phase modulation

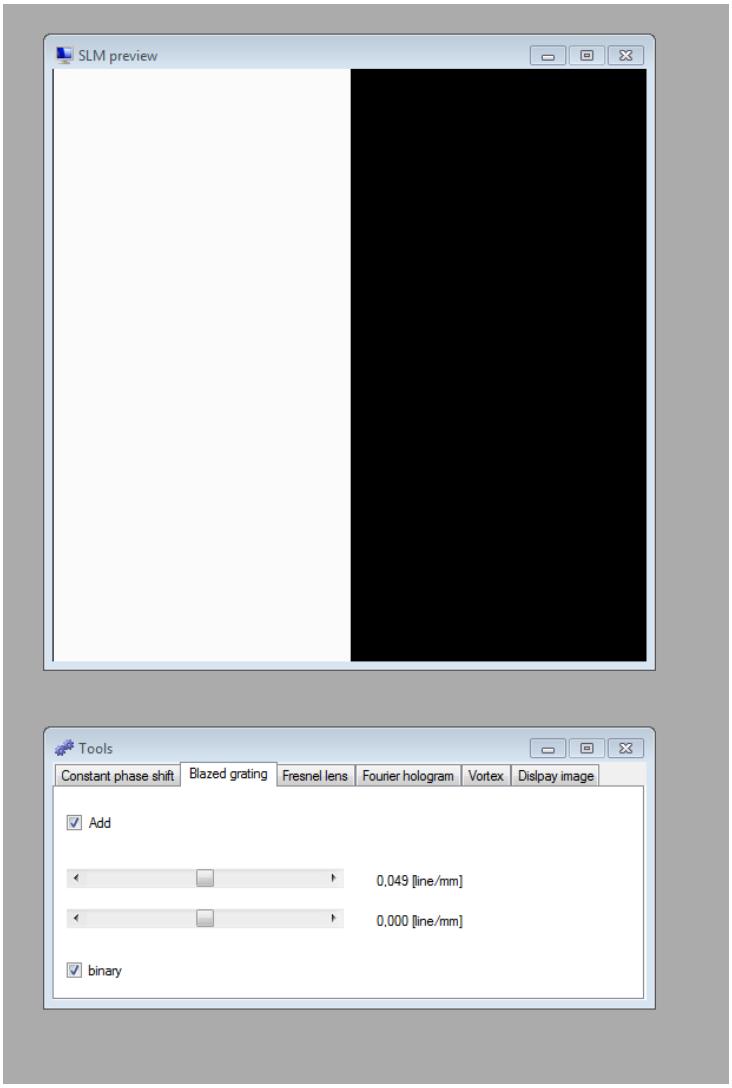


Fig. 9.

2.5. SLM as a diffraction object

2.5.1. Displaying diffraction grating

Set the optical system shown in Fig. 10. The CCD camera should be situated at the lens' focal plane. In the *Tools* window choose the bookmark *Blazed grating* and check the box *Add*. Set the grating spacing and orientation using the slider (along OX and OY direction). At the CCD camera observe the diffraction pattern from the grating (see fig. 11). Note that its shape depends on the grating spacing and orientation. Note that the grating parameters can by dynamically changed.

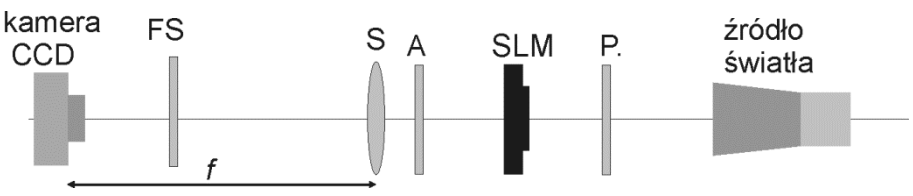


Fig. 10. Set-up for displaying and observation the diffraction spectra

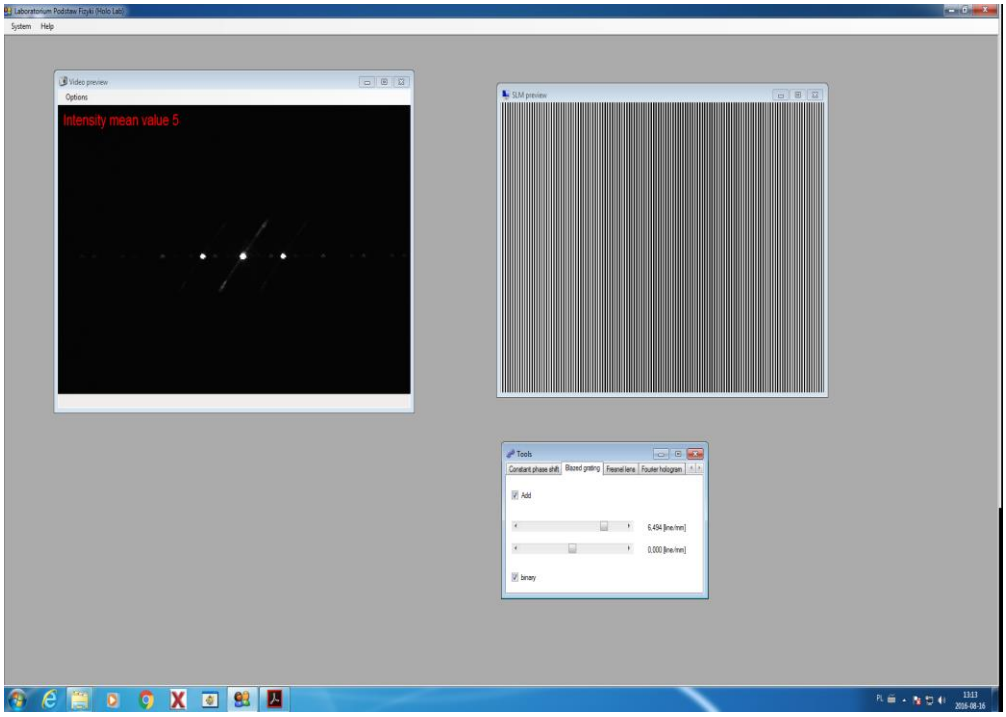


Fig. 11 Exemplary diffraction pattern from the grating (*Video preview* widow), phase map of the diffraction grating *(SLM preview* window) which was set at the *Tools* window.

2.5.2. Displaying hologram

To do this task we need optical system shown in fig. 10. From the *Tools* window choose the bookmark *Display image* and load any image. Check the button *Add.* Next, from the bookmark Fourier hologram, click the button *Wylicz* hologram. In the SLM preview window, the hologram of the image appears. On the CCD (when situated at the lens focal plane) we can observe reconstructed hologram.

2.5.3. Displaying the combination of the phase maps

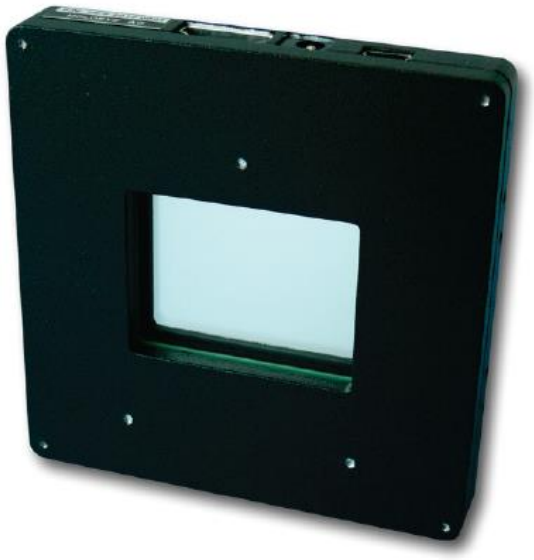
SLM allows to display together many different phase maps. We can display simultaneously hologram, Fresnel lens, prism, grating etc. For example, if we display phase map of the hologram and Fresnel lens together, the observation plane of the hologram will be defocused. If we display phase map of the hologram and diffraction grating together, the reconstructed hologram will be shifted in the plane perpendicular to the optical axis. Below is shortly discussed, how it can be done. We need the experimental set-up is shown in fig. 10.

1. Display the hologram mask on the SLM (From the *Tools* window choose the bookmark *Display image* and load any image. Check the button *Add*. Next, from the bookmark *Fourier hologram*, click the button *Wylicz*). The reconstructed hologram should appear on the CCD camera.
2. Add mask of the diffraction grating to already displayed mask of the hologram. To do this go to the bookmark *Blazed grating*, check the button *Add*, and using slider set the grating spacing and orientation. The reconstructed hologram, observed on the CCD camera, should be shifted in the direction perpendicular to the optical axis. The amount of the shift depends on the gratin parameters.

3. Add the mask of the Fresnel lens to already displayed mask of the hologram and grating. Go to the bookmark *Fresnel lens* in the *Tools* window (check the button Add). Using the slider set the focal length of the lens. The image observed on the CCD camera becomes blurred. You can find sharp image by moving the camera or glass lens (preferred) along the optical axis.

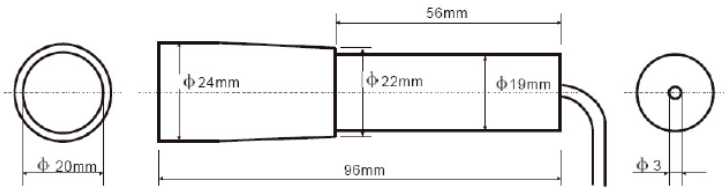
Opracowała
Agnieszka Popiołek-Masajada

TECHNICAL PARAMETERS:



Modulator

Display Mode: twisted nematic
Active area: 36.9 x 27.6 mm
Diagonal: 1.8”
Pixel size: 36μm
Resolution: 1024 x 768 Pixel - XGA
Image frame rate: max 60Hz
Operating voltage: 12V- 2.5A
Working temperature: -10° ~+40°



Laser module

Wavelength: 650nm
Operating power supply: 5V, 120 mA