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LABORATORY REPORT: HOLOGRAPHY

INTRODUCTION

Lights are electromagnetic waves.

A monochromatic optical wave can be mathematically expressed as a wave equation: $x = A\cos(\omega t + \phi - \frac{2\pi r}{\lambda})$

where A is the amplitude and $(\omega t + \varphi - \frac{2\pi r}{\lambda})$ carries phase information. The way we view any given object is to observe the brightness (amplitude), color (wavelength), and shape/distance (phase).

A conventional photograph records the focused image of an object on a photographic film or plate. A hologram is a photographic recording of an optical interference pattern. The amplitude and phase of light coming from the object are stored in the hologram. The phase information enables us to reconstruct the original wavefront and hence obtain a three-dimensional image in space.

The holography experience in this lab will consist of two steps, a) recording: the amplitude and phase information of an object is recorded on a film, b) viewing: illuminating the film to reconstruct the object that was being filmed.

This experiment uses a 658nm diode laser as a source of coherent light which irradiates the objects, and also provides a reference beam of uniform amplitude and phase.

PROCESS

1. Recording

At the very beginning, we prepare light path according to Fig. First, we have a dark environment .Then we adjust the path length of the reference and object beam, so that

the path difference is small. Then, we adjust the devices so that both the object and reference beams are irradiating the film area uniformly.
We are told that the ratio between the object and reference beams should better between 1:1 to 1:10. Then my partner keeps adjusting the optics till these conditions are met. Successfully we get an optical film (wrapped in black paper) and mount it onto the holder. Then, we expose the film to light for about 0.5 second and after that we dismount the film.

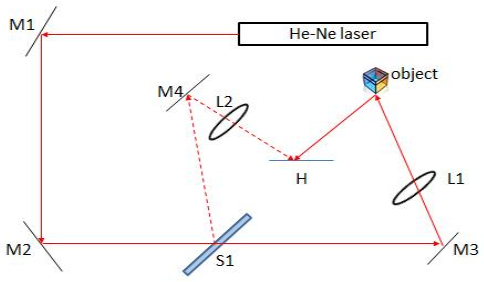

Figure 1: recording of a hologram

2. Film development

After getting a film, we take it to the dark room to develop. There are three bath basins: developer, stop bath (water), and fixer. According to the instructor, we immerse the film into development liquid. My partner flips the film up and down with the tweezers and we wait till the gray-scale is similar to the color on the bottom of the basin. This usually takes 2 minutes and 25 seconds.
Later, we rinse the film in the water basin for 25 seconds, and we take it to the fixer. I immerse it in the fixer for 3 minutes. We take the film to the viewing room and dry the film.

3. Viewing

The principle to reconstruct image from a hologram is via light diffraction. If a laser beam irradiates onto the film exactly like the object beam, diffraction will happen on the pattern recorded on the hologram. As you can see figure below.

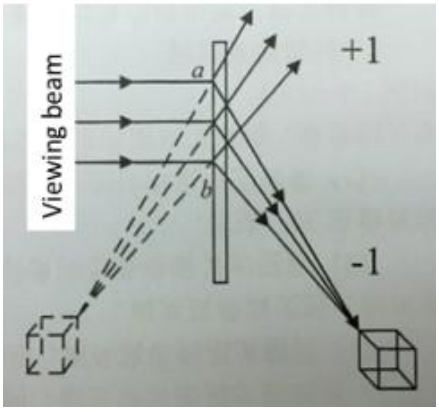

Figure 2: illustration of image reconstruction in hologram.

We are all excited to get ready to view the film. Before viewing, we have a high expectation about it. We use a viewing beam to irradiate the film. After having made sure the emulsion side is facing the beam, we adjust our viewing angle on the other side of the film to observe an expected 3-D image of the object. However, we are

unlucky to find the image. No matter what angle we try, we can't find it. We suppose it is because the angle is too large to find. So we try once again, luckily, we finally find the 3-D image which is a lovely white horse.

CONCLUSION

The key of the experiment is to choose the laser with good coherence and stability as the light source. The adjustment of the optical path is more important. A good light path can both make the object and reference light interfere and ensure that the interference fringes interval clear and the contrast is appropriate. So first adjust the object light and the reference light path, in order to ensure interference can occur, then adjust the between object beam and reference beam angle transitive light and reference light intensity ratio and guarantee the definition and contrast of the hologram. In addition, the system should be stable when the exposure.