

MAS.450/854: Holographic Imaging – Lab Notes

#6: OFF-AXIS HOLOGRAPHY, Part 2: Transmission Masters

Introduction-

This lab exercise elaborates on your previous off-axis “Leith & Upatnieks” holography experience in several ways. First, you will use a beamsplitter to separate the object illumination and the reference beams. You’ll use an attenuator to adjust their relative intensities to reach a more favorable beam ratio than could be produced last time. Also, the object illumination direction will be more controllable, so that a more pleasing object rendering will be possible (time will limit us to only a single illumination beam here). Because the beams travel over long and separated paths, via different mirrors, there are many more opportunities to lose coherence between them due to vibration, air currents, etc. You will have to use more care in setting up in order to get a bright hologram.

Secondly, we will be using a collimated reference beam in order to later project an undistorted real image with the (also collimated) “phase-conjugate” or “time reverse” of the reference beam in the next lab. You will produce this beam with the aid of a large diameter lens, which must be carefully aligned. You will learn which side of the lens to face toward the spatial filter, and how to know when the lens is centered and at the correct distance.

In order to use an overhead illumination beam in viewing subsequent holograms, we would like to have an overhead reference beam in exposing this hologram. But without an overhead mirror support of sufficient stability in our lab, it is much easier to set the object on its side for the exposure. This generally requires attaching the object sideways to a stand with 5-minute epoxy or “hot glue” (which probably improves the object's stability at the same time). This is a long lab, and only one or two objects can be chosen for recording; team up on a good choice. Your object should be somewhat smaller than 4”x5” inches because the image will be enlarged by about 17% in a later lab.

Because this hologram will be used as a “master hologram” for subsequent transfers (in the next lab, for example), it is especially important that it be bright and clear. You will use a capillary-action plate holder to provide both extra plate stability and an anti-reflection backing to avoid “wood grain” fringes on the holographic plate. There may also be time to experiment with beam ratios and processing methods to further improve the results.

Experimental Topics:

- 1) “Rough out” the optical set up that you work out with your TA, and make sure that the path lengths from the beamsplitter to the plate via the object and reference beam paths are equal. Line up the undiverged beams on the mounted object and on the plate holder center.
- 2) Place the collimating lens in the undiverged reference beam (with its flat side toward the beam), and center and align it by superimposing the two back-reflections on the incoming beam. Diverge the reference beam with a lens-pinhole spatial filter and adjust its distance from the collimator with the aid of a large vertically mounted mirror (in the plate holder, perhaps) to find when the beam is focused back as a small spot near the pinhole. Your TA may show you other collimation tests. The focal length of the 190 mm diameter lens is about 750 mm (about 30”).
- 3) Diverge the object illumination beam with a microscope objective (no pinhole is necessary here) to best light your scene, as though you were using an overhead spotlight (you can try some experiments with the lighting, if time allows). Determine which “slice” of the object you wish to put in the plane of your later holograms, and carefully set its distance from the plate to be 300 mm. Measure the object and reference beam intensities at the hologram plate holder, and adjust the attenuator to obtain a useful ratio. Calculate the exposure time for several beam ratios (perhaps 5, 7, and 10) and choose from among them.
- 4) Baffling: Using black cardboard cards as baffles, carefully block any light “spilled” by the beamsplitter, mirrors, spatial filters, etc., that might hit the plate. Look through the gray glass holder to find any bright spots that the plate might “see.” Be especially careful of light scattered in the reference beam; the resulting low-frequency gratings can steal a lot of diffraction efficiency from a hologram!
- 5) Try the same exposure as last time (around 600 ergs/cm^2 , modified as experience suggests), with the perpendicular to the plate bisecting the angle between the center of the object and the reference beam. Develop and bleach the exposed plate *yourself*, using the processes suggested by your TA.
- 6) After processing, examine the virtual image produced when the hologram is replaced in the plate holder, and diagnose the exposure and any of its problems. Reshoot if necessary. Then rotate the plate 180° around a vertical axis, and observe the projected real image. Measure its distance and size and compare them to those of the object. Comment in your lab book about the image’s “pseudoscopic” qualities, unusual aspects, and so forth.