

MAS 450/854: Holographic Imaging Lab Notes

#4: IN-LINE TRANSMISSION HOLOGRAMS

Note: you will make your first hologram in this lab, and you should bring your own object to try to shoot (only two will be used in each lab). See section #2 below for details on choosing an appropriate object.

Introduction:

Professor Gabor's original holography experiments rear-illuminated the objects so that the light scattered by the objects would overlap and interfere with the unscattered beam to form the holographic exposure. He used microscopically small opaque objects, but we can observe the same phenomena with large objects if we use laser light, and the results are much more vivid with translucent or refracting objects. In-line transmission holography makes minimum demands on the coherence of the laser and the stability of the system. And the holograms can be viewed fairly well even with white light. The interference fringes are fairly coarse, so that coarser-grained higher-speed emulsions can be used. The compromise is that the objects generally shadow their own reference beam, and their reconstructed images, and also that secondary images and undiffracted light often obscure the reconstructions. Although they are very primitive, in-line transmission holograms, or "Gabor holograms," display most of the problems and effects seen later in much more sophisticated hologram types.

Experimental Topics:

1. The experimental setup is very similar to that for the exposure of the in-line holographic optical elements made in Lab #3. The beam is simply diverged with a microscope objective, and falls upon a plate about two meters away. Place the objects a few tens of centimeters upstream from the plate, each being positioned so that it doesn't block very much of the light from the diverging lens, but letting the object catch some light and scatter it toward the plate. Proper choice of an object can greatly heighten the impact of a Gabor "in-line" hologram, and many unusual choices have worked out well. My favorites are cut glass and sanded glass objects, clear or frosted plastic toys, and other "crystalline" or "glittery" objects. Of course, they have to be rigid (although this setup can tolerate more object "floppiness" than most other types of holography). It is interesting to use objects at two or more distances to display parallax and relative depth. You can pre-evaluate your own objects at home by backlighting them with a slide projector, high-intensity lamp, or other similarly concentrated light source to mimic the laser beam and viewing them against a black background. Bring some choices to the lab, and be prepared to improvise when you get there.
2. The straight-through, unscattered, diverged beam, which is now the "reference beam," will dominate the exposure. The object you have chosen and how you set it up determine the intensity of the "object beam". The "beam ratio" is hard to measure, and can't be adjusted anyway, so don't worry about it here. If you can see the object through the plate holder frame, it probably will show up in the hologram. The exposure should again be calculated to give a developed plate density of about 0.6. Process in the same way as the "holographic lens."
3. Replace the processed and dried hologram in the plate holder, remove the objects, and illuminate the hologram with the diverged "reference beam." Confirm the location of the "true" or "virtual" image, and note them in your book. Search for the "conjugate" or "real" image focused on the viewer's side of the hologram (you may have to shade part of the hologram to block the illumination and see that image). Compare the distances of the virtual and real images from the hologram, and their magnifications. (Note: if the object is too far from the plate, it may not have a real image. Can you explain why?). Look for secondary virtual and real images. Describe and explain them in your notebook.
4. As a rule, the virtual image is obscured by the out-of-focus real image and by the glare of the straight-through illumination beam. Find parts of the plate that give unobscured images and show how you would design a setup to give an even clearer image of your scene. You may even have time to try some extra exposures with these changes.
5. Look through the hologram at the area around the illumination source and see if there is any diffracted "halo" light that has some structure corresponding to structure in the image. The object beam is so weak in this experiment that the "halo" may not be visible unless there are strongly repetitive elements in the object.