MAS 450/854 Holographic Imaging: Lab Notes
#7: FULL-APERTURE TRANSFER

Introduction-

The closer an image is to the plane of a hologram, the less vulnerable it is to blurring by the size and color bandwidth of the illumination source. One way to bring the image near the hologram plane is to place the object very near the plate when shooting, but this usually blocks part of the reference beam. Another way is to present an aerial real image to the plate as the holographic object. This can be an image projected by a large diameter lens or concave mirror, but we generally prefer a holographic projection. In this case, a pseudoscopic (reversed-depth) real image is projected by a first or "master" hologram, usually referred to as "H1," onto a second or "transfer" hologram, usually referred to as "H2." To the extent that the image is strictly in the plane of the H2 hologram, we call that hologram an "image-plane hologram." However, this term is usually misleading because the image may actually extend for many tens of millimeters on either side of the hologram, the limit being set only by the amount of blur that is deemed acceptable by the viewer. Thus we refer to these holograms instead as "projected image holograms," which is not very informative, or as "full-aperture transfers," which at least distinguishes them from "rainbow holograms," which are produced in a similar way (as you will see in the next lab).
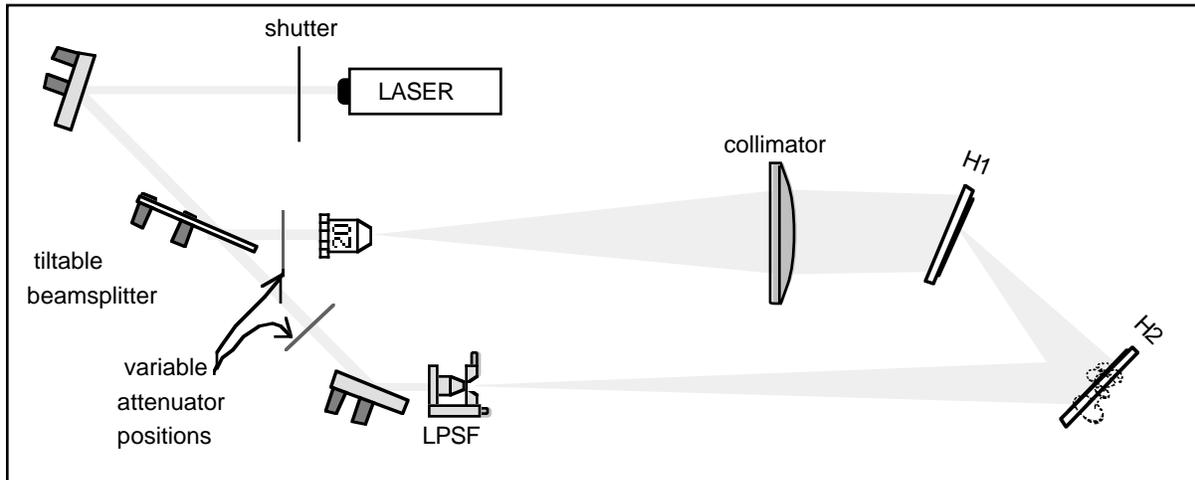
Holograms have several advantages over lenses as projectors of real images, especially because they can have large widths compared to the image throwing distance, and thus provide wide viewing zones. In this lab, you will use the off-axis hologram recorded in the previous session as a "master" hologram, illuminating it through its back with a collimated "projection" beam, the "conjugate" of its reference beam, to project a real image. You will position the transfer plate so as to be straddled by that real image, and a second reference beam brought to it. That beam would ideally be a converging beam, anticipating a final viewing illumination that is diverging, but we lack suitable large diameter lenses and will instead use the longest diverging reference beam throw that is practical on our table. The price of imperfect conjugates in the H2 will be a modest "forced perspective" type distortion in the final image.

Experimental Topics-

1.   Rough out the transfer geometry according to your TA's suggestions. A good basic system might resemble a parallelogram, and should make it easy to get a good path length match. If only one spatial filter is available, use it for the reference beam. Tilt the beamsplitter so that the beam is level with the table top, 200 mm above the table, and aimed at the center of the H1. You should start with a plain glass beamsplitter, but keep a dielectric beamsplitter handy to swap in later. Line up the collimator carefully.

2.   Install the clear glass plate holder at the H1 location downstream in the projection beam, and "xylene on" the master hologram from the previous lab in an orientation such that the real image is projected toward the reference beam path. To help do this, hold the hologram up to a light (use a laser if you can) so as the view the virtual image (you should mark the upper right-hand corner while in this position). The projection beam will then want to come up from near your navel, through the glass side of the plate, in the direction opposite to the present illumination. Flip the plate bottom over top, and see if you can find the real image now hanging in front of the hologram. If you are using a laser, you may be able to notice that the image is peculiarly "outside in." Now carry the plate around to the holder and bring the projection beam in at the same angle, with the real image heading toward the center of the table. The emulsion side of the hologram should be xylened to the clear glass, so that the image is projected through the plate holder.

3.   Locate the best "mid-plane" or "straddle plane" of the projected image by passing a white card through it and finding the best average focus (don't expect a very good focus, though). Mount the gray glass holder in that plane, its perpendicular aimed at the center of the H1. Be sure to make a note of the H1-H2 separation.

4.   Remove the microscope objective again and probe the H1 master plate with the raw, undiverged laser beam by adjusting the beamsplitter. Observe the real image (which now has lots of depth of focus) projected on a white card in the transfer plane, noting the amount of relative motion between image points at various depths. Replace the microscope objective.

5.   Introduce the reference beam for H2 from as far down the table as practical (from 1500 to 2000 mm from the spatial filter). If all goes well, the reference beam angle should be nearly 45 degrees, but this is not very important. Judging the beam ratio is tricky in this kind of setup, as the object beam is usually very spotty. The reference beam should be at least three times as bright as the brightest object point, but this is less critical if that point is right on the hologram plane (which it often is). "Cut and try" is really the only way to tell what works

best, but 3:1 is a good place to start. If the object beam is too "hot," there will be streaks or "burns" around the highlights in the image. If it is too weak, the image be dim and of low contrast. Expose to give good density for bleaching, and process with the chemistry that your TA recommends.

6.   Examine the finished hologram through its back with laser illumination (approximate phase conjugation) to view the "orthoscopic" or "correct-depth" image. Look for the edges of the holographic "window" hanging in front of the plate (the real image of the H1). Note the distance to the illuminating point source and the distances from the hologram to the sides and the top of the viewing zone (determined by focusing on a ground glass, or by the parallax method). Flip the hologram over (top to bottom) to view the virtual image of H1 floating behind the plate, and the pseudoscopic image now straddling the plate. Finally, illuminate the hologram through its back again with a point-like source of white light, such as the spotlight, and note the color blurring that you see. What is the useful depth (before the blurring becomes unacceptable) of the image you have produced? What is the color of matte surfaces near the hologram plane, and why?

lab #7: approximate set-up