PSE605A (Photonics Lab Techniques)

Lab Report: Experiment 11

Holography

Submitted by

Md Sk Sahidulla

Roll Number: **231160005**

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Submitted to

Dr. Pratik Sen

Mr. Moiranghthem Bikramjit

Center for Lasers and Photonics

IIT KANPUR

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1 Title: Alignment, acquisition, processing and reconstruction of holograms

2 Objective

- To create the transmission holograms of 3D object using He-Ne laser.

3 Equipments

He-Ne Laser, Beam steerer, Beam splitter, Spatial filter, High reflecting folding mirrors,3D object, Measuring scale, Solutions A and B, Bleach, De-ionized water, Optical table, Stand, Photographic plate.

4 Theory

The hologram is a record of the interference pattern created when two beams of laser light interfere on the holographic surface. One beam, called the reference beam, strikes the holographic plate directly from the laser, or after bouncing off several mirrors. The other beam, called the object beam, reaches the holographic plate after scattering off of an object which is being holographed. These two beams are initially coherent and in phase with one another, but after the object beam bounces off of an object, it will be out of phase with the reference beam. The two beams will interfere at the plate and create areas of high amplitude and low amplitude, light and dark bands. These are recorded by the holographic surface, and preserved through the developing process. The bands of light and dark act as an extremely sophisticated diffraction grating, so that when light passes through the plate or film, it interferes to form the exact image of the object that was recorded. Viewing the hologram at different angles will give a different view of the object, thus giving it its three dimensional appearance. The exact wave front produced by an object is duplicated by the hologram.

5 Procedure

1. Align the laser beam to be straight i.e., Adjust the beam such that its horizontal position and vertical position is same as beam propagates.

2. To do the above, take board with white paper near the beam steerer and locate the position of beam, subsequently move the board forward and observe the beam spot and the direction of beam. Adjust steerer vertical screw to bring near the middle and again observe the beam direction. If vertical height of beam is ok then go for horizontal adjustment and don't touch vertical screw again.

3. After alignement, use variable beam splitter at an angle (around 45deg) to divide beam into reference and object beams.

4. Reference and object beam ratio is to be about 4:1. Adjust beam splitter by rotating the wheel such that reference is brighter than object beam.

5. For diffraction grating hologram, if object beam is brighter than reference then use second order reflected beam which is low intensity compared to reference beam.

6. After beam splitter, use the spatial filter. Remove the pinhole and adjust height such that the beam goes through the centre of the object lens and the enlarged (focused and then diffracted by lens) beam at the same spot as before spatial filter.

7. Place the pinhole tightly and adjust horizontal and vertical screws such that maximum light observed at the same spot of the beam before.

8. Bring the object lens closer to the pinhole i.e., less than 1mm and observe the intensity by adjusting pin hole screws such that uniform maximum intensity is observed without any circular rings around it.

9. Adjust height of mirror such that beam is at the centre of uniform beam spot.

10. Do the adjustment of spatial filter and mirror for object beam also as above.

11. Place blazed diffraction grating or object on magnet stand and its face towards photographic plate then focus object beam on grating or object by adjusting the mirror such that total beam spot incident on grating or object.

12. For grating, observe the grating zeroth, first and second order beams and notice that first order intensity is more than the zeroth order intensity (because of blazed grating) .

13. The grating that we use is the reflection type grating i.e., the orders that we observe, is the reflection from the grating.

14. Adjust mirror angle in a way that second order from the grating falls on the photographic plate.

15. Measure the distance of reference beam and object beam from the beam splitter to the photographic plate stand with the help of rope or the scale.

16. Adjust reference beam mirror by moving backward or forward such that both the beams distance is approximately same.

17. Adjust mirror of reference beam such that it falls on the photographic plate without touching the grating or the object.

18. Adjust the photographic plate stand and mirrors such that both beams fall on the plate at same spot by blocking one beam at a time. Carefully adjust with the help of the white paper because both beams spot mismatch makes the interference pattern differ.

19. Prepare chemical solutions:
    a) Wear hand gloves; clean all containers with water and again with deionized water also.
    b) One container fills completely with deionized water.
    c) Second container (written developer) fills completely with the bleaching solution.
    d) Third container fills with 35ml solution A plus 35ml solution B.
    e) Pour enough deionized water in large beaker for cleaning the measuring beaker and the photographic plate.

20. the Close all doors and switch off lights except green light. Block the laser source before placing photographic plate with black paper. Take out the photographic plate in the dark surroundings and check for its silver halide face then place the silver halide face towards the object, in stand tightly. Carefully handle the photographic plate.

21. Expose the beams on a photographic plate for 1min, and measure 1min by stopwatch carefully. Then stop the laser source.

22. Remove the plate then put it in the solution A plus B by holding with the holder. Don't leave in the container, hold at the edge within the solution and start stopwatch. Wait for about 2min and observe the photographic plate turn into black.

23. After the plate turn into black, place it in deionized water container and rinse it for 1min. And then place it in bleaching solution for 1min to become transparent.

24. Then place it in deionized water and clean and rinse it and let it dry outside. You can see rainbow pattern on the plate as well as interference pattern.

25. After chemical process, photosensitive part is removed from plate then we can see the image formed on it in the presence of light by letting the reference beam on it.

26. Determine the grating efficiency of the hologram. Compare and discuss the results with the true value.

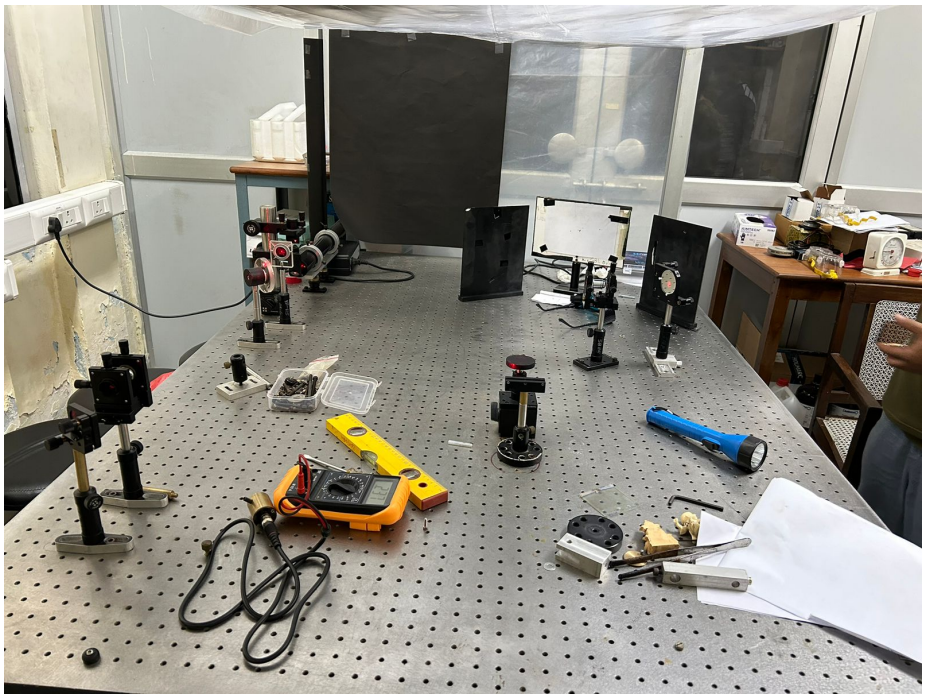

Figure 1: Set up

6 Result

6.1 Object

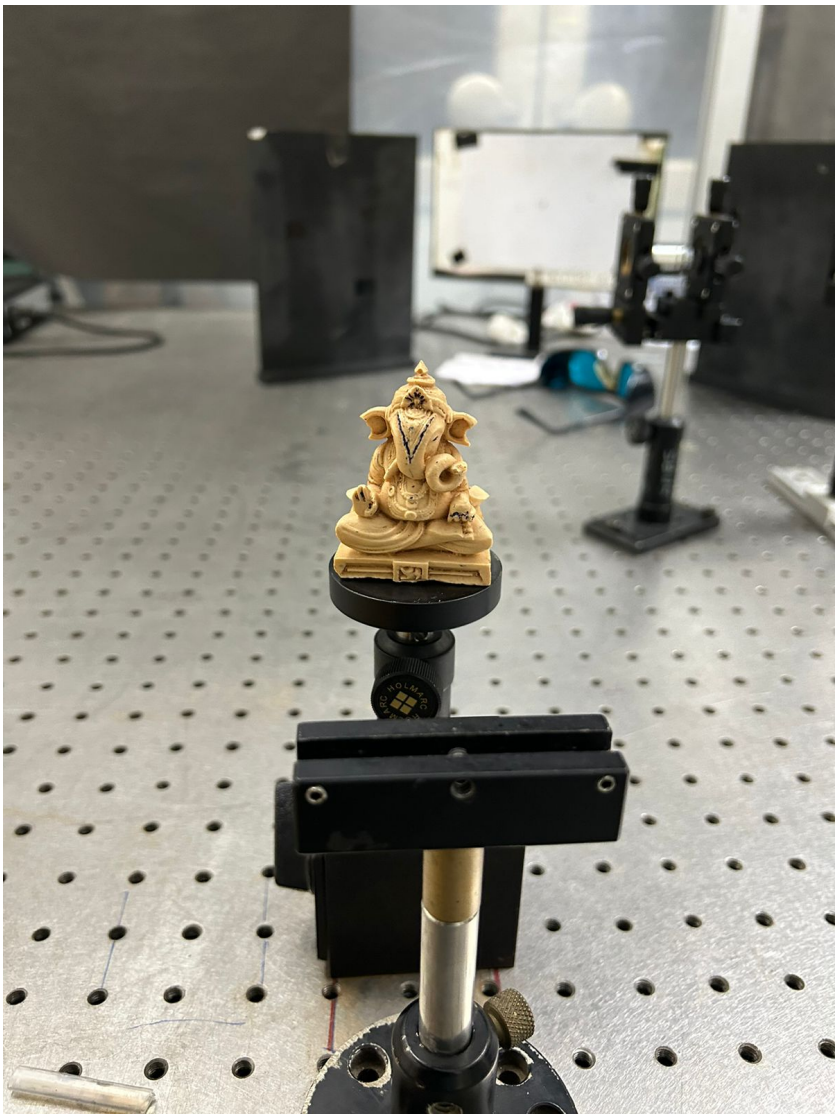

Figure 2: Original 3D object

6.2 Hologram

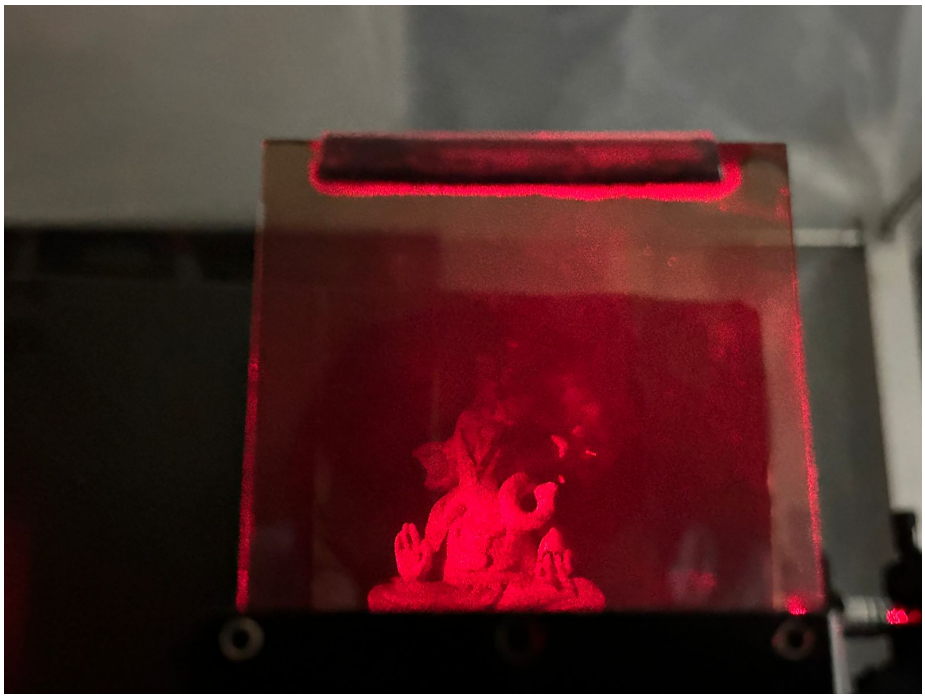

Figure 3: Hologram of the 3D object

7 Discussions & Conclusions

- **Dark Room:**
  The room must be dark during this experiment. Otherwise, the holographic plate will be affected. So, you wouldn't get the hologram.
- **Mixing ratio of the chemicals:**
  The chemical should be mixed in the appropriate proportion. During this process, the hand gloves should be used.
- **Position of the 3D object:**
  The Distance between the reference beam and the object has to be nearly equal and less than the coherence length. Otherwise, interference wouldn't happen.
- **Object and Reference beam intensity ratio:**
  After splitting the beam from the wheel beam splitter, the reference beam intensity should be greater than the object beam such that the intensity of both the beams would be nearly equal on the holographic plate.
- **Avoid touching:**
  No one should touch the reflecting are of the mirror, pinhole of the spatial filter, and the holographic area of the plate.
- **Alignment:**
  All the components have to be perfectly aligned. Every component has to be in the same height.

8 Appendix

8.1 Precautions

- Take care of the laser beam during the alignment.
- The Spatial filter must be aligned properly so that the reference beam does not hit the object.
- While using chemical processing to develop the hologram, always take care of the photographic plate so that it may not fall down.
- Multimeter connection must be properly done with the photodetector.

8.2 Source of Error

- It's imperative to maintain precise alignment to avoid significant errors introduced by misalignment.
- Ensuring that the path length is shorter than the coherence length is crucial for achieving interference.

- Securely tighten the beam splitter to prevent any movement that could disrupt alignment.
- Handle the photographic plate with care during chemical processing to prevent accidental falls.
- Shield the room effectively to prevent any stray light from damaging the film.
- Identify the side of the film with coating accurately using an air blow method

9 References

Optics, Ajoy Ghatak, Tata McGraw-Hill Education, 2005.
Saxby, Graham, Practical Holography, 3rd edition. Prentice-Hall, Inc., 1996
Pedrotti, Leno S., and Frank L. Pedrotti, Introduction to Optics, 2nd edition. Prentice-Hall, Inc., 1993.