Holography

Iria Monterroso, supervisor: Tomasz Kawalec

Faculty of Physics, Astronomy and Computer Science, Jagiellonian University, Kraków, Poland

Abstract

This experiment was dedicated to the production of holograms using a coherent beam of light produced by a He-Ne laser. In order to do so, three methods have been studied: common holography, volume holography and digital holography.

Introduction

Holography is a photographic technique in three dimensions based on the physical principles of interference and diffraction. It was first discovered by the physicist Dennis Gabor in the late 1940's.

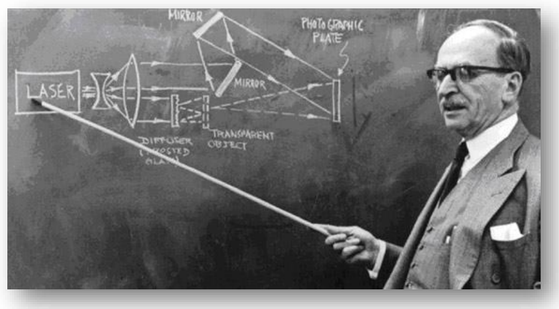


Fig: Dennis Gabor explaining his discover because of which he received the Nobel Prize in 1971

After the development of the laser in 1960 it has found applications in a lot of fields: from security (as a sign of authenticity in currencies and credits cards) to art, as well as being a very promising technique for data storage.

Physical principles

Coherence of light

Coherence of the light beam is one of the principal requirements for the creation of a hologram. The coherence of the laser used can be measured with a Michelson interferometer:

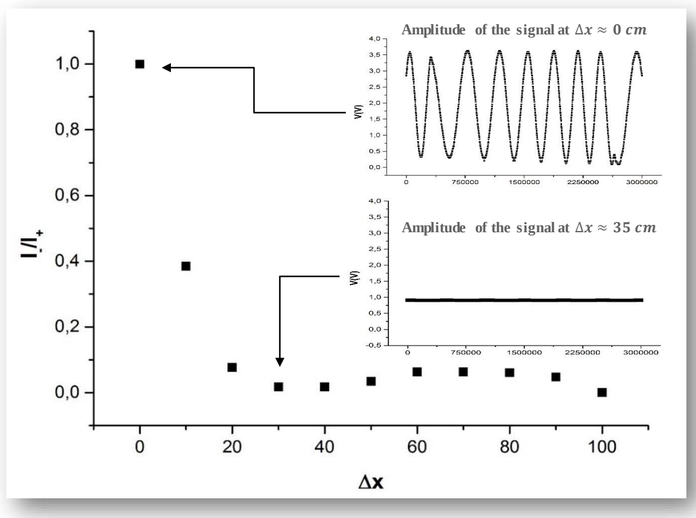


Fig: $(I^+ - I^-)/(I^+ + I^-)$ vs Δx (where Δx is the difference in the optical path of the beams)

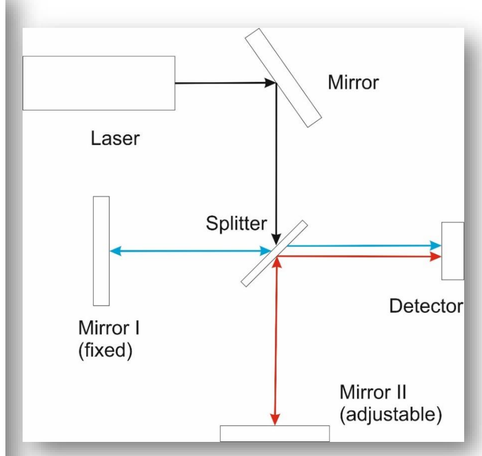


Fig: scheme of the Michelson interferometer

Studying the dependence between the intensity of the interference pattern and the difference in the optical path (Δx) we obtain the lenght of coherence is $L \approx 35\ cm$

Recording of the Hologram: principle of interference

The creation of holograms is based on the interference of two (or more) light beams due to superposition when they reach the recording material (RM). One of them *(reference beam)* reachs the RM directly, while the other *(object beam)* comes from the reflection off the object.

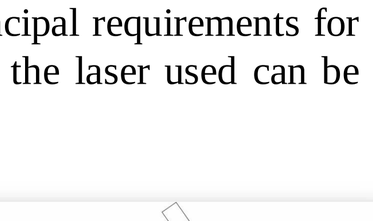


Fig: when tho waves interact with each other they create an interference pattern.

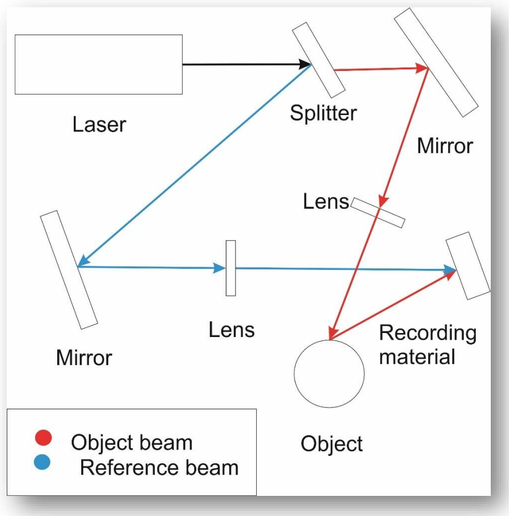
Fig: this interaction can be constructive (the waves are in phase), destructive (the waves have opposite phase) or something in between.

Reconstruction of the Hologram: principle of diffraction

Holograms are chemically treated to convert the recorded interference pattern into fringes. After that, reconstruction of the hologram can be made thanks to the principle of diffraction.

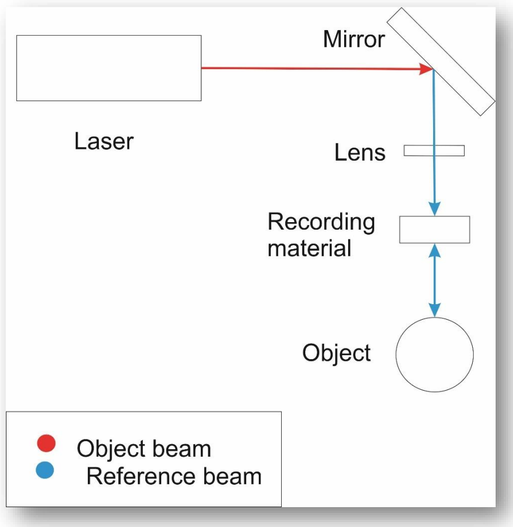
Experimental Setup

Common Holography



- The recording of the hologram is done in the Surface of the photographic plate.
- A beam of the same wavelenght as the laser used to record the hologram is needed in order to reconstruct the image.

Volume Holography



- The recording of the hologram is done within the volumen of the photographic plate.
- Holograms can be seen using white light thanks to Bragg's selection: only one wavelenght is filtered for reconstruction.

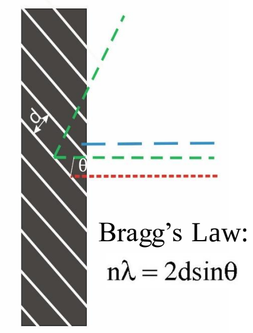
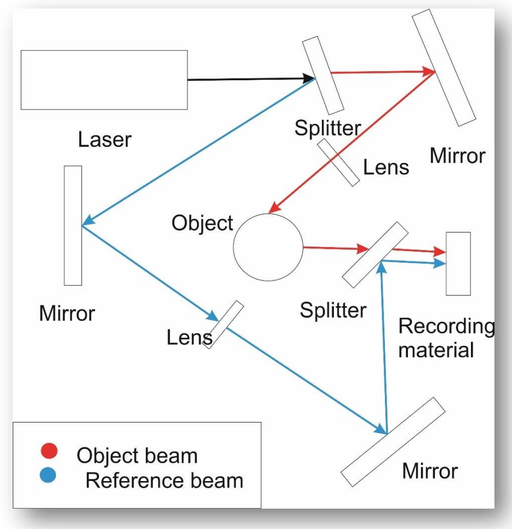


Fig: transversal view of the emulsion

Digital Holography



- The recording device is an electronic sensor array.
- Since the pixels of the camera are greater than the grains on the photographic plate (3,45 µm), the angle between the RB and the OB must be close to 0º, which is archieved using a splitter.
- The reconstruction of the hologram is done numerically using Fourier transformation.

Results

Fig: original object

Fig: common hologram

Fig: digital hologram

Bibliography

1. **Laser spectroscopy: Vol. I:Basic principles, W. Demtroeder**
2. **Eugene Hehcht, Optics, Addison Wesley, 2002**