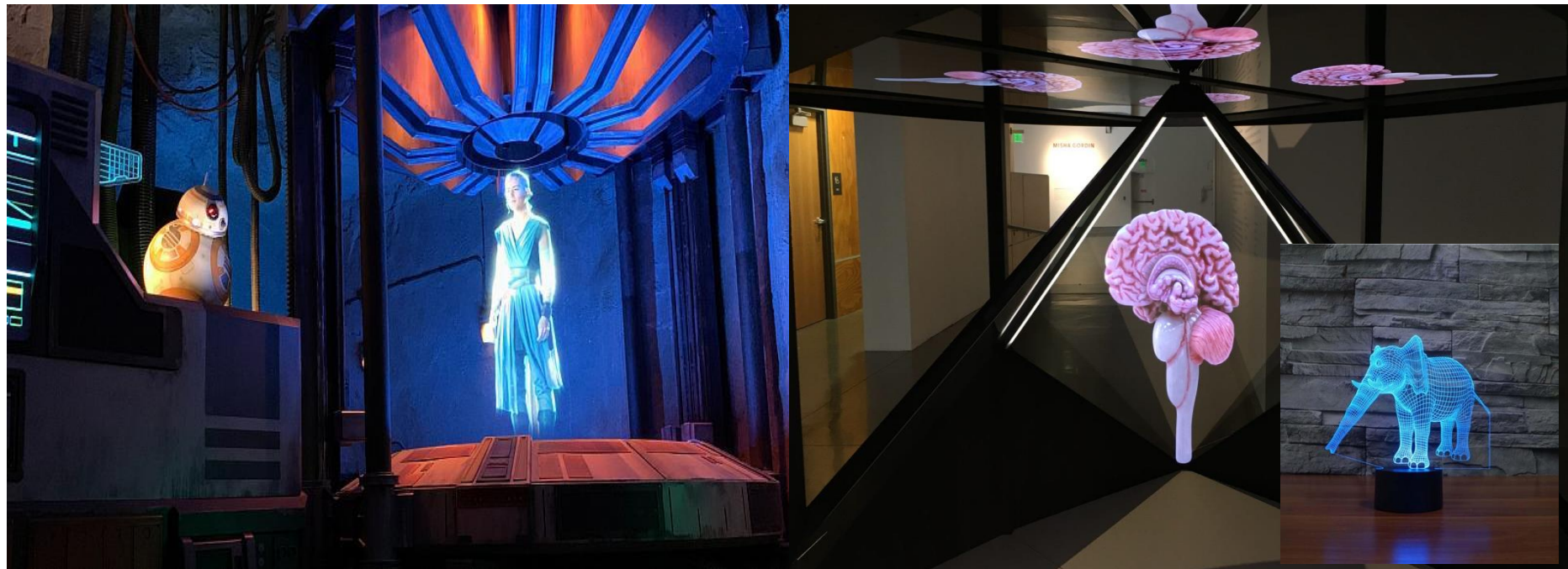




UNIT-IV

Laser Holography and Optical Fibre

Lecture-4: Holography





Content of Lecture

- BASIC PRINCIPLE OF HOLOGRAPHY.
- CONSTRUCTION OF HOLOGRAM.
- RECONSTRUCTION OF IMAGE FROM HOLOGRAM.
- DIFFERENCES BETWEEN PHOTOGRAPHY AND HOLOGRAPHY.
- PROPERTIES OF HOLOGRAMS.
- TYPES OF HOLOGRAMS.
- APPLICATIONS OF HOLOGRAPHY.



HOLOGRAPHY

❖ In the photographic methods for images of objects the information about the phase of the wave (reflected from the object) is not recorded.

❖ During 1948, Dennis Gabor invented a two-step lens less imaging process.



HOLOGRAPHY

- ❖ The word **holography** is the combination of two Greek words: **holos** and **graphein**.
- ❖ **Holos** stands for **whole** and **graphein** stands for to **write**. Hence, holography means writing the complete image.
- ❖ Holography is actually a recording of interference pattern formed between two beams of coherent light coming from the same source. In holography, intense coherent light is required.
- ❖ In this process, both the amplitude and the phase components of the light wave are recorded on a light-sensitive medium such as a photographic plate.
- ❖ This recording is known as a **hologram**.



BASIC PRINCIPLE OF HOLOGRAPHY

- ❖ Holography is a method in which one not only records the amplitude of the light wave (reflected from the object), but also the phase of it.
- ❖ Holography is a two-step process. First step is the recording of hologram where the object is transformed into a photographic record.
- ❖ The second step is the reconstruction in which the hologram is transformed into the image.



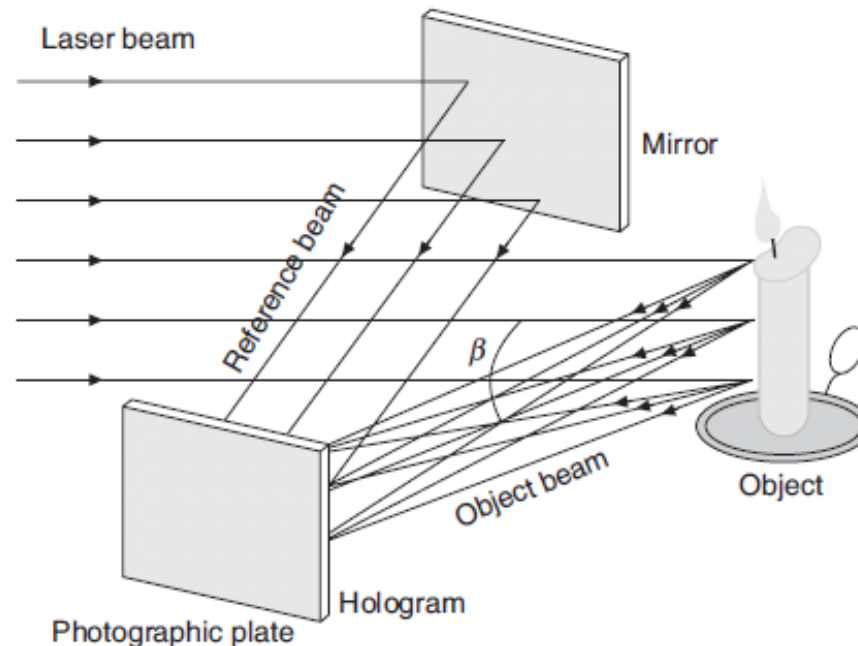
BASIC PRINCIPLE OF HOLOGRAPHY

- ❖ Hologram actually contains information not only about the amplitude but also about the phase of the object beam, which produces a three dimensional image of an object.
- ❖ The image will change its appearance if you look at it from a different angle.
- ❖ Holography is the lens less photography in which hologram is a result of the interference occurring between the coherent light (from laser), reflected from the object and the light from a coherent reference beam, obtained by splitting the light from the same laser source.



CONSTRUCTION OF THE HOLOGRAM

- To construct the hologram, a broad laser beam is divided into two beams, namely, a reference beam and an object beam, by the beam splitter in the form of mirror as shown in Figure.
- Object beam directly illuminates the object, while the reference beam, after being reflected from the mirror, is collected on the photographic plate. Thus, the film is exposed simultaneously by both reference beam and object beam.





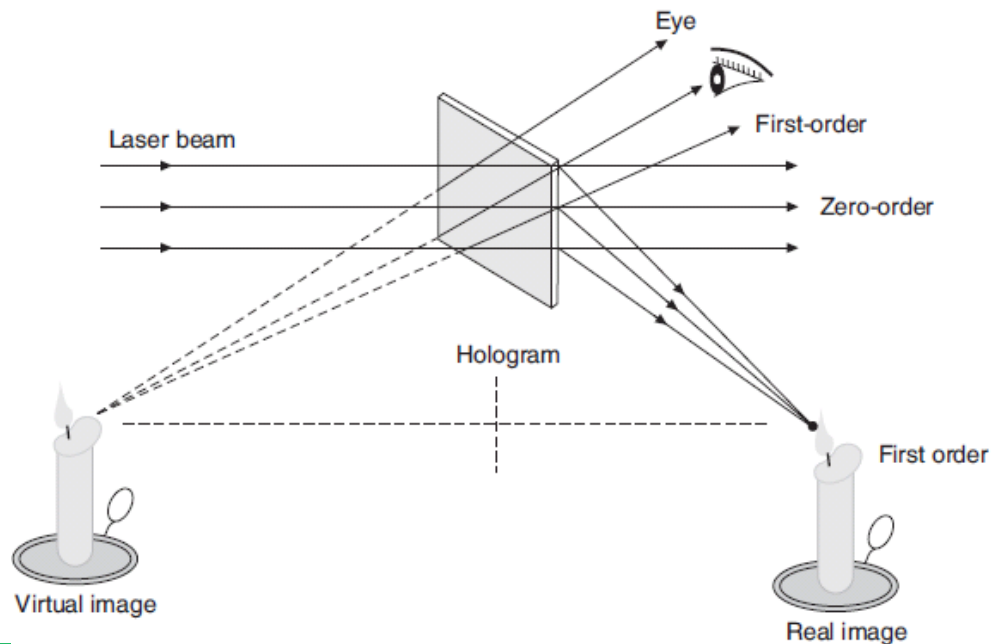
CONSTRUCTION OF THE HOLOGRAM

- ❖ These two beams are coherent because they are from the same laser source.
- ❖ These coherent sources interfere and give a complicated interference pattern on the photographic plate.
- ❖ The developed negative of these interference fringe patterns is a **hologram**.
- ❖ Thus, the hologram does not contain a distinct image of the object, but carries a record of both the intensity and the relative phase of the light waves at each point.
- ❖ Thus, the resulting hologram contains all the information needed to reproduce the exact replica of the object.



RECONSTRUCTION OF THE IMAGE

- ❖ The reconstruction of the object is schematically shown in Figure.
- ❖ In this process, the hologram is illuminated by a parallel beam of light, called the reconstruction beam, from the laser source. Most of the light passes straight through, but the complex of fine fringes acts as an elaborate diffraction grating.





RECONSTRUCTION OF THE IMAGE

- ❖ Light is diffracted from this grating and two images: a virtual image and a real image are produced.
- ❖ Virtual image is obtained at the original position of the object where the hologram was constructed. The real image can be photographed directly without using a lens. The virtual image observed through the hologram appears in full three-dimensional form.
- ❖ This type of hologram is known as a *transmission hologram since the image is seen by looking through it.*



DIFFERENCE BETWEEN A HOLOGRAM AND AN ORDINARY PHOTOGRAPH

❖ In a **photograph**, the information is stored in an orderly fashion, i.e., each point in the object relates to a conjugate point in the image. **Whereas** in a **hologram**, there is no such relationship, i.e., the light from every point on the object goes to the entire hologram.

❖ HOLOGRAM HAS TWO MAIN ADVANTAGES:

- **(i)** According to the viewing style of the observer, the image is seen in three dimensions.
- **(ii)** Each part of the hologram would reconstruct the whole object, and not just a part of it.



IMPORTANT PROPERTIES OF A HOLOGRAM

- Each part of a hologram contains information about the entire object.
- Hologram is a reliable medium for data storage, because a small part of hologram can reconstruct the entire image.
- Information holding capacity of a hologram is extremely high. For example the hologram of size 6×9 mm can hold the information of one printed page.



IMPORTANT PROPERTIES OF A HOLOGRAM

- On the hologram, information is recorded in the form of interference pattern. The type of the pattern obtained depends on the reference beam which is used to record the hologram.
- Any beam which is coherent and identical to the original reference beam can be used for the reconstruction of the image of the hologram.
- If the wavelength of the reconstructing beam is greater than that of the original reference beam, the reconstructed image will be a magnified image. This magnification is proportional to the ratio of the two wavelengths.



TYPES OF HOLOGRAMS

According to the selection of the source, photographic plate, and viewing angle, there are many types of holograms. Some of them are given below:

(i) Reflection holograms:

- ❖ Reflection holograms are viewed with white light by choosing a suitable white-light source such as spot light, sun light, and flash light.
- ❖ They are made with two beams approaching the holographic plate from opposite sides.

(ii) Volume holograms:

- ❖ In this method, the object wave is reflected from the object and propagates backward, and overlaps the incoming reference wave. The two waves form a standing wave pattern.
- ❖ The fringes are recorded by the photo-emulsion throughout its entire thickness to form a volume hologram.



TYPES OF HOLOGRAMS

(iii) Multiple-channel holograms:

- ❖ In the multiple-channel hologram, two or more images are visible from different angles.
- ❖ These multiple channels can be classified as simple one and multiplex.
- ❖ In the case of simple one, there are few images, and each is viewed from different angles.
- ❖ In the case of multiplex, a large number of flat pictures of a subject, viewed from different angles, are combined into a single three-dimensional image of the object.



TYPES OF HOLOGRAMS

- **(IV) Rainbow holograms:**

- ❖ Rainbow hologram is also known as white-light transmission hologram.
- ❖ When this hologram is viewed with a white-light point source, a very bright colour image can be reconstructed. A true-colour hologram image can be observed when the hologram is viewed in the correct plane.

- **(V) Polymer hologram:**

- ❖ These are made from light-sensitive plastics.

- **(VI) Dichromate holograms:**

- ❖ In this type of holograms, glass-sandwiched dichromated gelatin is used as a holographic recording medium.



APPLICATIONS OF HOLOGRAPHY

- **(i)** Holograms, made with X-rays or ultraviolet rays, are able to record images of particles smaller than visible light such as atoms or molecules.
- **(ii)** A holographic lens is used in an aircraft “head-up-display” to allow a fighter pilot to see critical cockpit instruments while looking straight ahead through the wind screen.
- **(iii)** Holography is widely used in non-destructive testing to study distortions resulting from stresses, strain, heat, and vibrations.
- **(iv)** Three-dimensional acoustical hologram of an opaque object is used to see the internal structure of an object.



APPLICATIONS OF HOLOGRAPHY

- **(v)** Holograms are used for security in many industries and are commonly found on a host of products and packaging.
- **(vi)** Holographic lenses are used in supermarket scanners to read bar codes on merchandise for the store's computers.
- **(vii)** Artists use holography to express their creativity.
- **(viii)** Holography is used for point-of-purchase advertising, taking the place of a photography of a product.
- **(ix)** Holograms are also used for data storage such as holographic hard devices.



APPLICATIONS OF HOLOGRAPHY

- **(x)** Dichromate holograms are used as jewellery pendants, watches, etc.
- **(xi)** Holographic techniques, such as holographic endoscopies, X-ray holography, and laser holograms are frequently used to diagnose dangerous diseases.
- **(xii)** Advanced holographic techniques have a variety of applications in ophthalmology, urology, otology, pathology, and orthopedics.
- **(xiii)** Holographic three-dimensional images of eyes and interferometric testing of human teeth and chest motion during respiration were carried out quite early.



Assignment Based on this Lecture

- Explain the basic principle of holography.
- Explain the construction of hologram.
- Explain the reconstruction of image from hologram.
- What are the differences between photography and holography.
- Explain the properties of Holograms.
- What are the types of Holograms.
- Mention the applications of Holography.