Holography and Fibre optics
Lecture -6

Minati Barman

Associate Professor

Department of physics

J N College,Boko

Holography is a advance form of photography. It is a lens less two steps imaging process which can produce three dimensional images.

In this photography both the intensity and amplitude of the scattered waves from the object is recorded.

Holography was first suggested by D. Gabor in 1961.

It consists of two steps:

　　　　i. recording
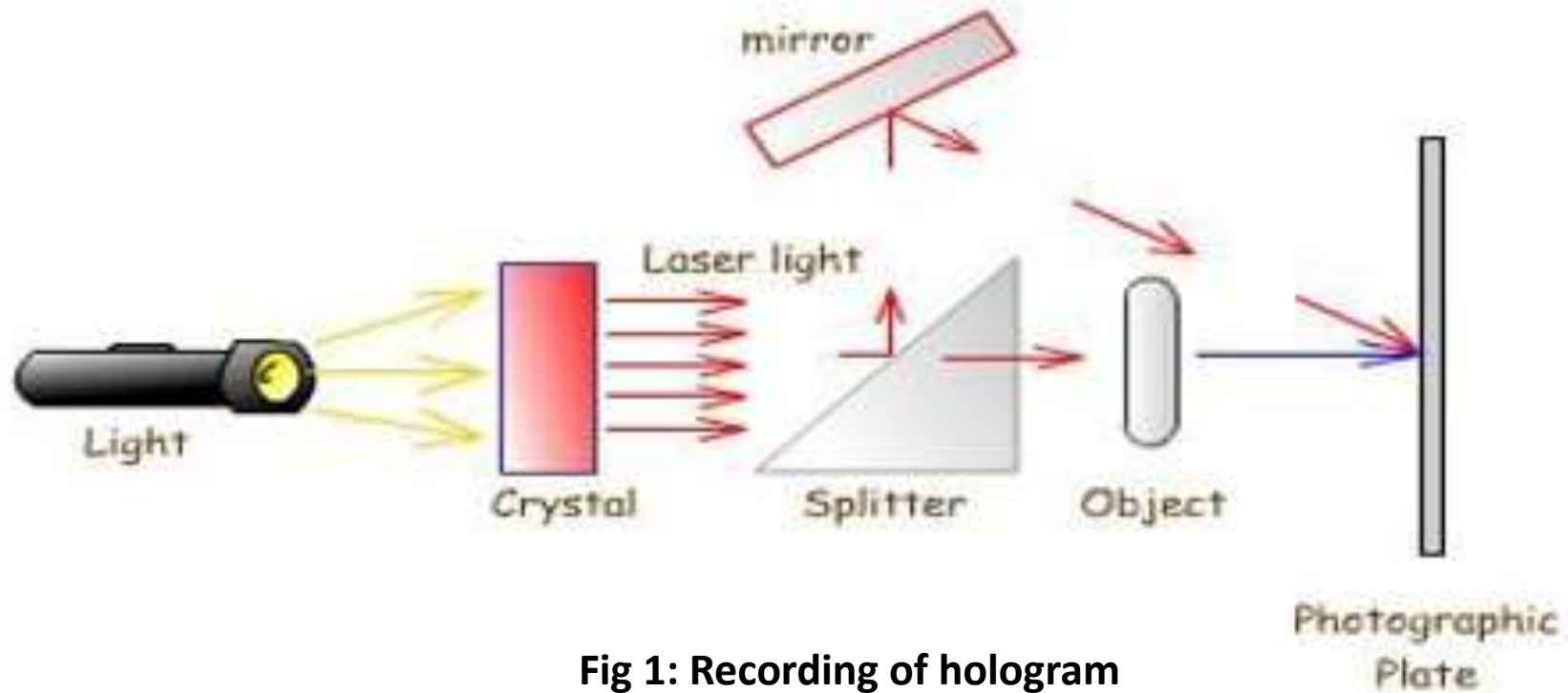
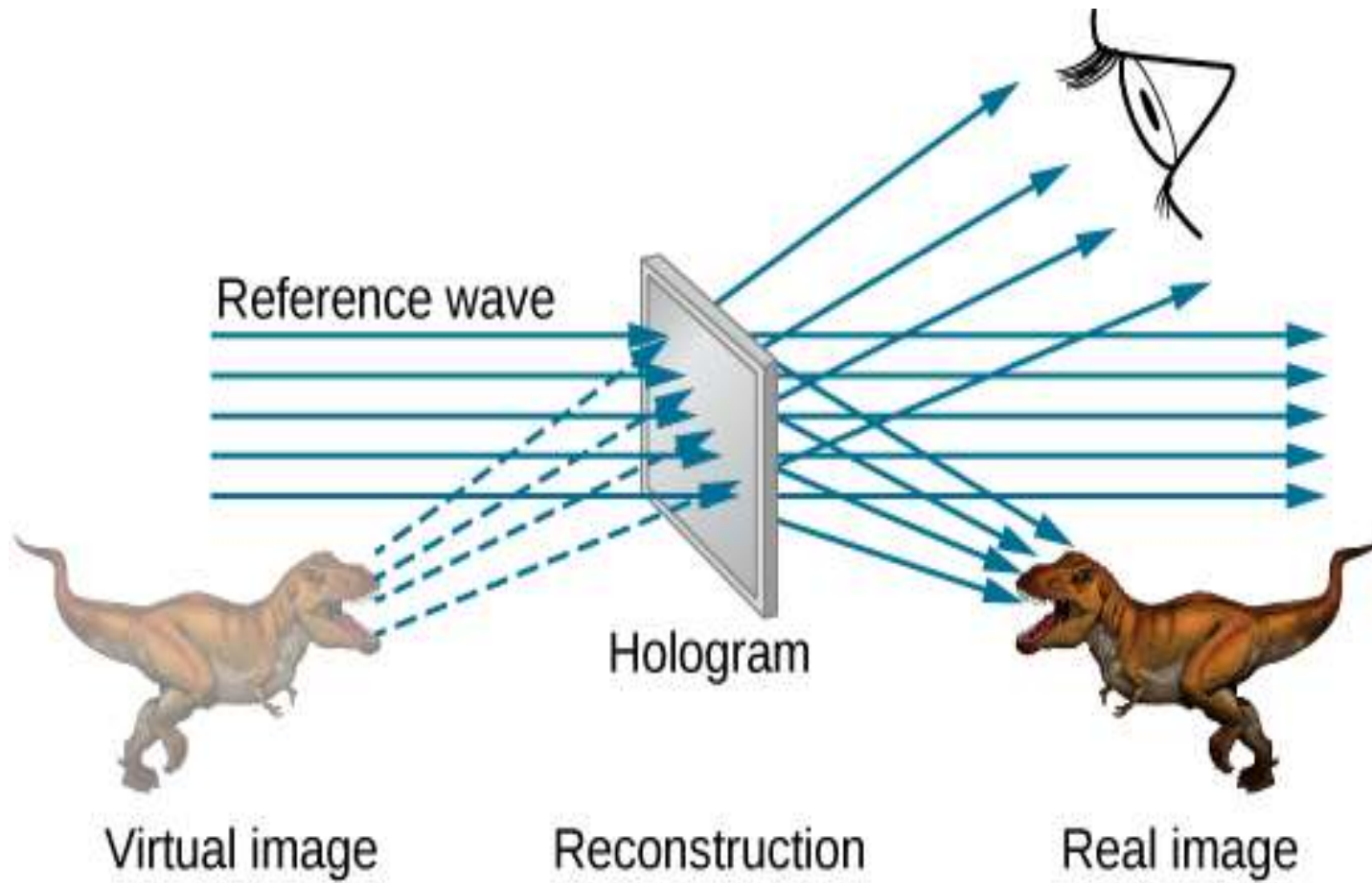　　　　ii. reconstruction of the image.

Fig 1: Recording of hologram

Fig 2: Reconstruction of images

Mathematical theory:

Let the complex amplitude of the light wave scattered by the object is

$$a = a_0 e^{i\varphi}$$

And the complex amplitude of the reference wave is

$$r = r_0 e^{i\emptyset}$$

So the complex resultant amplitude is

$$R = a + r$$

Therefore the intensity in the hologram plane

$$I = RR*$$
$$= (a + r)(a*+r*)$$
$$= aa* + ra* + r*a + rr*$$
$$= a_0^2 + r_0^2 + a_0 r_o \{ e^{i(\varphi-\emptyset)} + e^{-i(\varphi-\emptyset)} \}$$

$$I = a_0^2 + r_0^2 + 2a_0r_0\cos(\varphi - \emptyset) \quad ----(1)$$

By a suitable development process the amplitude transmittance of the hologram is adjusted to be proportional to I. Now if the original reference light is used to illuminate the hologram then complex amplitude of the light just after passing the hologram is

A= KrI   here K constant of proportionality.

= K (raa*+r²r* +arr*+ a*r²)

= K[$a_0^2 r_0 e^{i\emptyset}$+$r_0$²r +ar_0^2 +a*$r_0 e^{2i\emptyset}$]

= K[r_0^2(a + r) +$a_0^2 r_0 e^{i\emptyset}$ +a*$r_0 e^{2i\emptyset}$]   ---------(2)

- The 1st term represent a wave front with original amplitude which gives rise to 3D virtual image.

- If the reference wave is very strong, $\frac{a_0^2}{r_0^2} \ll 1$, then the 2nd term is negligible.

- For a reference wave whose complex phase and amplitude are almost constant all over the hologram , the 3rd term is proportional to the conjugate of the object wave amplitude. It generates the real image.

- Holography is used to make three-dimensional pictures and it does not confine itself to the visible spectrum. Microwaves are used to detect objects through otherwise impenetrable barriers. X-rays and ultraviolet light are used to detect particles smaller than the visible light.
- Holography is also used to detect stress in materials.
- In Europe telephone credit cards use holograms to record the amount of remaining credit. Fighter pilots use holographic displays of their instruments so they can keep looking straight up. Museums keep archival records in holograms.

****