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ENGINEERING PHYSICS

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ENGINEERING PHYSICS

Unit IV: Holography

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Class #45

- What is Holography?
- Construction of a hologram
- Creation of Image
- Mathematics of In line Holography
- Off axis Holography

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Holography

➢ *Suggested Reading*

1. Optics, E. Hecht

2. Course material developed by the Department

➢ *Reference Videos*

https://ocw.mit.edu/resources/res-6-005-understanding-lasers-and-fiberoptics-spring-2008/laser-fundamentals-i/

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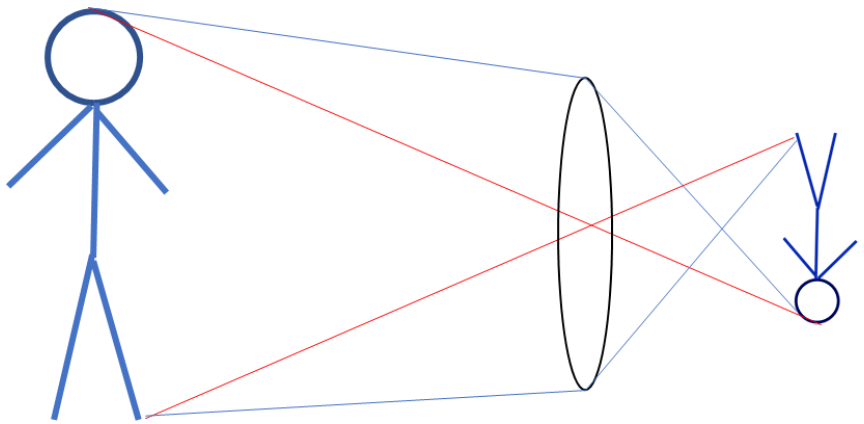
2D Photography

The intensity $I(x,y) = |E(x,y)|^2$

where E(x, y) is the electric field



2D Photography

- **2D projection of 3D object**
- **Only intensity *I (x,y)* is captured**
- **Phase information is lost**
- **No depth information**

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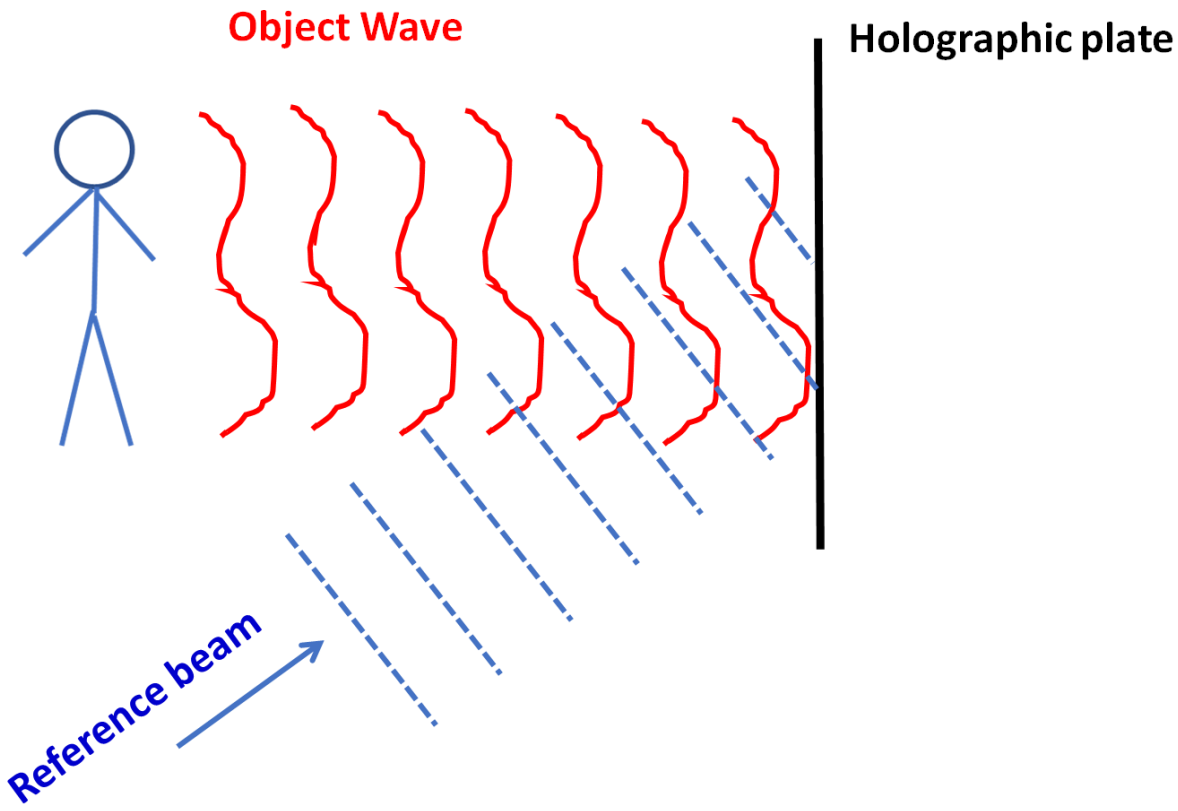
Holography



To retain phase information we create an
Interference pattern on a photographic plate (hologram)
of light scattered from the object* and a *reference beam

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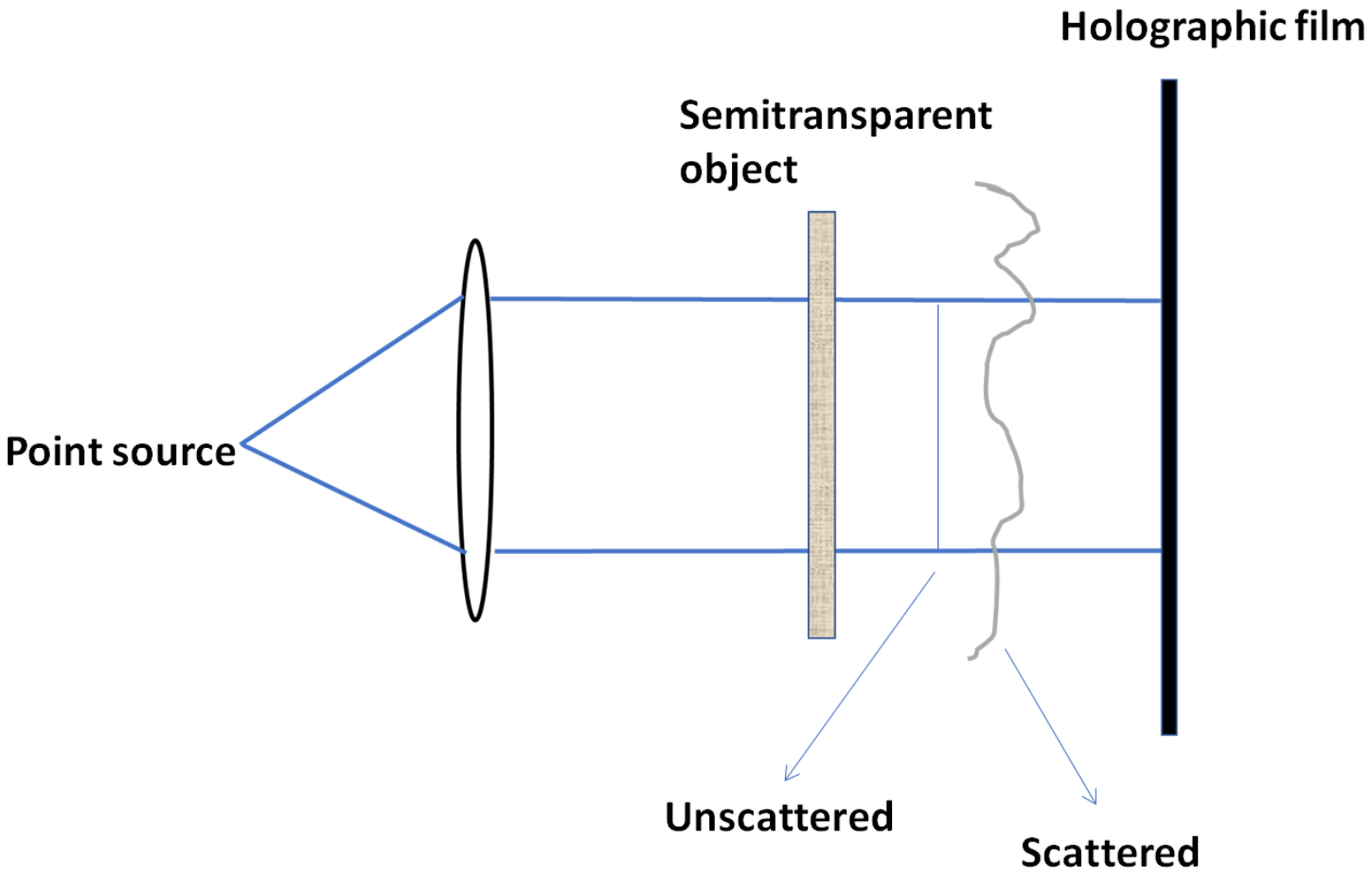
Inline Holography



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Mathematics of Inline Holography

Consider an object wave (scattered from the object) represented by $E_o(x, y)$ *and a reference beam (unscattered) represented by* E_R *which remains constant at all* (x, y).

Intensity at the holographic plate

$$I = \left|E_o(x, y) + E_R\right|^2$$

$$I = \left(E_o^*(x, y) + E_R^*\right)\left(E_o(x, y) + E_R\right)$$

$$I = \left|E_o(x, y)\right|^2 + \left|E_R\right|^2 + E_o^*(x, y)E_R + E_o(x, y)E_R^* \quad ----(1)$$

Holography

Imagine that the holographic plate's transparency is proprtional to the light intensity

Transparency $T(x, y) = a + b\, I(x, y)$

where a *and* b *are* constants

The light passing through the hologram when illuminated only by the reference beam

$E(x, y) = E_R\ T(x, y)$

$E = E_R(a + b\, I)$

$E = aE_R + b\, E_R\, I$ ***Substitute for I from eq(1)***

$$E = aE_R + bE_R(|E_o(x,y)|^2 + |E_R|^2 + E_o^*(x,y)E_R + E_o(x,y)E_R^*)$$

$$E(x,y) = aE_R + bE_R|E_R|^2 + bE_R|E_o(x,y)|^2 + bE_o^*(x,y)|E_R|^2 + E_o(x,y)E_R^2$$

$E = aE_R + bE_R|E_R|^2$ Constant Term: as E_R is constant

$+ bE_R|E_o(x,y)|^2$ Scattered: Negligible

$+ bE_o^*(x,y)|E_R|^2$ Image of the object

$+ bE_o(x,y)E_R^2$ Image of the object

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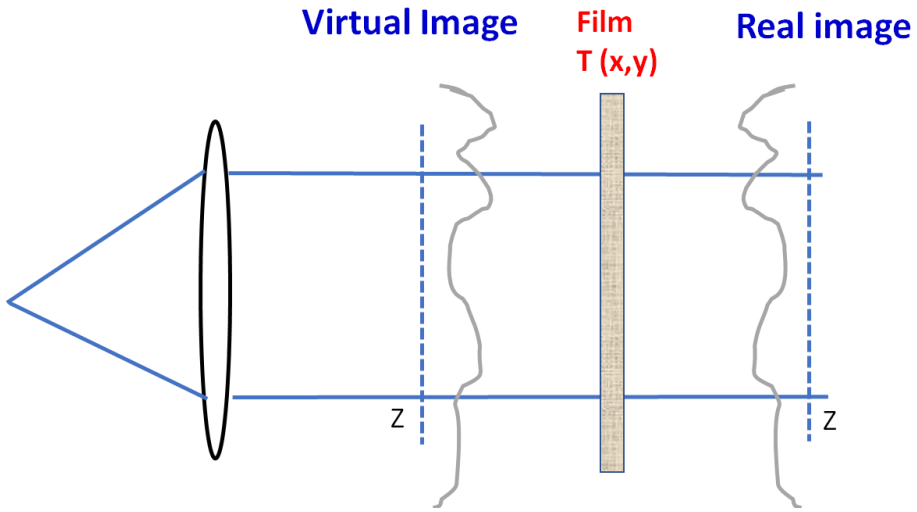
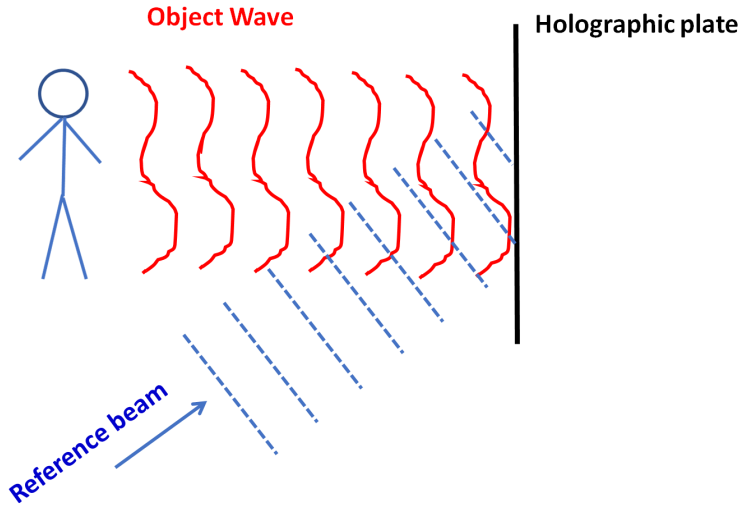
Holography



Inline Holography

Problem of Twin images



Off- axis Holography

Solves the twin image problem

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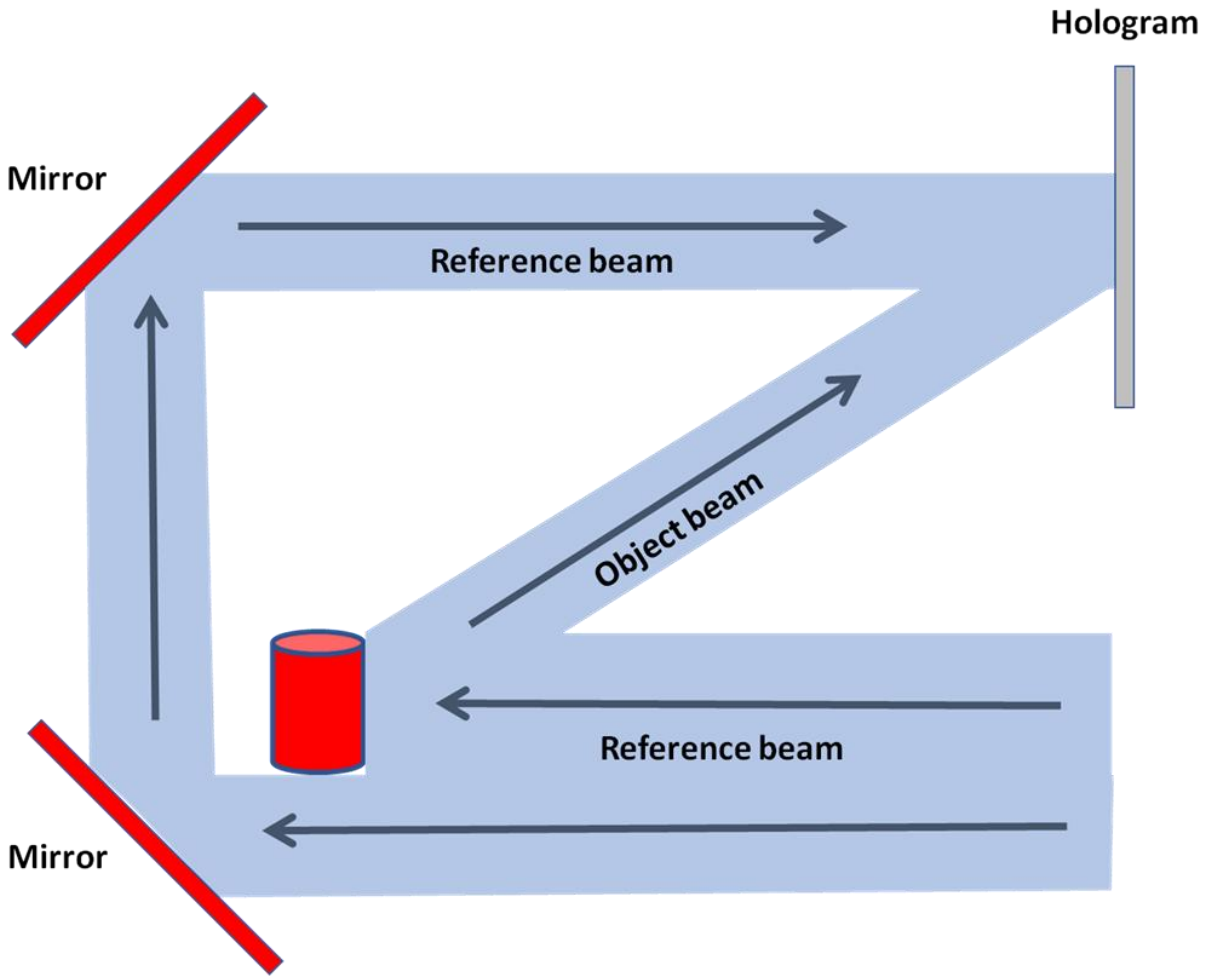
Holography: Construction of Hologram



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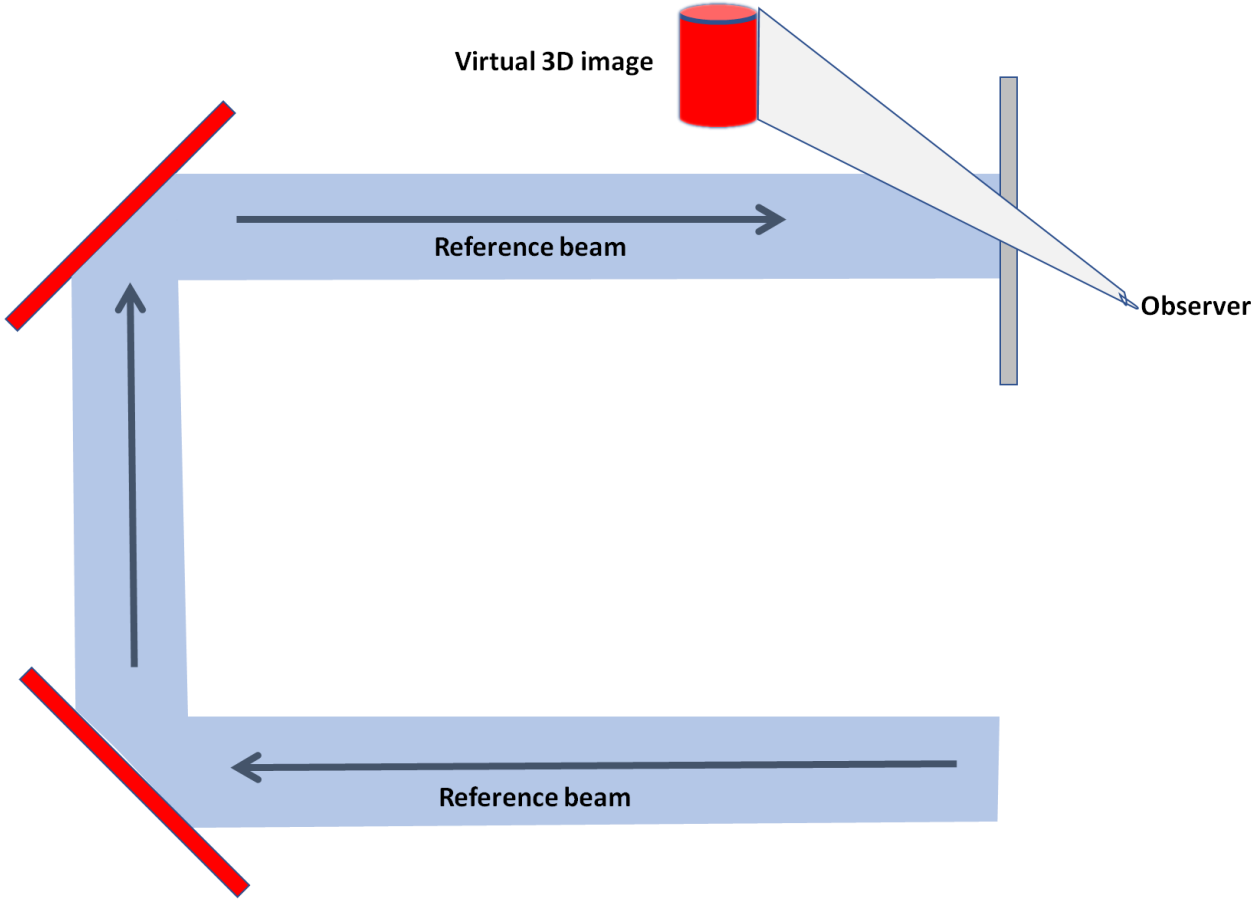
Holography: Image creation



Holography

Check Your Understanding (Yes/No)

1. Holography produces 3D colour images

2. Lasers are generally used for holography

3. Interference pattern is stored on a hologram

4. Holographic data storage can in future be used as computer memory/storage

THANK YOU

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