

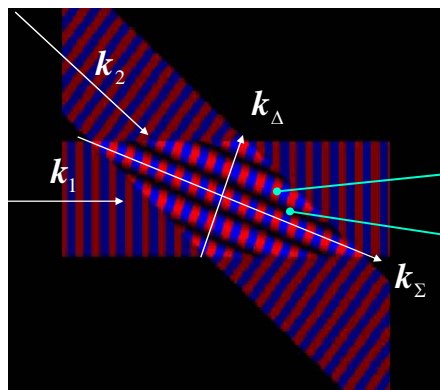
OPTI 380A

Intermediate Optics Lab 9: Michelson Interferometer

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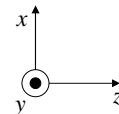
Two Vector Plane Waves -Dynamics

(Time Domain Dynamics)



- For $\lambda_1 = \lambda_2$, $\omega_\Delta = 0$ and modulation is stationary.
- For $\lambda_1 = \lambda_2$, $\mathbf{k}_\Delta \perp \mathbf{k}_\Sigma$
- Power flow is along *constructive* lines.
- Total energy is conserved due to *destructive* lines.

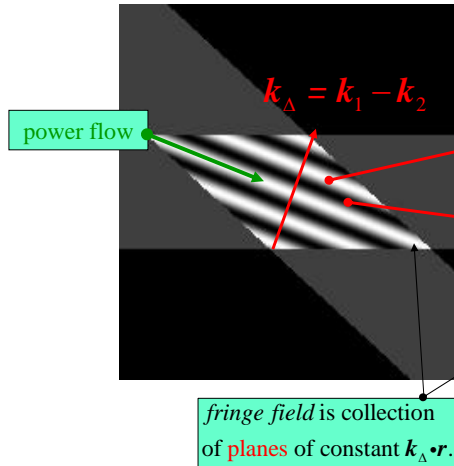
Red = negative field amplitude
Blue = positive field amplitude



Two Vector Plane Waves - Irradiance

(Time Averaged Irradiance)

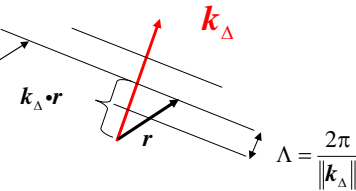
(We will drop the y subscript for now and assume $\beta=0$.)



$$I(\mathbf{r}) = CA^2 [1 + \cos(\mathbf{k}_\Delta \cdot \mathbf{r})]$$

When $(\mathbf{k}_1 - \mathbf{k}_2) \cdot \mathbf{r} = 2\pi m$, a *bright* fringe occurs from *constructive* interference.

When $(\mathbf{k}_1 - \mathbf{k}_2) \cdot \mathbf{r} = 2\pi(m + 1/2)$, a *dark* fringe occurs from *destructive* interference.



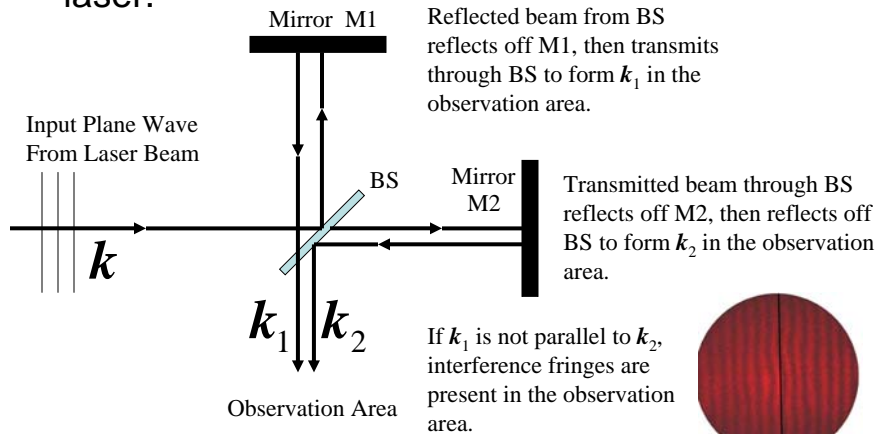
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3

Interferometer Basics

- Start with understanding principle of interference in a division of amplitude interferometer using a laser.



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4

Interferometer Characteristics

- OPDs of much less than λ can be measured easily.
- Very sensitive to mirror tilt, which determines direction of interfering plane waves and thus fringe spacing Λ .
- Fringe spacing Λ also depends on wavelength.

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5



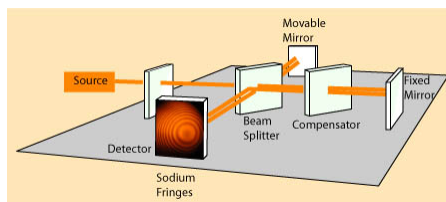
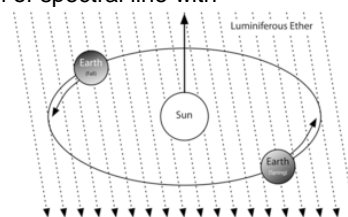
Michelson Interferometer



Albert Abraham Michelson (1852-1931)

- (1) Michelson-Morley experiment: measurement of aether (the absolute reference)
- (2) Study of fine structure of spectral lines
- (3) Comparison of wavelength of spectral line with standard meter
- (4) Speed of light

light should move "faster" along the arm oriented in the direction ether is moving



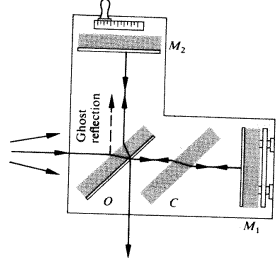
Michelson did not have a laser!!!

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6

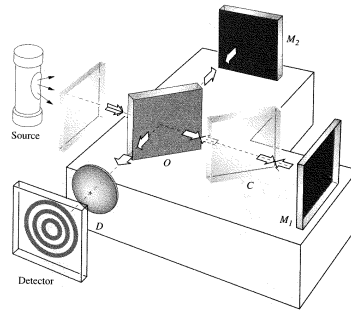
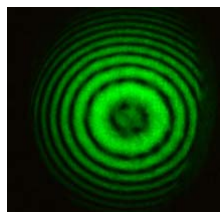
Michelson Interferometer Construction



Division of amplitude

Compensator plate: equal path length and wavelength dispersion

Source: Extended, incoherent, quasimonochromatic (not a laser)

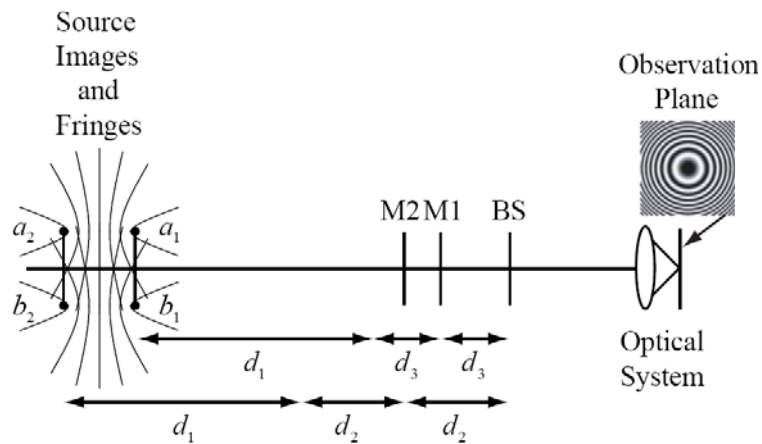


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7

Michelson Interferometer from the Observer's Perspective



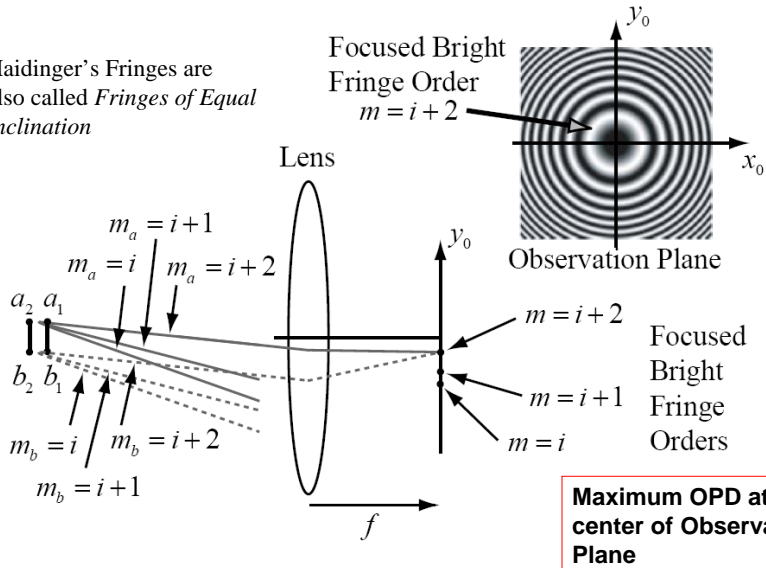
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8

Haidinger's Fringes

Haidinger's Fringes are also called *Fringes of Equal Inclination*



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9

Theory

Detector sees two sources, S1 and S2 with optical path difference

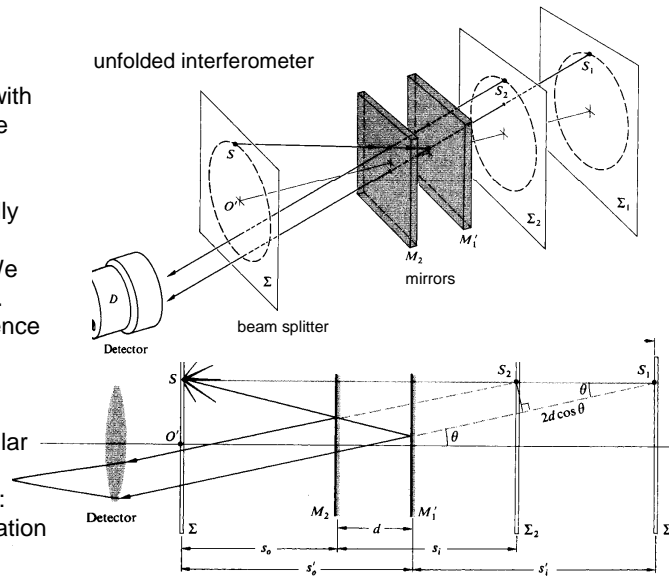
$$OPD = 2d \cos \theta$$

One beam is externally reflected; the other is internally reflected. We get a 180 phase shift. Constructive interference exists when

$$2d \cos \theta = m\lambda$$

Parallel mirror = circular fringes

Fix angle & Fix fringe:
Fringe of equal inclination (Haidinger's Fringes)



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10

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Michelson Interferometer

Michelson Interferometer Theory summary

System parameters information

Wavelength (in vacuum) : 633 nm
 Mirrors distance : 0.0 mm
 Refraction index : 1.0
 Display area width : 1.25 mm
 Lens focal length : 50 mm

System parameters

Wavelength
 Mirrors distance
 Refraction index
 Source type
 Extended Point (Twyman)

Diagram Graphic

About Exit

Applet running...

10/24/2009 <http://www.ubres.com/java/optics/index.en.html> OPTI380A - Lab 9: Michelson Interferometer 11

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Michelson Interferometer with Tilted Mirrors

Fringes of Equal Thickness

Source Images and Fringes

Fringes "localized" at mirrors.

(Images mirrors onto observation plane)

Imaging System

Observation Plane

θ Decreases

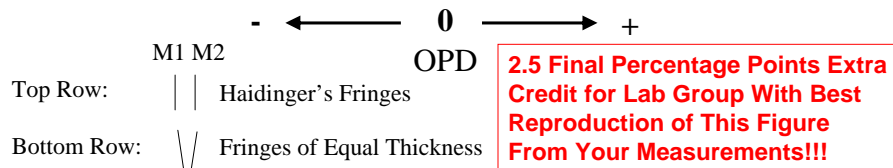
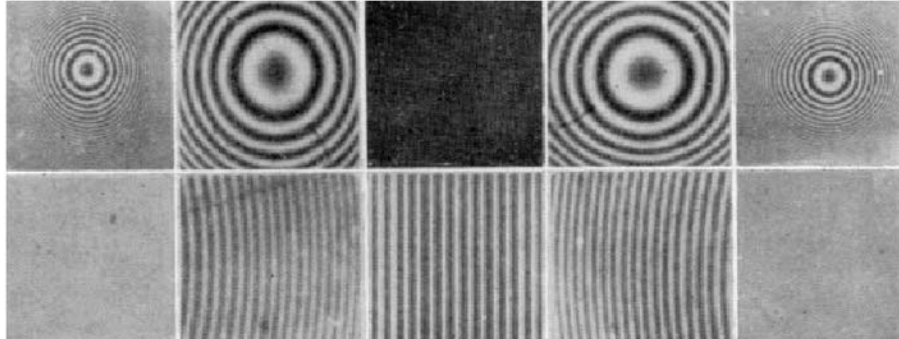
$m_a = 0$
 $m_b = 0$
 Can have OPD = 0 in observation area.

θ

θ Decreases

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Michelson Interferometer Fringes



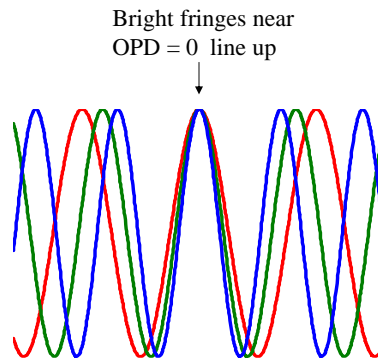
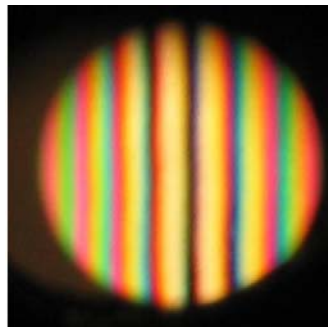
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13

White-Light Fringes

- Only possible with fringes of equal thickness (tilted mirrors)
- $OPD = 0$ fringe is white.
- Colors disperse fringes at larger OPDs.
- Not possible with fringes of equal inclination (Haidinger's fringes).



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14