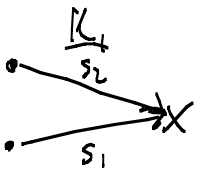
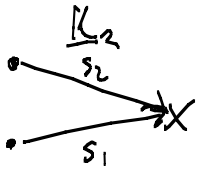
Beats





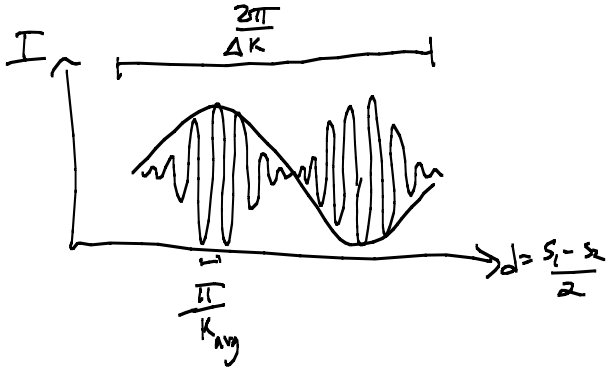
$$E = 2E_0 \cos\left(k_1 \frac{(s_1+s_2)}{2} - \omega t\right) \cos\left(k_1 \frac{s_1-s_2}{2}\right) \qquad E = 2E_0 \cos\left(k_2 \frac{(s_1+s_2)}{2} - \omega t\right) \cos\left(k_2 \frac{s_1-s_2}{2}\right)$$

$$E_{tot} = E_1(t) \cos\left(k_1 \frac{s_1-s_2}{2}\right) + E_2(t) \cos\left(k_2 \frac{s_1-s_2}{2}\right)$$

Using: $\cos u + \cos v = 2 \cos \frac{u+v}{2} \cos \frac{u-v}{2}$ and ignoring time-varying terms

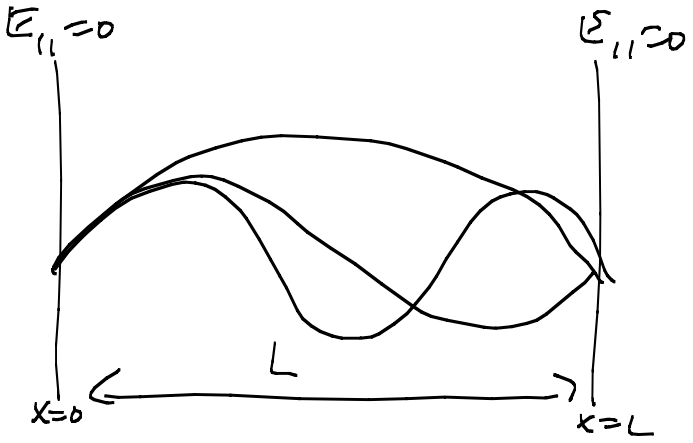
$$E_{tot} \propto \cos\left(\frac{k_1+k_2}{2}\left(\frac{s_1-s_2}{2}\right)\right) \cos\left(\frac{k_1-k_2}{2}\left(\frac{s_1-s_2}{2}\right)\right)$$

$$I \propto E_{tot}^2 \propto \cos\left(\underbrace{\frac{k_1+k_2}{2}}_{k_{avg}}(s_1-s_2)\right) \cos\left(\underbrace{(k_1-k_2)}_{\Delta k}\left(\frac{s_1-s_2}{2}\right)\right)$$



Laser modes

Classical wave eqn w/ B.C.'s:



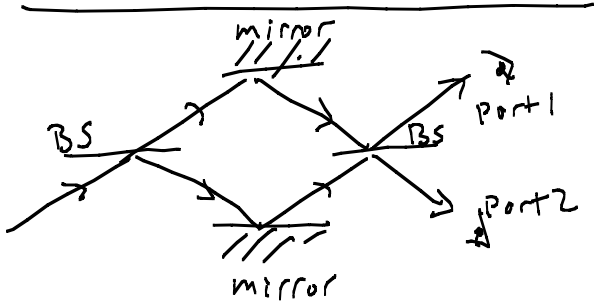
$$E = \sin(K_{sc} x)$$

$$K_{sc} = \frac{m\pi}{L} \qquad m = 1, 2, 3 \ldots$$

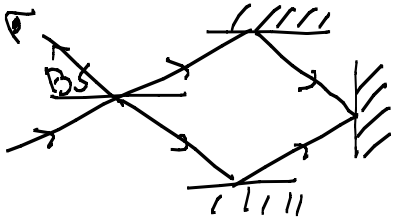
$$\Delta K_{sc} = \frac{\pi}{L} \qquad K_{air} = \frac{K_{sc}}{n}$$

$$\Delta K_{air} = \frac{\Delta K_{sc}}{n} = \frac{\pi}{nL} \qquad L = \frac{\pi}{n \Delta K_{air}}$$

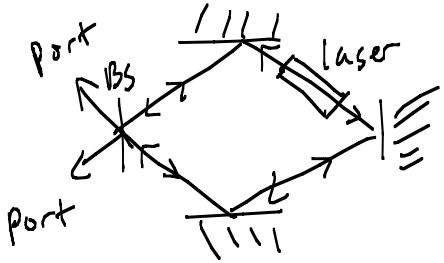
Other Interferometers:



"Mach - Zehnder"



"Sagnac"



"ring laser"

Applications

Tests of Relativity:

Special

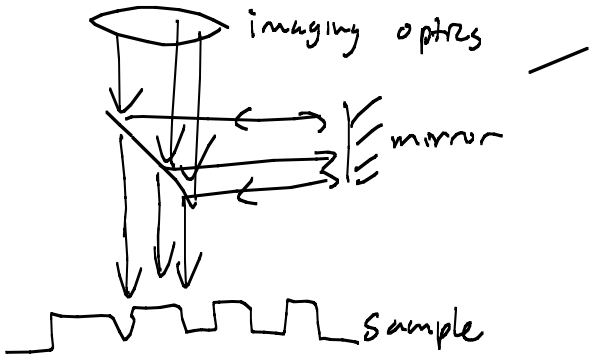
Michelson-Morley expt.

Fizeau

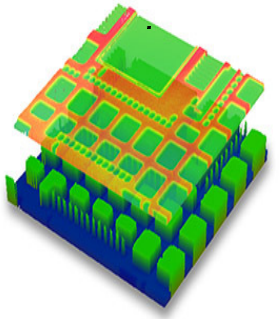
General

LIGO: 2 modified MM interferometers (LA + WA)
2.5 miles arm length.

Metrology:



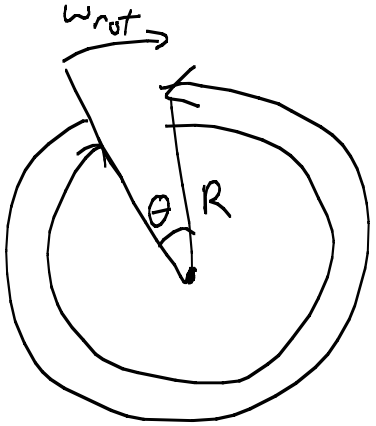
Imaging interferometer



Zygo.com

gyroscopes: inertial guidance

Sagnac interferometer:



$\pm$: cw
$\mp$: ccw

$$t \simeq \frac{2\pi R}{c} \pm \frac{(\omega t)R}{c}$$

$$t\left(1 \mp \frac{\omega_{rot} R}{c}\right) = \frac{2\pi R}{c}$$

$$(1+\varepsilon)^n \sim 1 + n\varepsilon \quad (\varepsilon \ll 1)$$

$$t = \frac{2\pi R}{c}\left(1 \mp \frac{\omega_{rot} R}{c}\right)^{-1} \sim \frac{2\pi R}{c}\left(1 \pm \frac{\omega_{rot} R}{c}\right)$$

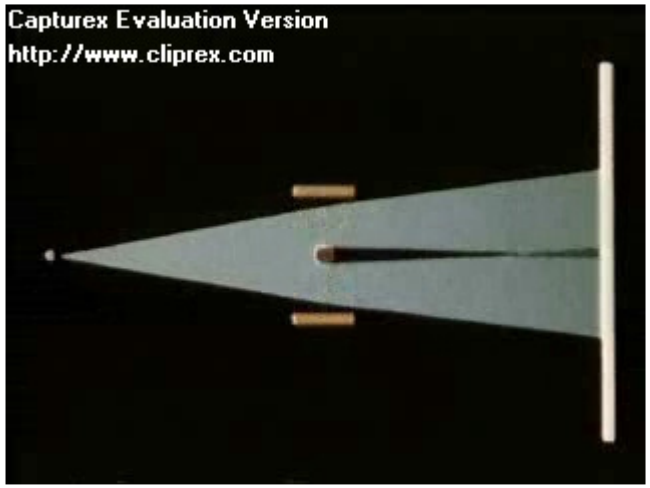
$$\Delta\phi = \omega \Delta t = 2\omega \frac{2\pi R}{c} \frac{\omega_{rot} R}{c} = \frac{4\pi R^2}{c^2} \omega \omega_{rot}$$

↑
Interference

Important for airplane/submarine/etc navigation

Electron Interferometry: Vacuum

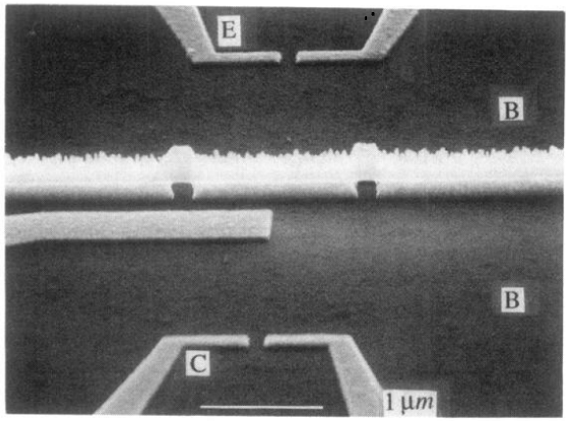
electrostatic biprism



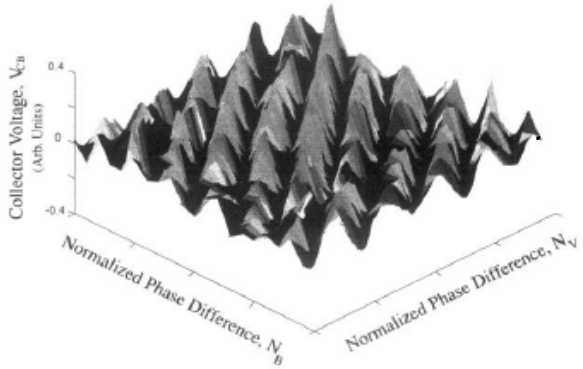
Like Young's 2-slit experiment

Electron Interferometry: Solid State

two-slit:



A. Yacoby, M. Heiblum, V. Umansky, H. Shtrikman, and D. Mahalu
- Phys. Rev. Lett. 73, 3149 (1994)



An electronic Mach–Zehnder interferometer

Yang Ji, Yunchul Chung, D. Sprinzak, M. Heiblum, D. Mahalu & Hadas Shtrikman

NATURE | VOL 422 | 27 MARCH 2003 | 415