Superposition of waves of different k

$$\frac{\partial^2}{\partial z^2}\vec{E} = \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\vec{E}$$

D'Alembert solution: $\vec{E} \rightarrow E(z \pm ct)$

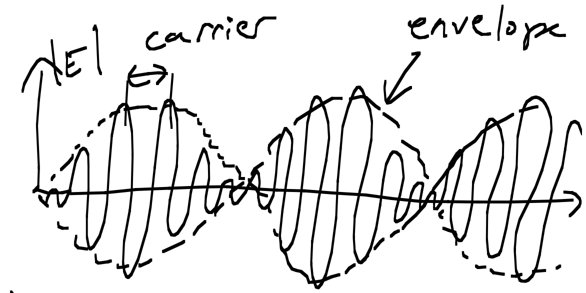
$c = \frac{\omega}{k}$ "phase velocity"

$$|E| = \cos\left[\left(k_0 - \frac{\Delta k}{2}\right)z - \left(\omega_0 - \frac{\Delta \omega}{2}\right)t\right] + \cos\left[\left(k_0 + \frac{\Delta k}{2}\right)z - \left(\omega_0 + \frac{\Delta \omega}{2}\right)t\right]$$

$$\cos(u-v) + \cos(u+v) = 2\sin(u)\sin(v)$$

$$= 2\sin(k_0 z - \omega_0 t)\sin(\Delta k z - \Delta \omega t)$$

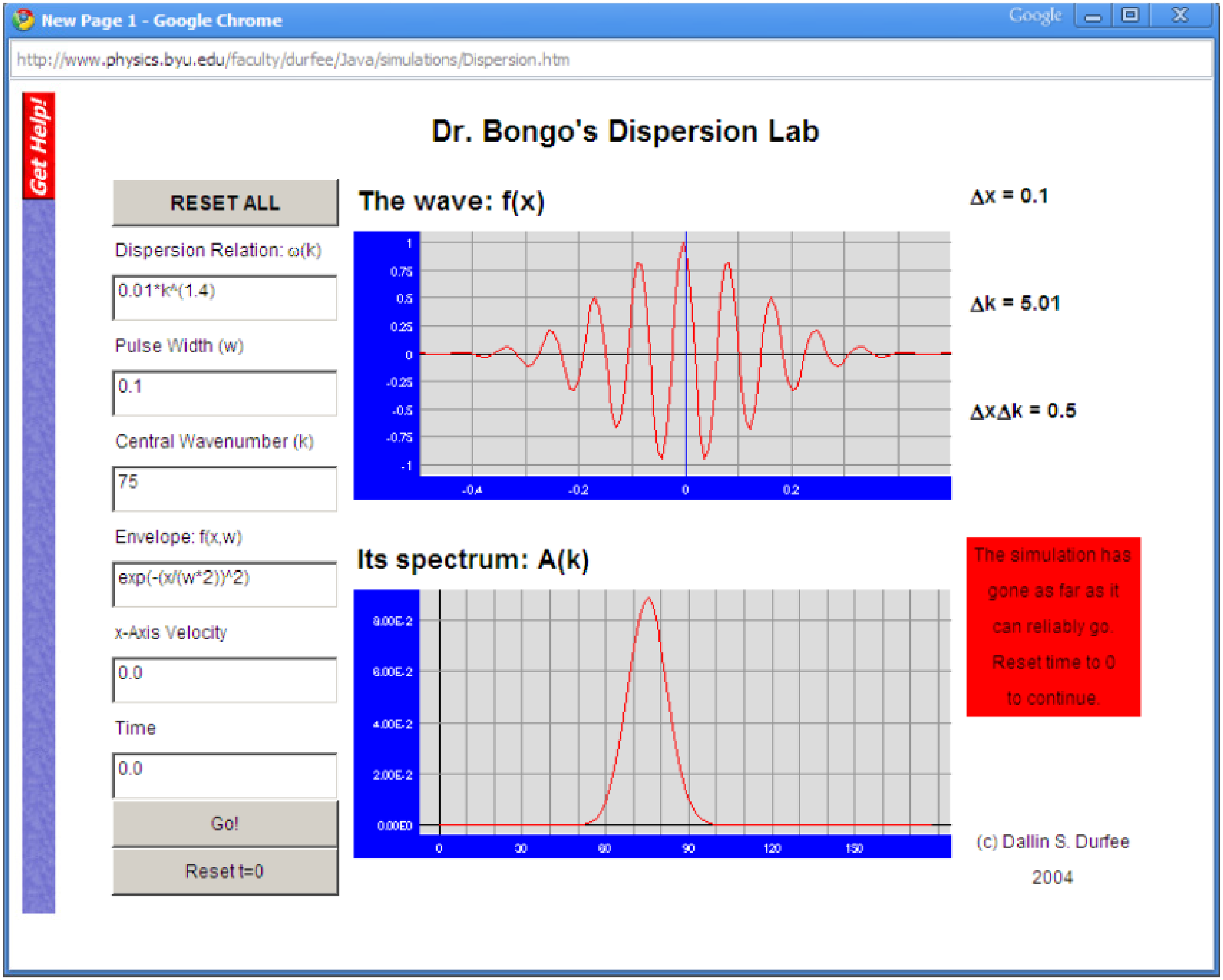
phase velocity $\frac{\omega_0}{k_0}$ — group velocity $\frac{\Delta\omega}{\Delta k}$



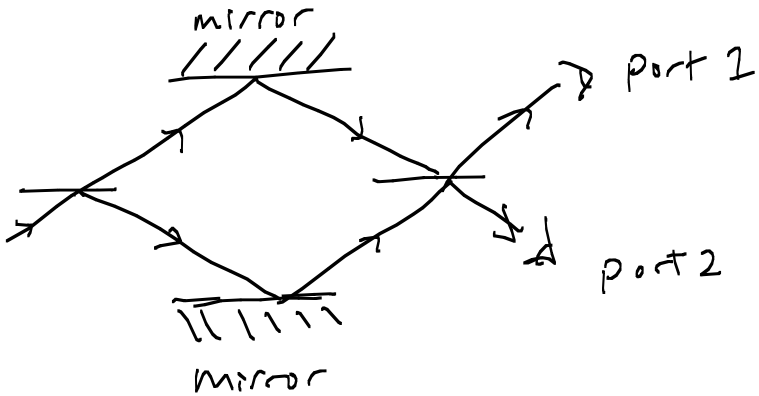
Continuum of waves: $|E| = \int_{-\infty}^{\infty} A(k) e^{i(kz - \omega(k)t)} dk$

group velocity $\frac{\Delta \omega}{\Delta k} \longrightarrow \frac{d\omega(k)}{dk}$

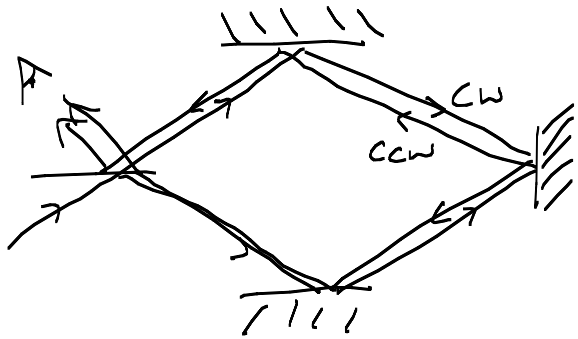
for light in vacuum, $\omega(k) = kc$ "dispersion rel'n" $V_p = V_g$


New Page 1 - Google Chrome
http://www.physics.byu.edu/faculty/durfee/Java/simulations/Dispersion.htm
Get Help!
Dr. Bongo's Dispersion Lab
RESET ALL
Dispersion Relation: ω(k)
0.01*k^(1.4)
Pulse Width (w)
0.1
Central Wavenumber (k)
75
Envelope: f(x,w)
exp(-(x/(w*2))^2)
x-Axis Velocity
0.0
Time
0.0
Go!
Reset t=0
The wave: f(x)
Its spectrum: A(k)
Δx = 0.1
Δk = 5.01
ΔxΔk = 0.5
The simulation has gone as far as it can reliably go. Reset time to 0 to continue.
(c) Dallin S. Durfee
2004

Interferometers (not Michelson, Young, Fabry-Perot)



"Mach-Zehnder"



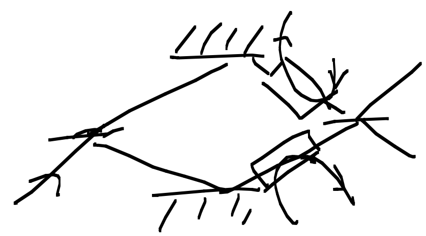
"Sagnac"

"ring laser" Interferometer

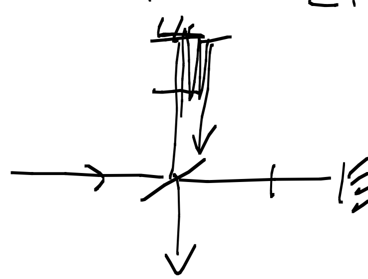
Applications

tests of Relativity:

Special Relativity: Michelson-Morley no orientation dependence for EM propagation.

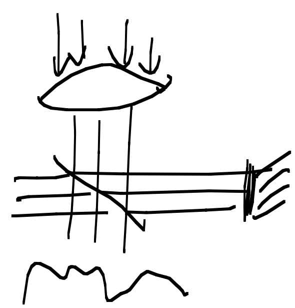
Fizeau  equivalence of inertial frames

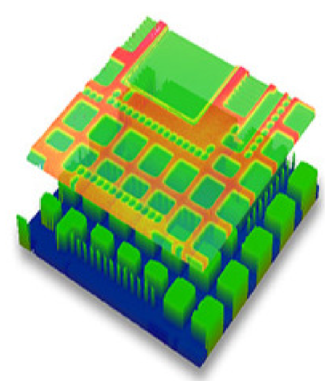
General Relativity: LIGO: 2 × 2.5 mile interferometers.



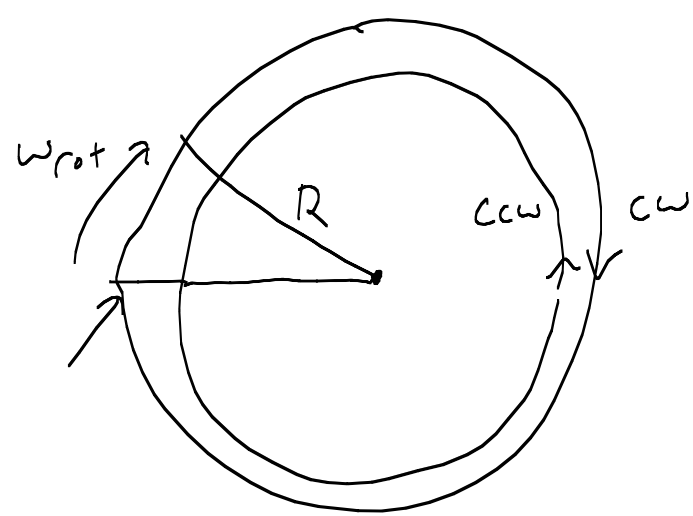
Metrology:

Imaging Interferometers





gyroscopes (sagnac): rotating frame detection



$\pm$: cw / ccw

$$t = \frac{2\pi R}{c} \pm \frac{(w_{rot} t) R}{c}$$

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

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

$$\Delta\phi = w \Delta t = w\left(\frac{4\pi R^2}{c^2} w_{rot}\right) = \frac{4\pi R^2}{c} w_{rot} K$$

interference (→ $\Delta\phi$)

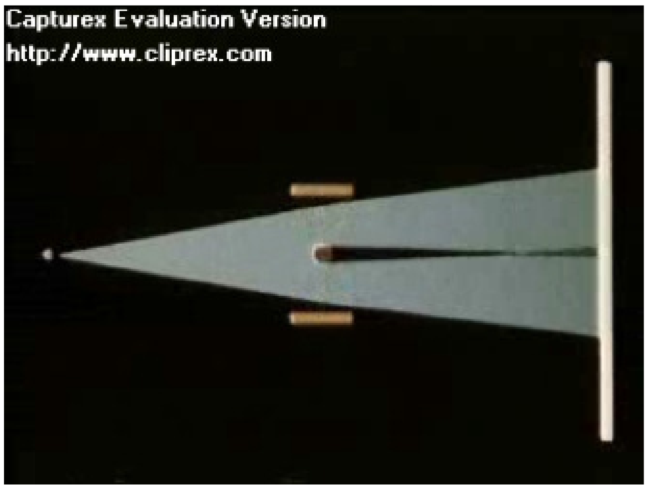
$w = kc$

used for inertial guidance

e.g, submarines, airplanes, etc.

Electron Interferometry: Vacuum

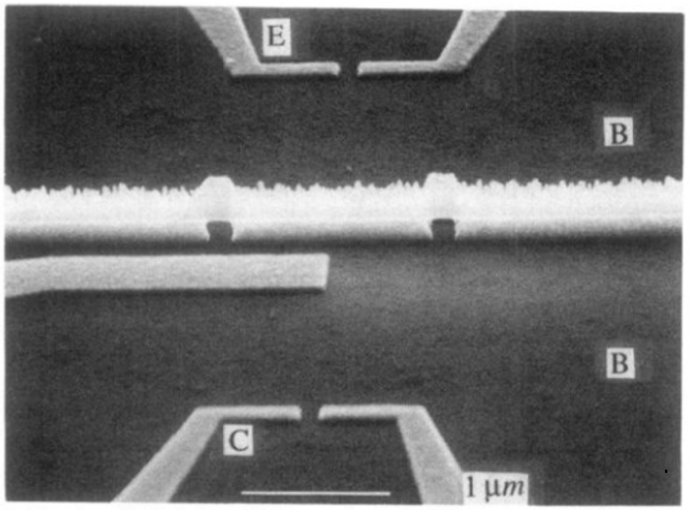
electrostatic biprism



Like Young's 2-slit experiment

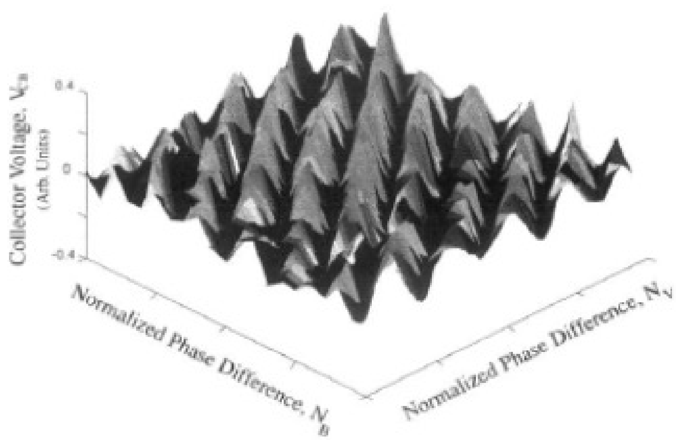
Electron Interferometry: Solid State

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

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