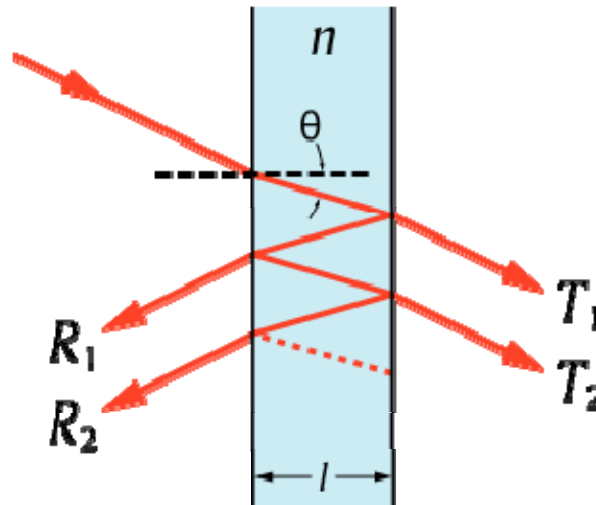


Interferometric Spectroscopy

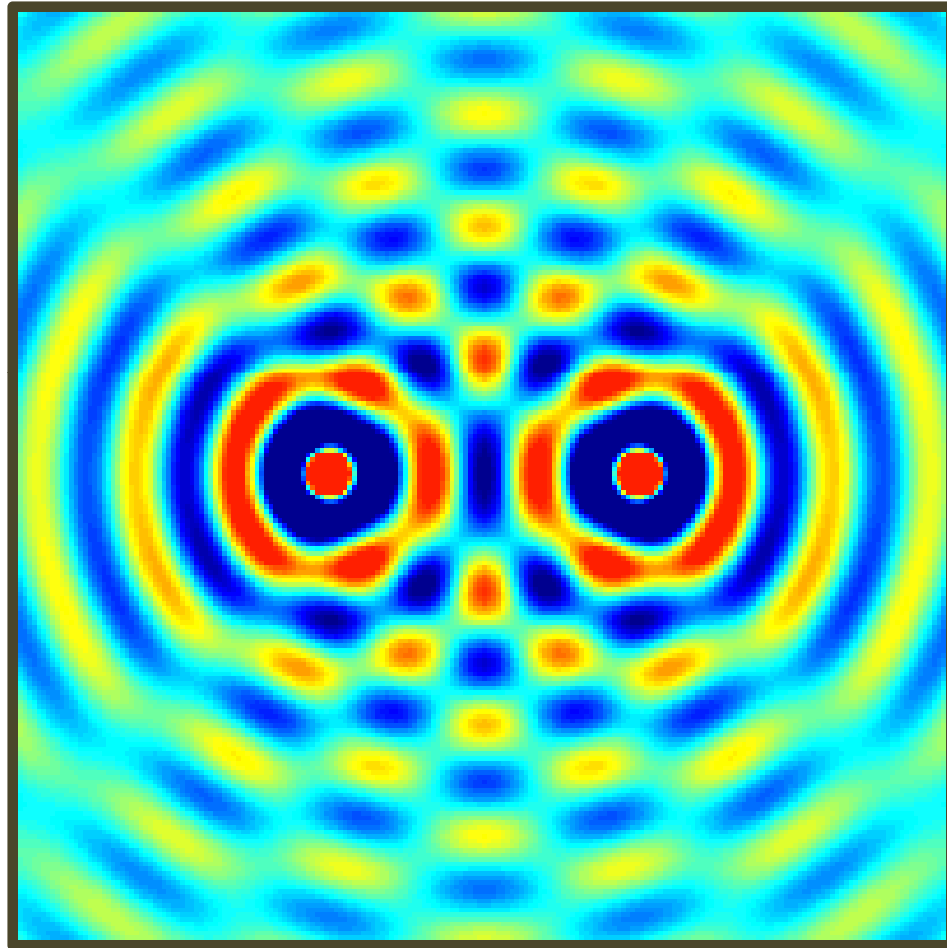
Week of November 8, 2010



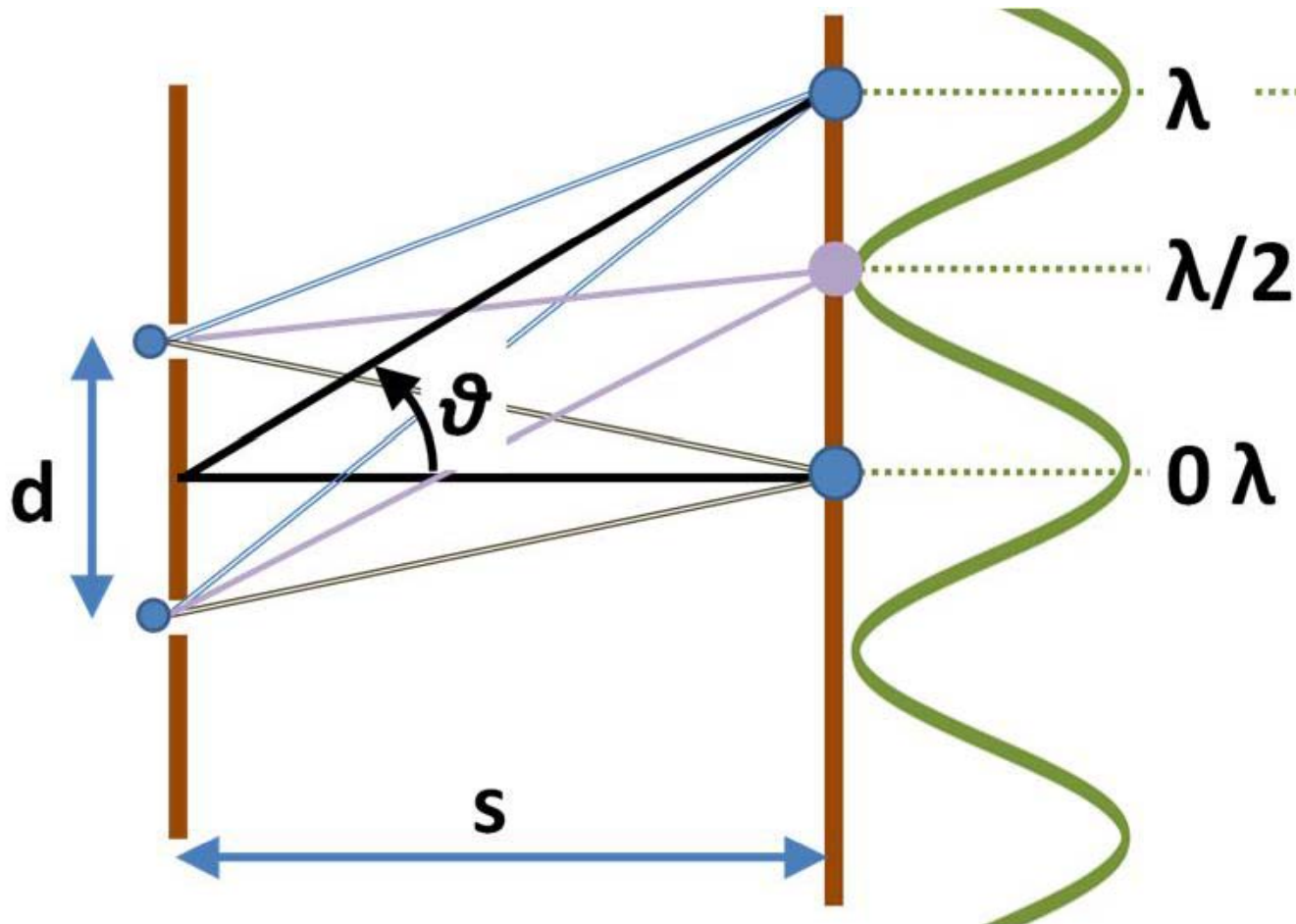
**Atomic and Nuclear Physics Laboratory
(Physics 4780)**

The University of Toledo
Instructor: Randy Ellingson

Interference



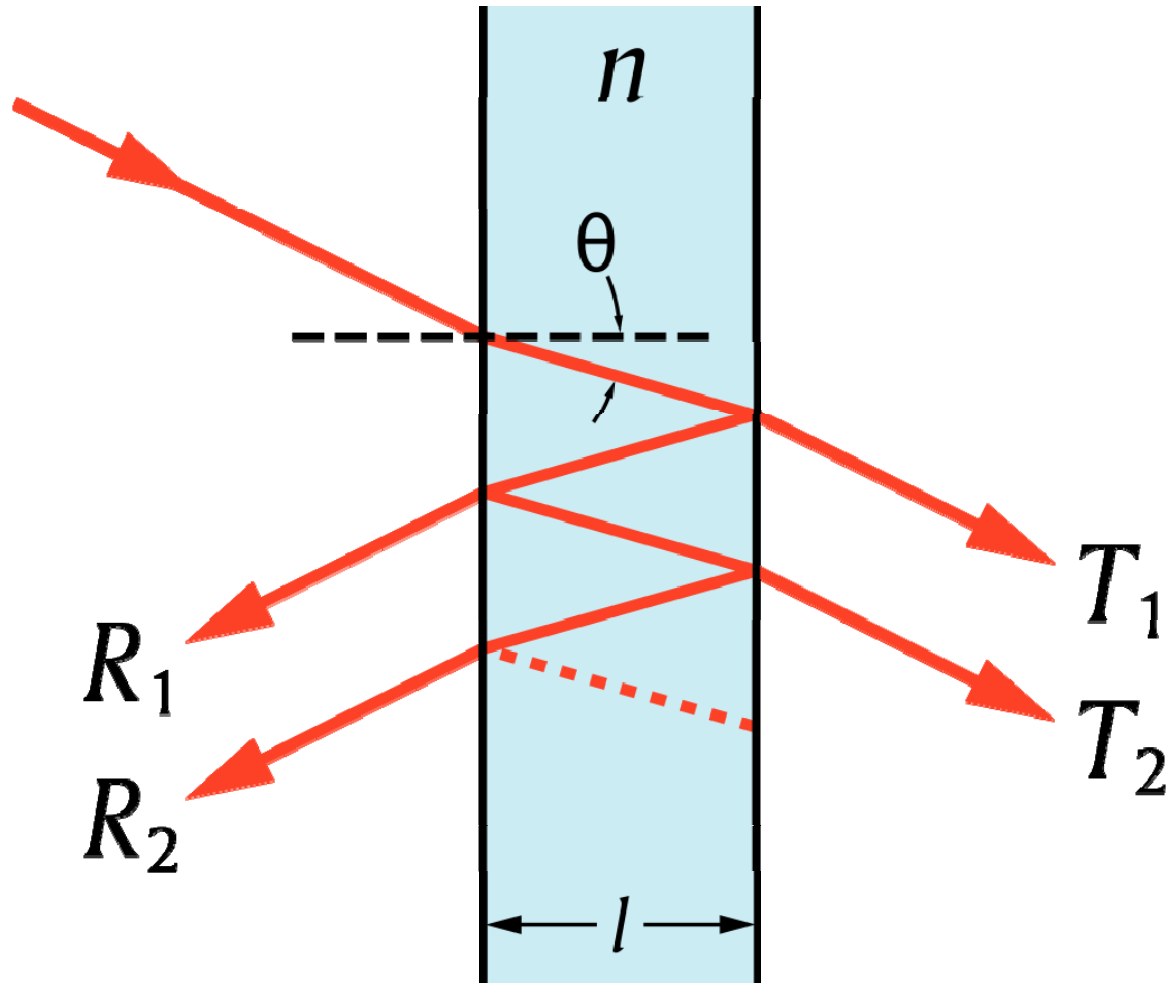
Interference (double-slit)



$$d \sin \theta = m\lambda$$

$$d \sin \theta = \left(m + \frac{1}{2}\right)\lambda$$

Fabry-Pérot Interferometer



Light enters a Fabry-Perot interferometer and undergoes multiple internal reflections.

Fabry-Pérot Interferometer

Phase difference between successive reflections off the same surface:

$$\delta = \left(\frac{2\pi}{\lambda} \right) 2nl \cos \theta$$

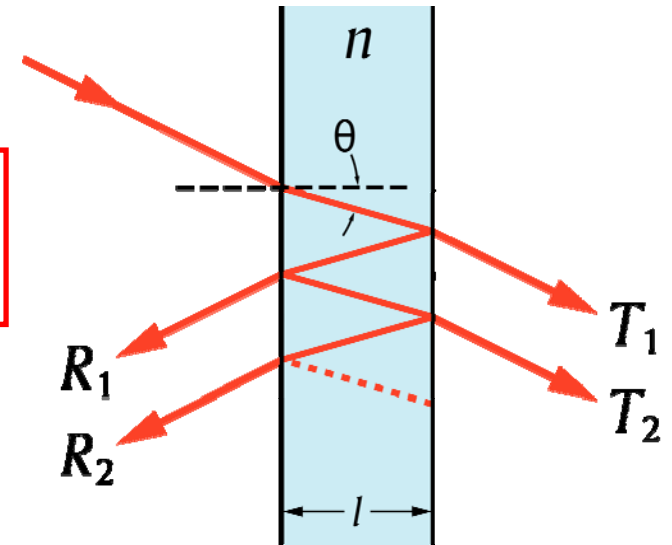
(optical path difference between successive transmitted beams)

When both reflecting surfaces have reflectance R , the transmission of the etalon is given by:

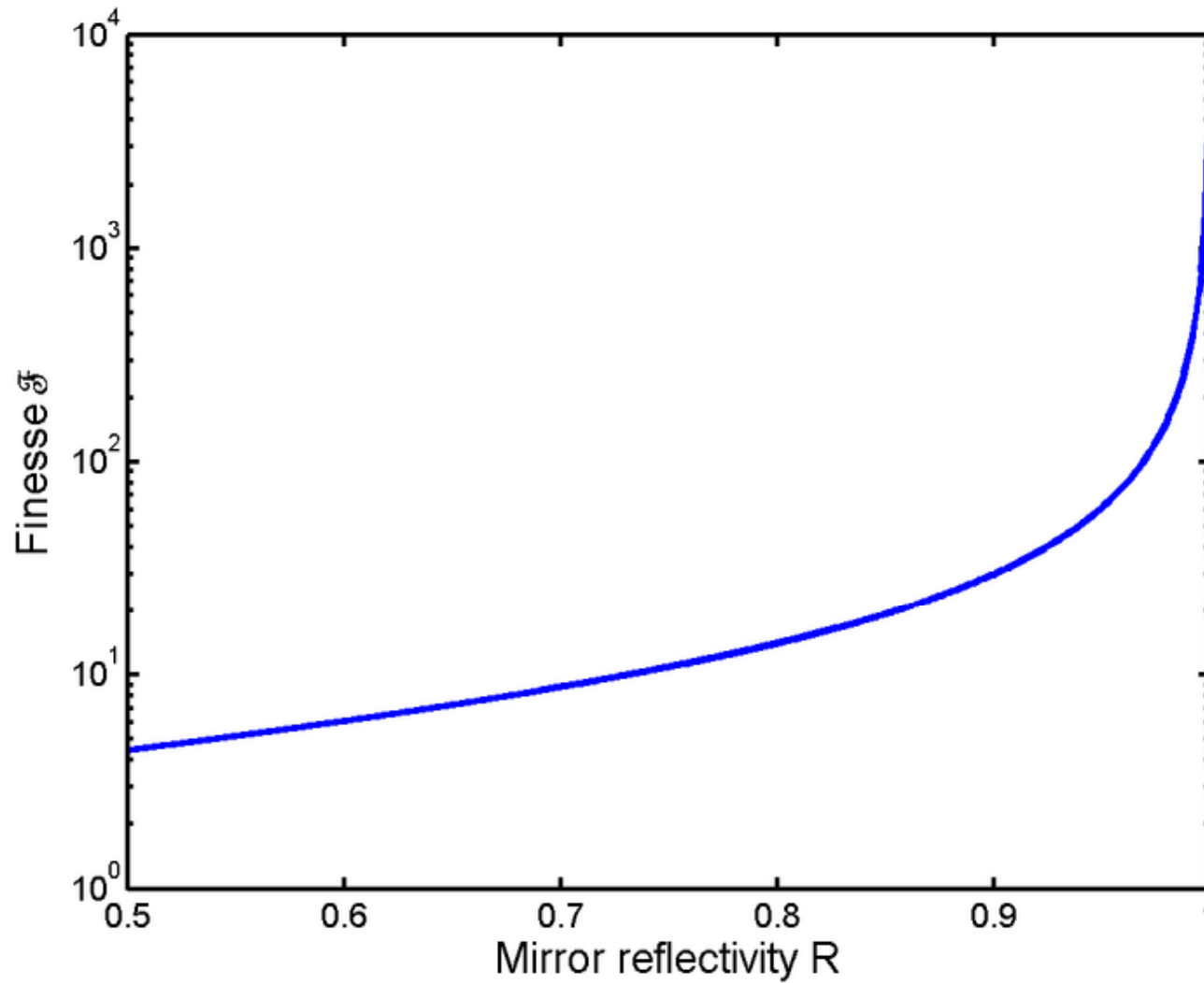
$$T = \frac{(1-R)^2}{1+R^2-2R\cos(\delta)} = \frac{1}{1+F\sin^2\left(\frac{\delta}{2}\right)}$$

where $F = \frac{4R}{(1-R)^2}$

F is the *coefficient of finesse* (not the same as the *finesse*).



Cavity (or Etalon) Finesse



$$F = \frac{4R}{(1-R)^2}$$

Fabry-Pérot Interferometer

With no absorption, $R = 1 - T$

The wavelength spacing between successive transmission peaks is called the *free spectral range* (FSR):

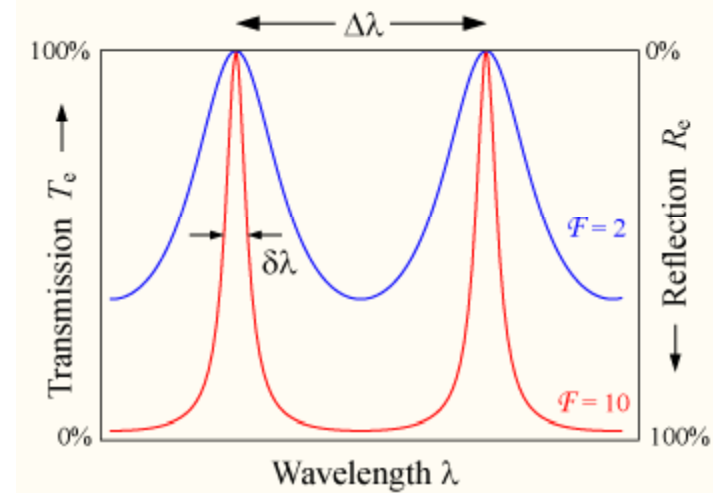
$$\Delta\lambda = \frac{\lambda_0^2}{2nl \cos \theta + \lambda_0} \approx \frac{\lambda_0^2}{2nl \cos \theta}$$

The finesse \mathfrak{F} is the ratio of the FSR to the width of any one transmission peak ($\delta\lambda$):

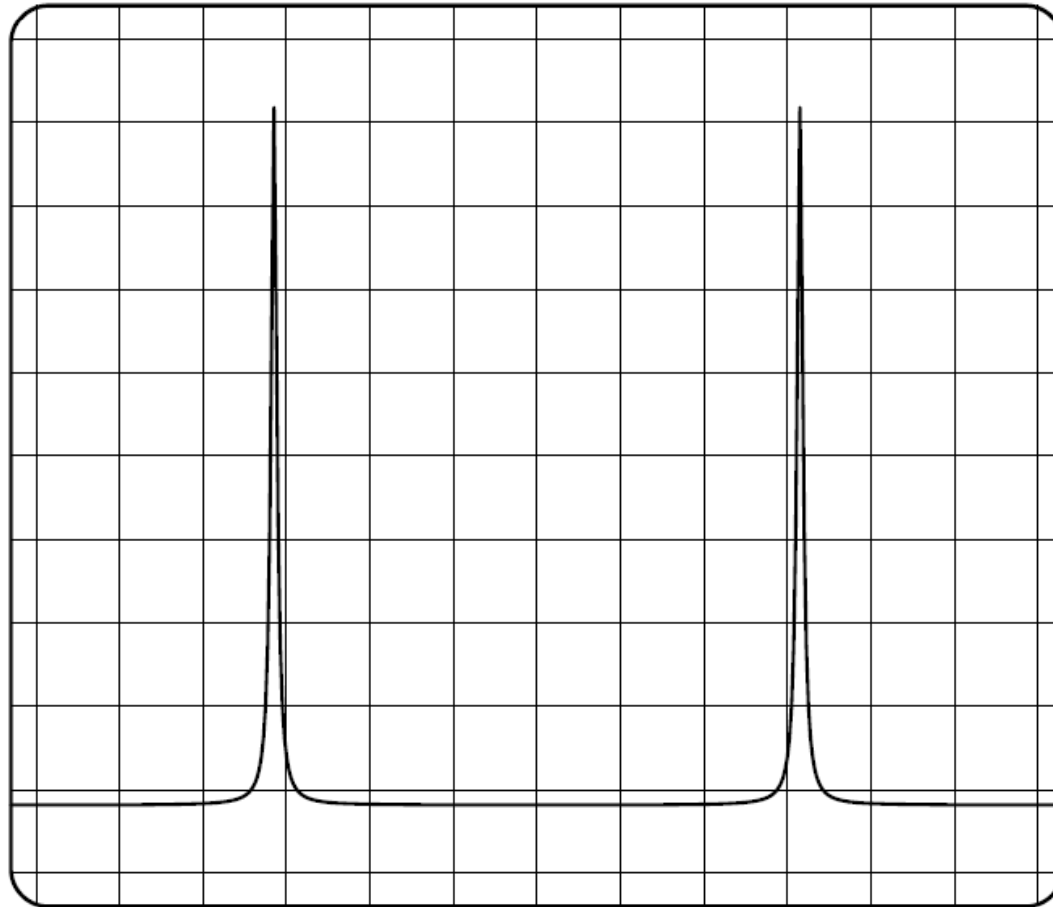
$$\mathfrak{F} = \frac{\Delta\lambda}{\delta\lambda} = \frac{\pi}{2 \arcsin\left(\frac{1}{\sqrt{F}}\right)}$$

For $R > 0.5$, \mathfrak{F} is often approximated by:

$$\mathfrak{F} \approx \frac{\pi\sqrt{F}}{2} = \frac{\pi R^{1/2}}{1-R}$$

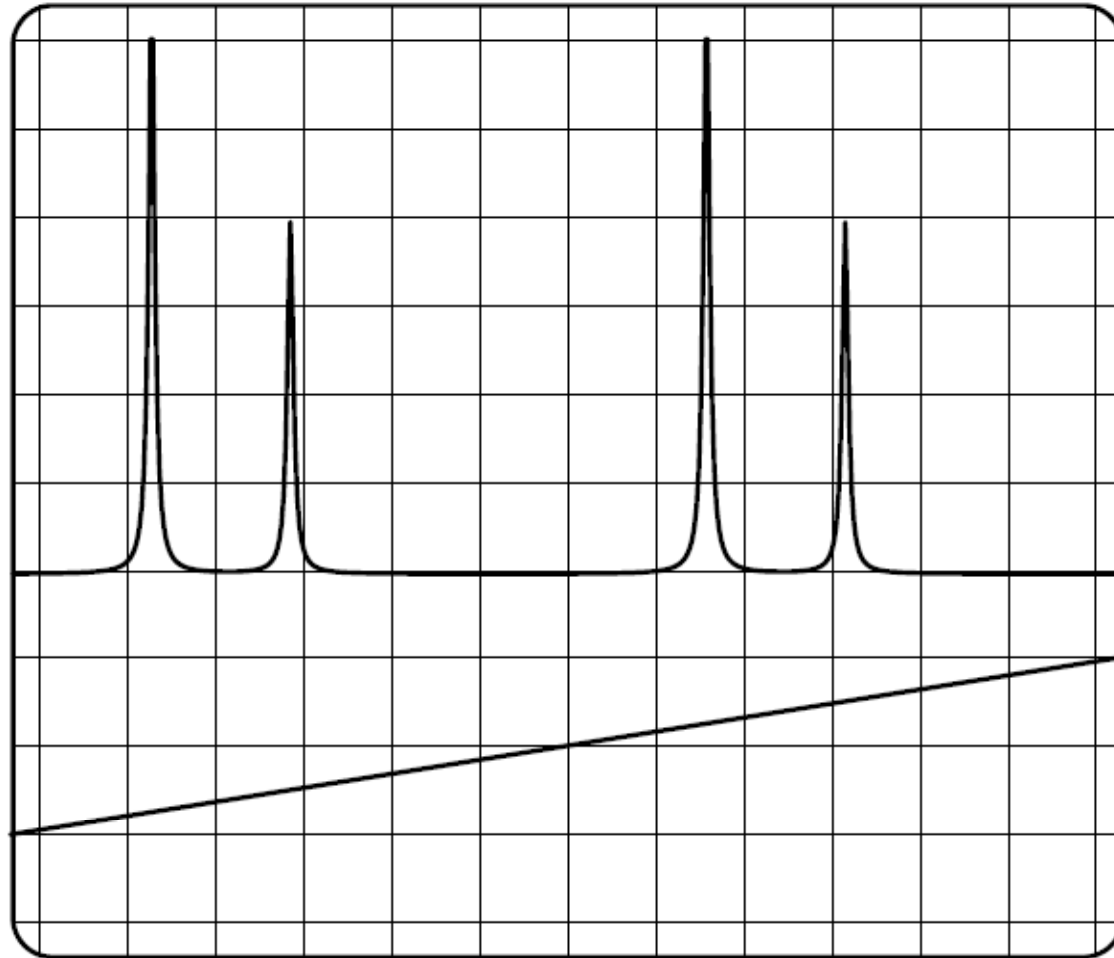


Typical Fabry-Perot interferogram (single mode)



Transmission signal on an oscilloscope with a periodic variation of the mirror distance d .

Two-mode laser operation



Example of a scan of a two mode laser. The lower trace shows the change in length of the F-P.