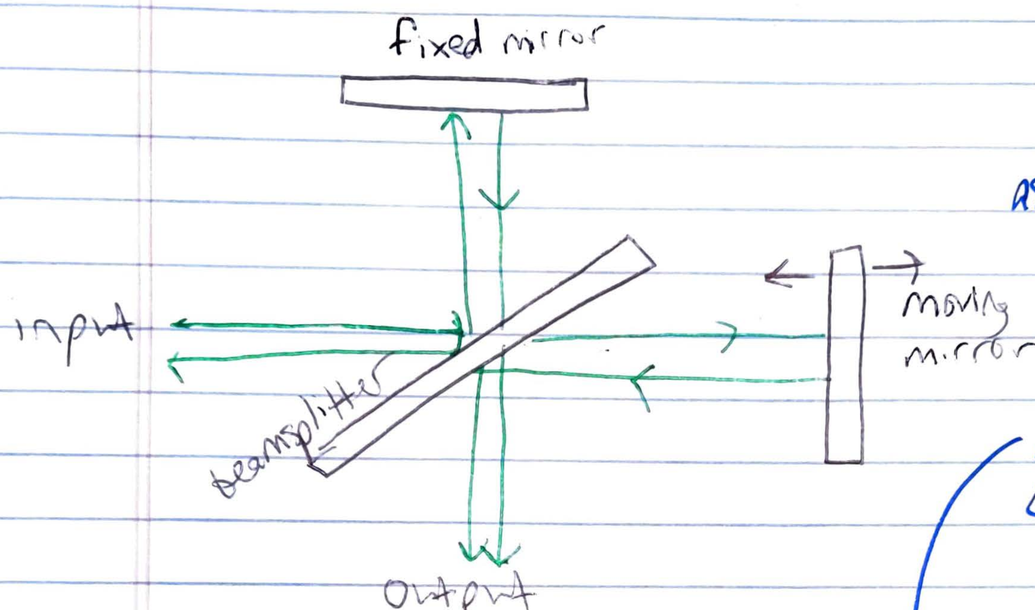
Fourier Transform Spectroscopy



output

$E = h_1 e^{j\phi_1} + h_2 e^{j\phi_2}$

assume $h_1 = h_2 = h$

$I = EE^*$

$I = 2h^2(1 + \cos(\phi_1 - \phi_2))$

$I = 2h^2\left(1 + \cos\left(\frac{2\pi\Delta}{\lambda}\right)\right)$

$\Delta = \lambda(\phi_1 - \phi_2)/2\pi$

Δ = path length difference

move mirror at v

$\Delta = vt$

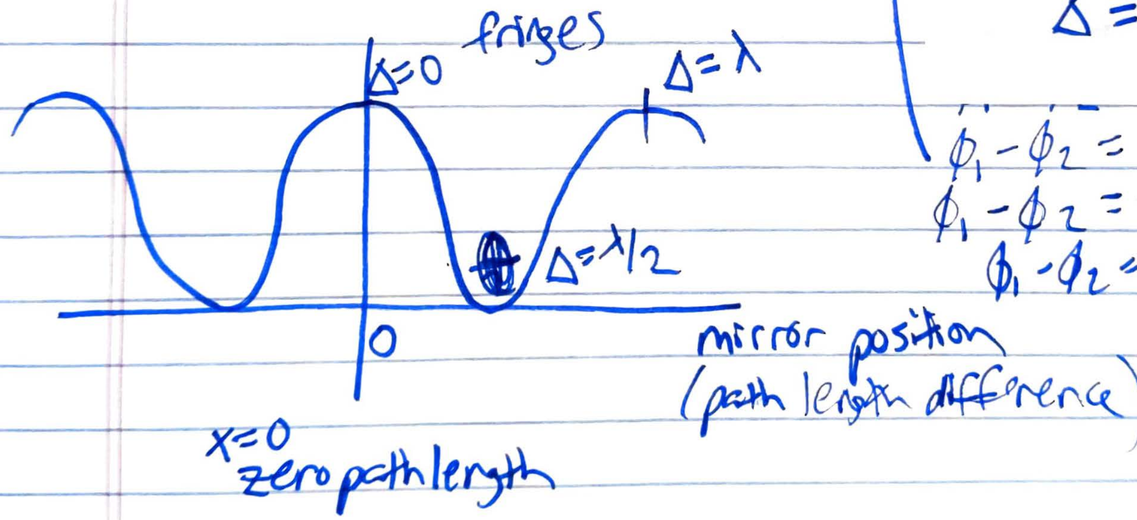
$\phi_1 - \phi_2 = 2\pi\Delta/\lambda$

$\phi_1 - \phi_2 = 2\pi vt/\lambda$

$\phi_1 - \phi_2 = 2\pi f t$

$f = \frac{2v}{\lambda}$

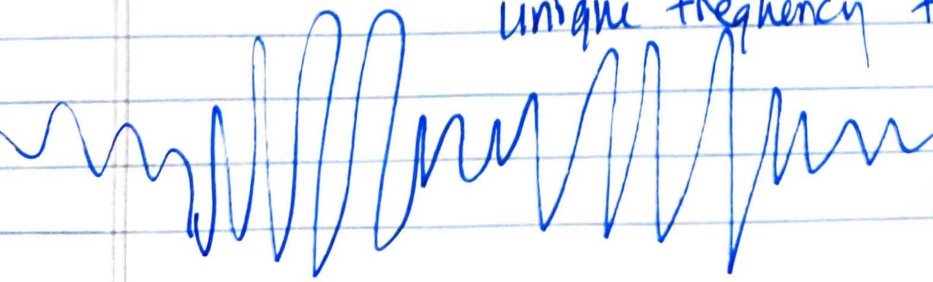
Monochromatic light (laser)



Broadband Light

$I(t) = \sum_n 2h_n^2 \cos(2\pi f_n t)$

unique frequency f_n for each wavelength



can invert w/ discrete Fourier Transform

"Fellget advantage"
"multiplex advantage"

In limit of detector noise dominated measurement, noise is not increased by measuring many wavelengths
S/N is improved by $\sqrt{\#}$ of spectral elements

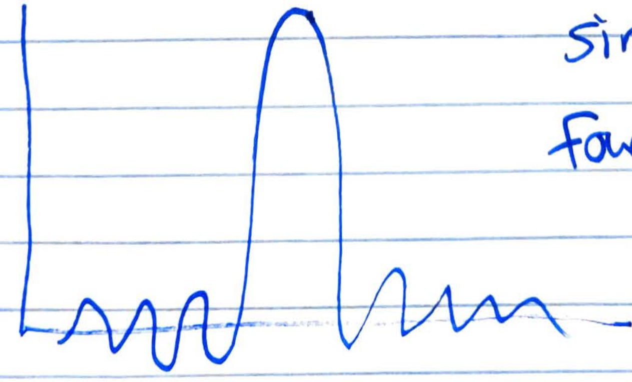
If shot noise / photon noise dominates, advantage disappears
noise $\propto \sqrt{P} \propto \sqrt{\#}$ of spectral elements

Hard limit on performance set by path-length difference and step size

step-size sets highest frequency / shortest wavelength

spectral resolution is set by largest possible excursion / path length difference

What does an unresolved spectral line look like?

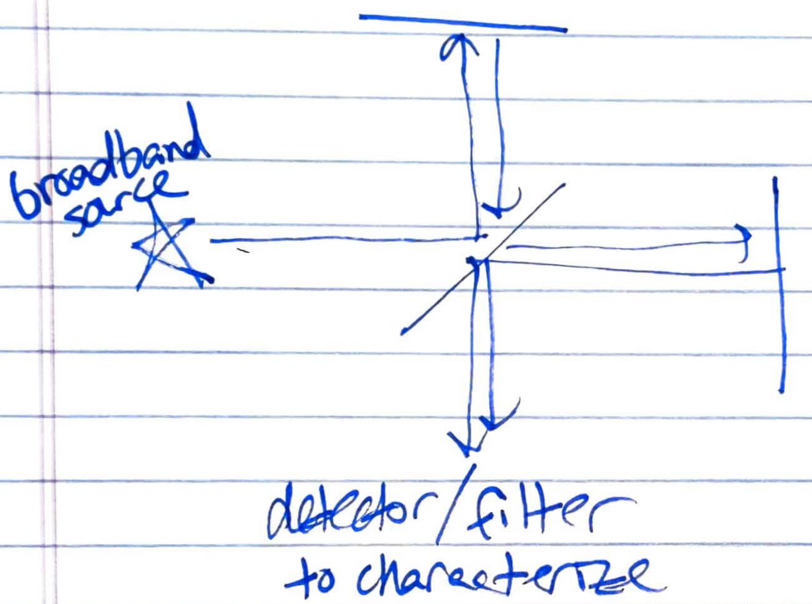


sinc function w/ ringing

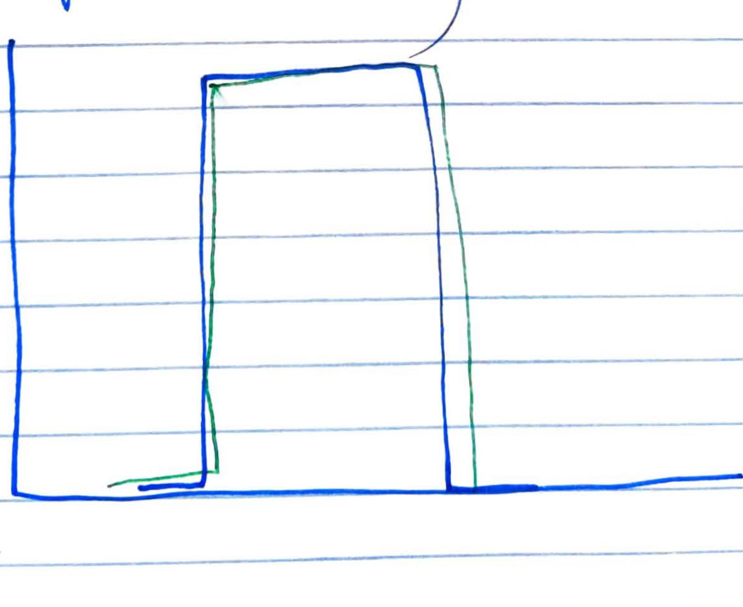
Fourier series is truncated

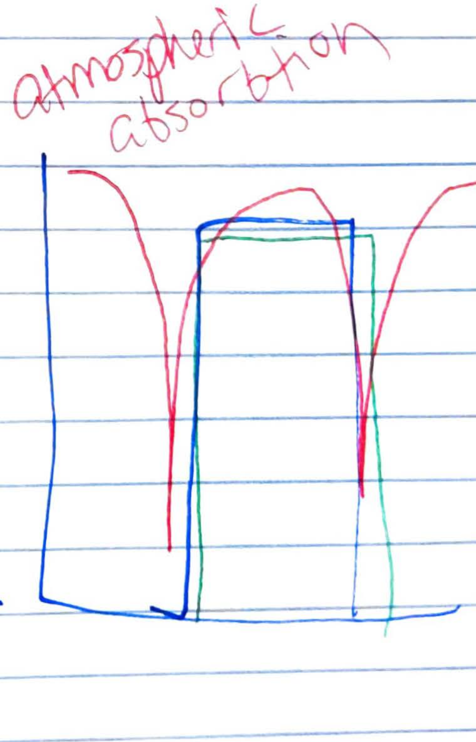
Fix by apodization

FTS can be used for observation
or
calibration



Bandpass matching





FTS can be used to measure <u>absorption</u>