How an FTIR Spectrometer Works

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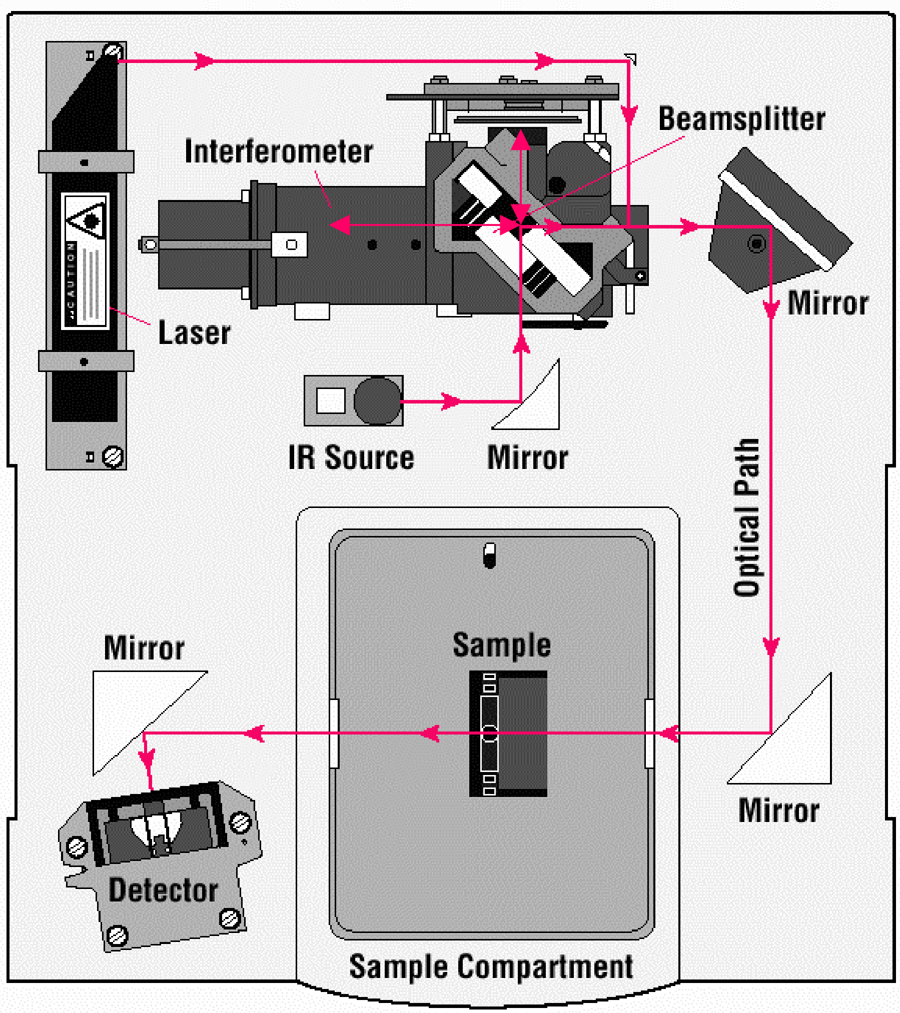
A Simple Spectrometer Layout



Pathlength difference = x

The intensity detected of two plane waves:

$$I = \left|\vec{E}\right|^2 = \left|E_1\right|^2 + \left|E_2\right|^2 + 2\vec{E}_1 \bullet \vec{E}_2 \cos(q)$$

Normal incidence, θ = kx, can simplify to:

$$I(x) = 2[1 + \cos(kx)]$$

For non-monochromatic light:

$$I(x) = \int_0^\infty [1 + \cos(kx)] G(k) dk$$

$$= \int_0^\infty G(k) dk + \int_0^\infty G(k) \frac{e^{ikx} + e^{-ikx}}{2} dk$$

$$= \frac{1}{2} I(0) + \frac{1}{2} \int_{-\infty}^{\infty} G(k) e^{ikx} dk$$

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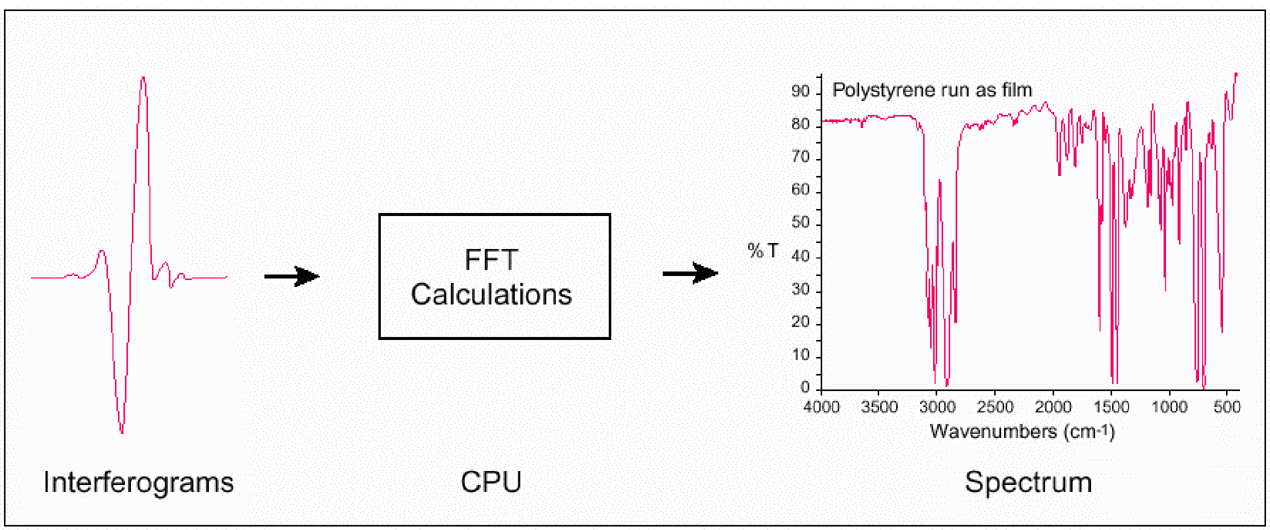
FTIR Math Continued

We can rewrite this to something more familiar:

$$W(x) \equiv \frac{2I(x) - I(0)}{\sqrt{2p}} = \frac{1}{\sqrt{2p}} \int_{-\infty}^{\infty} G(k) e^{ikx} dk$$

A Fourier Transform!

The detected intensity as a function of moving mirror position, I(x), can therefore be converted into G(k), the intensity spectrum as a function of frequency by a simple Fourier transform.



FTIR Spectrometers

In practice one cannot measure from -∞ to ∞. The resolution of a measurement is simply given by how far in x you measure.

$$resolution \propto \frac{1}{2px_{\max}}$$

Rapid-Scan measurements:

- Sweep mirror quickly, average many interferrograms
  - Very fast & easy
  - Not high resolution
  - Not for quickly changing signals or very low signal

Step-Scan measurements:

- Step to each x position, then measure (long average, or triggered time series). Can have very long path length.
  - Excellent for fast time resolution, low signals (lock-in)
  - Harder to run stably.