March 4, 2005

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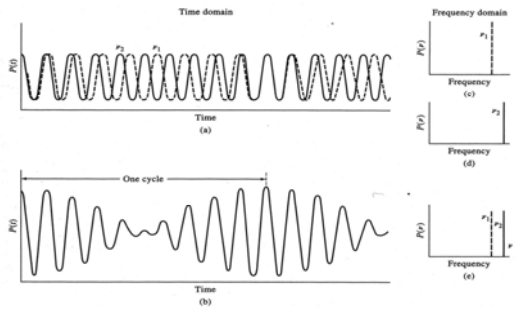
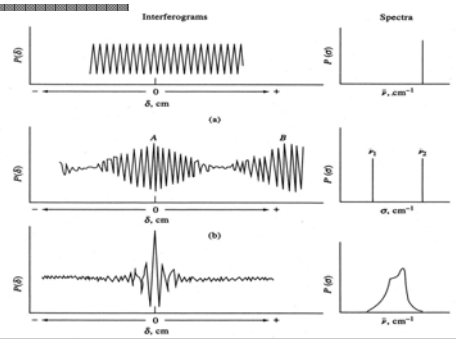
To the *Frequency Domain!*



From Interferogram to Spectrum



Resolution

- It can be shown that for two *"barely resolvable"* spectral features:

$$\Delta\bar{\nu} = 1/\delta$$

-where δ is the *maximum retardation* attainable with the interferometer.

So, to resolve two spectral features separated by 0.1 cm^{-1}, we need an interferometer with a maximum mirror displacement (x):

$x = \delta/2 = 10\ cm/2 =$ ***5 cm***

Why Bother with FT-Interferometry?

1. **Signal-to-Noise Enhancement**
   - **Multiplex Advantage ("Fellgett's Advantage")**
     -All wavelengths viewed *simultaneously*, so measurement time/resolution element is greater

     If measurement is limited by detector noise:

     S/N enhancement $\propto$ **(n)**$^{1/2}$

     where n = number of resolution elements

Multiplex Advantage: S/N

- So, suppose we acquire a spectrum from 500 - 3500 cm^{-1} with an effective bandwidth of 1 cm^{-1}

  If we spend the same amount of time acquiring the spectrum via FT-Interferometry as we do via scanning spectrometry, we should see a S/N enhancement of:

  n = 3000 resolution elements

  $(3000)^{1/2} \approx$ *55-fold* S/N enhancement

  This is the same as *signal averaging:* like averaging the signal 3000 times at each resolution element

Multiplex Advantage: *Time*

- Suppose we spent 6000 seconds acquiring the spectrum and we really don't need the enhanced S/N:

We can get the same S/N as with a dispersive system in $1/(n)^{1/2}$ of the time

In this case, this means it would take:
6000 sec/54.8 ≈ ***110 sec***

*So, 100 minutes (dispersive) versus **2 minutes** (FT-interferometry)!*

Other Advantages

- **Throughput Advantage ("Jacquinot's Advantage")**
  Increased light throughput (no limiting apertures) *independent of resolution,* results in an an increase in S/N.

  About a 100x S/N enhancement is claimed
  (not just for systems limited by detector noise)

2. **Precise Wavenumber Calibration**
   -due to internal standardization to laser
   -wavenumbers known to about 10^{-1} - 10^{-2} cm^{-1}
3. **Sheer Elegance and Simplicity!**

Spectroscopy:
Infrared Absorption Spectrometry

Chem 221
Instrumental Analysis
Spring 2005

Origins of IR Absorption

- Due to transitions between *vibrational* and/or *rotational* energy states of molecules
- **A molecule can absorb IR photons if:**
  - ✓ there is a ***change*** in the dipole moment of the molecule during a vibrational or rotational motion

  AND

  - ✓ The frequency associated with the photon matches the *frequency* of the vibrational motion
- So, *almost all molecules absorb in the IR* (except for homonuclear diatomics)