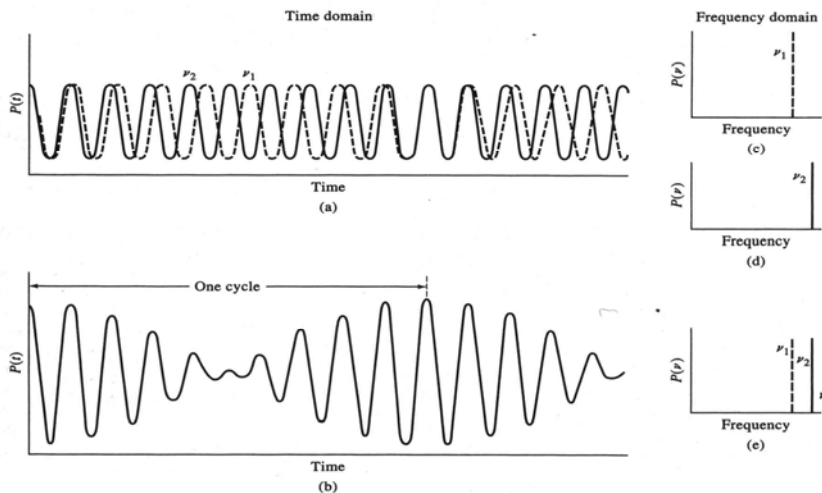


March 4, 2005

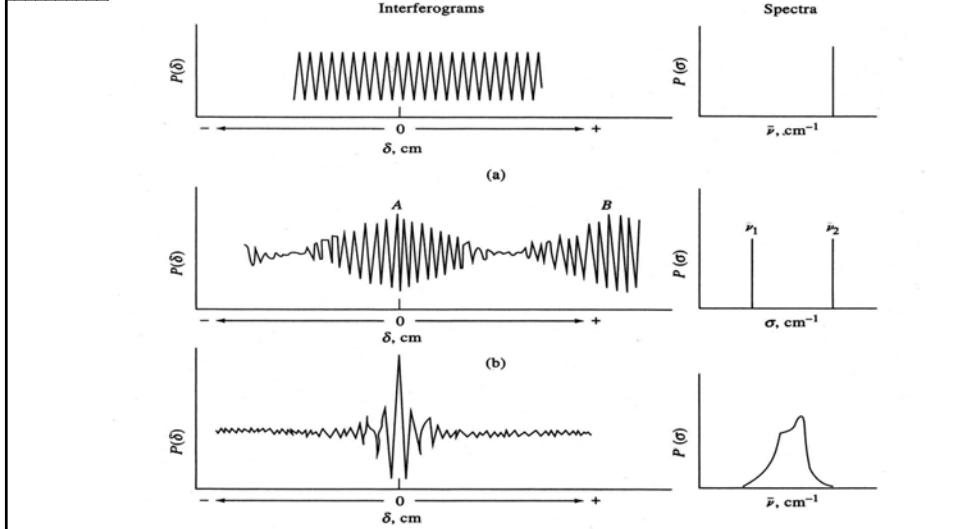
This space intentionally left blank

1

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):

$$x = \delta/2 = 10 \text{ cm}/2 = \underline{5 \text{ cm}}$$

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:

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

where n = number of resolution elements

5

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

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

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

6

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:

$$6000 \text{ sec} / 54.8 \approx \underline{110 \text{ sec}}$$

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

7

Other Advantages

- **Throughput Advantage ("Jacquinot's Advantage")**
Increased light throughput (no limiting apertures) independent of resolution, results in 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 $10^{-1} - 10^{-2} \text{ cm}^{-1}$
3. **Sheer Elegance and Simplicity!**

8

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)