February 28, 2005

- <u>Today's Office Hour:</u>
  - **Only until 1:50 p.m.** ☹

Resolving Power for a Grating

- So, in order to *just resolve* these two spectral lines: λ_1 = 4501 Å

  λ_2 = 4499 Å

  We need an instrument with a *resolving power* of:

  R = 4500/2 = ***<u>2250</u>***

- The *resolving power* of a diffraction grating:

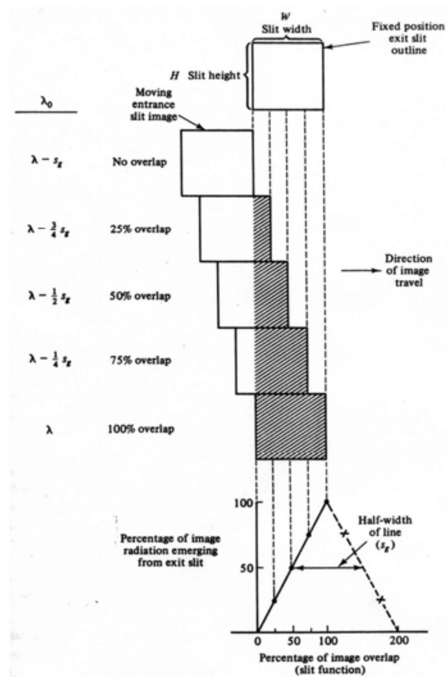
$$R = nN$$

spectral order (n)

facets illuminated on grating surface (N)

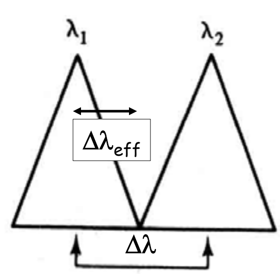
Slitwidth-Limited Resolution

- If $\Delta\lambda_{eff}$ is *greater* than the spectral linewidth, then resolution is controlled by the *slitwidth*
- Consider the *overlap function* of the entrance and exit slits of a scanning spectrometer:



Baseline-Resolution?

- Under slitwidth-limited resolution conditions, *baseline resolution* is attained when:



$$\Delta\lambda \geq 2\Delta\lambda_{eff}$$

So, $\Delta\lambda_{eff}$ must be *smaller* than the wavelength separation between the two spectral features (no more than $\frac{1}{2}\Delta\lambda$).

Effect of Slitwidth on Resolution

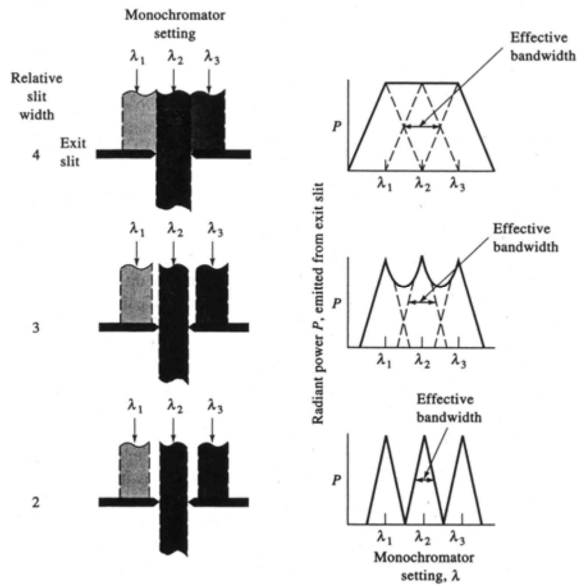
$\Delta\lambda = \Delta\lambda_{eff}$

"just resolved"

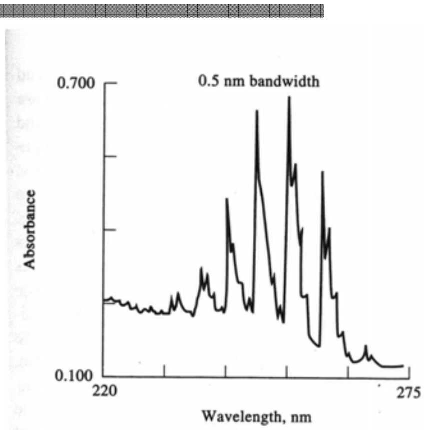
$\Delta\lambda > \Delta\lambda_{eff}$

$\Delta\lambda = 2\Delta\lambda_{eff}$

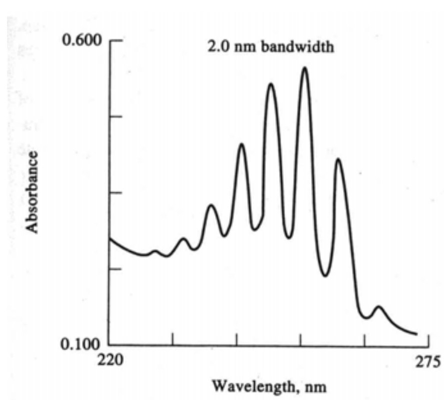
Baseline resolved



Effect of Slitwidth on *Spectrum* (Benzene)



(a)



(c)

How it all fits together

- Suppose we want to "just resolve" the following Iron doublet:

  λ_1 = 3099.90 Å **R**= 3099.935/0.07

  λ_2 = 3099.97 Å = ***44,000***

  Suppose that we have a *100-mm* wide grating ruled with *1200 gr/mm* ; it has a *first-order* **resolving power** of:

  R = nN = (1)(100 mm)(1200 gr/mm)

  R = ***120,000***

But, can we *really* resolve the two lines?

- Consider, now, the dispersion of the *monochromator* in which that grating is located:

  D^{-1} = 16 Å/mm

  In order to *just resolve* the two lines:

  $\Delta\lambda_{eff}$ = 0.07 Å

  This requires a *slitwidth* of:

  $\Delta\lambda_{eff} = D^{-1} \times w$

  w = 0.07 Å/16 Å/mm = *0.00438 mm*

  w ≈ ***4 μm***

How Can We *Improve* Resolution?

- **Decrease Slitwidth (w)**
  -limits light throughput
- **Operate in Higher Spectral Orders**
  -limits light throughput (decreased efficiency)
  $$D^{-1} \propto 1/n$$
- **Increase Focal Length**
  -limits light throughput (inverse square law)
  $$D^{-1} \propto 1/F$$