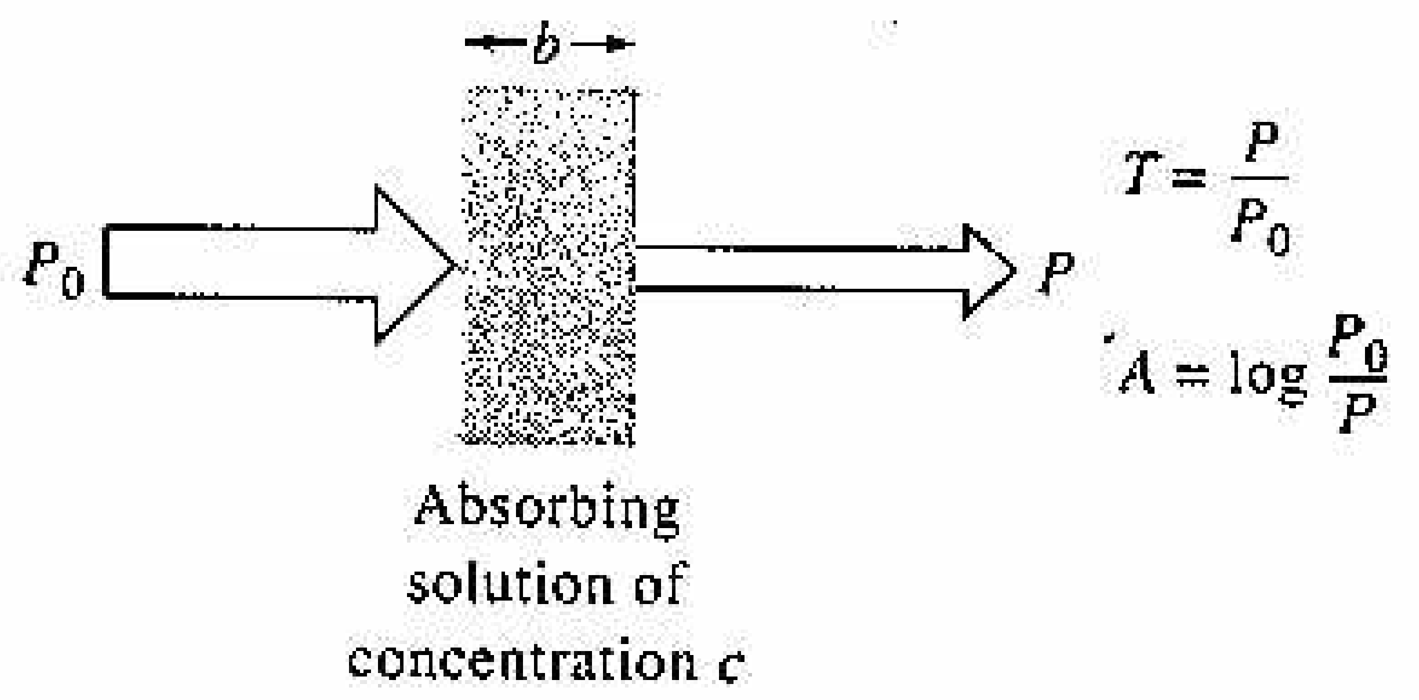
Chapter 18 – Fundamentals of Spectrophotometry (cont'd)
AND
Chapter 20 - Spectrophotometers

Homework for Chapter 20 –
Due Monday, April 13

Problems 20-1, 20-3, 20-4, 20-6, 20-9, 20-27

Note: We will talk about some applications of spectrophotometry in class, but will not have any homework assigned from Chapt. 19.

Absorption of Light



Absorption Methods, Transmittance

$T = P/P_o$

where T => transmittance

P => power of transmitted radiation

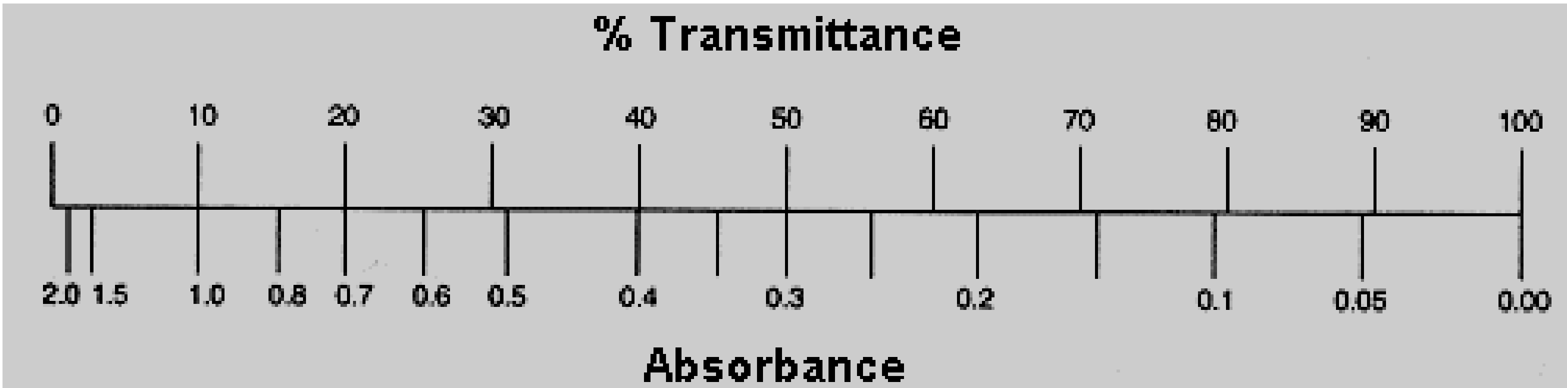
P_o => power of incident radiation

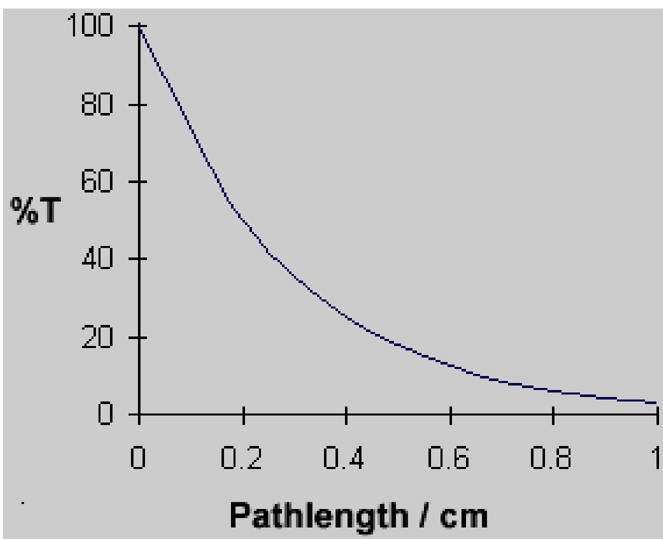
$\%T = (P/P_o)*100$

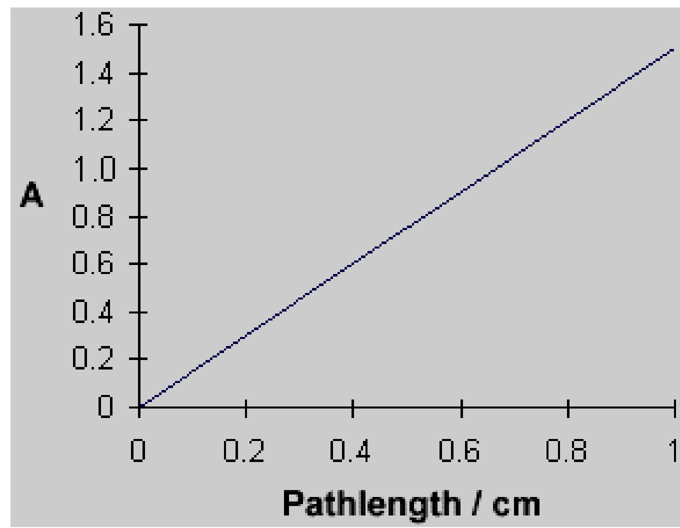
where $\%T$ => percent transmittance

Absorbance and transmittance

Absorbance => $A = -\log_{10}T = -\log_{10}(P/P_o)$







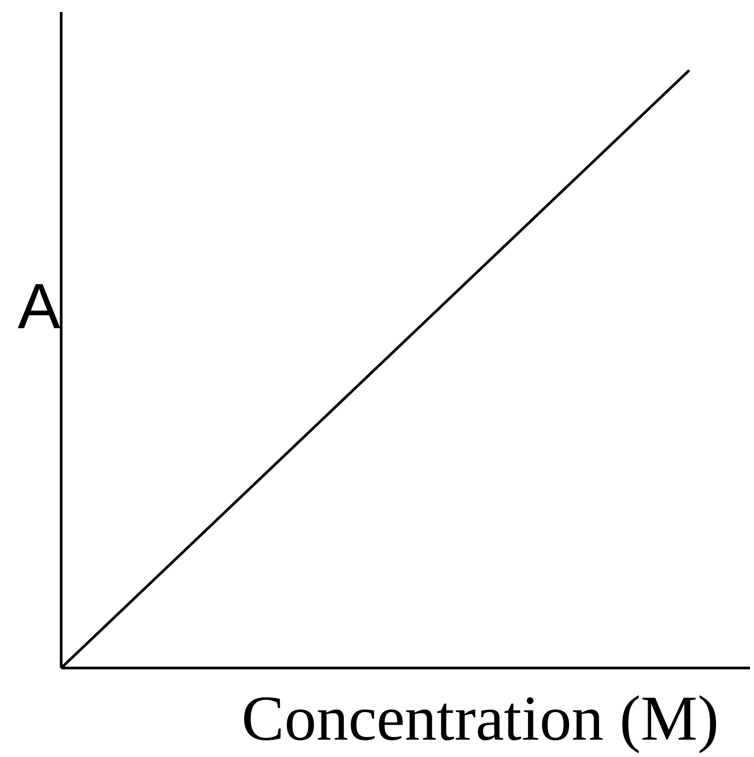
Absorption Methods, Beer's Law

$$A = \varepsilon b c$$

b => path length (cm)

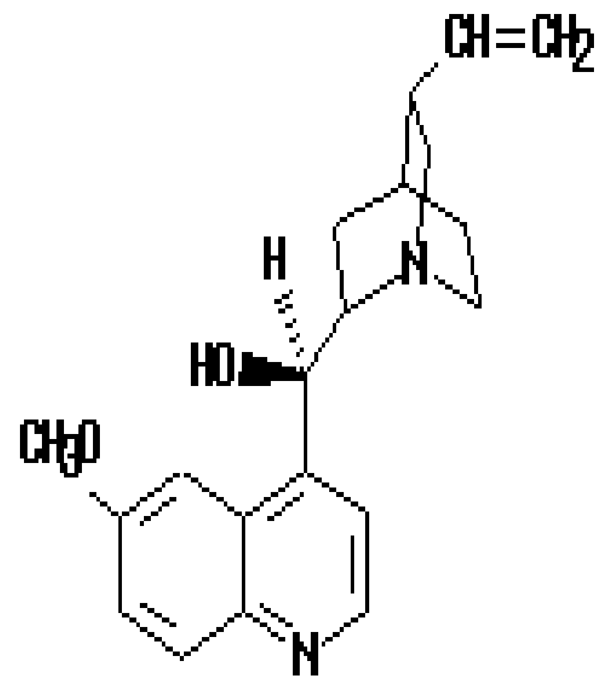
c => concentration (M)

ε => molar absorptivity ($M^{-1}cm^{-1}$)



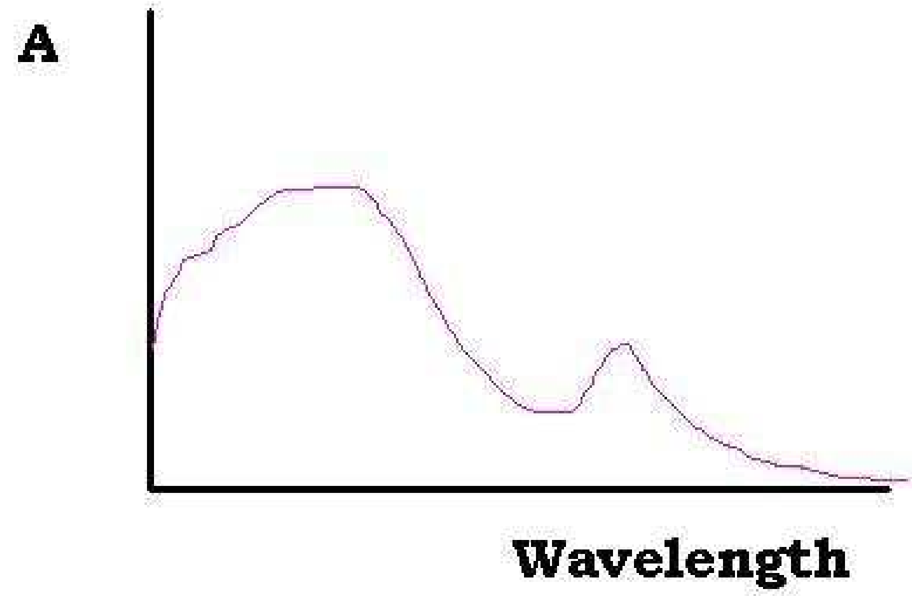
A “chromophore”

- A chromophore is a part of a molecule (functional group, ring structure, etc.) that is responsible for the absorption of light
- Examples: C=O in acetone; aromatic ring in xylene



Beer's Law

$A = \varepsilon bc$

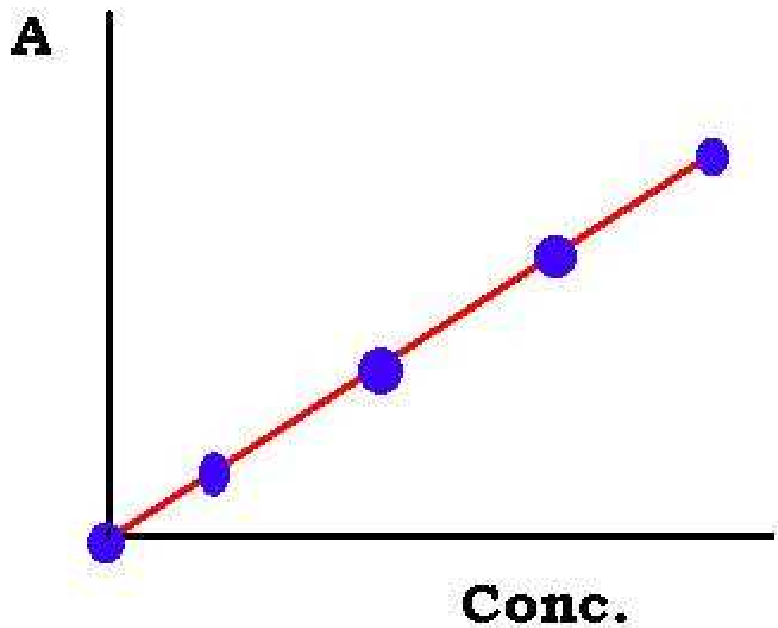


The absorption spectrum

A vs. λ

ε specific to each energy (λ)

Beer's Law calibration plot

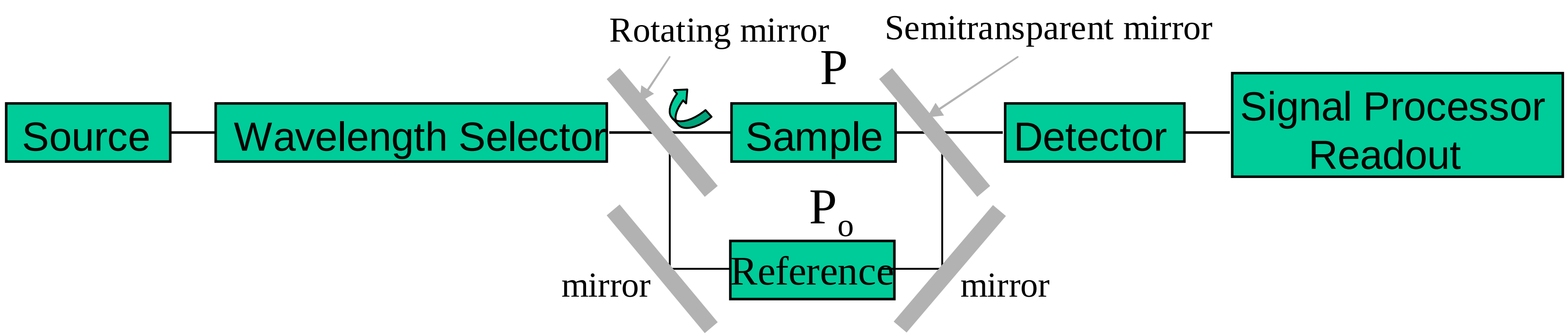


$A = \varepsilon bc$

A vs. c

ε and b constants

Components of Optical Instruments



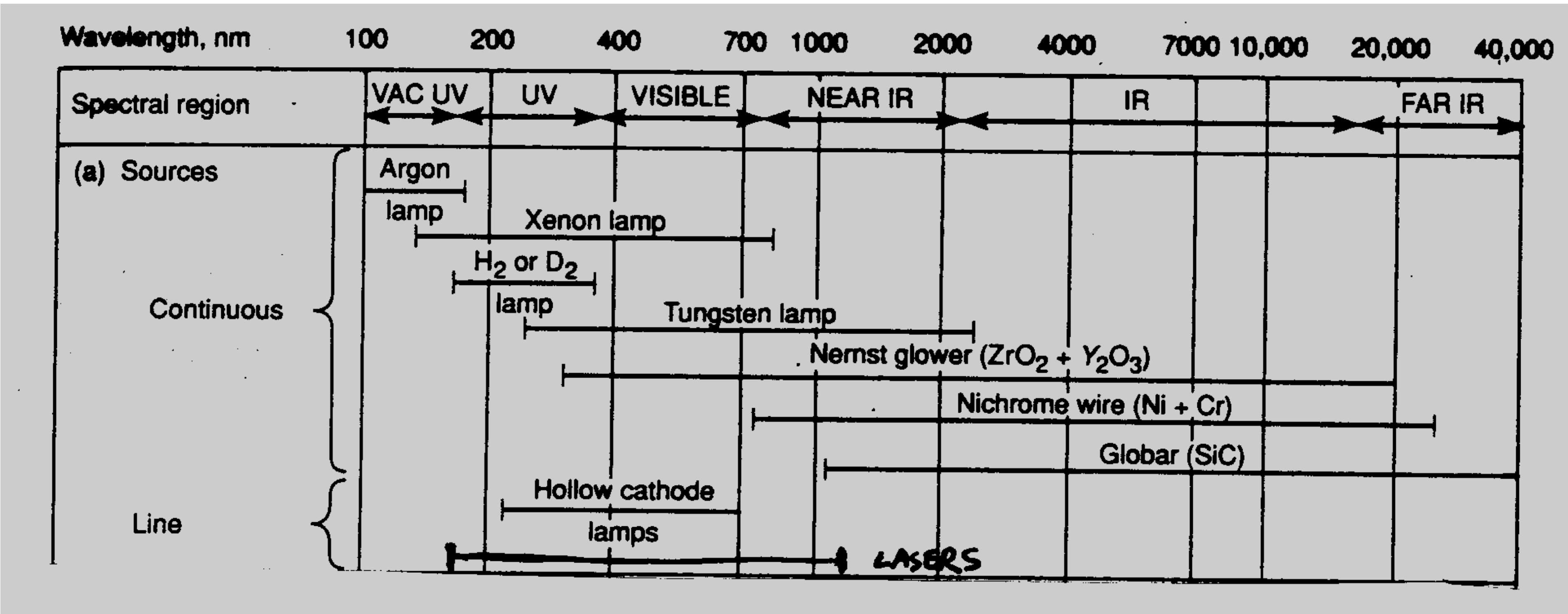
Absorption Spectrometer

Emission Flame Photometer

Flame Atomic Absorption Spectrometer

Fluorescence and/or Scattering Spectrometer

Light sources

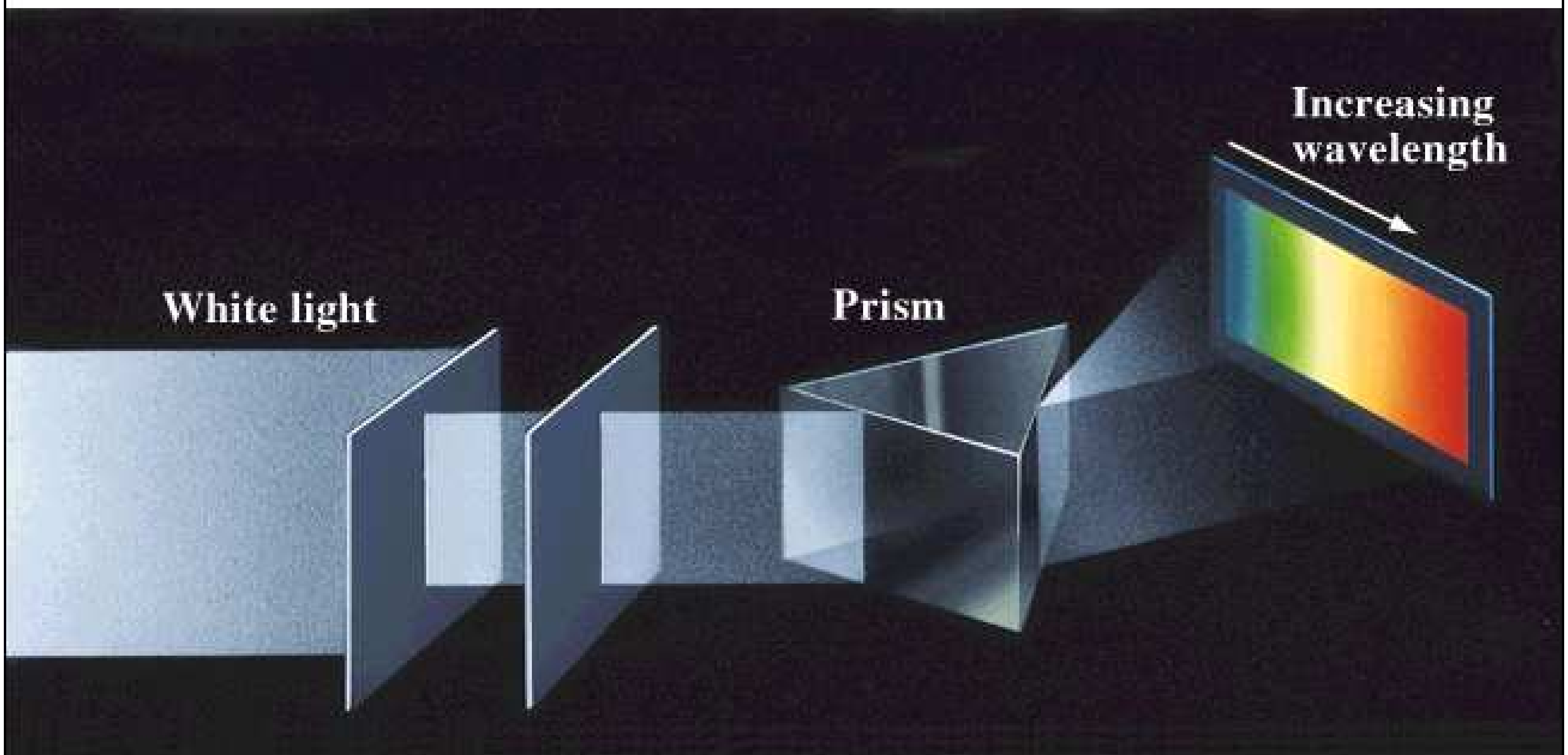


Examples of Sources

- Deuterium lamp - good source for UV continuum radiation - widely used in UV spectrophotometers
- Tungsten filament lamp - Good source of continuum radiation in the 330- 2000 nm range; common in visible, near-IR colorimeters, spectrophotometers. Stable light output with regulated power supply. Similar to regular light-bulb but run at 3000 K.
- Heated metal and ceramic filaments used for the "mid-IR", which is ~ 500-4000 cm^{-1} (A warm object is an efficient IR source). Common source for IR spectroscopy is called a Nernst Glower, globar, or a nichrome wire.

Purpose of monochromator:

Separation of multi-λ light into individual λ's



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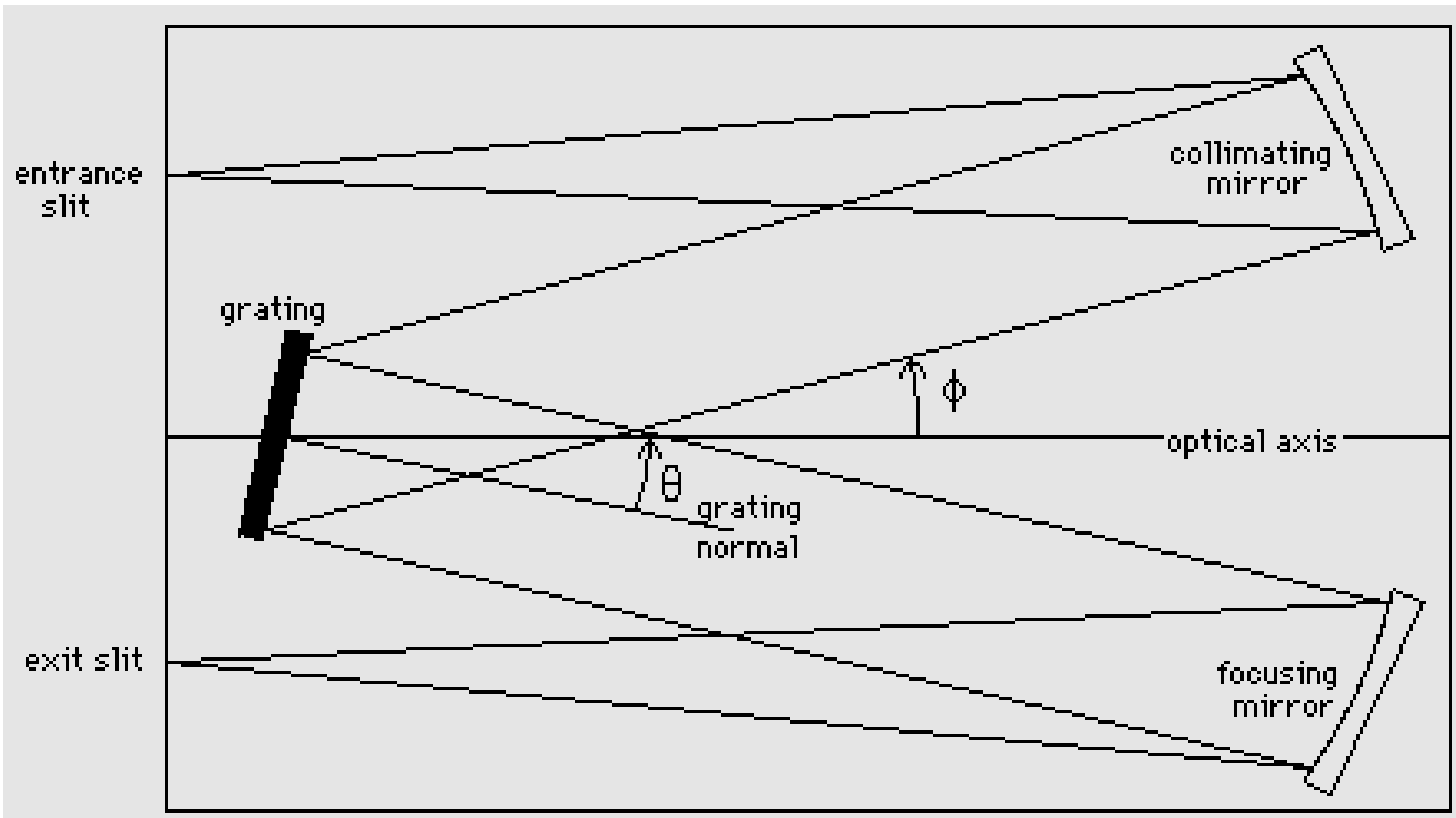
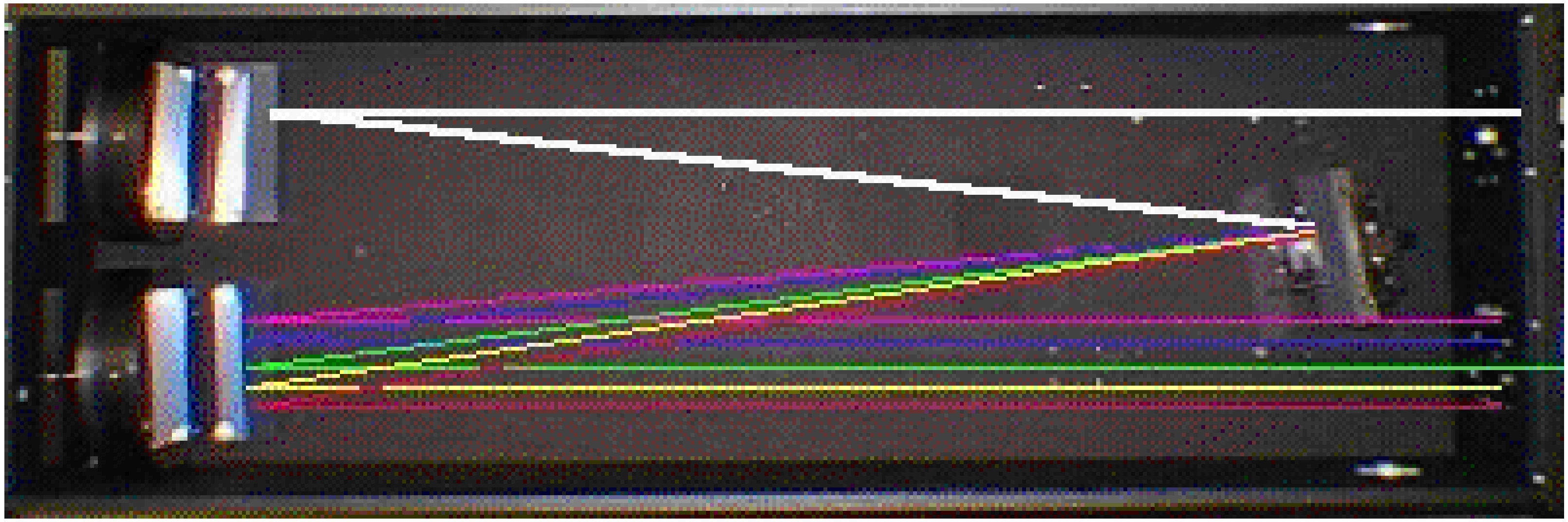
Monochromators

Components:

entrance slit, collimating element (lens or mirror), prism or grating as dispersing element, focusing element (lens or mirror), exit slit

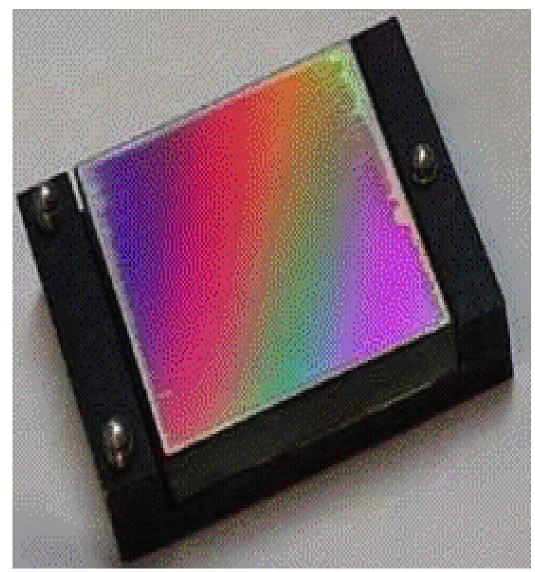


monochromator



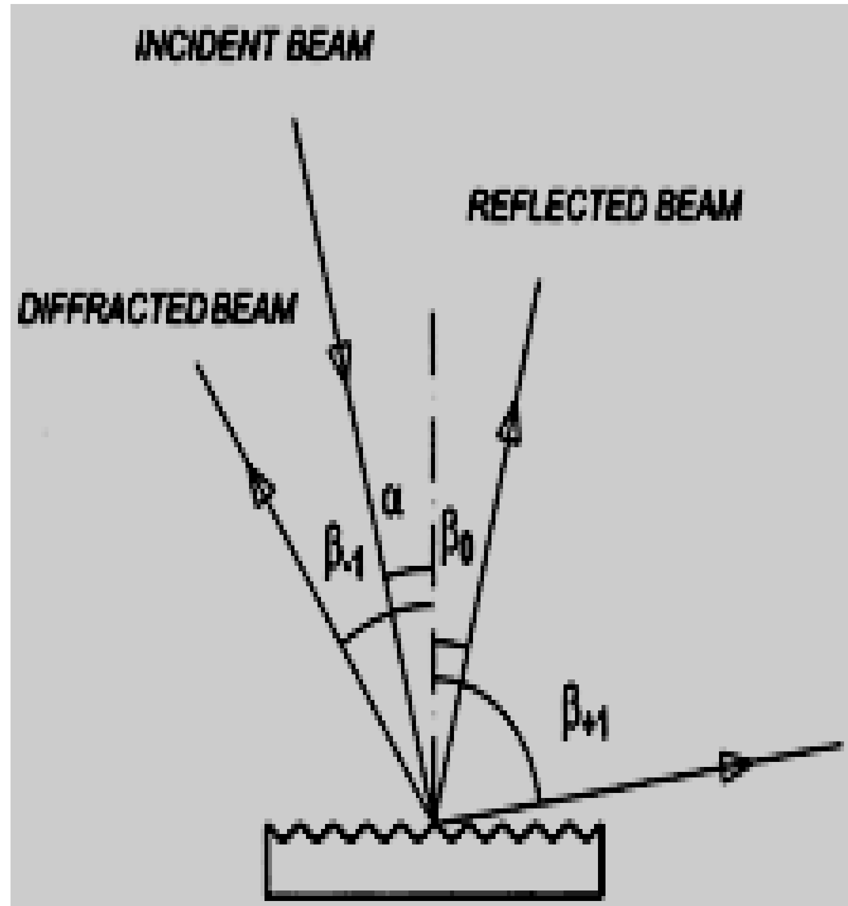
http://www.chem.hope.edu/~polik/labtour/monochromator-inside.html

An important use of diffraction is in producing monochromatic light from “white” light sources

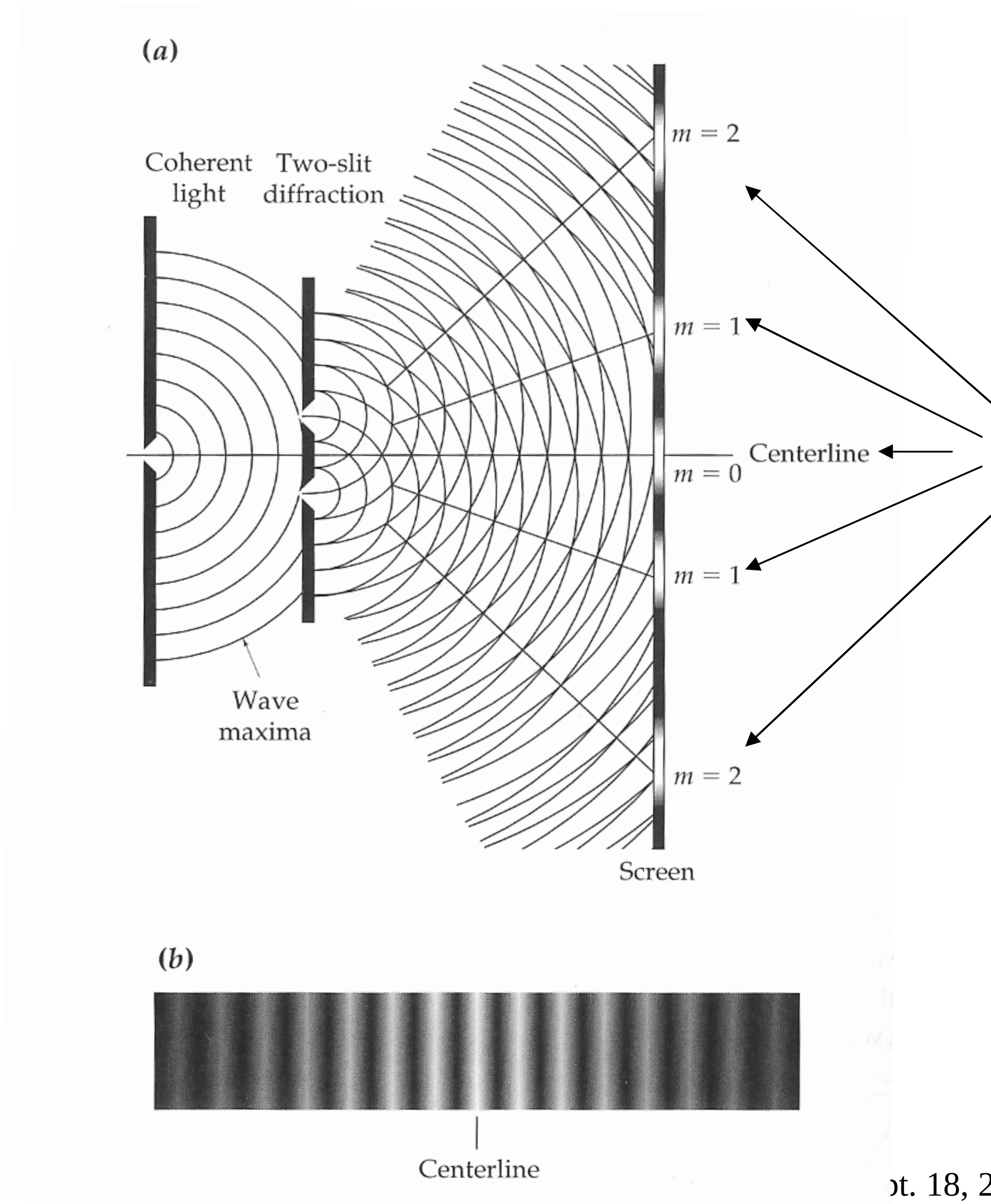


How do gratings work?

- The incident beam is diffracted in a manner given by Equation (1)
- The grooves act like multiple apertures providing the diffraction patterns (constructive & destructive interference)
- The term “m” is referred to as the **order** of the diffraction
- Dispersion increases with order but intensity diminishes



$$\sin\alpha + \sin\beta_m = -m\lambda/d$$



m: order

- where constructive interference occurs
- observe as bright spots (below)

ɔt. 18, 20

Sample Containers

Ultra-Violet
- quartz

Visible
- quartz
- glass

Infrared
- $NaCl$
- $AgCl$
- KBr

Criteria for Sample Containers
- **Transparent to excitation light**
- **Compatible with samples**
- **Rugged**

Types of Detectors

UV-Visible

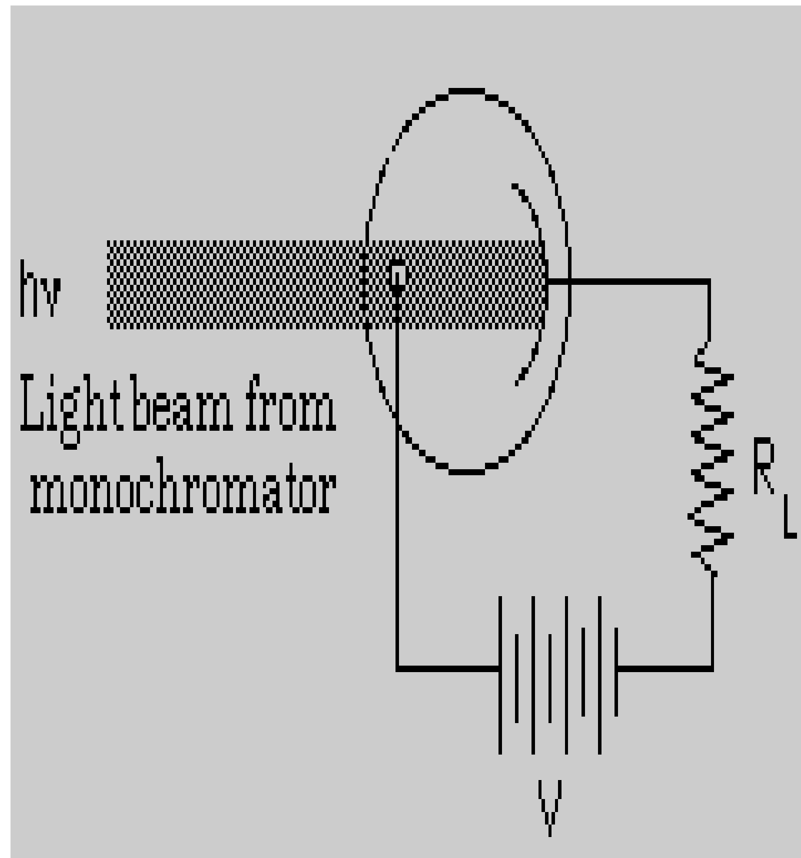
- **Photon Detectors**
- **Vacuum Phototubes**
- **Photomultiplier Tubes**
- **Photodiodes**
- **Linear Photodiode arrays**
- **Charge-Transfer (Charge Coupled Device, CCD)**

Infrared

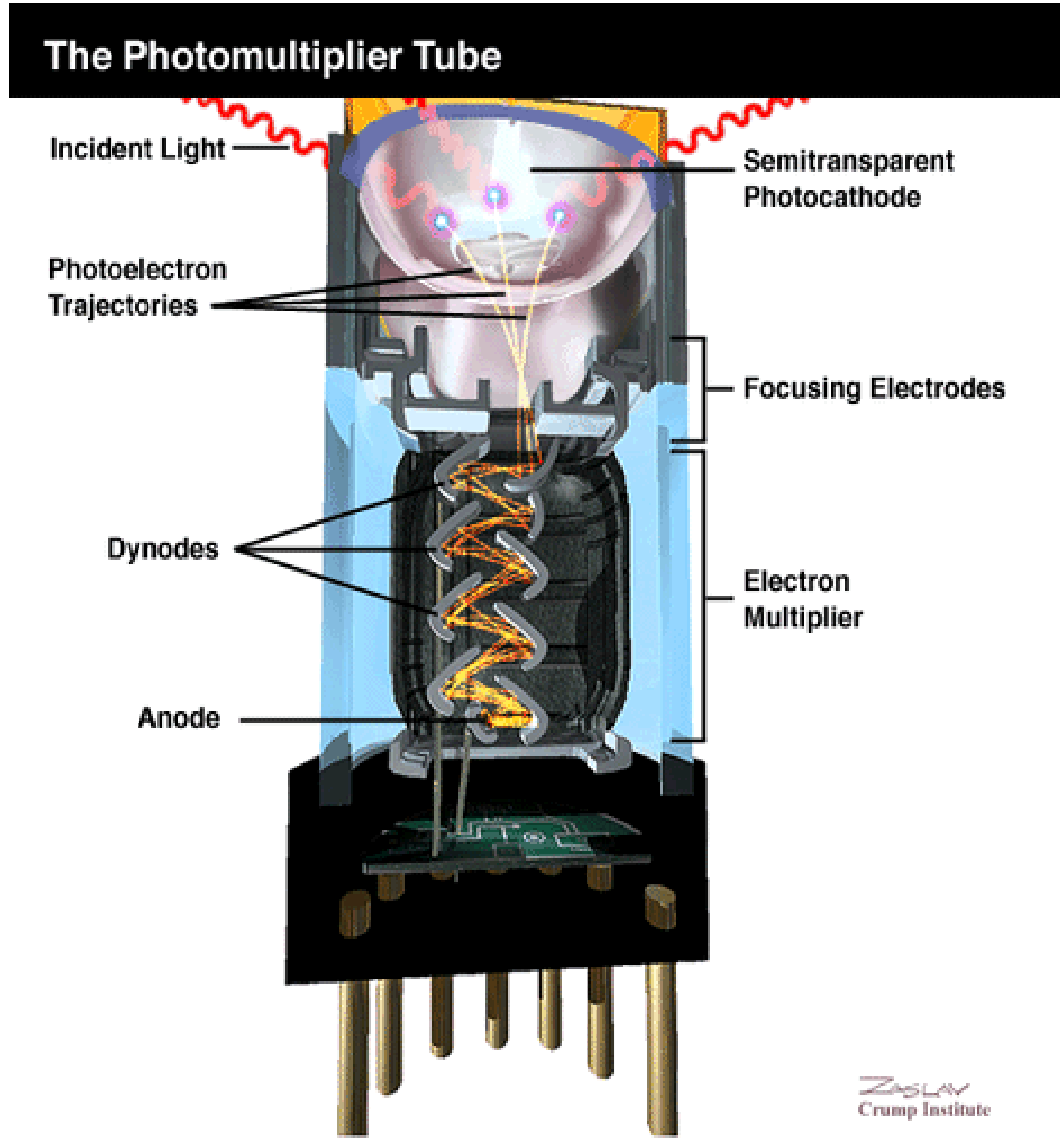
- **Heat Detectors**

Photoelectric effect based detectors: phototubes

- Phototubes are used for high light intensity applications
- Photons produce photoelectrons; the “photocurrent” is proportional to intensity

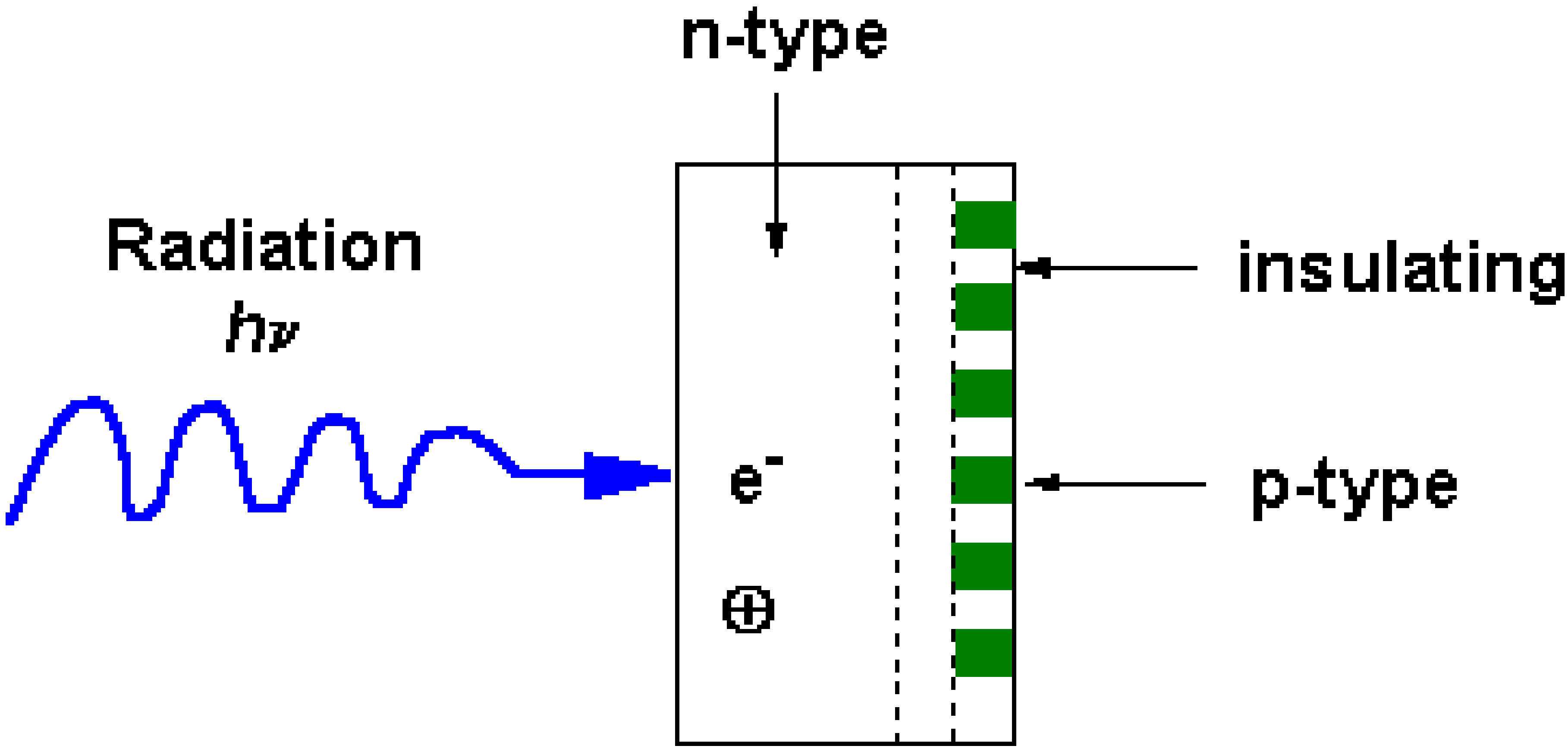


- **Photomultiplier tubes** are used for low light intensity and "photon counting" applications
- Photons strike primary electrode, emits e-; these electrons strike successive secondary surfaces, finally producing a large "pulse" of electrons



http://laxmi.nuc.ucla.edu:8248/M248_99/autorad/Scint/pmt.html

Semiconductor-base Detectors (Photodiodes and CCD's)



Detectors for IR

- Heat detectors
  - thermocouple
  - Ferroelectric
- Semiconductor-based detectors (like HgCdTe)
  - Low bandgap semiconductors
  - Must be cooled for good quantum efficiency, low noise