

February 14, 2005

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• Exam #1

• Wednesday, 7 pm, B104 Angell

• Office Hours:

• Today, 1:10 - 2:15 pm, A223 Cook



Happy Valentine's Day!

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# Spectroscopy:

## Intro/Background

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Chem 221  
Instrumental Analysis  
Spring 2005

## Definition and Overview

- The study of the interaction of *electromagnetic radiation (EMR)* with matter
- Scope and Purview:
  - *Properties of EMR*
  - *Atomic and Molecular Interactions with EMR*
  - *Instrumentation*
  - *Molecular Spectroscopy*
    - Infrared Absorption Spectrophotometry
    - Luminescence Spectrometry
    - Raman Spectroscopy
  - *Atomic Spectroscopy*
    - ✓ Absorption
    - ✓ Emission

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## Electromagnetic Radiation (EMR)

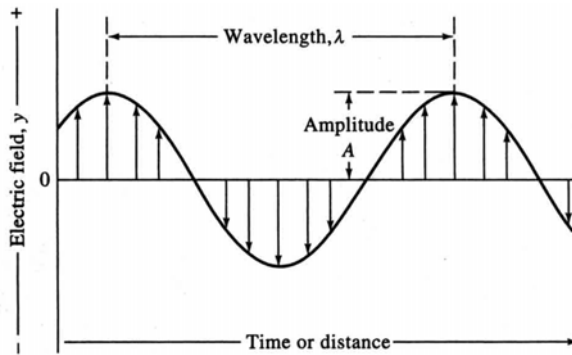
- So, just what is **EMR**?
  - an *oscillating* electric and magnetic field which travels through space
  - a discrete series of "particles" that possess a specific energy but have no mass

***BOTH!***

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# It's a Wave!

- Consider an oscillating electric field:



Characterized by:

- $\lambda$  - wavelength
- A** - amplitude
- $\nu$  - frequency

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# Wave Properties of EMR

- The product of  $\lambda$  and  $\nu$  is constant:

$$\lambda \times \nu = c$$

Since  $\nu$  has units of  $\text{sec}^{-1}$  and  $\lambda$  has units of length, their product,  $c$ , is the *velocity* of the wave:

-in a vacuum, all EMR travels at a velocity of:

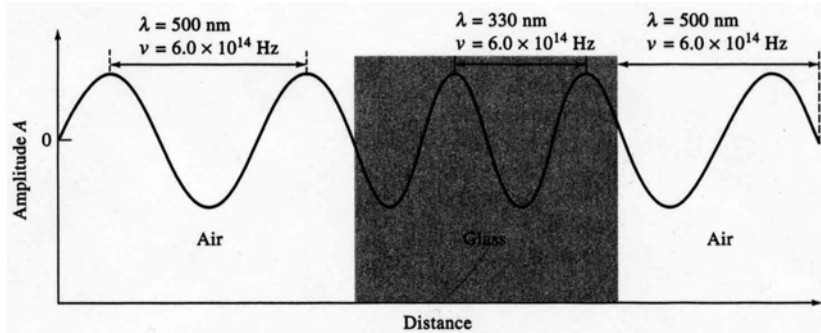
$$2.99792458 \times 10^8 \text{ m/s } (= c)$$

("The Speed of Light")

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# Propagation Velocity

- What happens as an EMR wave propagates from a *vacuum* into another medium?



Wavelength decreases, Frequency is unchanged, Velocity decreases

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# Refractive Index ( $n_i$ )

- Quantifies the magnitude of the EMR velocity decrease in a particular medium:

$$n_i = c/v_i$$

## Refractive Index

- varies with:

- medium

- frequency of EMR

( $n \uparrow$  as  $v \uparrow$ , generally)

EMR propagation  
velocity

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# Propagation Direction

- Propagation *direction* can also change:

## Reflection

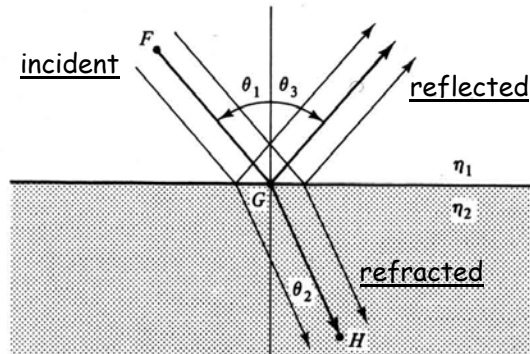
For  $\theta_1 = 0^\circ$ : Fresnel Eqn

$$\frac{I_R}{I_o} = \frac{(n_2 - n_1)^2}{(n_2 + n_1)^2}$$

## Refraction

Snell's Law:

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{n_2}{n_1}$$



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# Scattering

- Most EMR is *transmitted* through a medium (no direction change)
- BUT: a *small* amount is **scattered** isotropically:
  - **Rayleigh Scattering**
    - Elastic (no energy loss)
    - Due to interactions with "particles"  $\ll \lambda$ 
      - ✓ e.g., molecules, aggregates, etc.
    - Scatter intensity ( $I_S$ )  $\propto \lambda^{-4}$  (blue sky!)
    - $I_S$  increases with increasing particle size

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# Diffraction

- EMR can also be "bent" as it passes through a *narrow* (width  $\approx \lambda$ ) opening or barrier:

