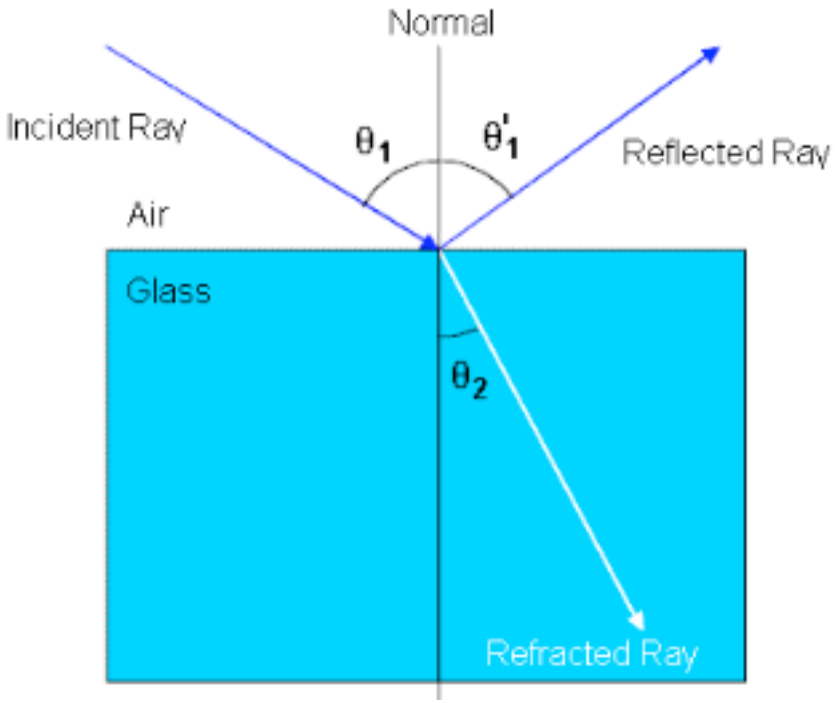
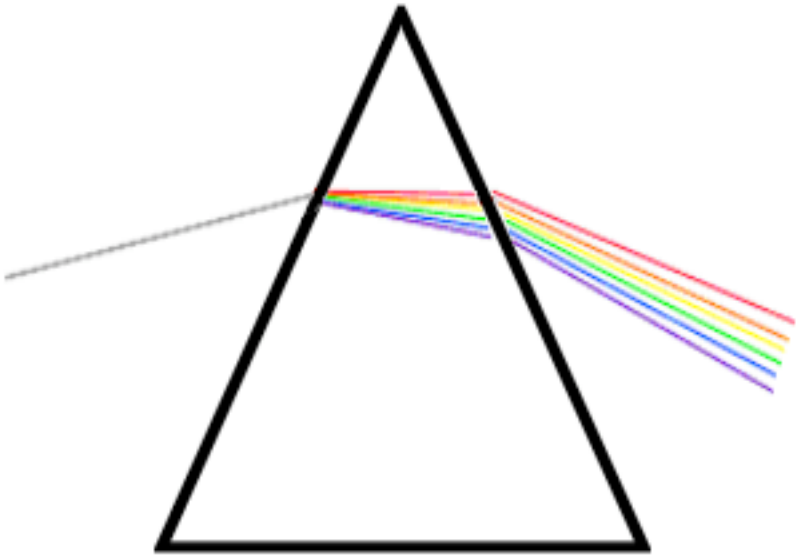
Light & Matter
Some Basic Optical Phenomena

Reflection, Refraction, and Dispersion





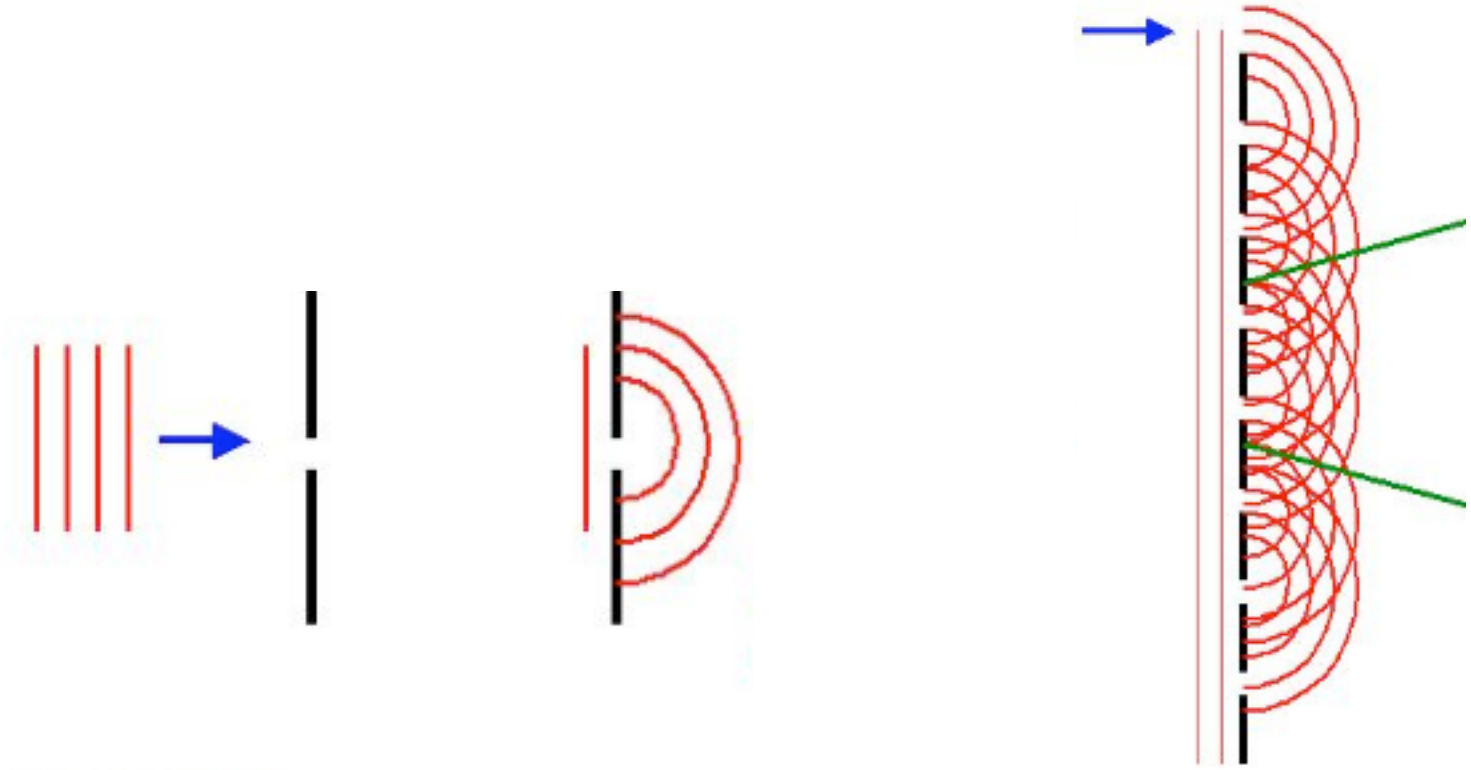
Reflection & Refraction **Refraction & Dispersion**

(Snell's Law and the Index of Refraction)

More Optical Phenomena

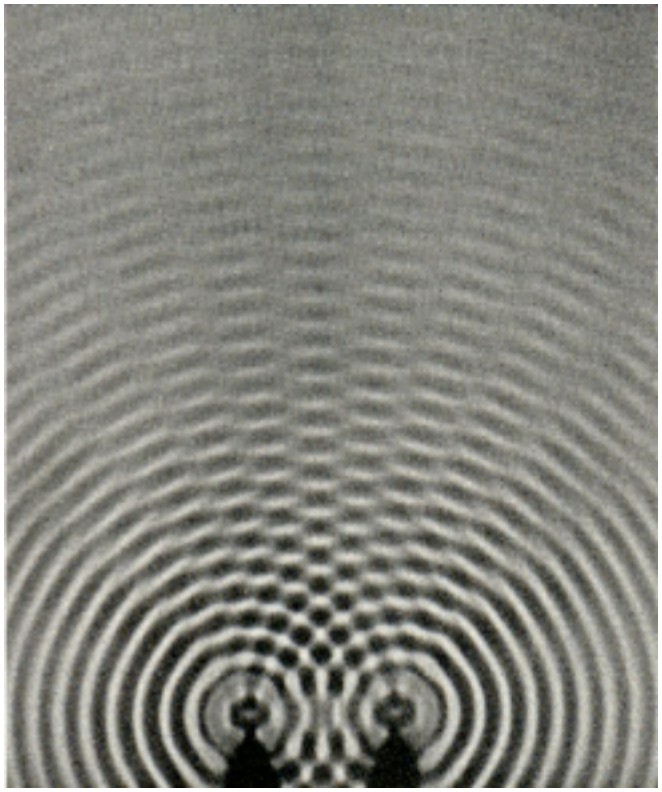
Wave Optics

Diffraction & **Interference***



*Note: The directions of the diffracted "rays" depends upon their wavelength.

Diffraction, Interference, and Wavelength



Since the direction of the diffracted "rays" depends upon their wavelength the phenomenon of diffraction can be used to disperse light. Diffraction gratings (diffraction) are often used instead of prisms (dispersion) to accomplish this.

Light & Matter: Four Basic Processes

Emission: The production of light by matter

$M \rightarrow h\nu + M$

(Cooling by radiation)

Absorption: The destruction of light by matter

$h\nu + M \rightarrow M$

(Heating by radiation)

Scattering: The redirection of light by matter

$h\nu + M \rightarrow h\nu + M$

(Neither heating nor cooling)

Stimulated Emission*: The "cloning" of light by matter

$h\nu + M \rightarrow h\nu + M + h\nu$

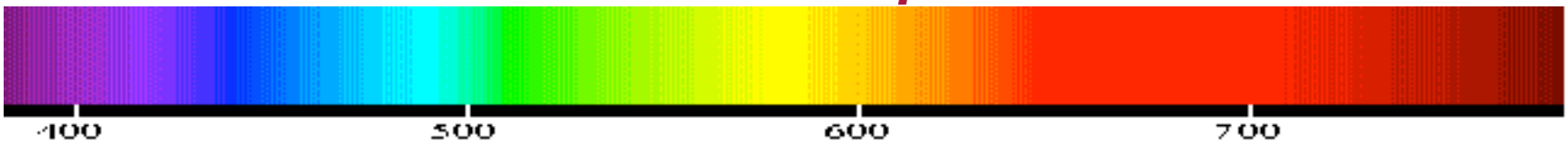
(Radiation induced cooling. Lasers & Masers)

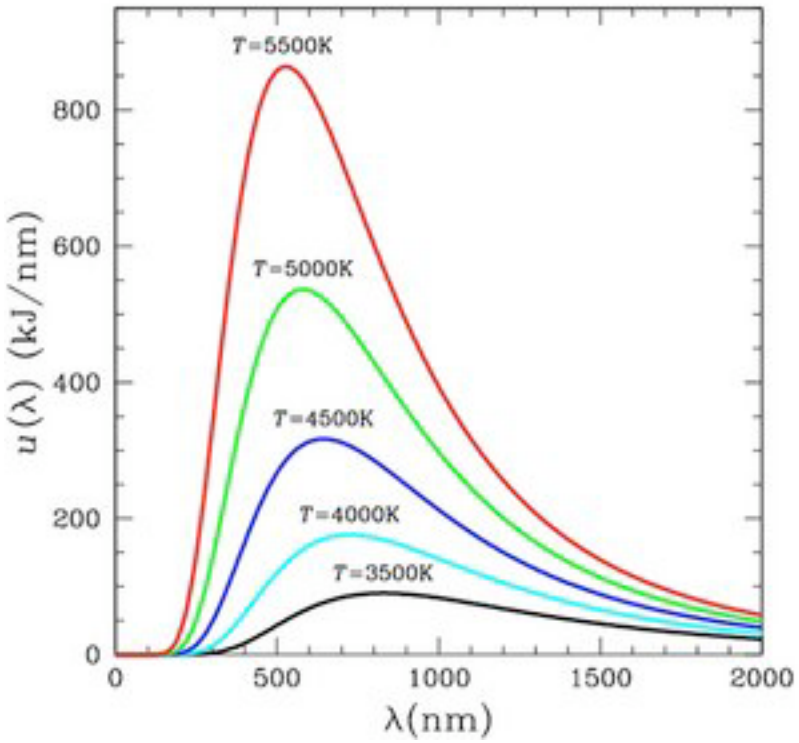
*** also known as Negative Absorption**

Spectra

The Emission Spectra of Solids & Liquids

Continuous Spectra





Digression: Black Body Radiation

"A Perfect Absorber is a Perfect Emitter"

Color & Temperature: Wien's Law

$\lambda_{peak}(nm)\ \mathbf{T}(°K) = \mathbf{2.90 \times 10^{6}}$ (a constant)

Example: T = 310°K* gives λ_{peak} = 9,355 nm

Luminosity, Temperature, and Surface Area: Stefan's Law

$\mathbf{F}(watts/m^2) = \mathbf{5.67 \times 10^{-8}}\ \mathbf{T^4}\ (°K)$

Example: T = 310°K gives F = 524 watts/m²

Real Objects are less than perfect absorbers and emitters: Stefan's Law and Wien's Law are only approximately true.

*Digression on Temperature Scales: 310 °K = 37 °C = 98.6 °F

Gas Spectra

The Emission Spectra of Gases

Emission Line Spectra

Line Spectra and the Composition of Gases

The Absorption Spectra of Gases

Absorption Line Spectra

Line Spectra and the Composition of Gases

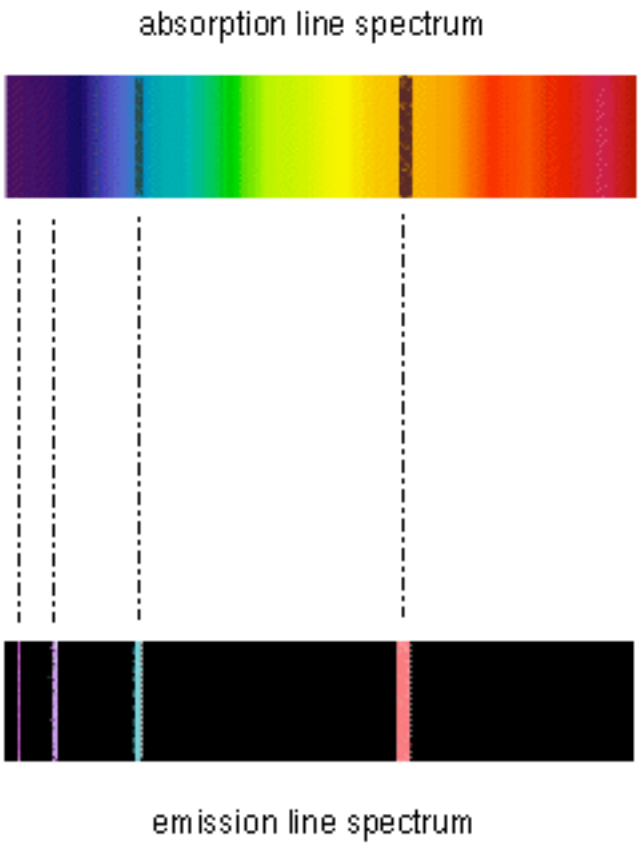
Spectral Fingerprinting

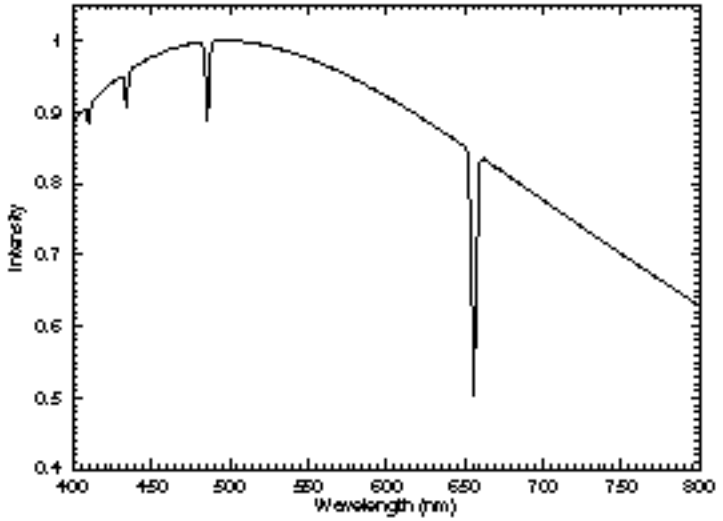
Rule: A gas can emit or absorb light only at a discrete set of wavelengths.

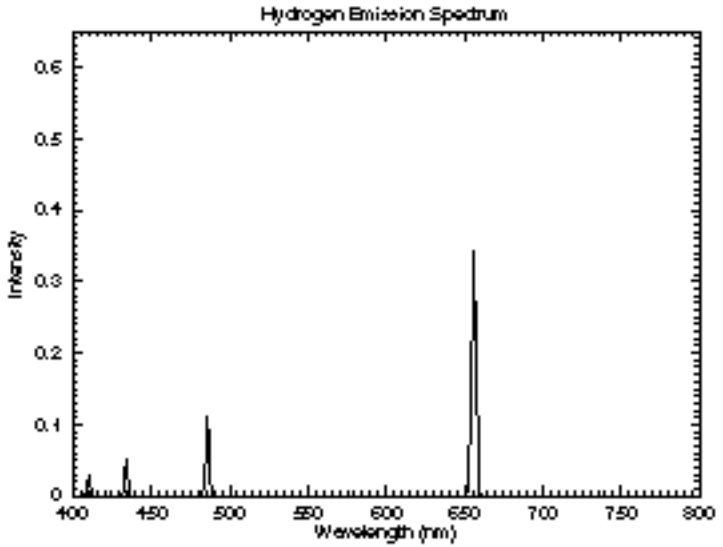
Rule: That set of wavelengths is unique to the composition of the gas.

Digression: Temperature, Pressure, and Abundance Effects

Absorption and Emission Line Spectra of Gases



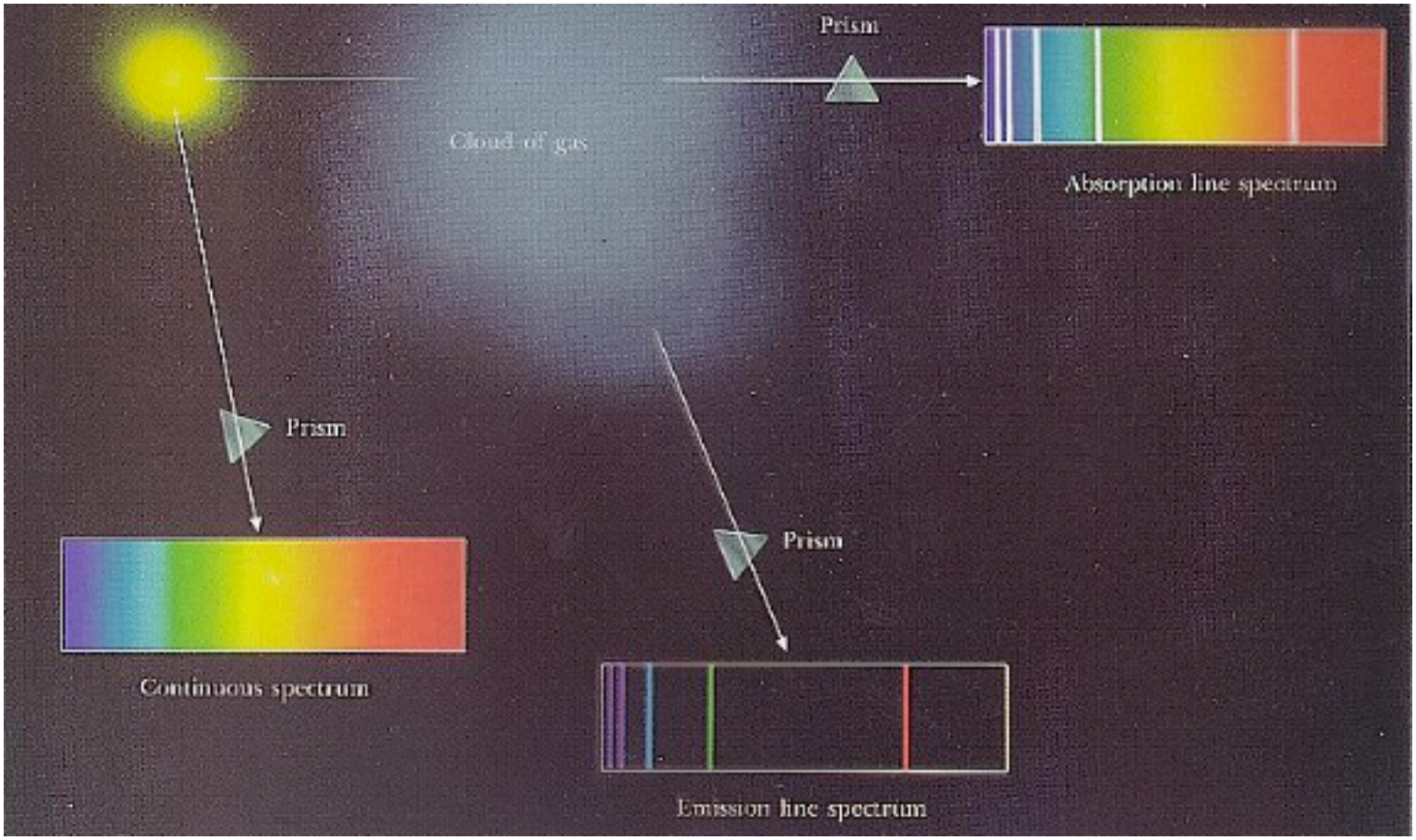




(The gas is hydrogen in this example.)

The Three Basic Types of Spectra

Continuous Source **Gas Cloud** **Disperser** **Composite Spectrum**



Note: The Composite Spectrum can contain both absorption and emission lines