

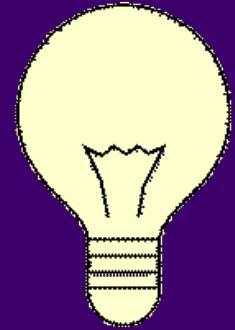
Spectroscopy

Today:

- Splitting light into separate colors (wavelengths)
- Spectra of thermal light sources
- Spectra of nonthermal light sources
- Absorption spectra
- How does motion of a light source affect its spectrum?

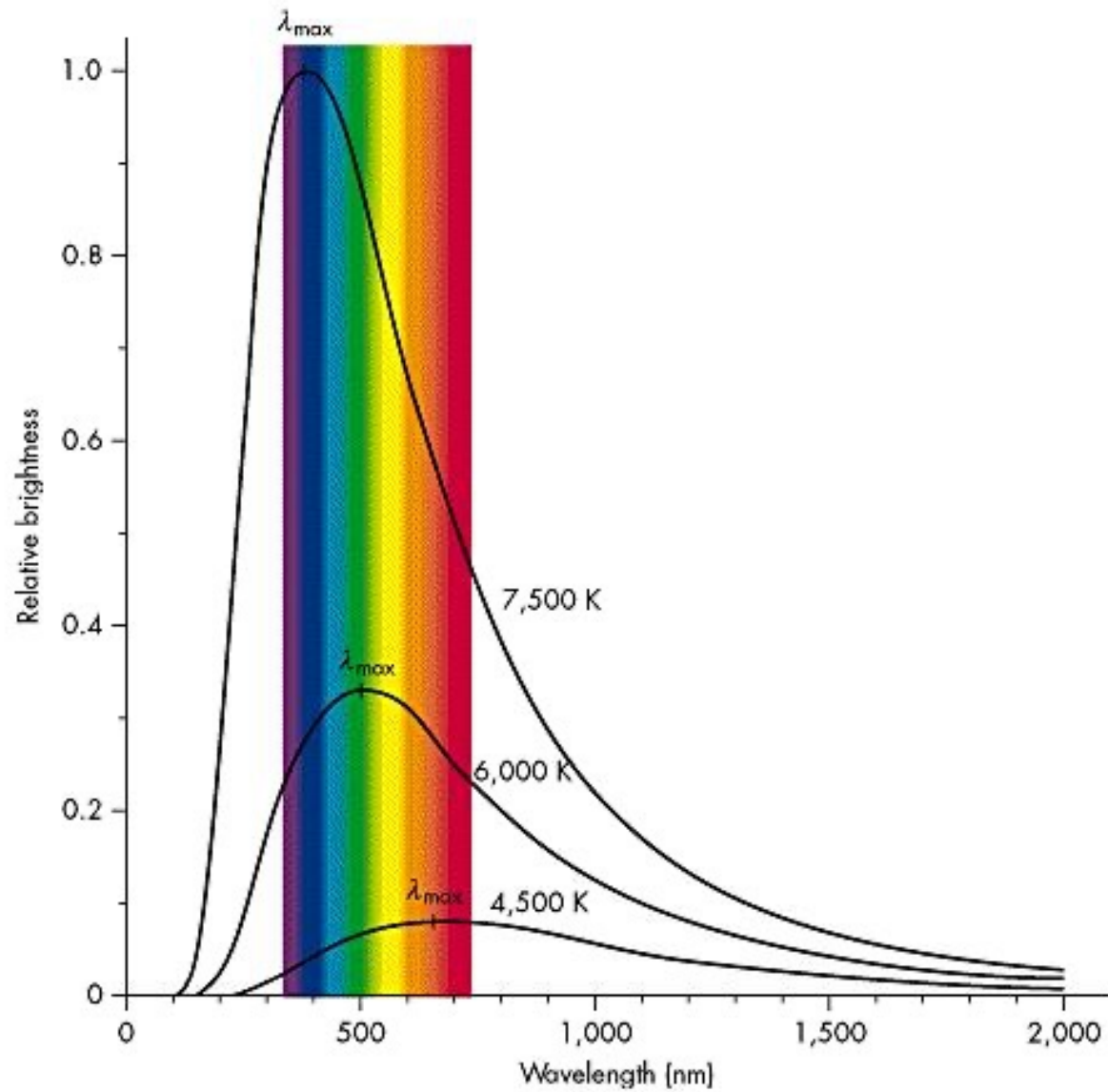
Thermal Light Sources

(Hot, opaque objects)



- Emit a continuous spectrum (all colors present)
- Hotter implies brighter
- Hotter implies bluer in color
- Brightness & color don't depend much on what the object is made of
- Examples: incandescent light filaments (3000 K); electric heating coils (1500 K); coals in a campfire (1500 K); your body (310 K); the sun minus its outer layers (6000 K)

Graphs of thermal spectrum





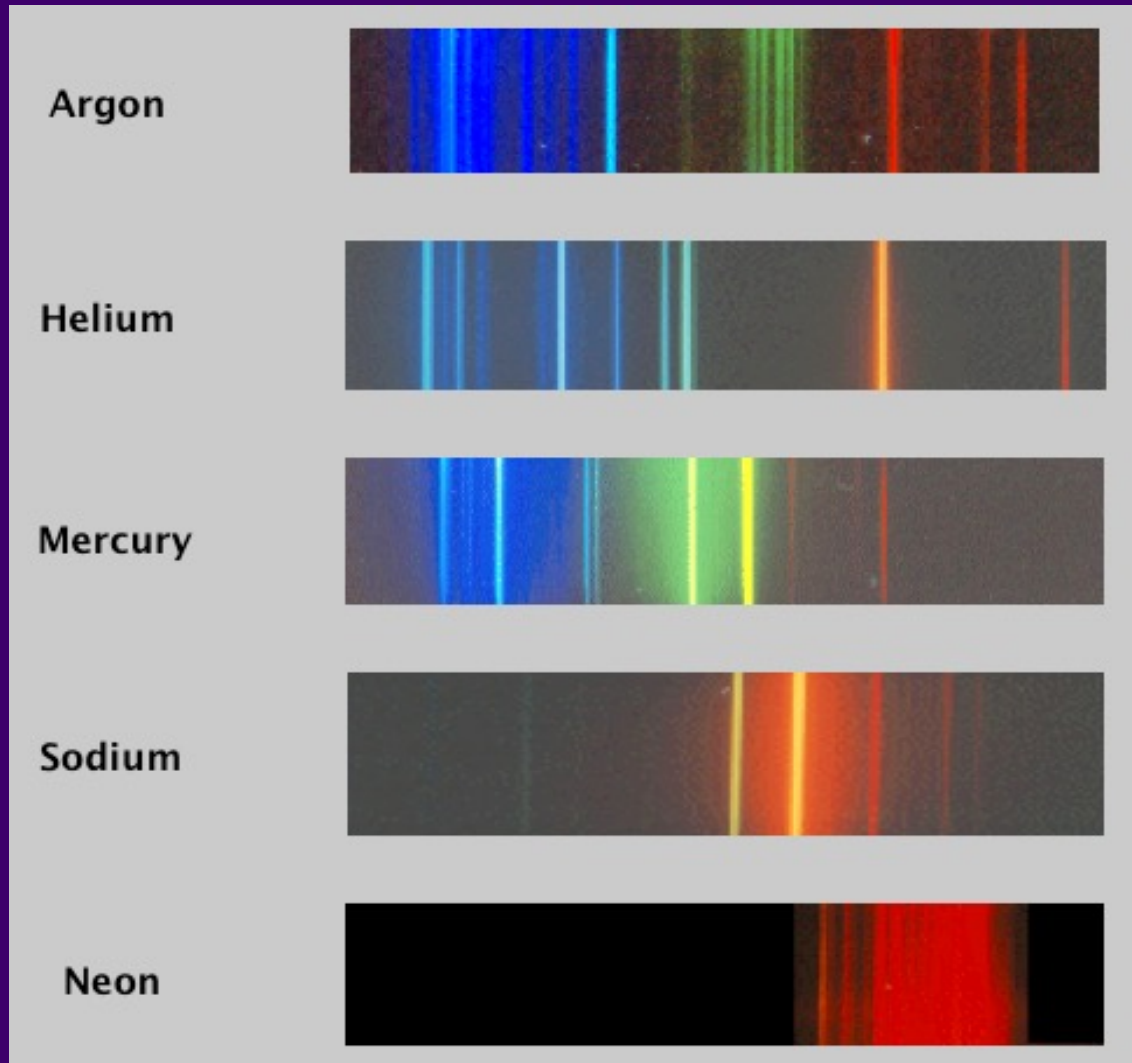
© David Malin

Infrared light is real!

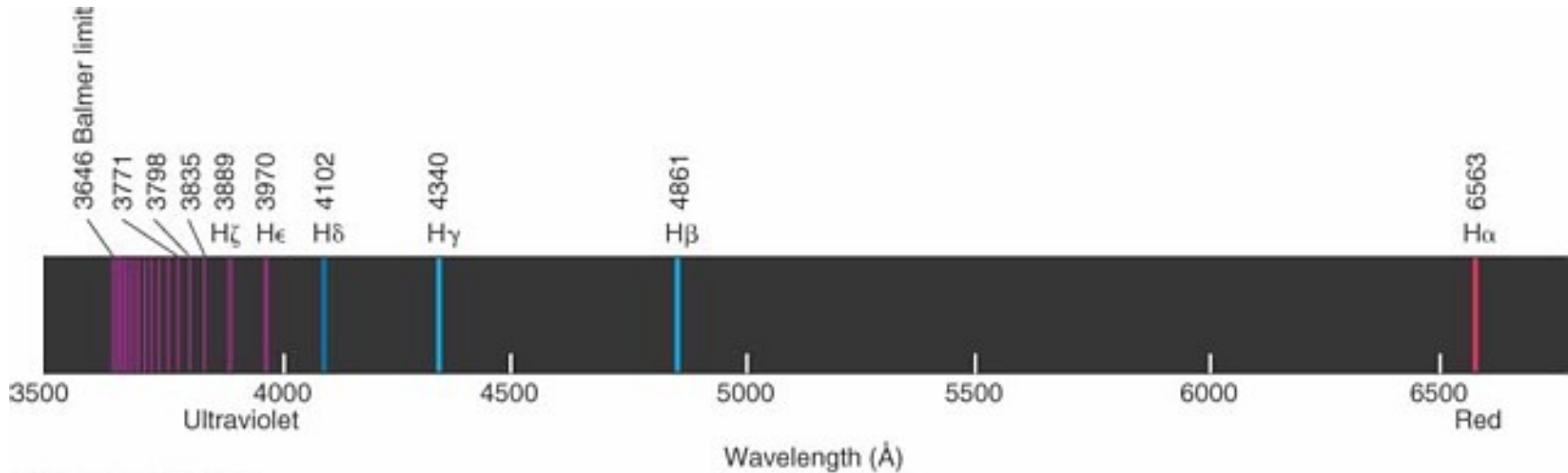


Emission Spectra (“nonthermal”)

from hot, transparent gases



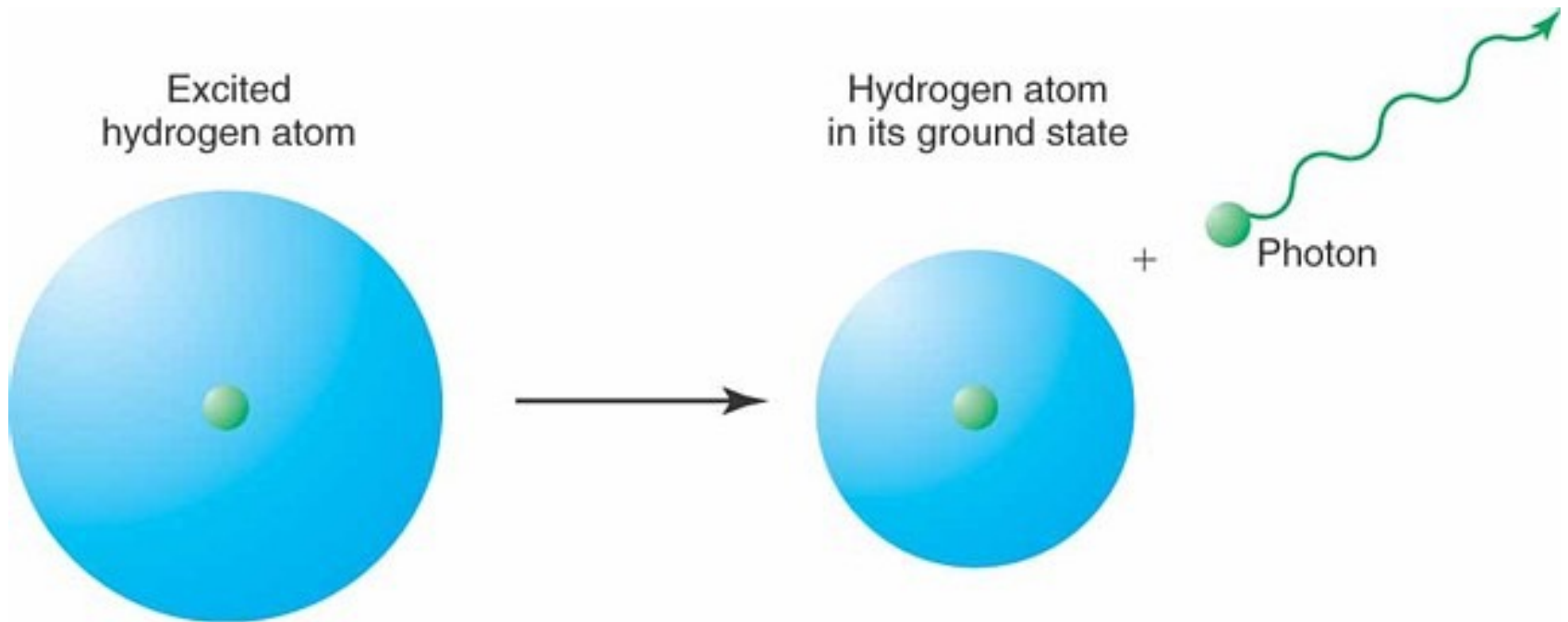
Hydrogen emission spectrum ("Balmer lines")



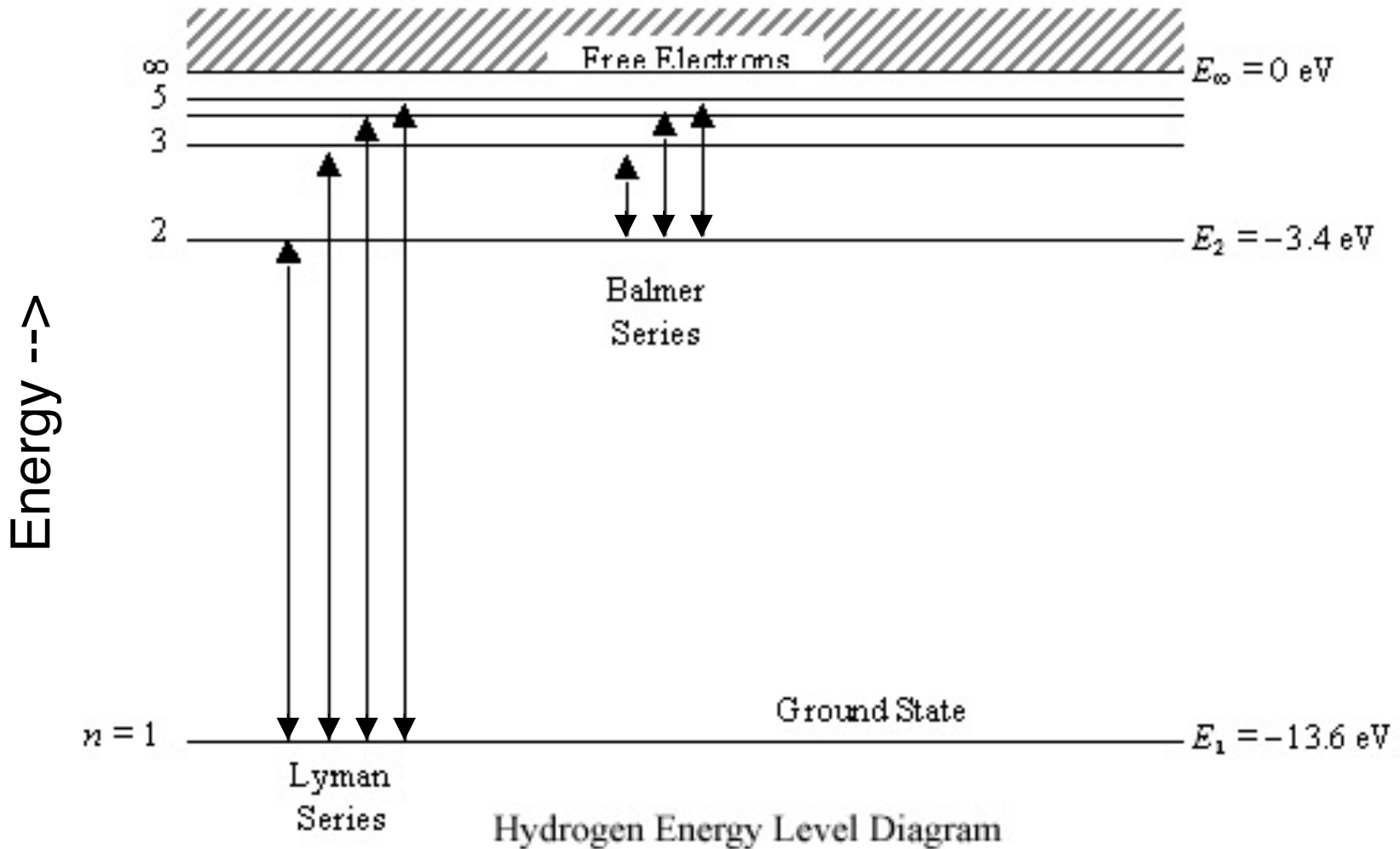




Emission of spectral lines



Hydrogen energy levels



Nonthermal Light Sources

(Especially hot, transparent gases)

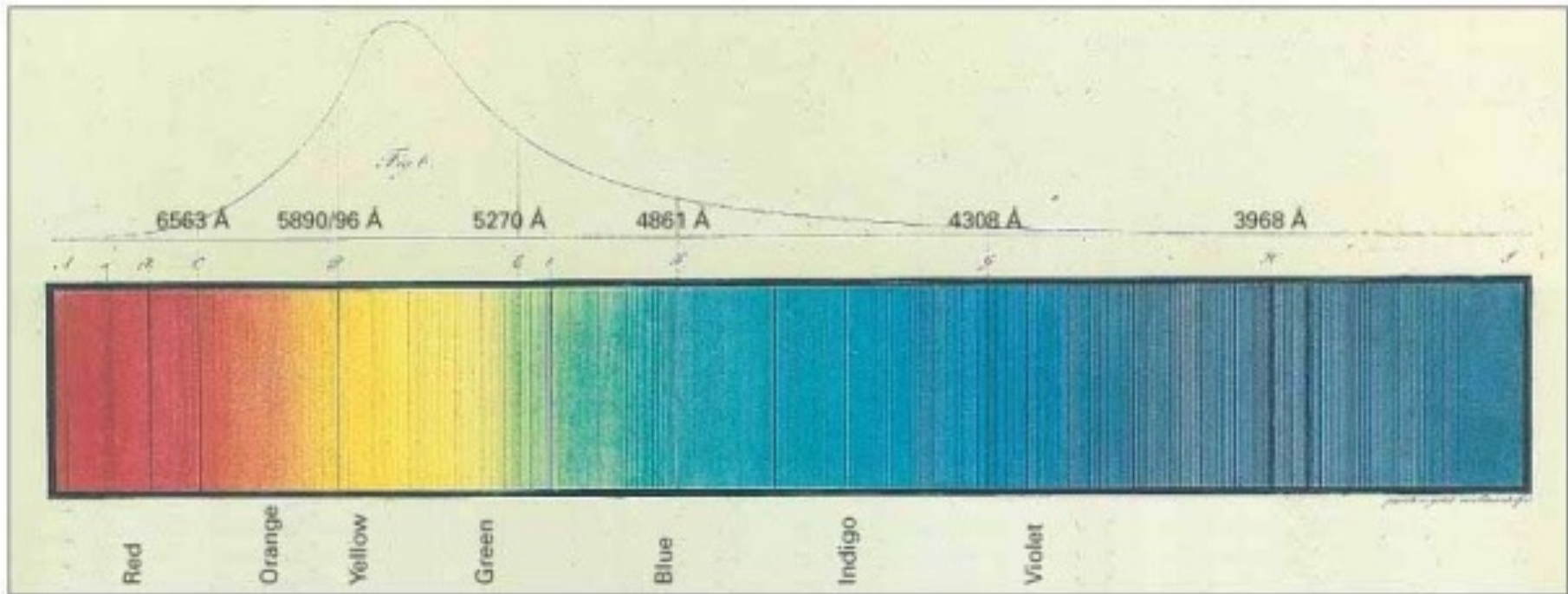


- Emit only a few precise wavelengths (colors)
- Temperature matters less than chemical composition
- Each element has its own spectral “signature”
- Examples: mercury and sodium vapor lights; lasers (just one wavelength); interstellar gas clouds

Thermal source plus cool gas



Absorption lines in sun's spectrum

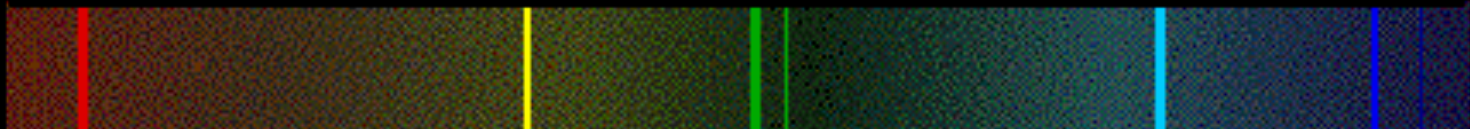


Three types of spectra

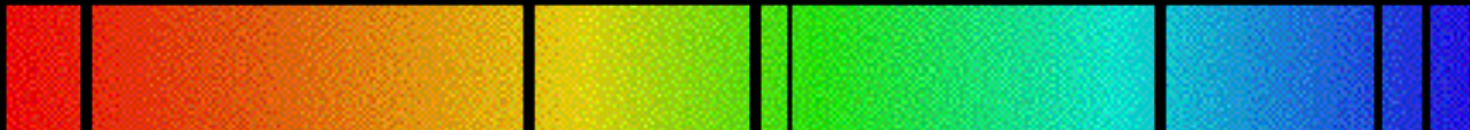
Continuous Spectrum



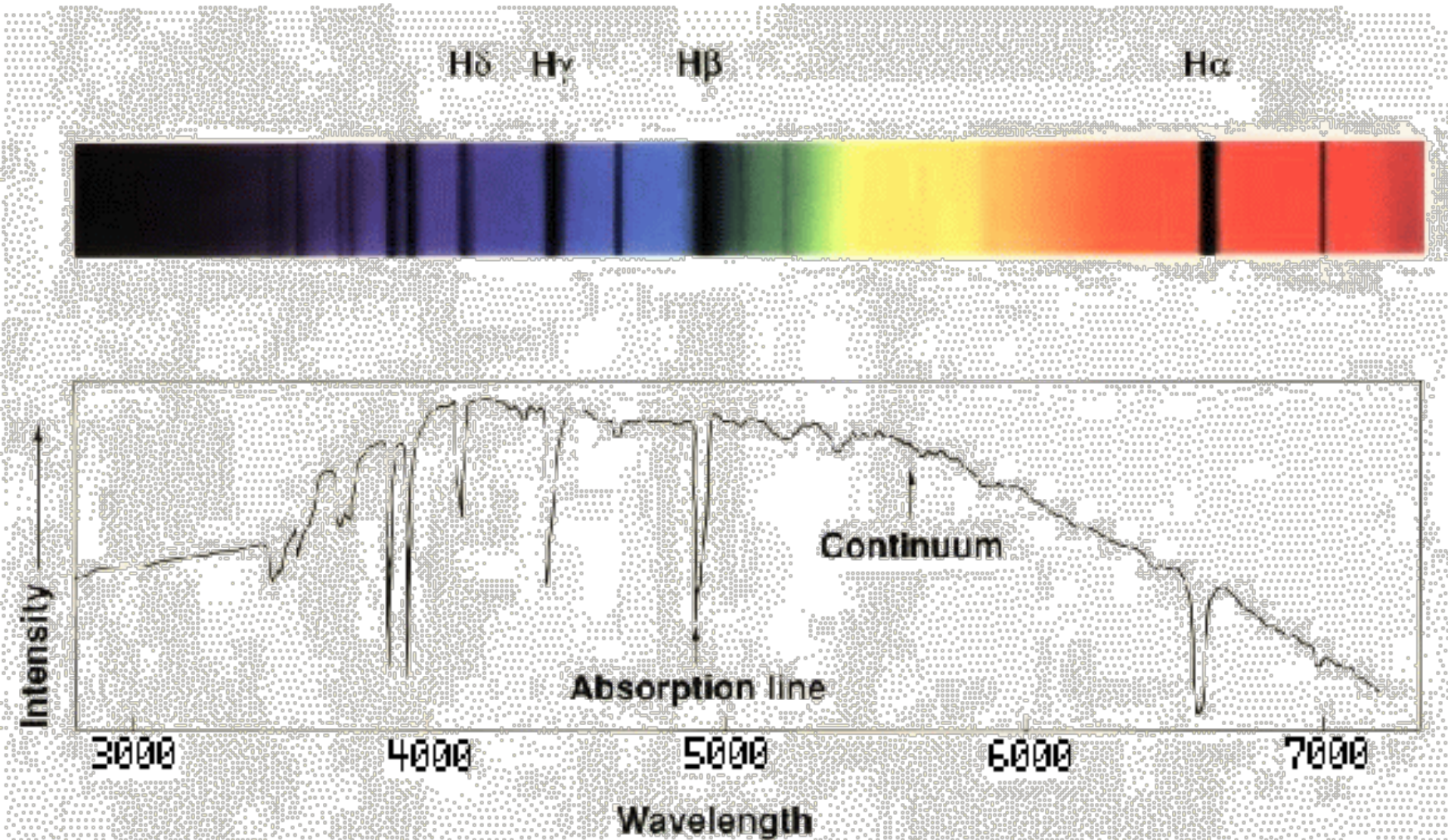
Emission Spectrum



Absorption Spectrum

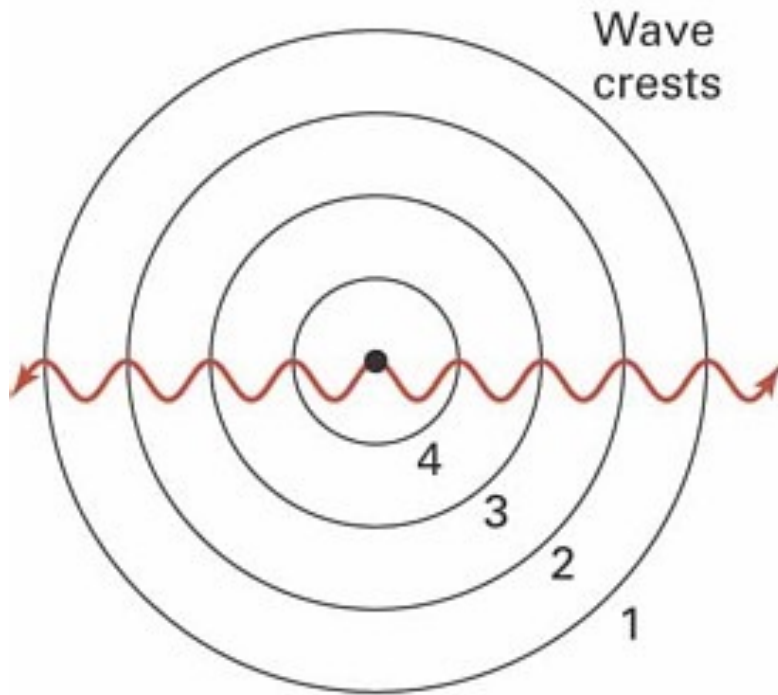


Spectrum photo vs. graph



What if a wave source is moving?

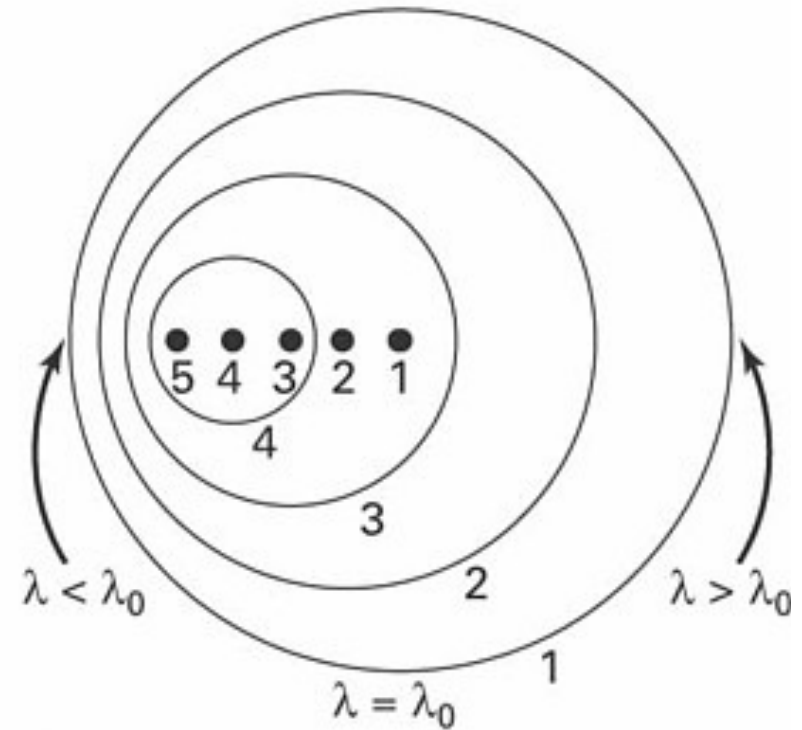
Stationary emitter
of waves, λ_0



A

© 2004 Thomson/Brooks Cole

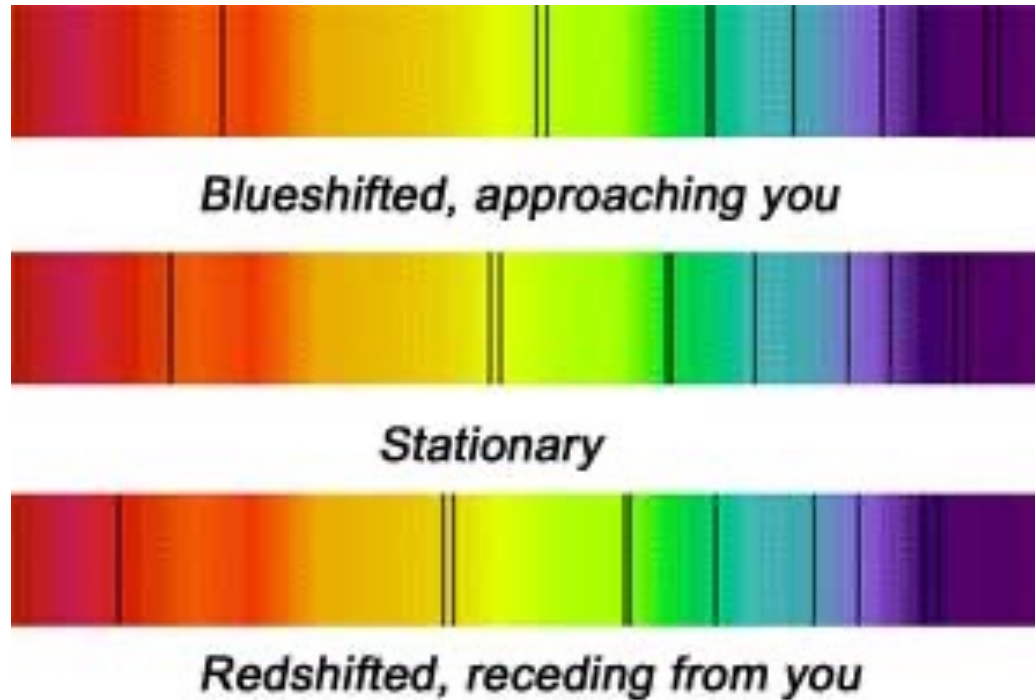
Moving emitter
of waves



B

“Doppler effect”

Doppler-shifted absorption spectra



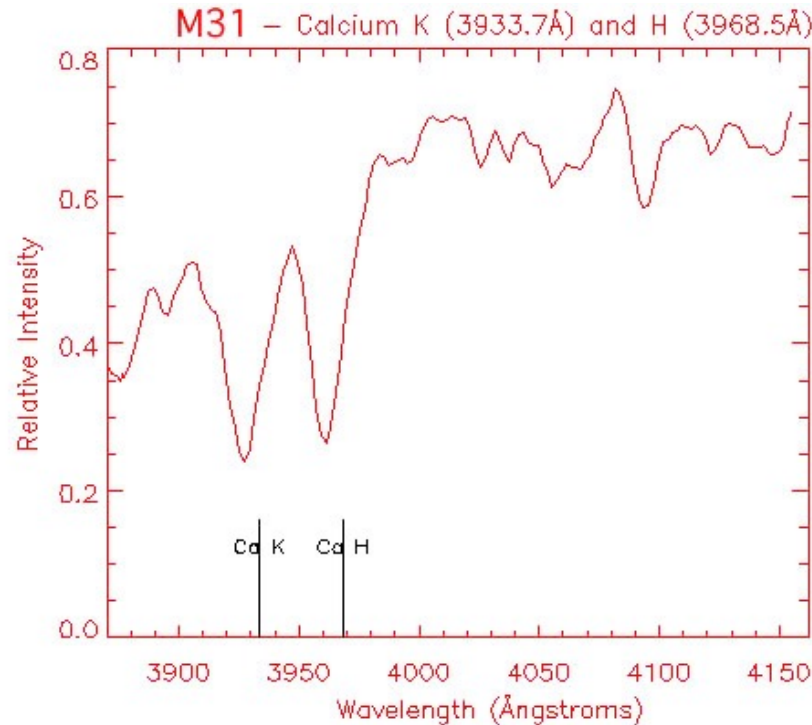
% shift in wavelength = speed of source,
as % of speed of light

Doppler-shifted absorption spectra



% shift in wavelength = speed of source,
as % of speed of light

Doppler-shifted absorption spectra



Shorter wavelengths implies it's moving *toward* us

Wavelengths are shifted by about 10 units (Angstroms) out of 4000, or 1 part in 400. Therefore this object is moving toward us at 1/400 the speed of light (750 km/s)

The Physics of Light

- Speed = 300,000 km/s
- Brightness of a source is measured in watts (a unit of power, energy/time)
- Diffraction indicates wavelike behavior
- Made of tiny units called photons
- Wavelength determines color and photon energy
- Hot, opaque object emits continuous spectrum, brighter and bluer if hotter
- Hot, transparent gas emits bright-line spectrum
- Thermal source viewed through cooler gas has dark-line “absorption” spectrum
- Doppler-shifted spectral lines indicate motion of source toward or away from us