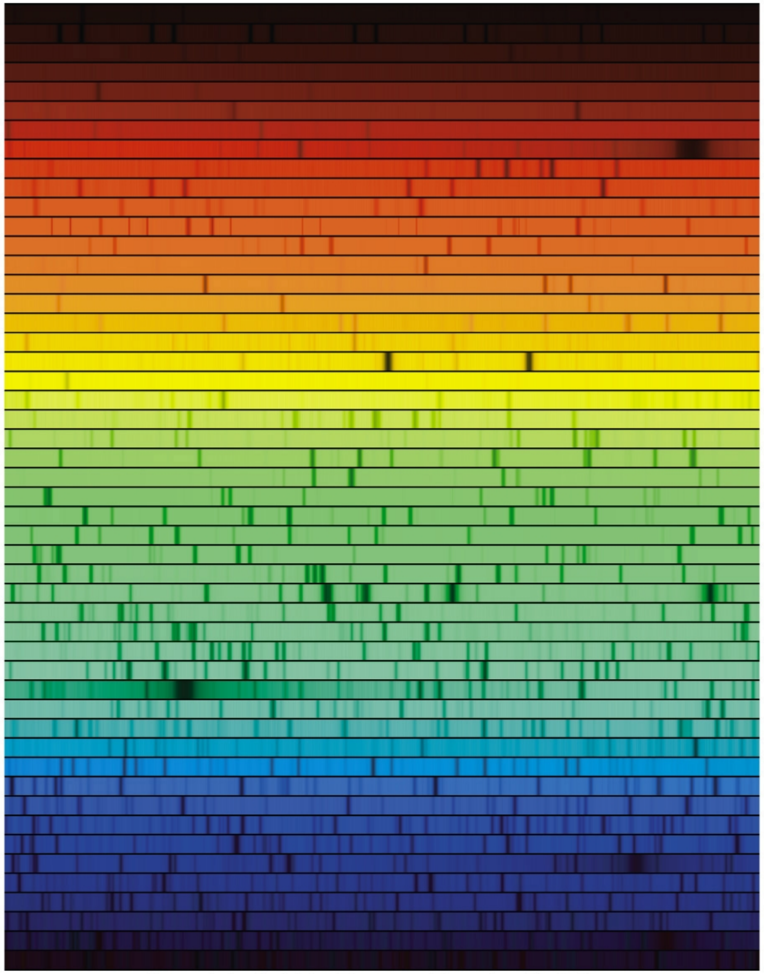
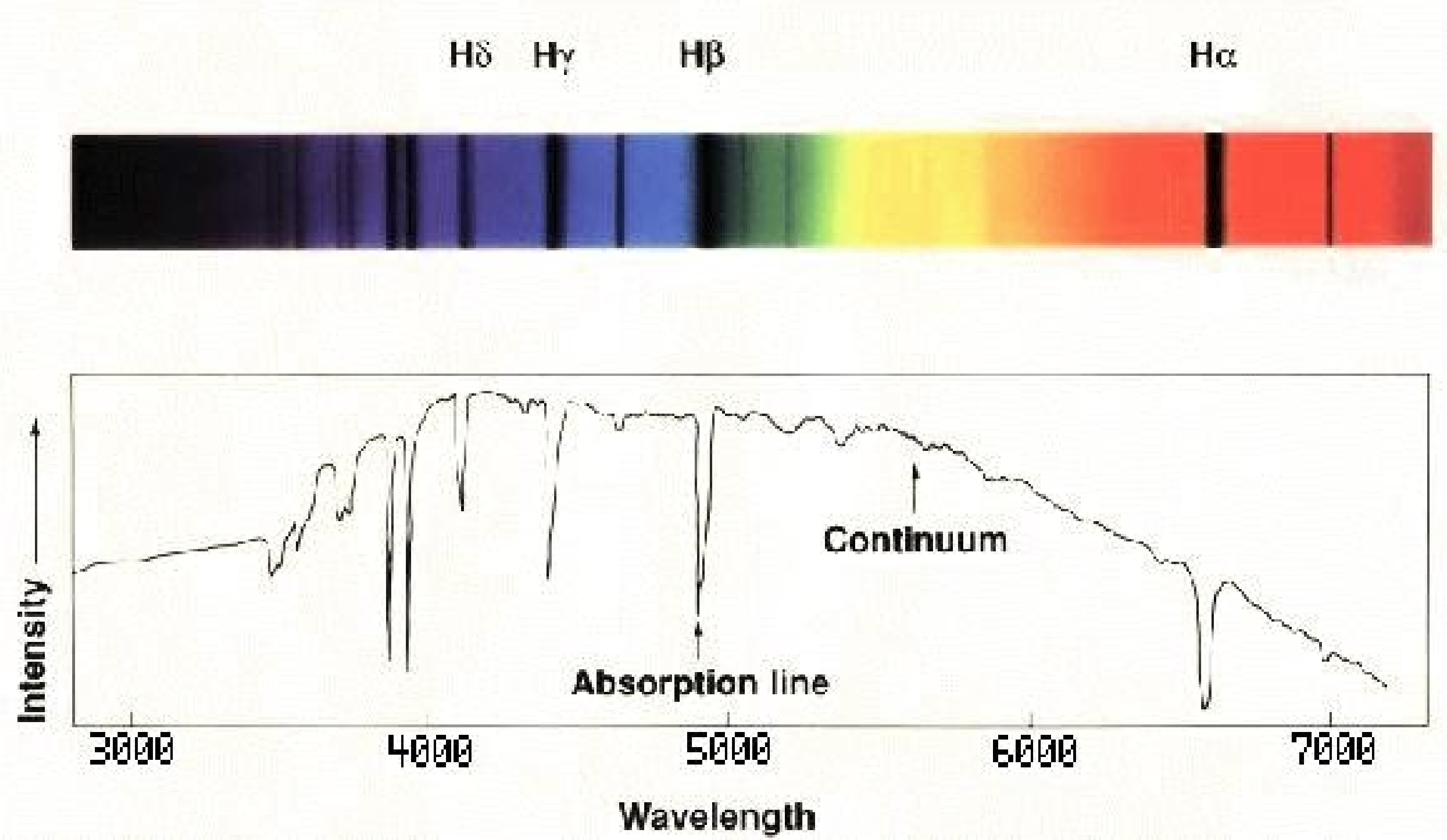
Chapter 4

Spectroscopy



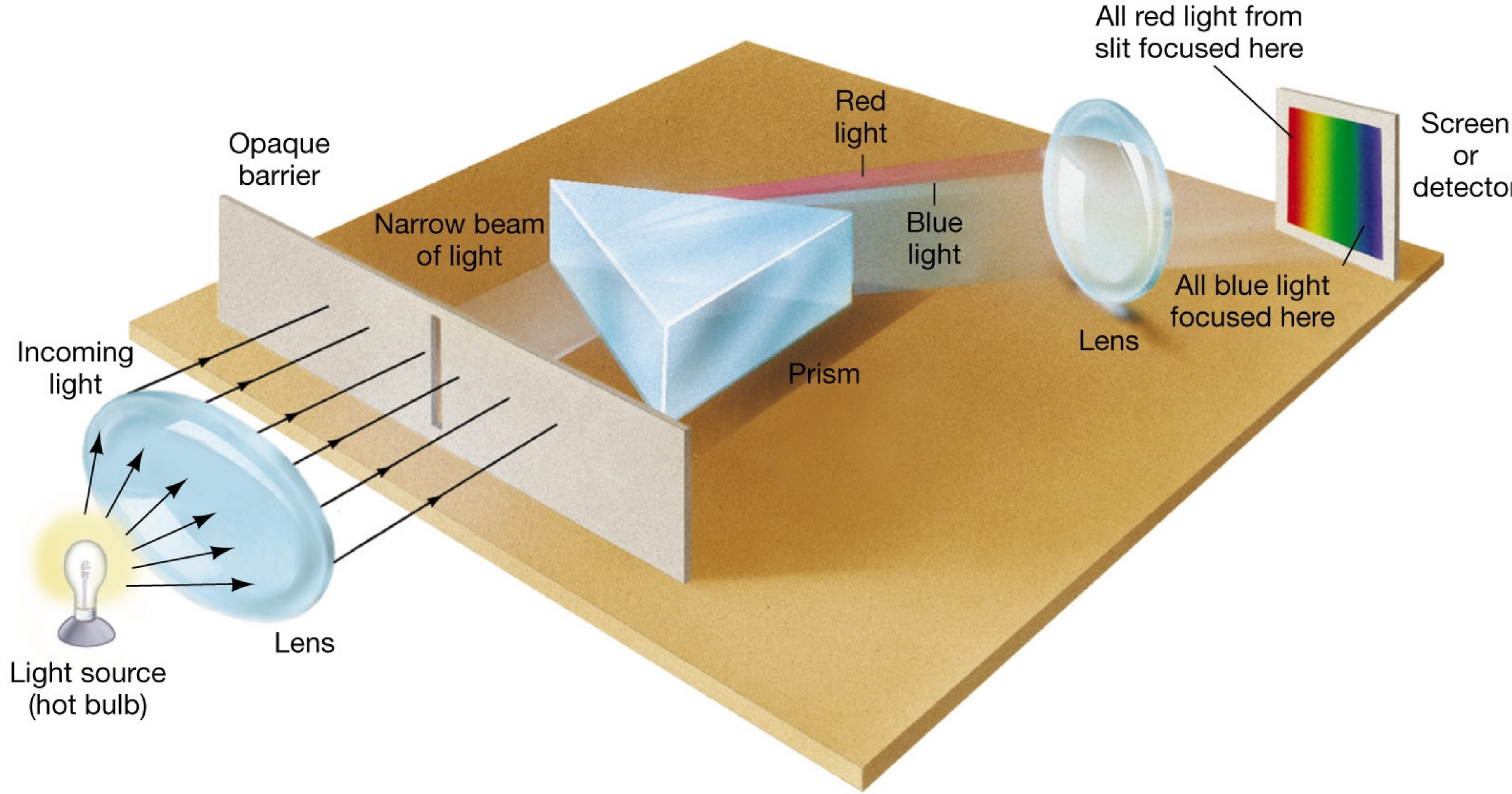
4.1 Spectral Lines

Spectrum: a display of light sorted by wavelength (or frequency or energy)
Spectrum: a graphic depiction of light intensity as a function of wavelength, frequency, or energy.



4.1 Spectral Lines

Spectroscope: **splits light into component colors**



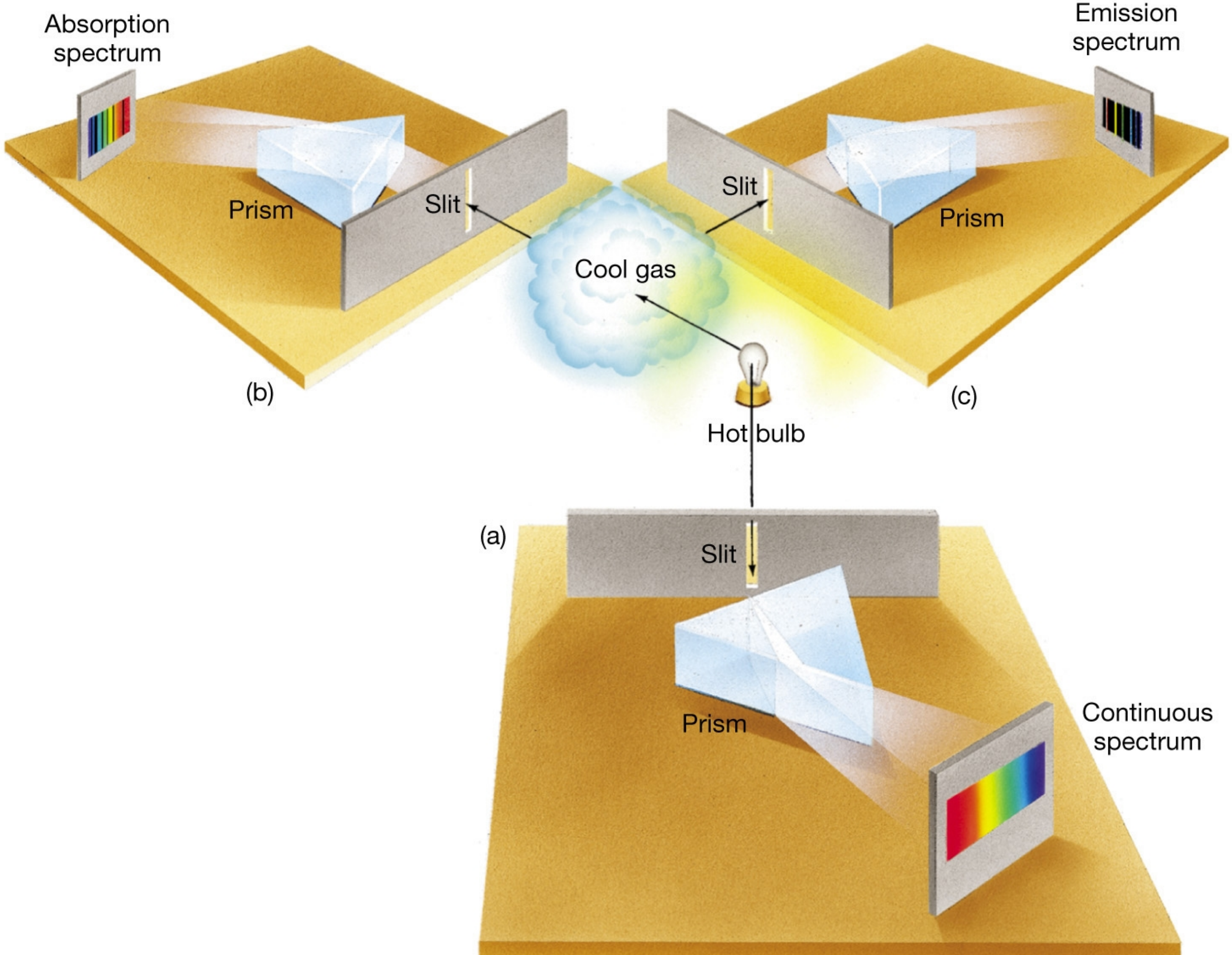
4.1 Spectral Lines

Kirchhoff's laws:

- **Luminous solid, liquid, or dense gas produces continuous spectrum**
- **Low-density, hot gas produces emission spectrum**
- **Continuous spectrum incident on cool, thin gas produces absorption spectrum**

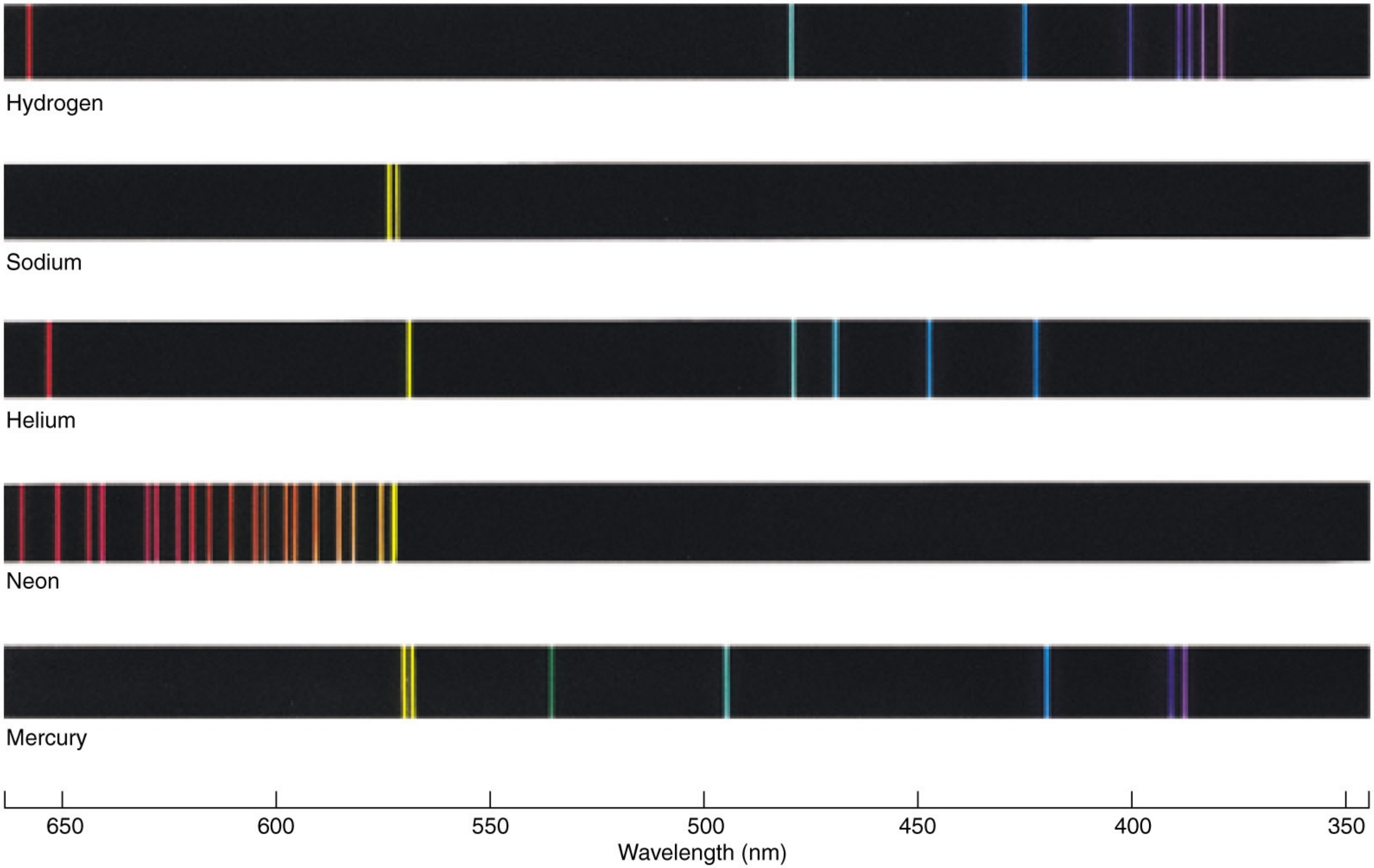
4.1 Spectral Lines

Kirchhoff's laws illustrated:



4.1 Spectral Lines

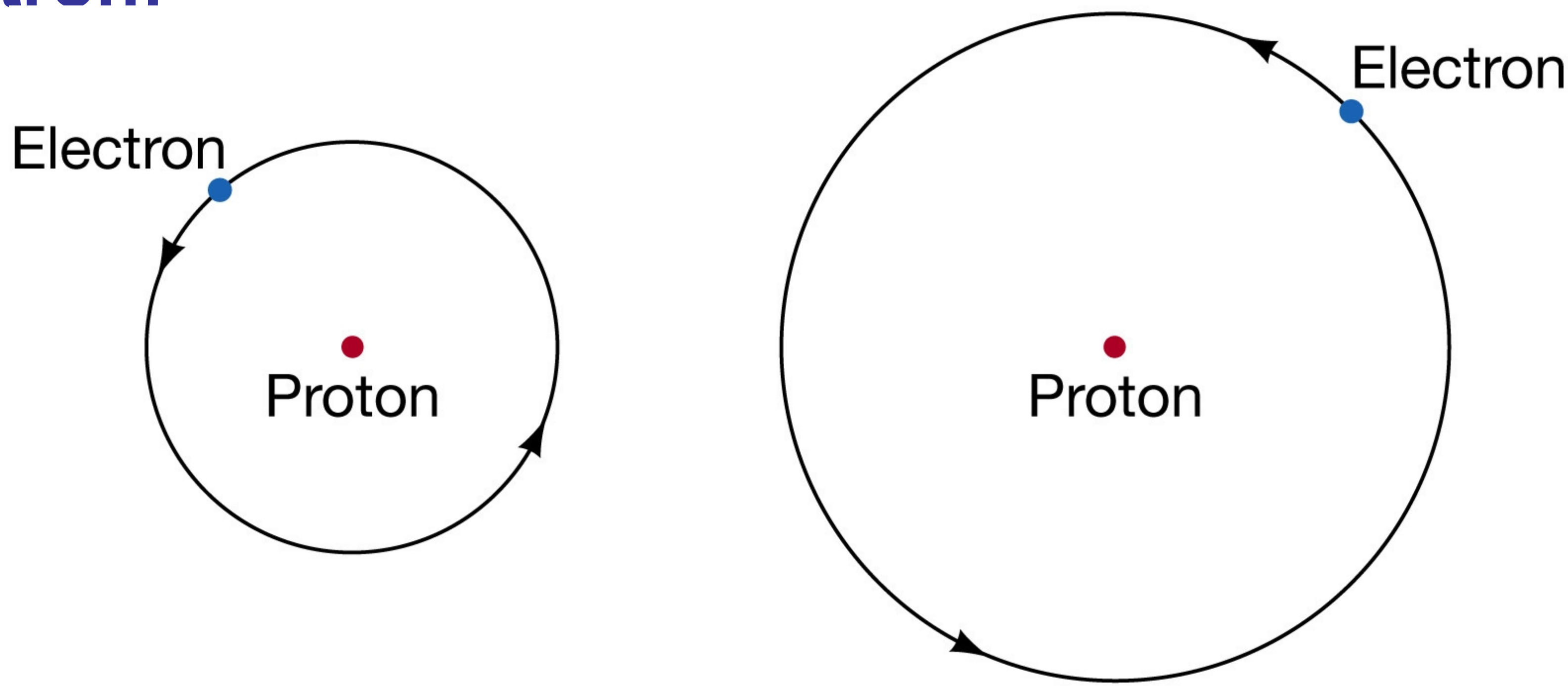
Emission spectrum each element has a characteristic spectrum.



4.2 The Formation of Spectral Lines

Existence of spectral lines required new model of atom, so that only certain amounts of energy could be emitted or absorbed.

Bohr model had certain allowed orbits for electron:

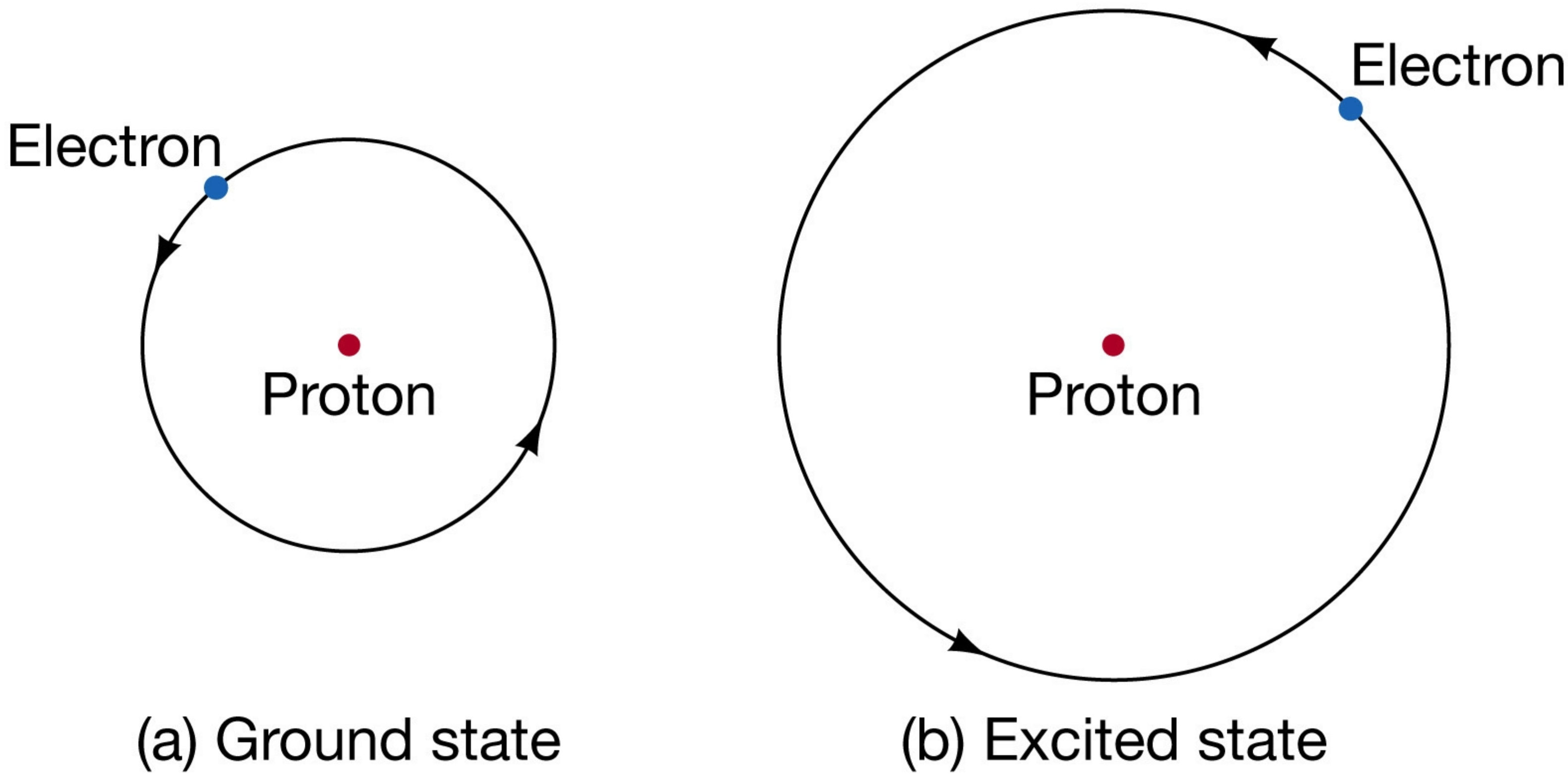


(a) Ground state

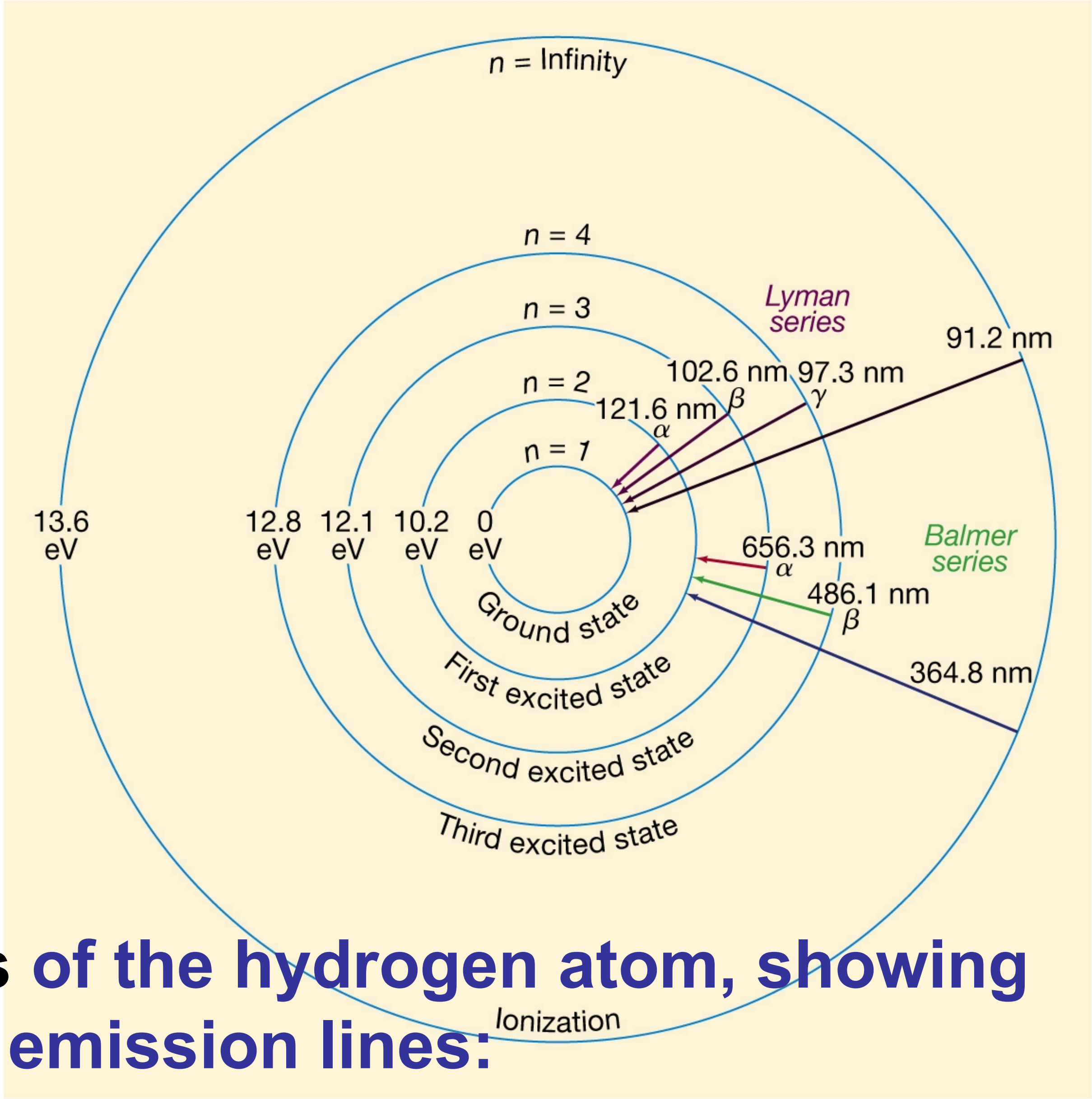
(b) Excited state

4.2 The Formation of Spectral Lines

Emission energies correspond to energy differences between allowed levels.



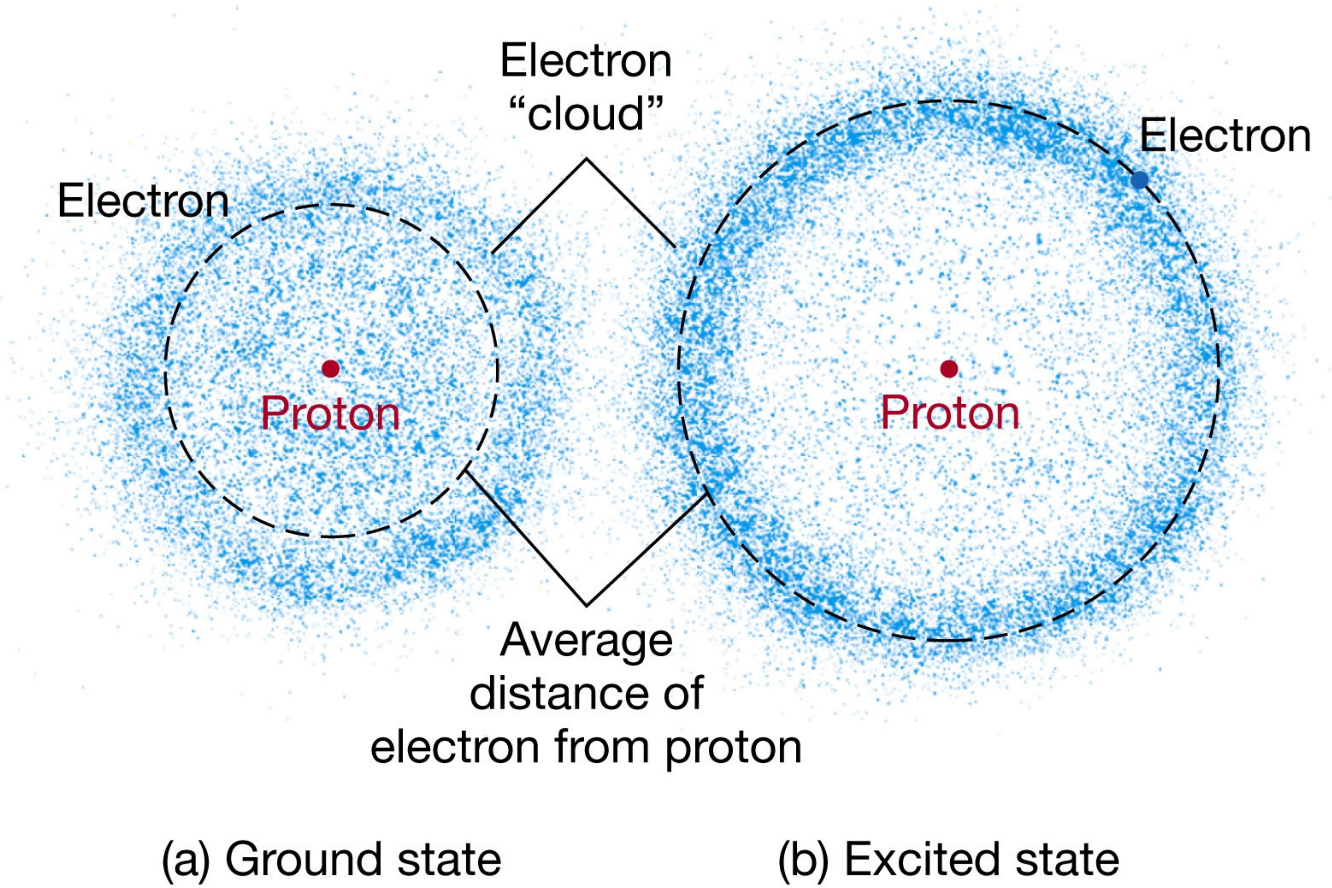
4.2 The Formation of Spectral Lines



Energy levels of the hydrogen atom, showing two series of emission lines:

4.2 The Formation of Spectral Lines

Modern model has electron "cloud" rather than orbit:



4.2 The Formation of Spectral Lines

Light particles (photons) each have energy *E*:

$$E = hf$$

Here, *h* is Planck's constant:

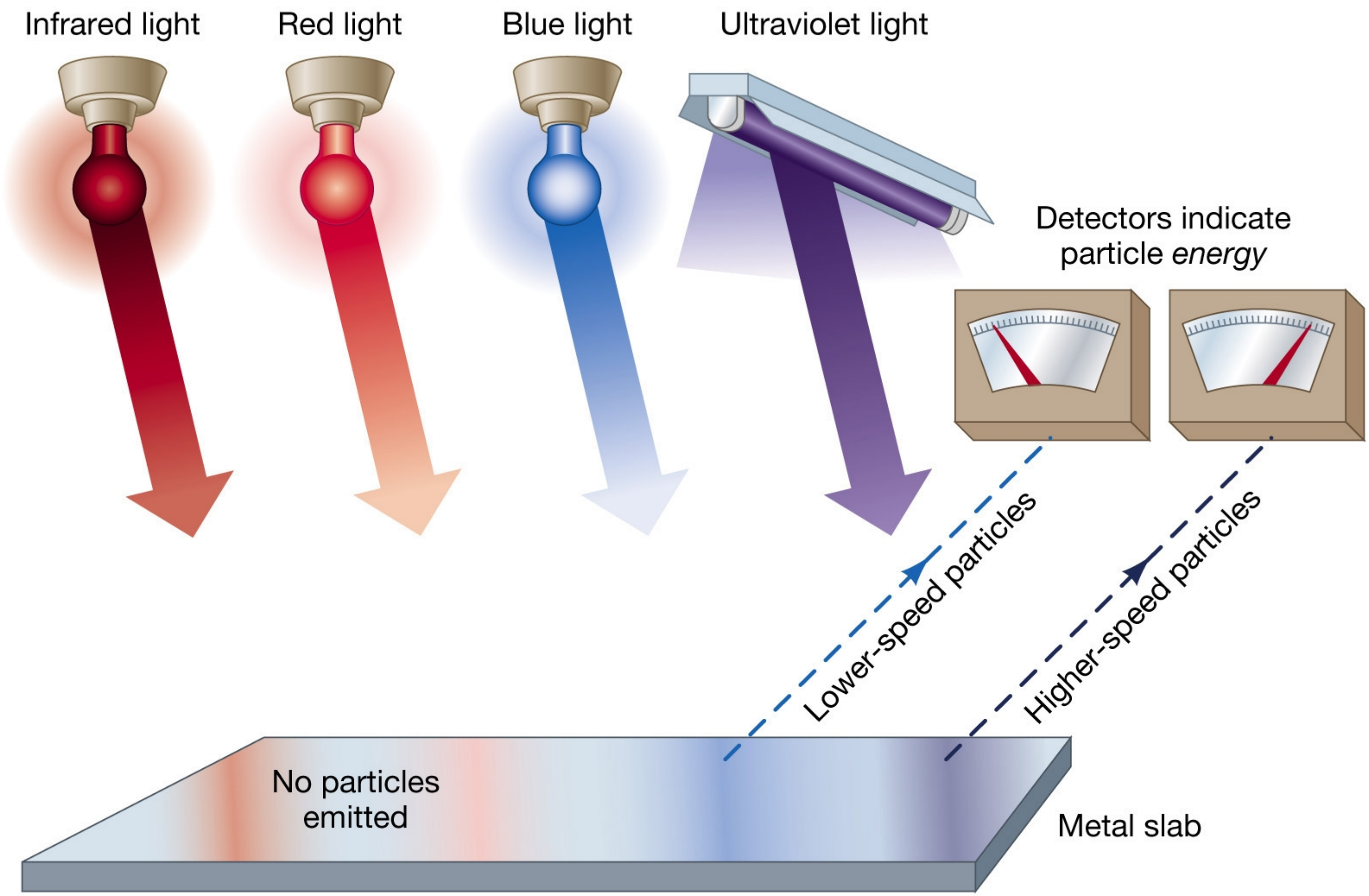
$$h = 6.63 \times 10^{-34}\,\mathrm{J \cdot s}$$

Photon *Energy* can also be related to wavelength, e.g.,

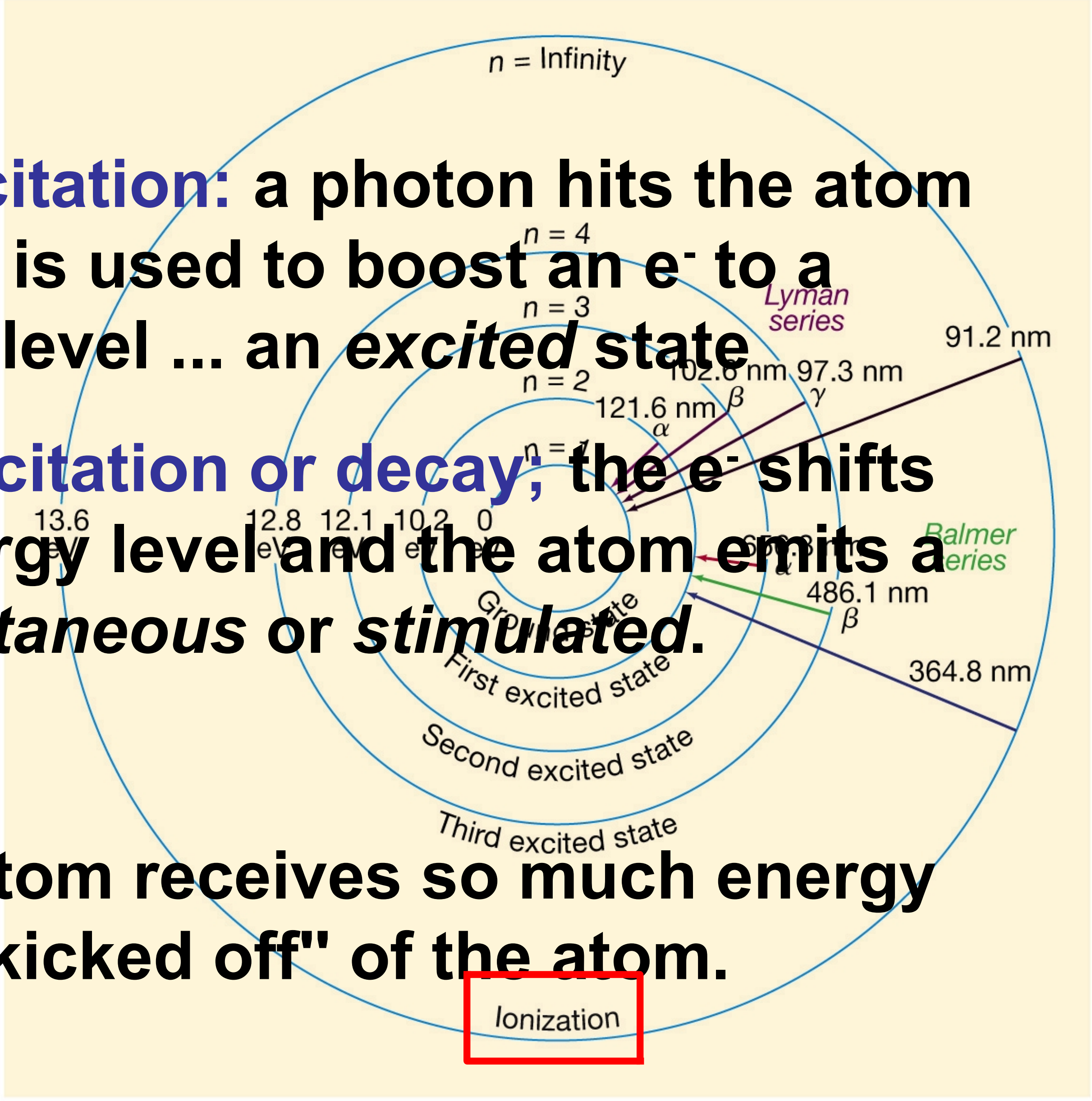
$E = hc/\lambda$ = *1240 eV/*λ (nm)

4.2 The Formation of Spectral Lines

Photoelectric effect can be understood only if light behaves like particles



4.2 The Formation of Spectral Lines



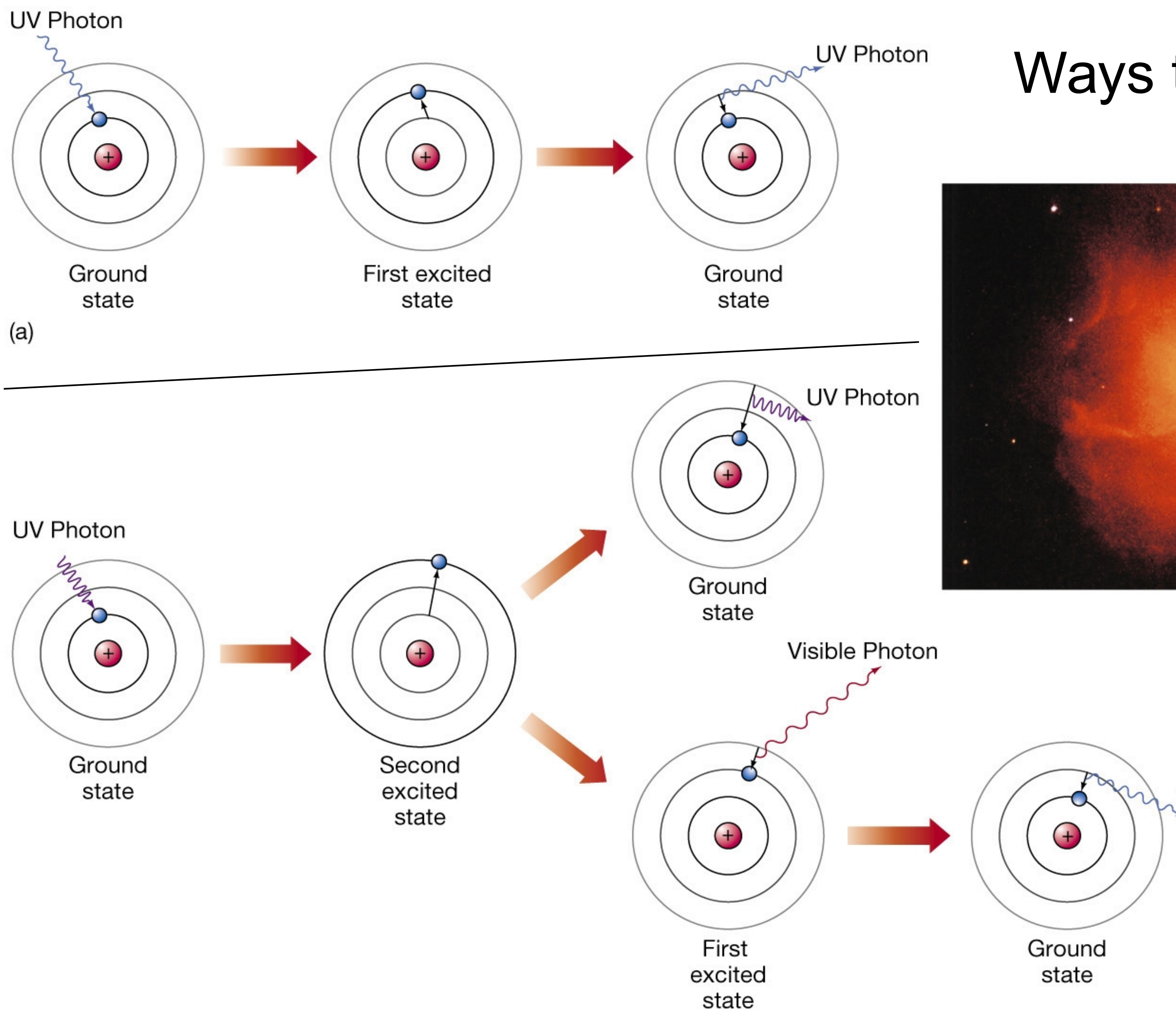
Absorption - excitation: a photon hits the atom and its energy is used to boost an e^- to a higher energy level ... an *excited* state

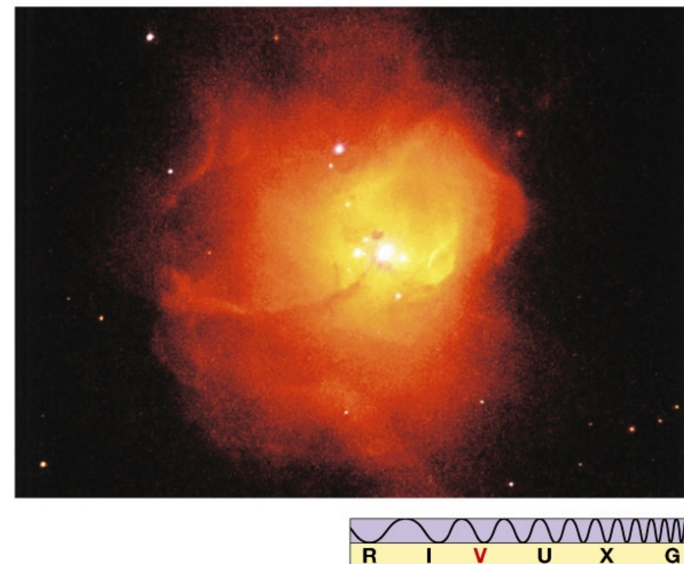
Emission - deexcitation or decay: the e^- shifts to a lower energy level and the atom emits a photon. *Spontaneous* or *stimulated*.

Ionization: the atom receives so much energy that the e- is "kicked off" of the atom.

4.2 The Formation of Spectral Lines

Ways to decay.

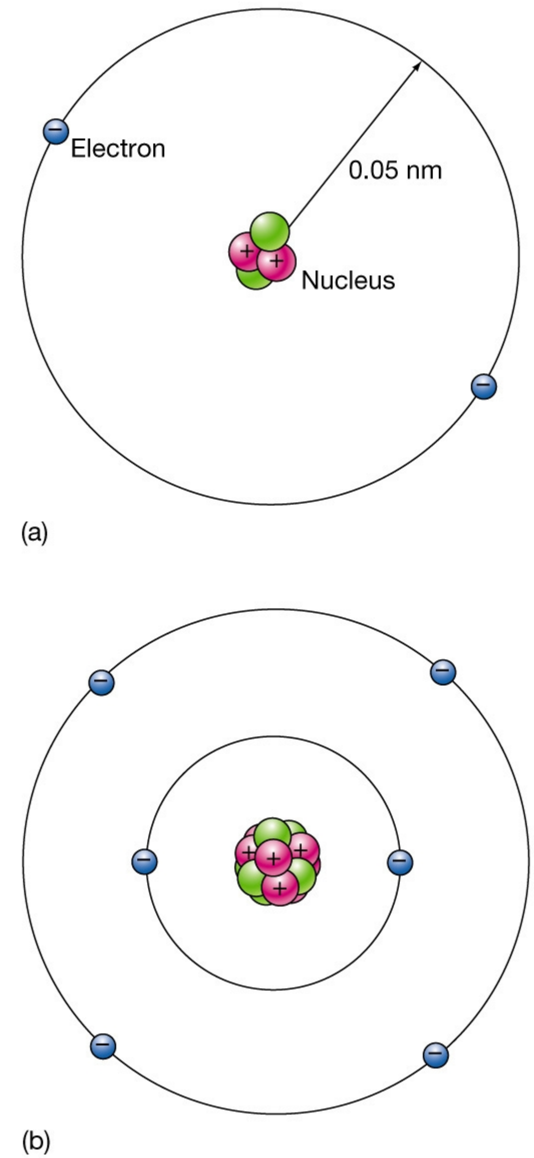




4.2 The Formation of Spectral Lines

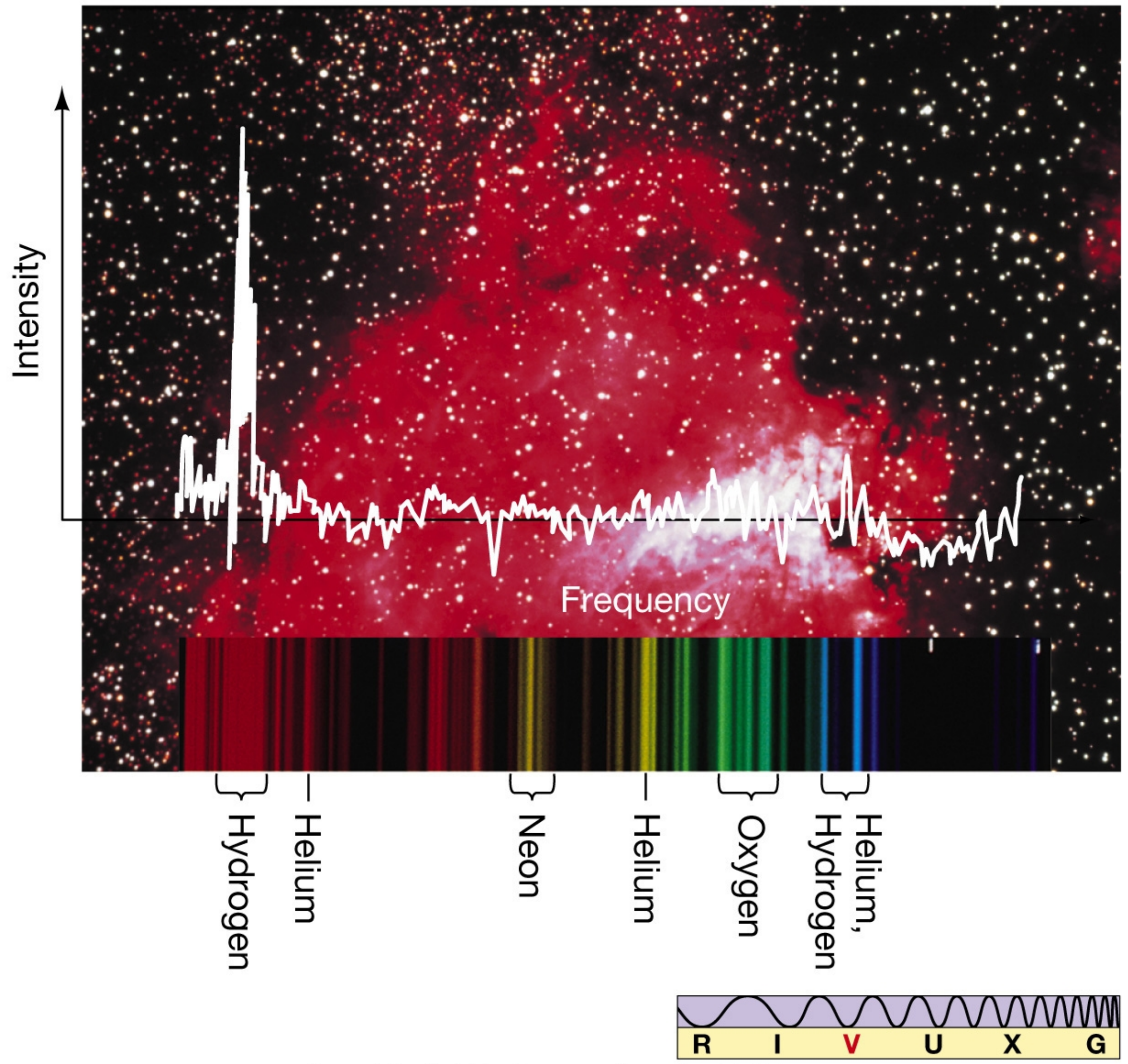
Multielectron atoms: much more complicated spectra, many more possible states

Ionization changes energy levels



4.2 The Formation of Spectral Lines

Emission lines can be used to identify atoms:



Summary of Chapter 4

- Spectroscope splits light beam into component frequencies
- Kirchoff's laws describe how the 3 types of spectra can form.
- Continuous, emission, and absorption spectra
- Both emission and absorption spectra can be observed from one gas cloud depending on line-of-sight.

Summary of Chapter 4, cont.

- Spectra can be explained using atomic models, with electrons occupying specific orbitals

- Emission and absorption lines result from transitions between orbitals

- Spectra can give us information about a stars temperature, composition, rotation, radial velocity, magnetic field strength, surface gravity (pressure) → star size.