3.9 Atomic Structure

PRE-LECTURE READING 3.9

- *Astronomy Today*, 8th Edition (Chaisson & McMillan)
- *Astronomy Today*, 7th Edition (Chaisson & McMillan)
- *Astronomy Today*, 6th Edition (Chaisson & McMillan)

VIDEO LECTURE

- Atomic Structure[1] (19:40)

SUPPLEMENTARY NOTES

Atom

- See Atom[2].
- Contains a nucleus surrounded by electrons
- Nucleus contains protons and neutrons
    - Number of protons determines the element
    - Number of neutrons determines the isotope of the element

Bohr Model

- See Bohr Model[3].
- Electrons do **not** orbit the nucleus like planets orbit the sun.
- Like light, electrons travel as waves, and interfere with themselves.
- Electrons are likely to be where this interference is constructive, and not likely to be where this interference is destructive.

Interference is constructive if the circumference of the orbital is an integer multiple of the electron wavelength, λ_e:

$$2\pi r = n\lambda_e \tag{14}$$

- r = radius of the orbital
- n = 1, 2, 3, ...

[1] http://youtu.be/1_18dmSgIqI
[2] http://en.wikipedia.org/wiki/Atom
[3] http://en.wikipedia.org/wiki/Bohr_model

- In other words, $r \propto n$, where
    - $n = 1$ is the ground state
    - $n = 2$ is the 1^{st} excited state
    - $n = 3$ is the 2^{nd} excited state, etc.
- Hence, the allowed values of r, and the orbitals that these values represent, are **quantized**.

Absorption and Emission of Energy

- Just as it takes a rocket energy to move away from a planet, it takes an electron energy to move away from a nucleus. However, since an electron constructively interferes with itself only at quantized distances, it can absorb (and emit) only quantized amounts of energy, corresponding to the energy differences between these orbitals.
- This energy can be in the form of light, or in the form of kinetic energy transferred in a collision with another atom or particle.
- If in the form of light:
    - Since electrons can absorb and emit only quantized energies, and since $E = h\nu$ (see Electromagnetic Spectrum), the frequencies of absorbed and emitted light are also quantized.
    - Since the frequencies of absorbed and emitted light are quantized, and since $\lambda = c/\nu$ (see Electromagnetic Spectrum), the wavelengths of absorbed and emitted light are also quantized.
- Unlike planets orbiting stars that get too close to one another, electron orbitals are **stable** against at least minor jostling: If the kinetic energy to be transferred in a collision with another atom or particle is less than the minimum energy that an electron can absorb or emit, the energy cannot be transferred and the electron will stay in its current orbital. This is why the atoms that we are made of, and that are in close proximity to each other and constantly jostling each other, do not fall apart.
- If an electron absorbs enough energy to jump more than one level, there are then multiple ways in which it may deexcite (i.e., it need not reemit the same photon that it absorbed).