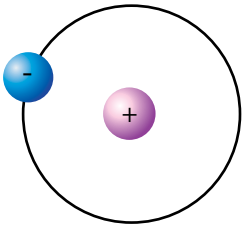
STUDYING THE LIGHT EMITTED BY CELESTIAL OBJECTS

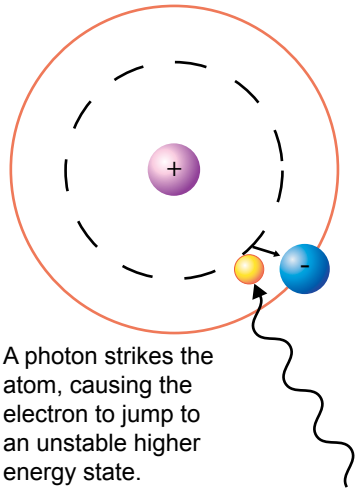
An absorption spectrum - the dark lines are produced when atoms absorb energy and electrons transition between energy levels. This causes the atoms to emit photons, some of which are absorbed by other atoms - and that in turn identifies the elements that produce the spectrum.

Astronomers can tell a great deal about stars by studying the light they emit. The light emitted by stars can be separated into its component wavelengths - its spectrum (think of the spectrum of visible light, the rainbow, created by a prism). There are three types of spectrums; continuous, emission and absorption. The absorption spectrum of a star yields the most clues to its makeup.



An unexcited hydrogen atom in its "ground" state.

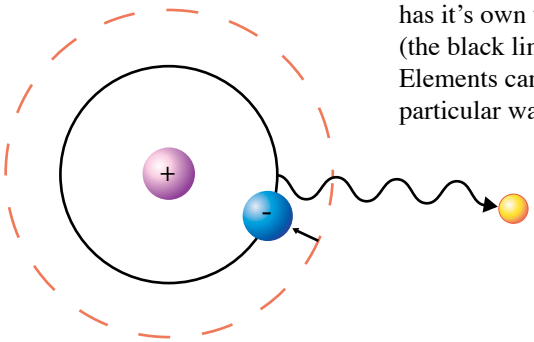
An electron has an "allowed orbit" of definite radius, and the "energy level" of an element is determined by its unique set of allowed electron orbits. If a sufficient amount of energy is applied to an atom one or more of its electrons can be removed from the atom entirely, and the amount of energy required to make that happen is referred to as that atom's "binding energy". When an atom loses an electron it has more positively than negatively charged particles, giving it a net positive charge, and the atom becomes an "ion" .



A photon strikes the atom, causing the electron to jump to an unstable higher energy state.

A photon is a particle of light that shows up on the either the ultraviolet, visible, or infrared portions of the electromagnetic spectrum. When a photon strikes a hydrogen atom, the atom may absorb an amount of energy that is not sufficient to remove its electron, but is enough to affect the electron. If exactly the right amount of energy (10.2 eV) is absorbed the electron jumps to a higher energy level, putting the atom in an unstable "excited state". If more energy is absorbed by the atom, it jumps to an even higher energy state. An atom cannot remain in this unstable state; the extra energy held by the electron will be emitted as a photon, causing the electron to jump back to a lower energy level. An "eV" is an electron volt, which is used to describe the energies in atoms. 13.6 eV is the amount of energy required to cause the electron to escape the hydrogen atom completely, "ionizing" the atom.

When a photon is emitted by an atom in an excited state, it does not travel out in the same direction as the original photon. As they travel out in different directions the photons emitted by a star go through clouds of gas, and some of the photons are absorbed by atoms in the gas. When atoms in the gas absorb photons their electrons jump up to higher energy levels, and each atom has it's own unique set of energy levels. The absorption spectrum from the star will exhibit gaps (the black lines) that correspond to the wavelengths of the photons that were absorbed by the gas. Elements can identified in absorption spectra because they have particular sets of black lines at particular wavelengths.



The electron loses the extra energy and jumps back to a lower energy state; the extra energy lost is emitted by the atom as a photon.

Many atoms in stars are ionized, and each ion has a unique "spectral signature", placing it in a specific spot on the electromagnetic spectrum. By studying the electromagnetic spectrum emitted by a star, astronomers can determine the chemical composition of the star, how much of the different elements are in the star, what the densities of those elements are, and the temperatures. A hydrogen emission spectrum is illustrated at right.

Electron jumps from 4th excited state to 1st excited state, violet light emitted.

Electron jumps from 3rd excited state to 1st excited state, blue light emitted.

Electron jumps from 2nd excited state to 1st excited state, red light emitted.