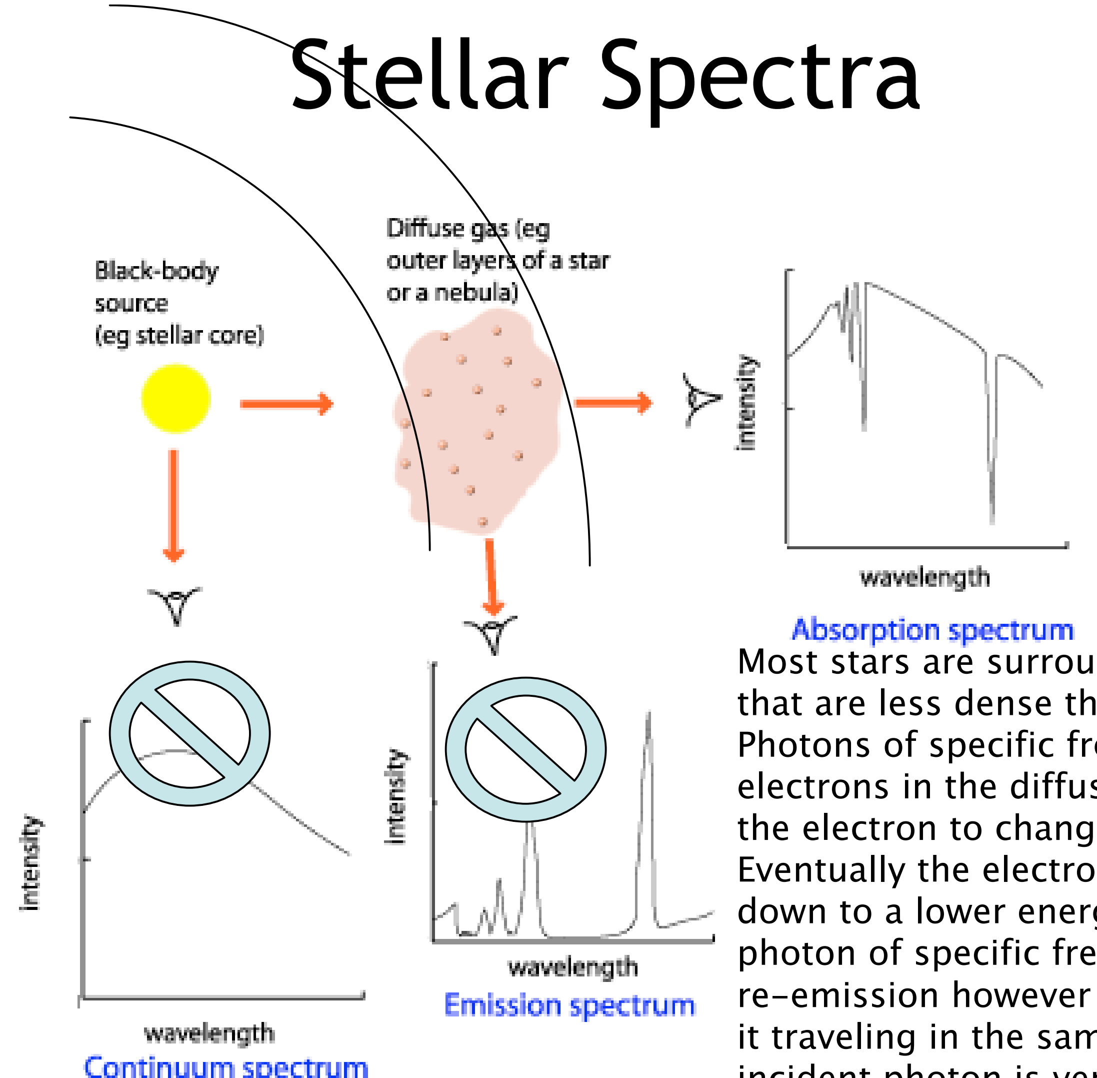
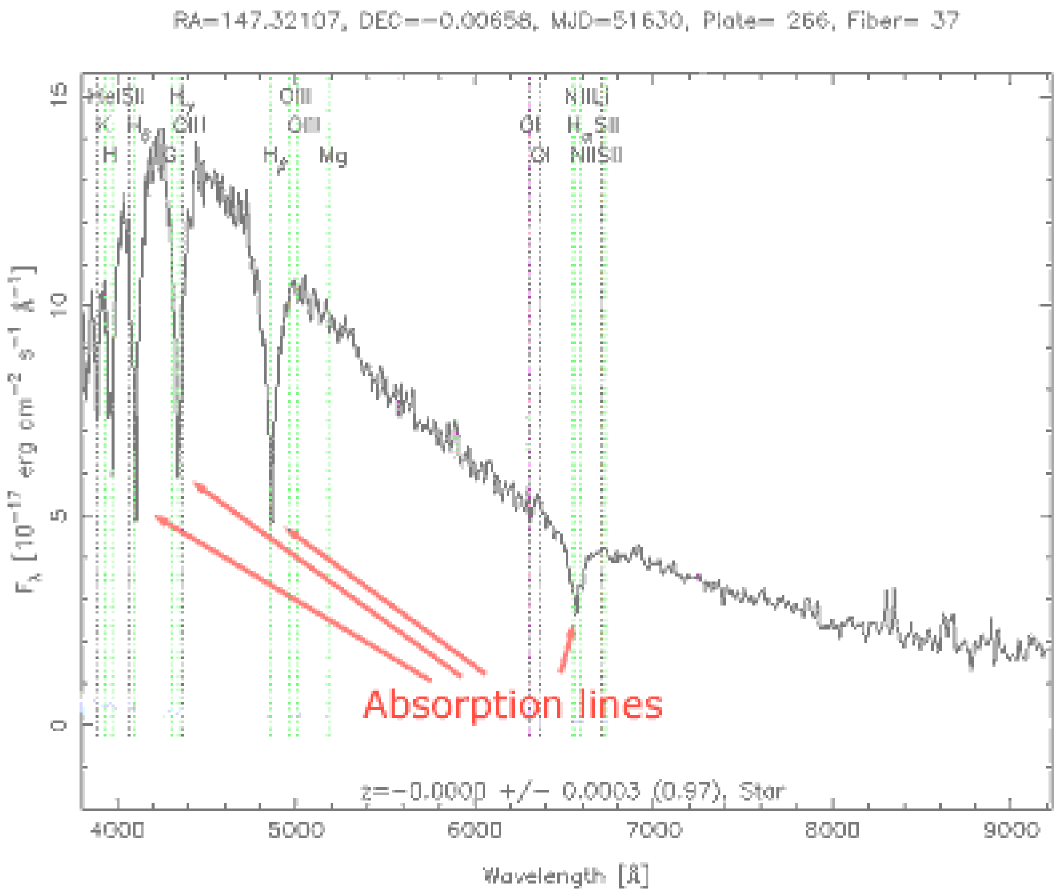
Stellar Spectra



The core of a star emits blackbody radiation

Most stars are surrounded by outer layers of gas that are less dense than the core.
Photons of specific frequency can be absorbed by electrons in the diffuse outer layer of gas, causing the electron to change energy levels.
Eventually the electron will de-excite and jump down to a lower energy level, emitting a new photon of specific frequency. The direction of this re-emission however is random so the chances of it traveling in the same path as the original incident photon is very small. The net effect of this is that the intensity of light at the wavelength of that photon will be less in the direction of an observer. This means that the resultant spectrum will show absorption lines or a decrease in intensity as shown in the dips in the absorption spectrum.

Stellar Spectra



Note the characteristic absorption line features including strong lines for Hα, Hβ, Hγ and Hδ – the Balmer Series. The overall shape of the spectrum approximates a black body curve with a peak wavelength. This can be used to determine the effective temperature of the star. Stars of different temperatures, size and metallicities will have different spectra but most exhibit absorption lines even if they do not all show strong Balmer lines as in this star

Spectral Types

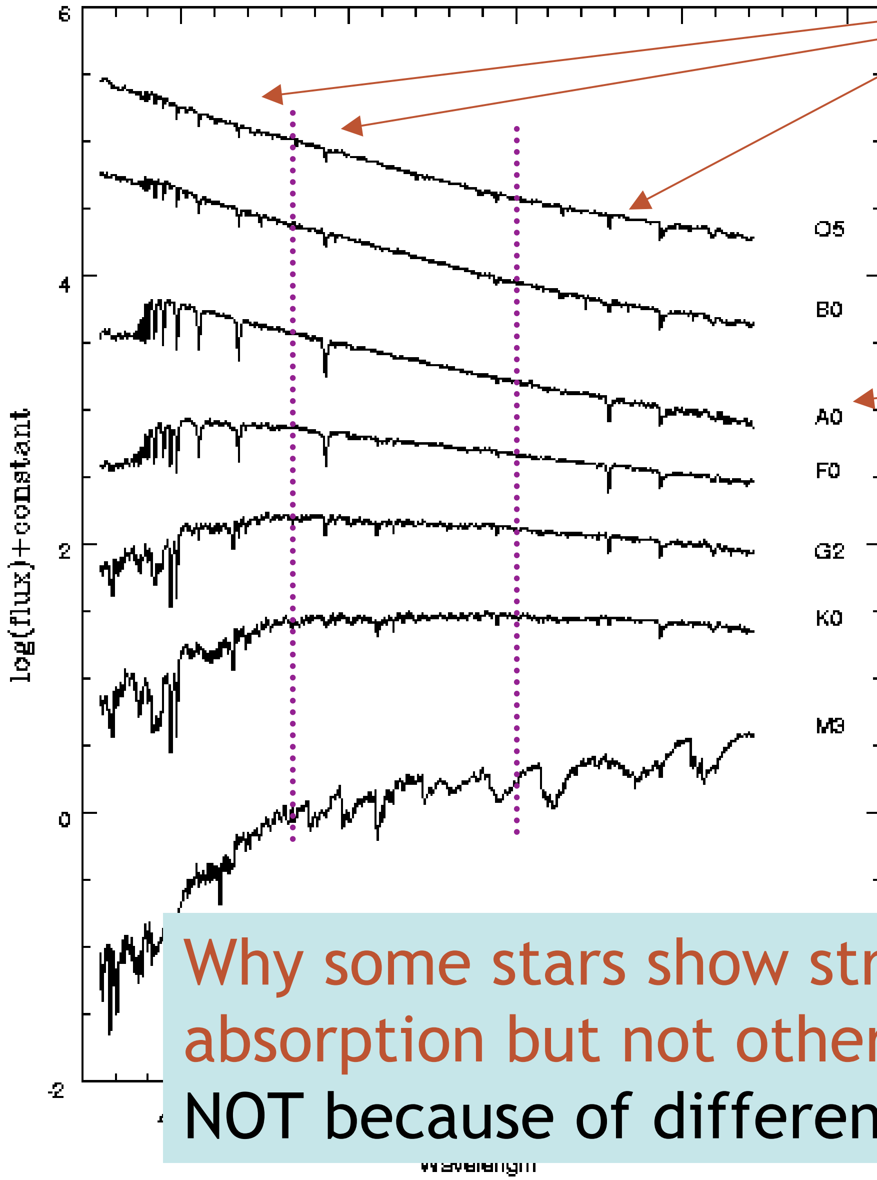
it was realized that different stars had dramatically different absorption lines in their spectra. Some had very strong absorption due to hydrogen, some had no absorption due to hydrogen, some were in between.

With no knowledge of the cause, stars were classified based on the strength of the hydrogen lines in absorption:

A star -- strongest H lines

B star -- next strongest

and so on (although many letters were skipped)



Hydrogen lines

H lines at Max strength

Why some stars show strong absorption but not others?

NOT because of different composition!!!

- Think about how absorption lines are produced. Hydrogen lines in the visible part of the spectrum (known as the Balmer Series) are created when a photon is absorbed by bouncing an electron from the 1st excited level to a higher excited level.
- Photons with just the right energy to move an electron from the 1st excited state to the 2nd excited state have an energy of (E2-E1) =10.2 eV. This is in the red part of the spectrum and this absorption line is called Hα

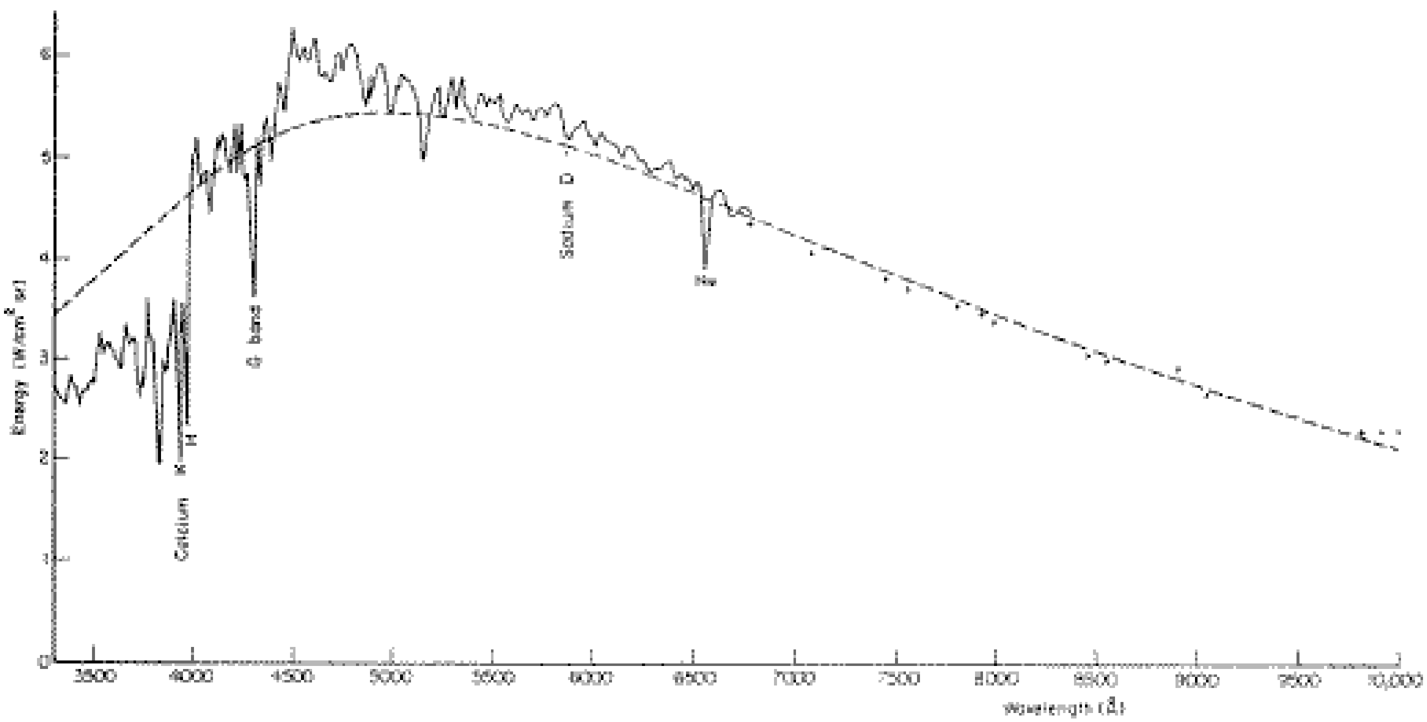
  - For one of the visible-light transitions to happen, there must be some H atoms in the gas with their electrons in the 1st excited state.

Let’s consider hydrogen at
the “surface” (photosphere) of the Sun

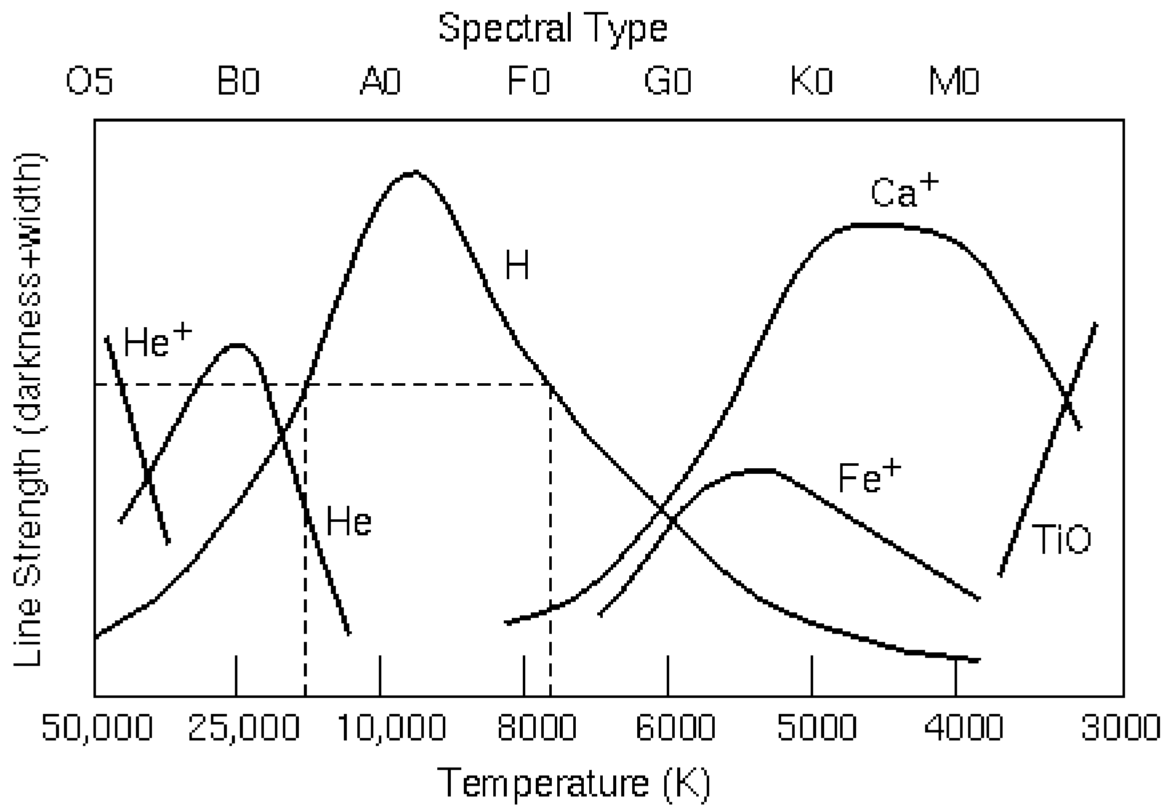
Use Saha equation to determine degree of ionization and the Boltzmann equation to reveal the distribution of electrons between the ground and the first excited state.

The Sun photosphere had about 5e6 H atoms for each Calcium atom. Dominant absorption lines are those due to C II (H, K) !!

Spectrum of the Sun



Dependence of spectral line strengths on TEMPERATURE



Cross-referencing different line strengths narrows the possible temperature range. A given strength for the Hydrogen line could mean two possible temperatures (hot or warm). If Helium line is present, then the choice is the hot temperature. If the ionized Calcium line is present (and Helium not present), then the choice is the warm temperature.