

Q

There is a situation ~~the~~ (several in fact) where measuring the color of a star will give us an erroneous value for its temperature , making it seem cooler than it really is.

What might cause this ?

A

Reddening due to dust along the line of sight to the star , whether in the atmosphere , between the Earth & the star , or surrounding the star .

Dust comes in all ~~sizes~~ both dense clouds (easy to see in Milky Way) but also in smoother, more diffuse form.

It both absorbs light, so we need to say

$$m - M = 5 \log d - 5 + A$$

↑  
extinction due to  
dust

And also scatters light.

~~Secondly~~, Shorter wavelengths are scattered more than longer ones, altho' exact relation between  $\lambda$  & scattering depends on size of dust particles

(cf Rayleigh scattering in atmosphere  
 $\propto \lambda^{-4}$ )

We see the scattered light directly  
in blue reflection nebulae

We describe the reddening caused  
by dust by the change in color  
it produces

$$eg E(B-V) = B-V - (B-V)_0$$

$\uparrow$                        $\uparrow$   
observed              intrinsic

(or  $E(V-I)$ ,  $E(U-B)$ , etc.)

We can measure the relation between  
 $A_V$  and  $E(B-V)$ :

$$A_V = 3.2 E(B-V)$$

extinction              reddening

# TODAY

Stellar spectra.

Q

What can we learn from spectra  
that we can't get just as  
easily from colors & brightnesses  
of stars?

## Classifying stars by spectra

Around 1900, large efforts made  
to classify stars by their spectra  
(Taxonomy only)

Stars classified as type A, B, C, ... etc

Some classes were more common than  
others and are still in use today

It was found that stars of a given  
spectral type had similar colors:

O and B stars very blue

⋮

G stars (like Sun) yellow

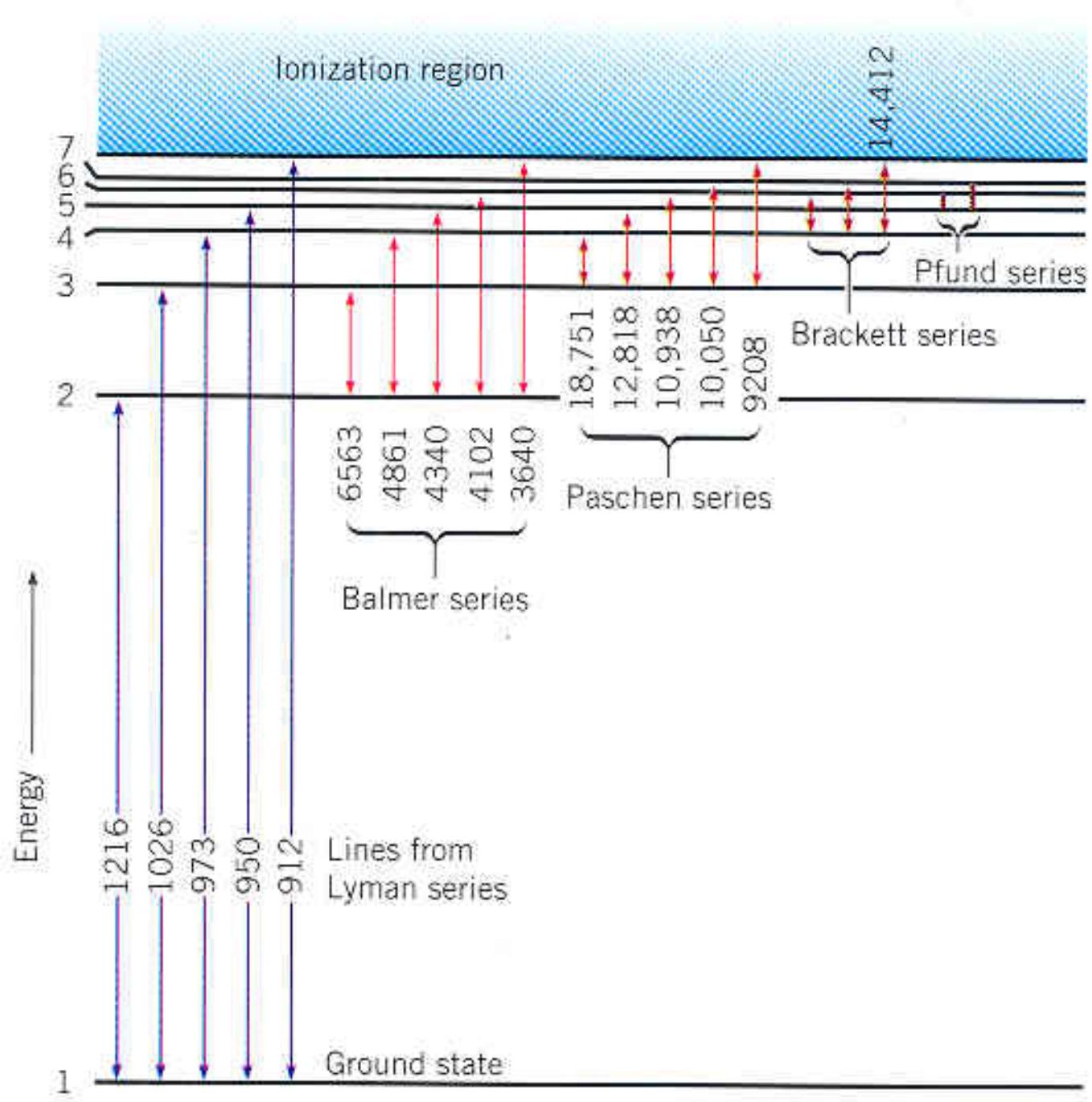
⋮

M stars very red

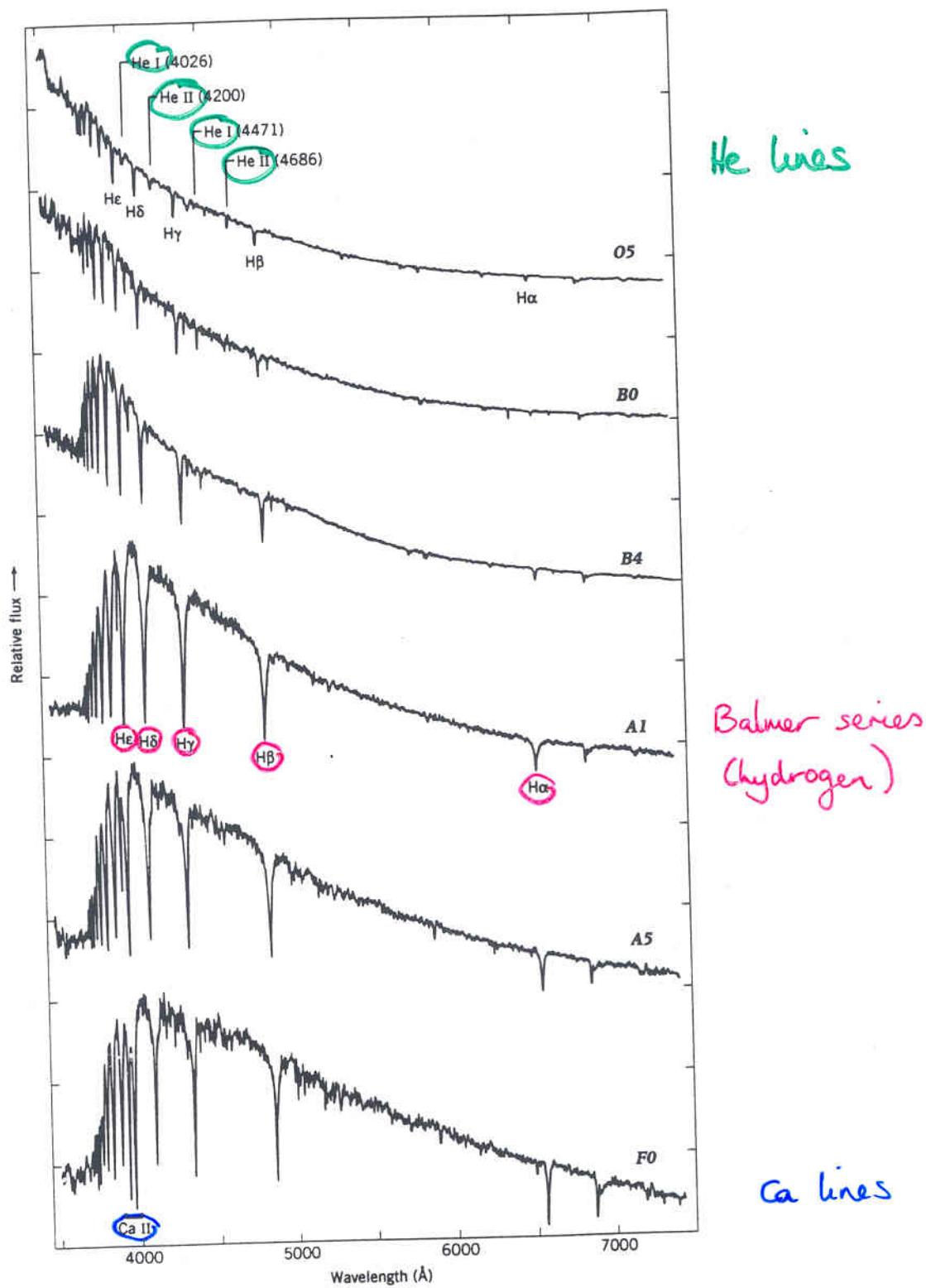
So, the star's temperature not only affects its color, but also what lines are seen in its spectrum

Review question

What do we need to produce the Balmer ~~sun~~ lines from a hydrogen atom ?

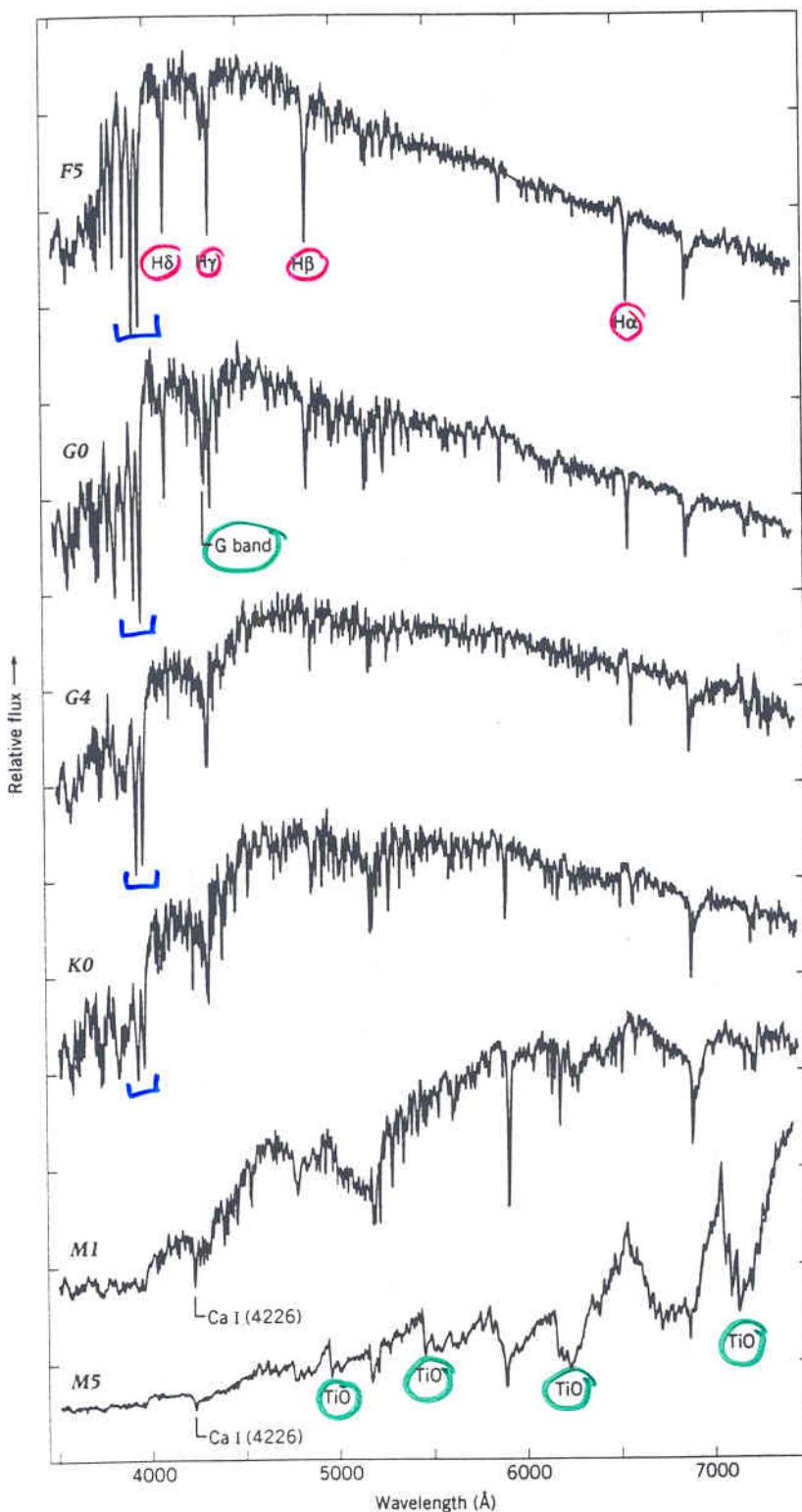


Part IV  
Discovering the Nature and Evolution of Stars



Kit Figure 14-1-1a Standard stars of known spectral type.

Part IV  
Discovering the Nature and Evolution of Stars



Balmer lines weaker

G band - not just a single line

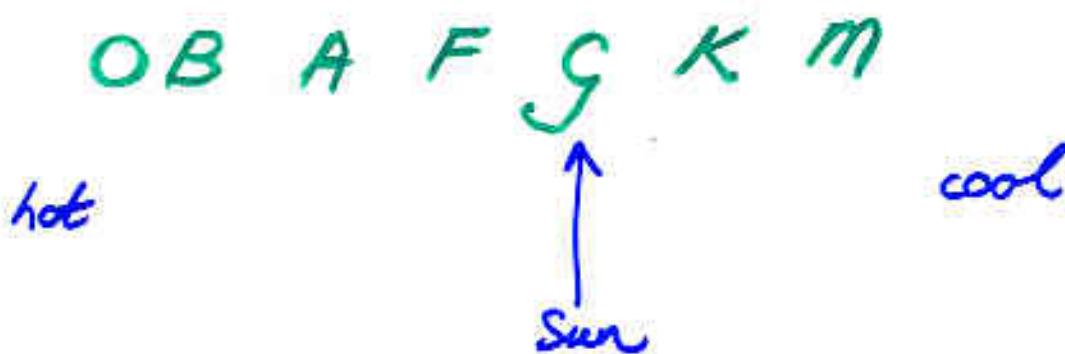
Ca lines strong

TiO and other molecules cause bands of absorption

Kit Figure 14-1-1b Standard stars of known spectral type.

Main thing that determines the appearance of a star's spectrum is its (photospheric) temperature

Spectral types :



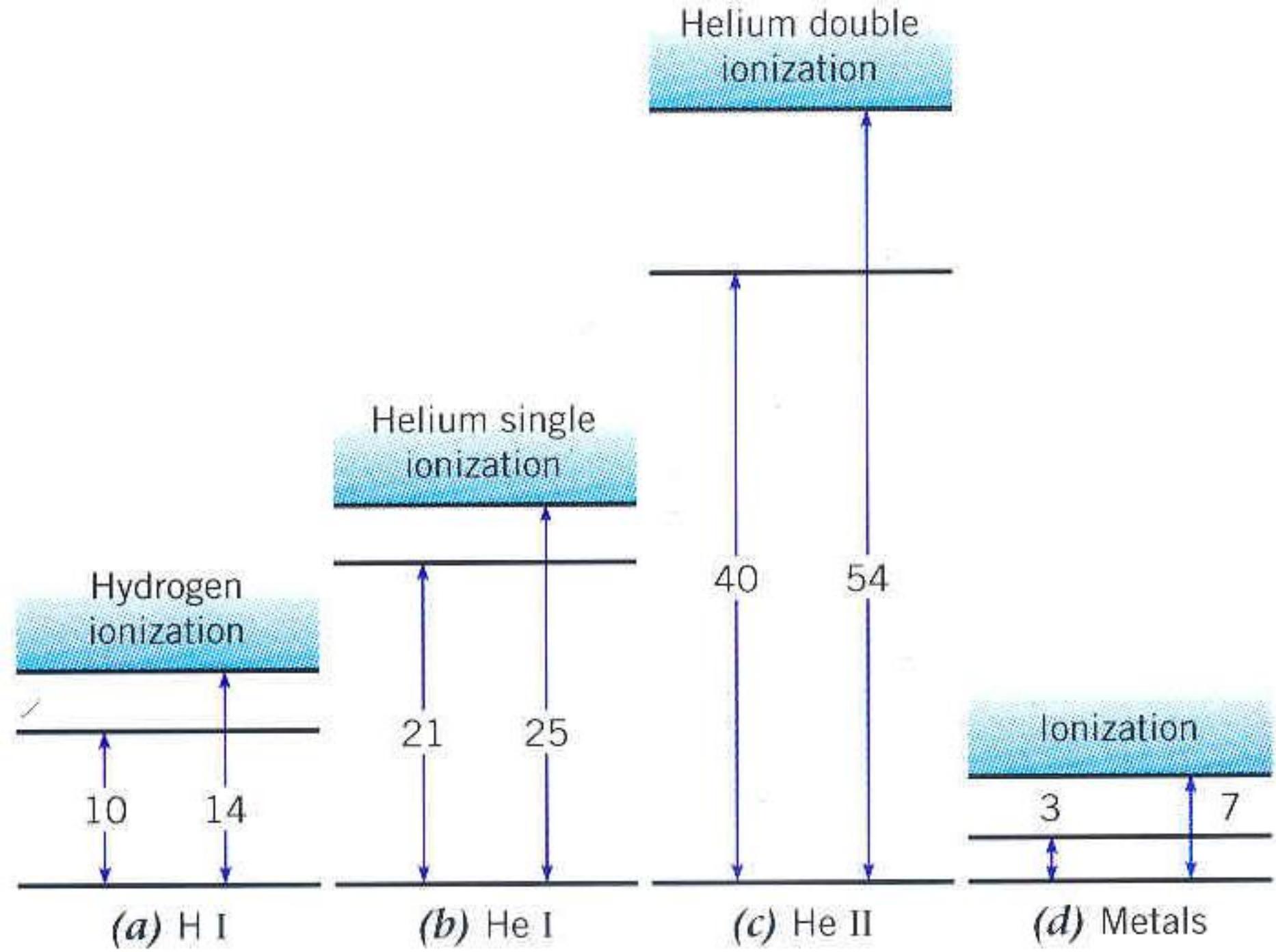
Recall that H and He are two most abundant elements in universe

So H lines are very important

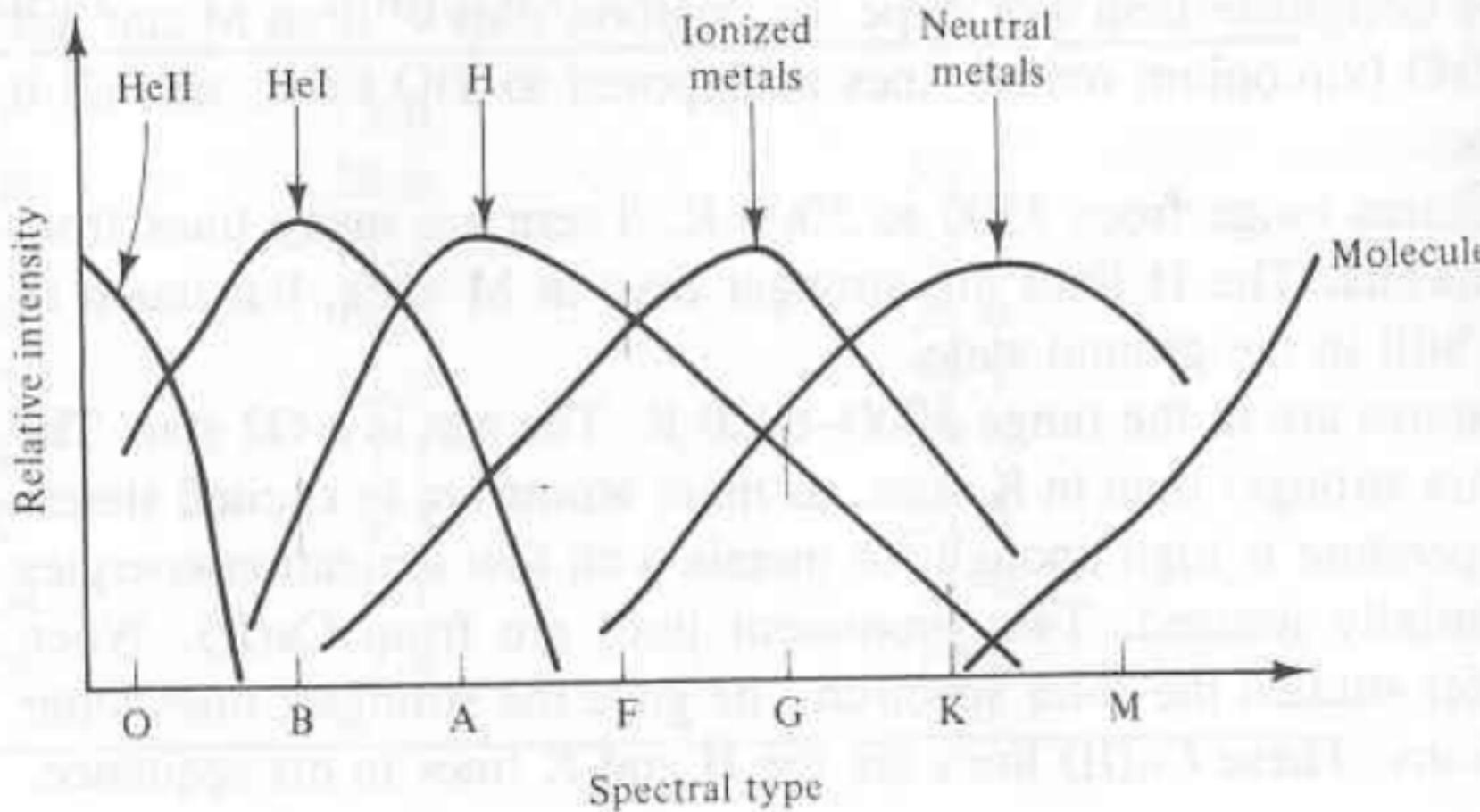
## Classification of stellar spectra

### \* what's important \*

- most of the Universe is hydrogen, so the Balmer series (transitions of H atom in visible region) is important
  - what it looks like
  - what transitions in the atom cause it
- He lines (next most common element; very hard to get a He atom excited)
- "metal" lines from elements such as Ca, Fe
- molecules in cool stars
- the physics that causes these lines to be seen in stars at different temperature



**Figure 3.10** The relative strength of spectral lines from important species as a function of spectral type. Each species shows the effects of excitation and ionization. For example, the increase in H line strengths from K to A stars is because the increasing temperature results in more hydrogen in the  $n = 2$  levels and higher. However, the higher temperatures of the B and O stars ionize the hydrogen, and the lines get weaker.



**TABLE 3.1** Ionization Energies (eV)

Atom	Singly ionized	Doubly ionized
H	13.6	
He	24.6	54.4
C	11.3	24.4
N	14.5	29.6
O	13.6	35.1
Na	5.1	47.3
K	4.3	31.8
Ca	6.1	11.9
Fe	7.9	16.2

## O, B stars

Hottest stars are so hot that all H in photosphere fully ionized  
⇒ no Balmer lines

## A stars

Temperature just right for Balmer lines : significant no of electrons in 1st excited state

## F, G, K, M stars

Cooler, so H in ground state

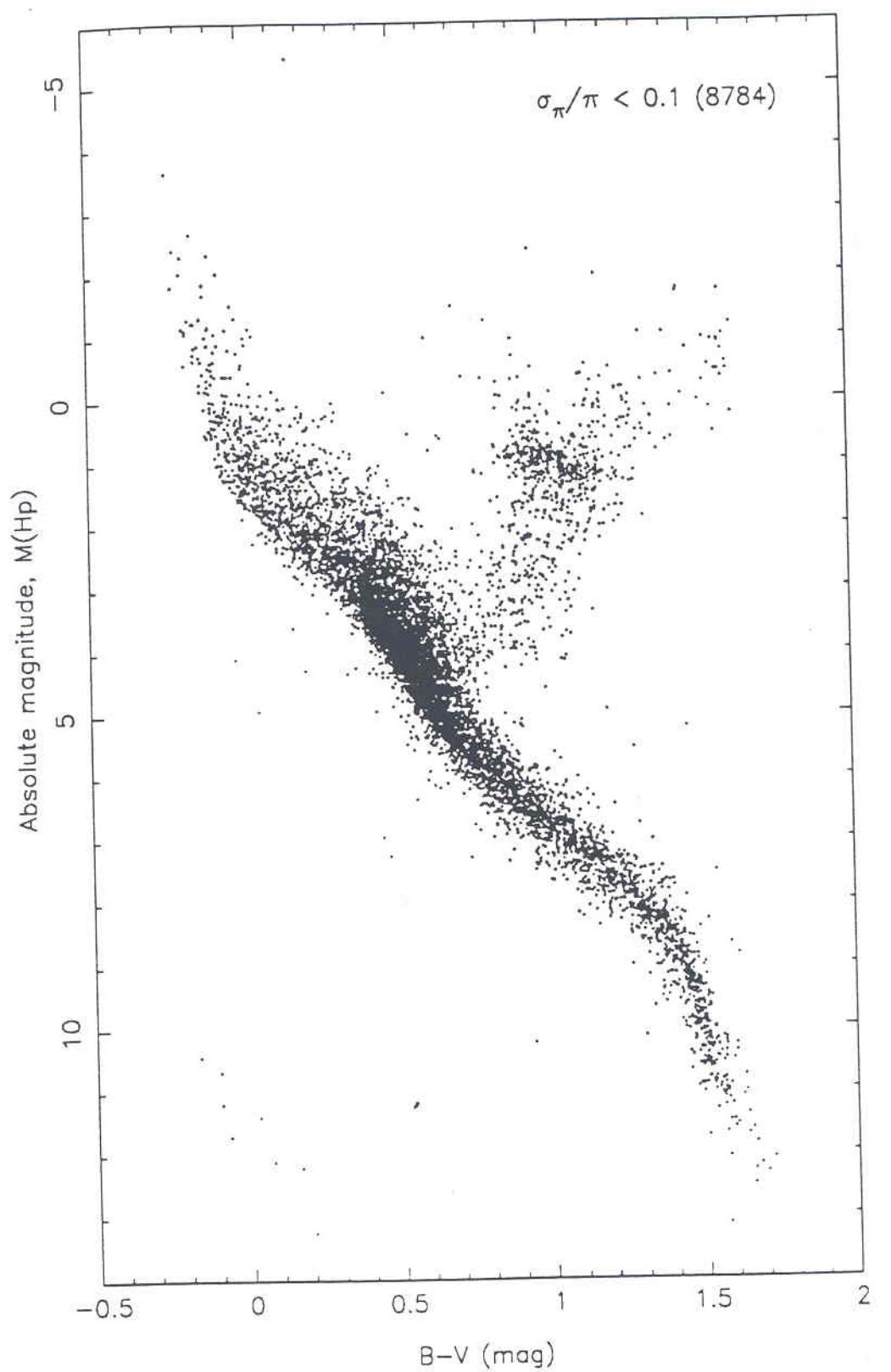
"Metal" lines stronger

Coolest ones have molecules surviving (TiO, etc)

## The H-R diagram

Plotting temperature ( $B-V$ , sp. type) against luminosity for a sample of stars shows that they are preferentially found in certain ranges of temp & luminosity

This is a very useful diagnostic for studies of stellar structure & evolution



Hipparcos satellite measured parallaxes very accurately  $\Rightarrow$  good  $M_V$ , i.e. luminosity measures