Doppler Effect
Telescopes
Stars

D.J. Pisano

Associate Professor of Physics & Astronomy

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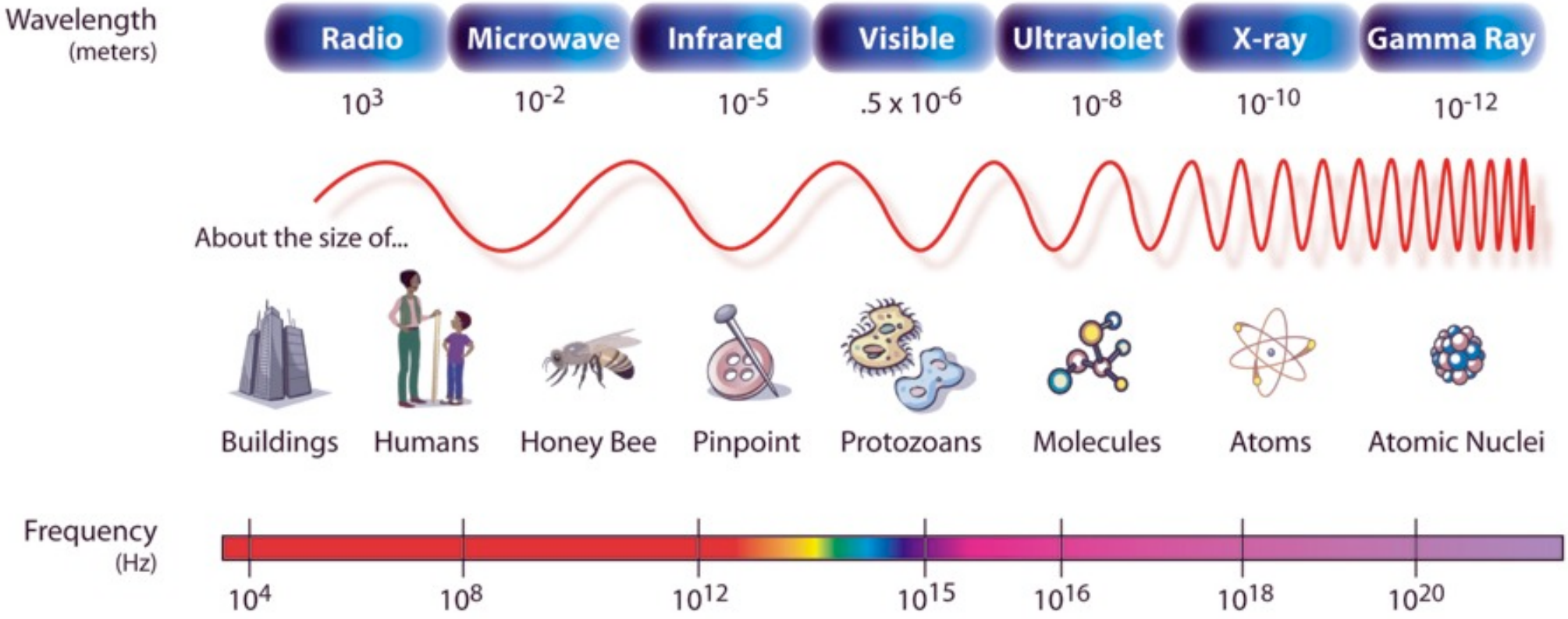
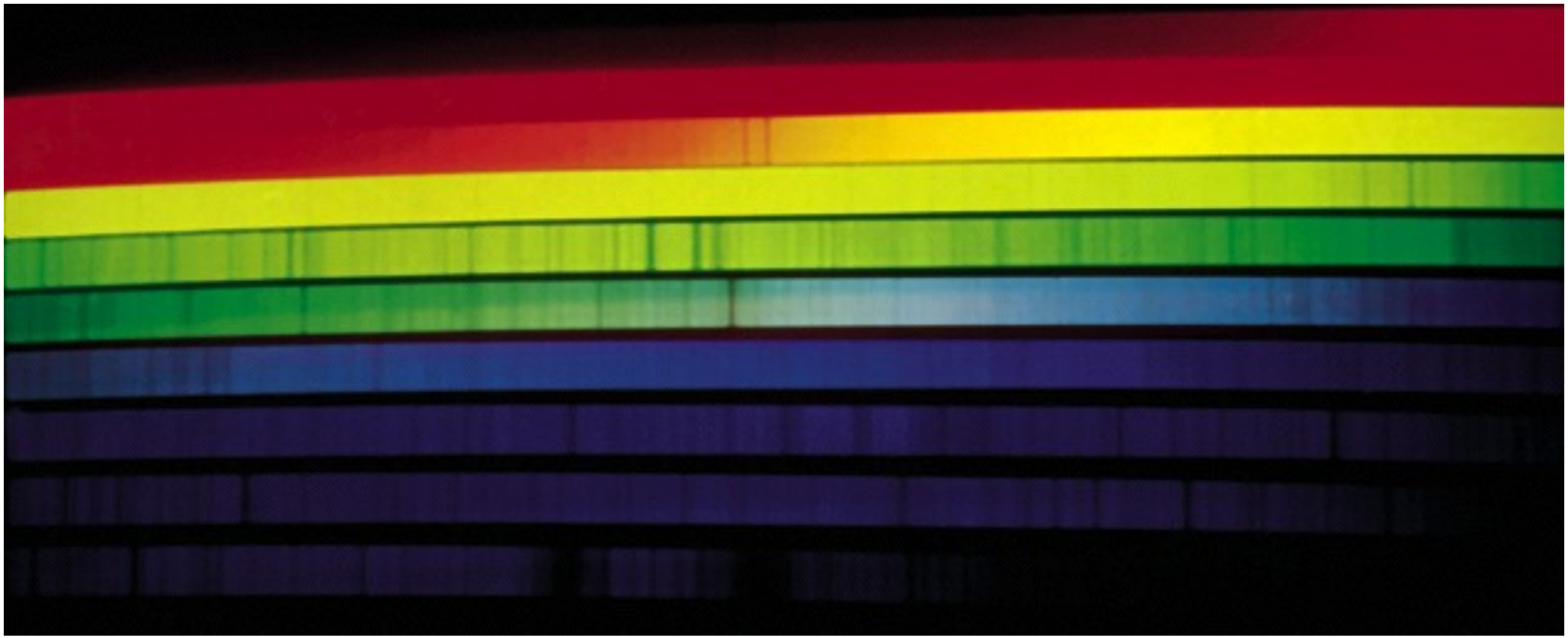
The Electromagnetic Spectrum

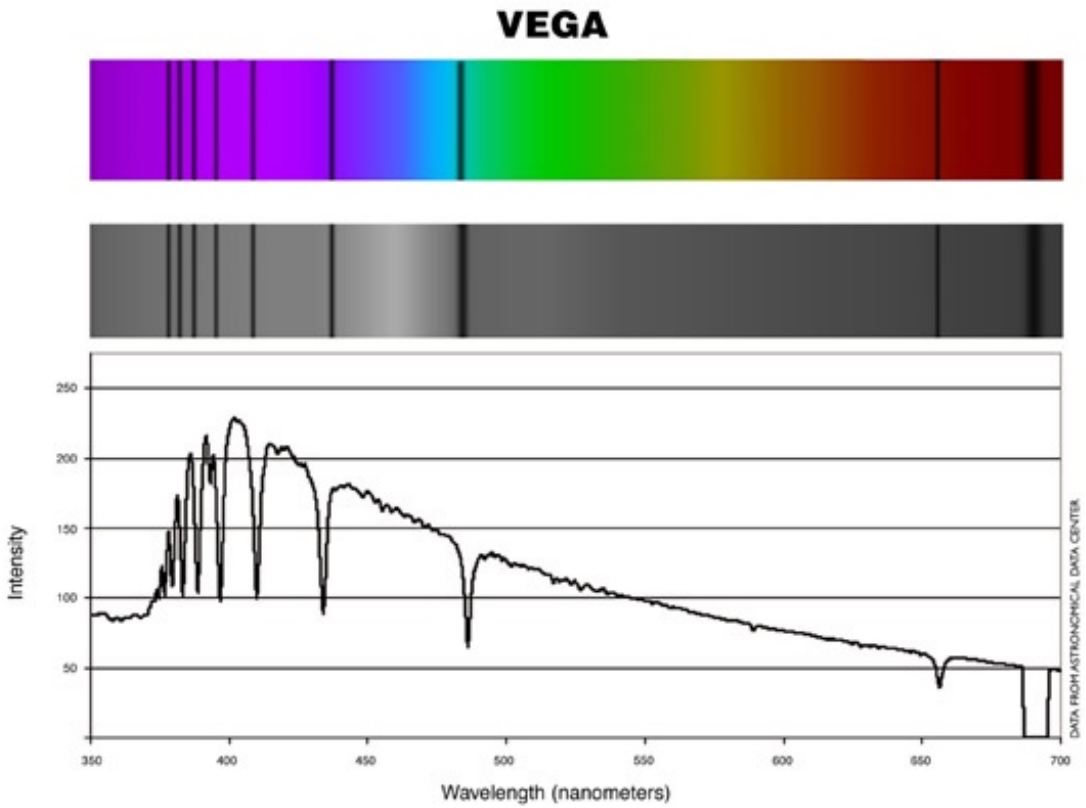


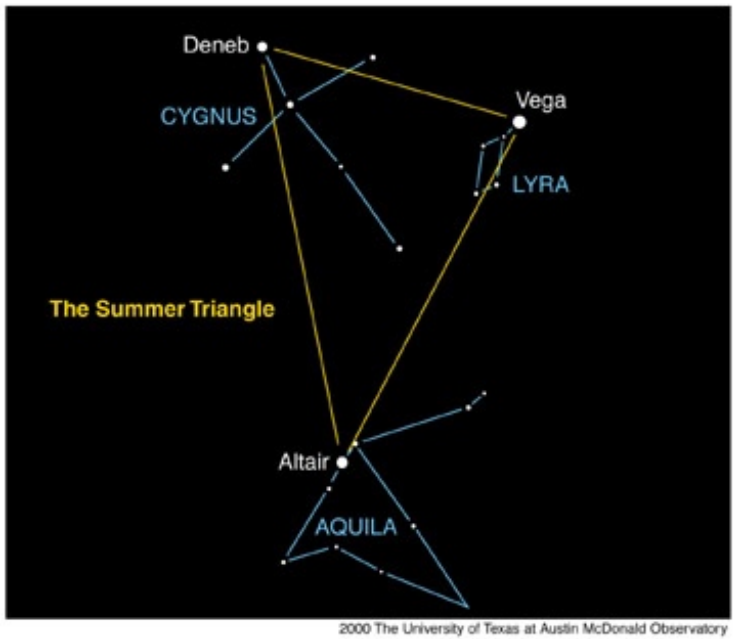
Lower Frequency = Longer Wavelength = Low Energy

Higher Frequency = Shorter Wavelength = High Energy

The Sun’s Spectrum





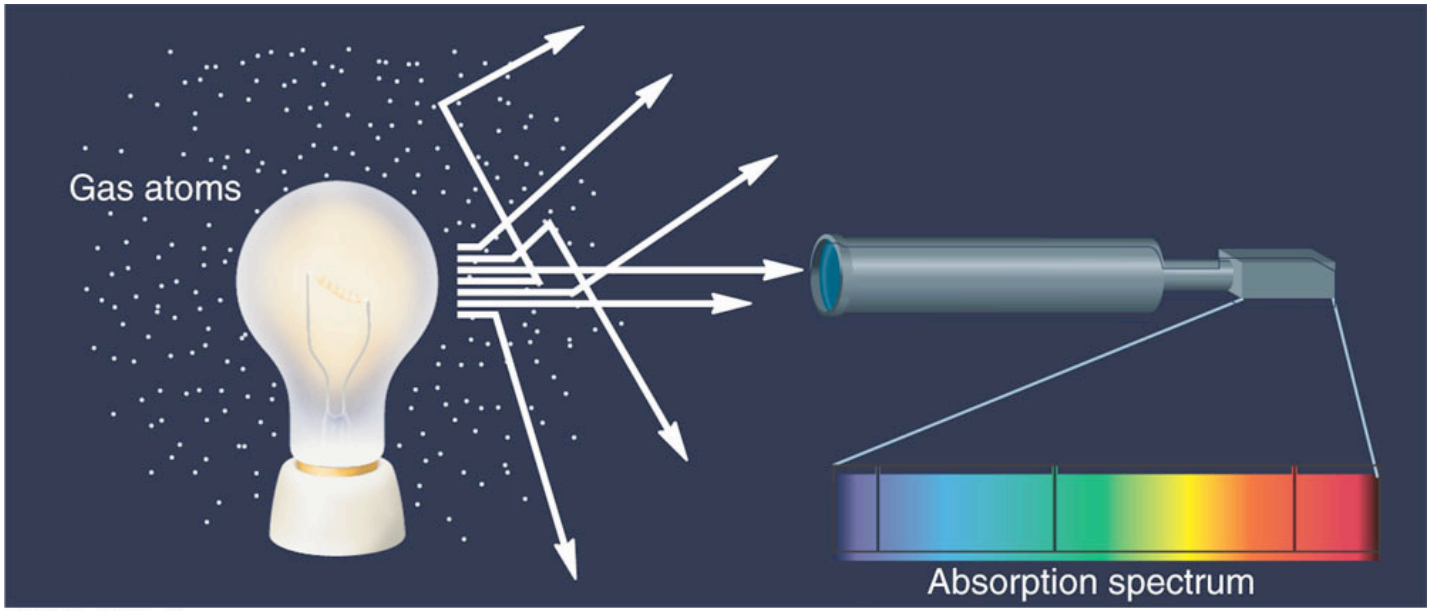


All stars produce dark line absorption spectra:

Why?

Kirchoff's Law #3

When light from a hot, dense object passes through a cooler, low density gas, the result is an *absorption spectrum.* The absorption lines are at the same location as the emission lines would be.

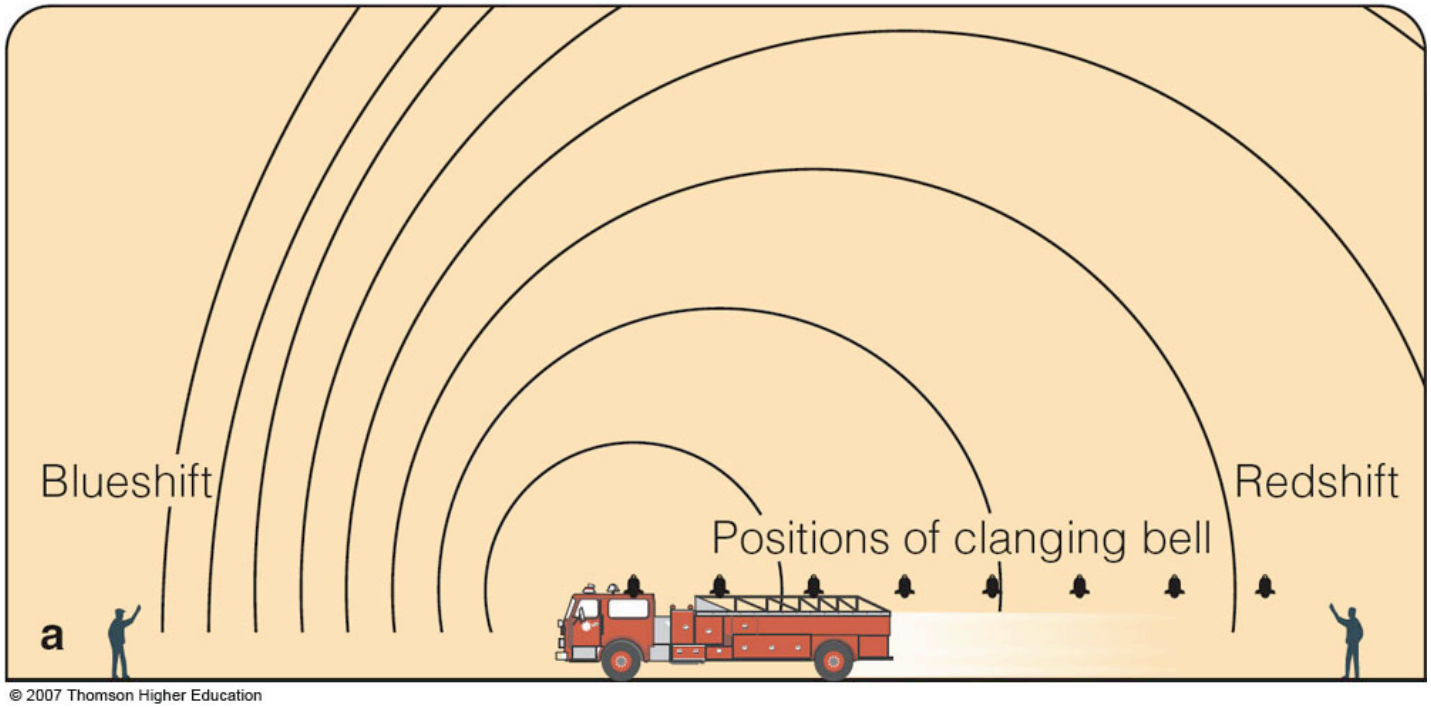


Doppler Effect

Definition: The change in wavelength of light due to the relative motion between the source and the observer along the line of sight.

Doppler Effect

The Doppler effect is the same for light as it is for sound.



higher frequency lower frequency

Doppler Effect

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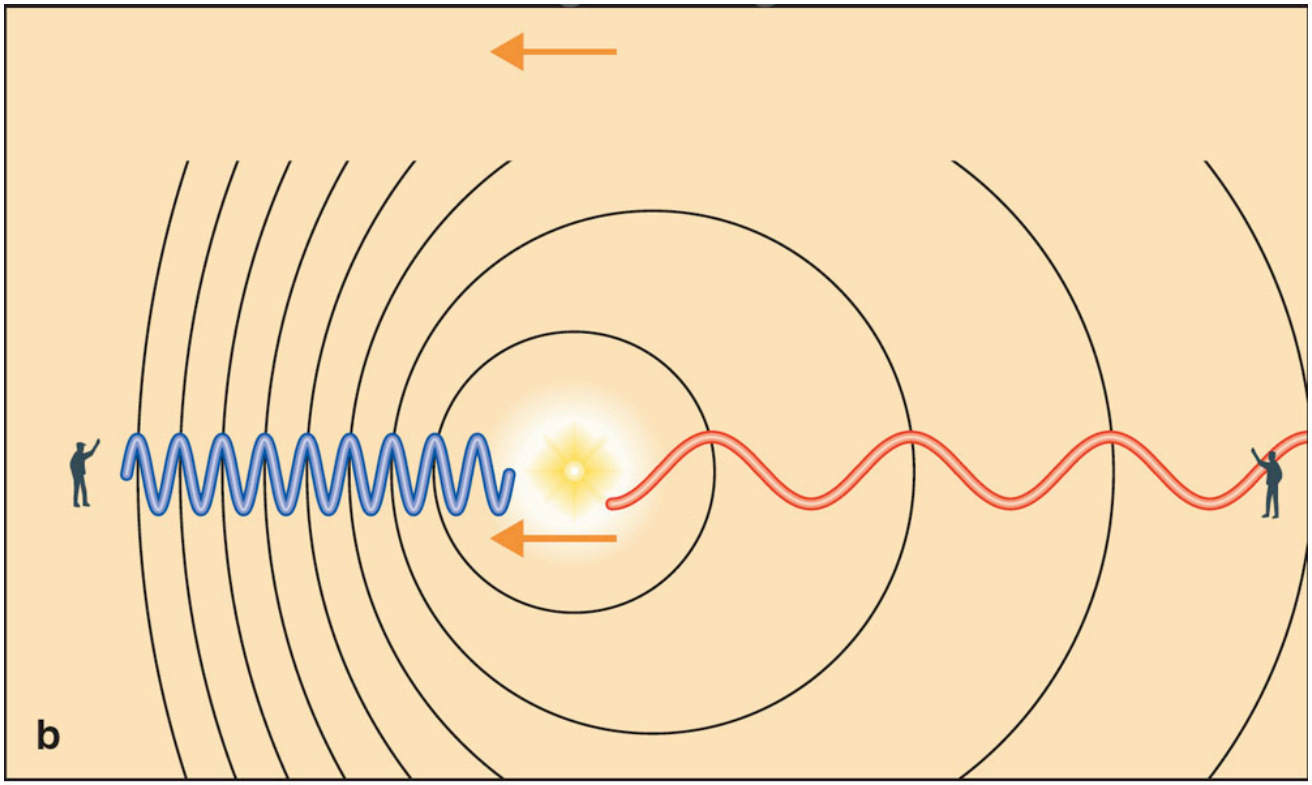
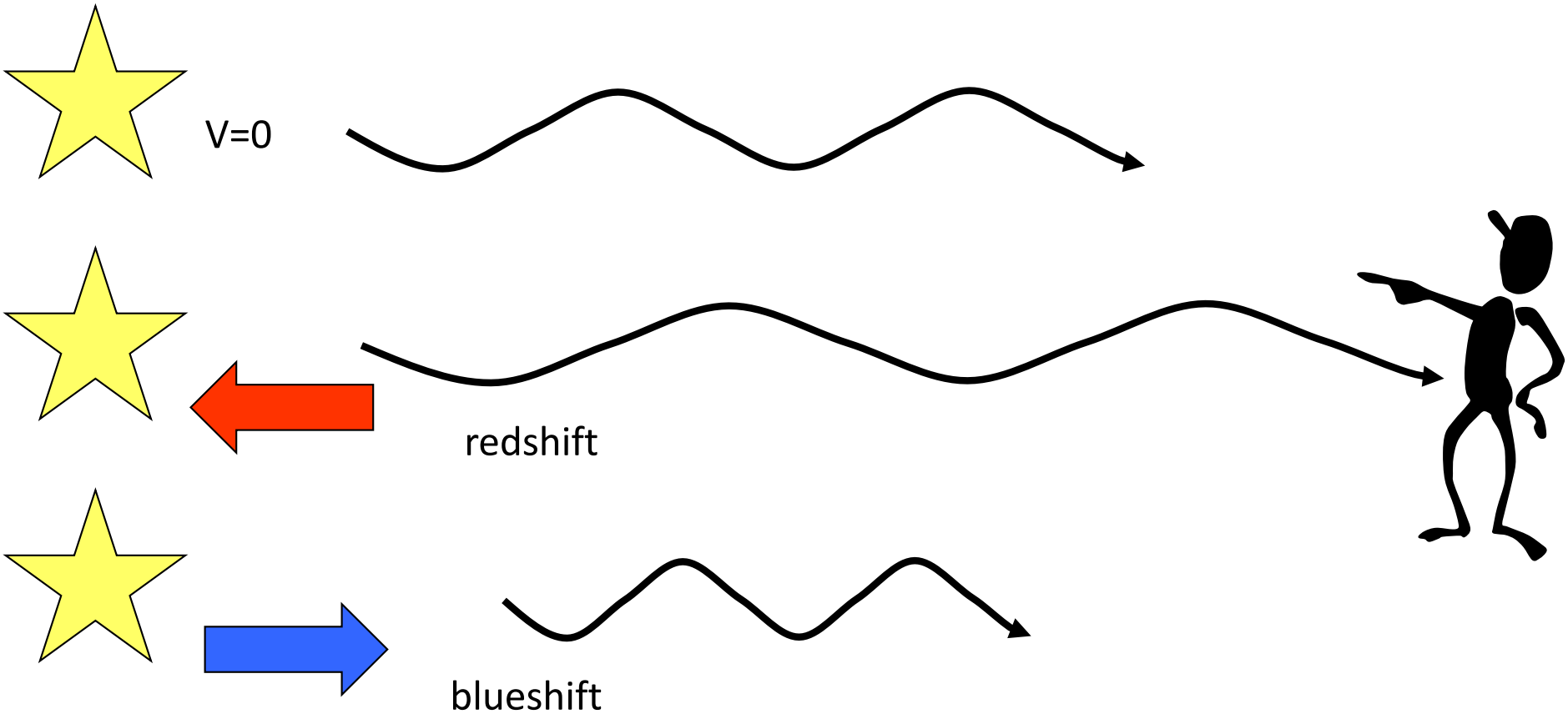


higher frequency

lower frequency

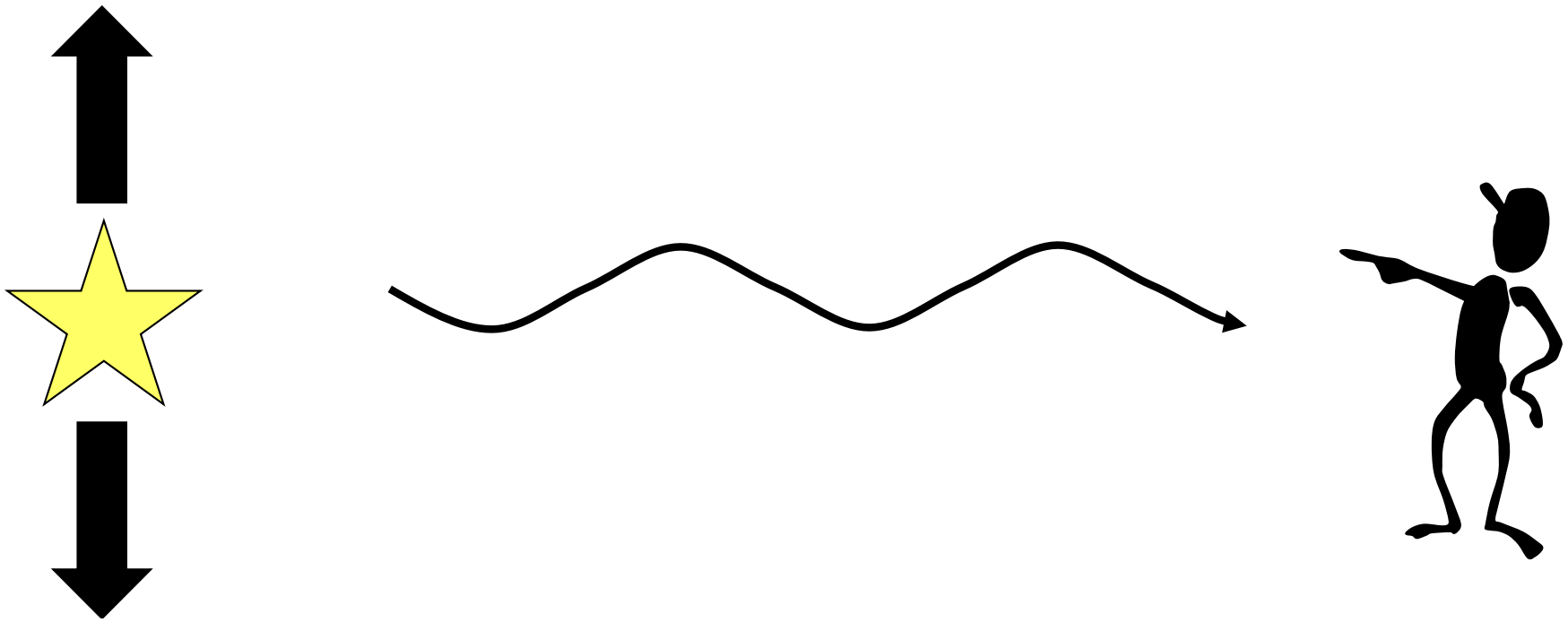
Doppler Effect

- When something which is giving off light moves towards or away from you, the wavelength of the emitted light is changed or shifted

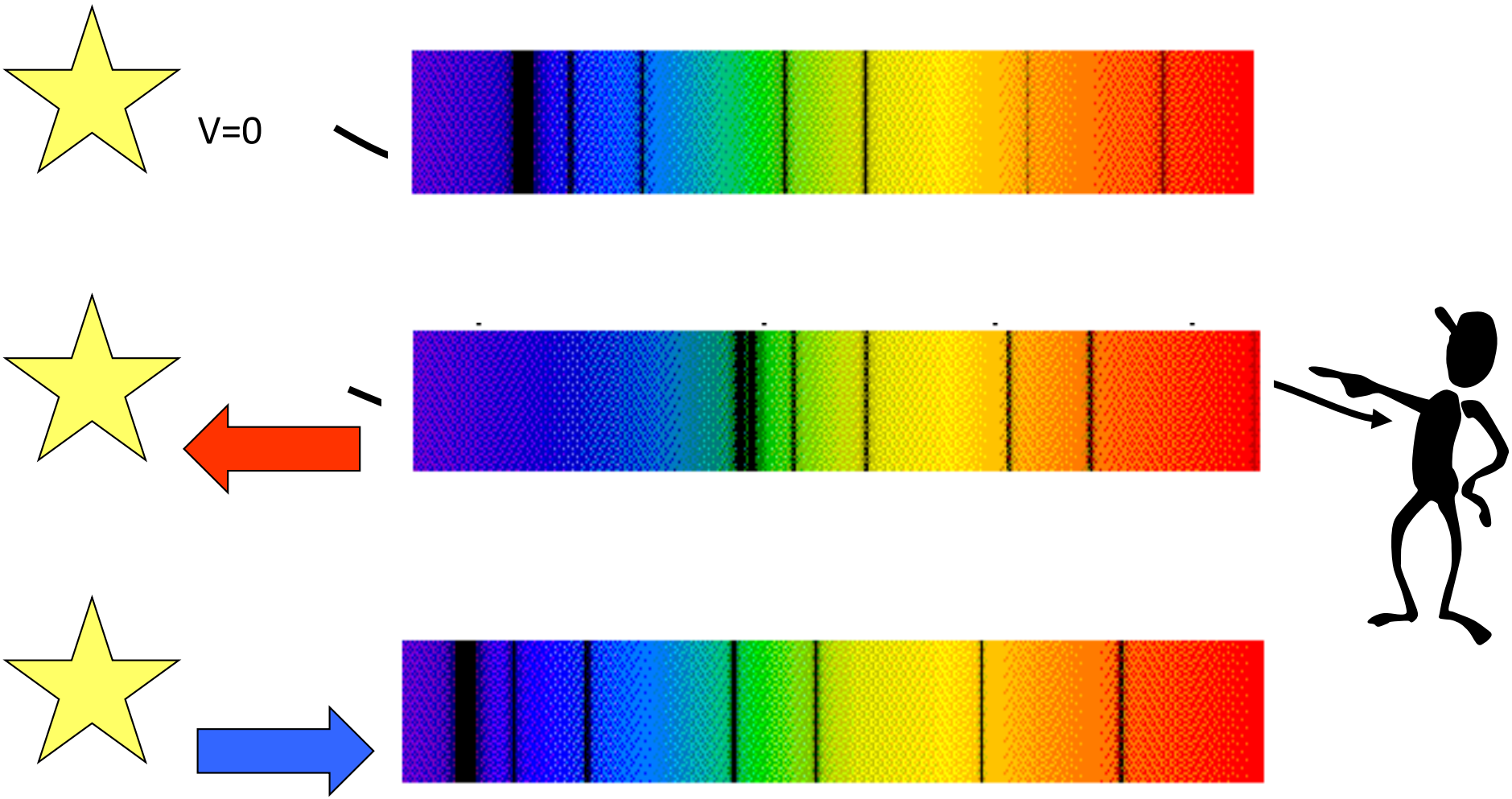


Doppler Effect

- "Along the line of sight" means the Doppler Effect happens only if the object which is emitting light is ***moving towards you or away from you***.
  - An object moving "**side to side**" or **perpendicular**, relative to your line of sight, will ***not*** experience a Doppler Effect.



Astronomy Application

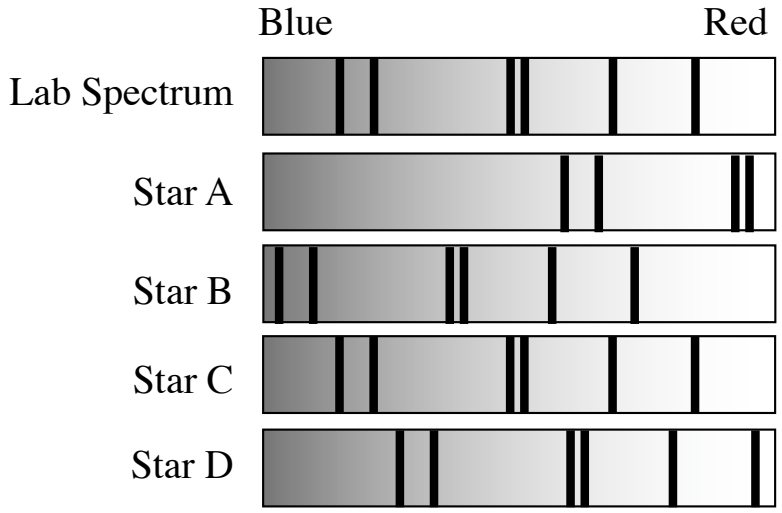


Review Questions

The Doppler Effect causes light from a source moving away to:

A. be shifted to shorter wavelengths.
B. be shifted to longer wavelengths.
C. be unchanged.

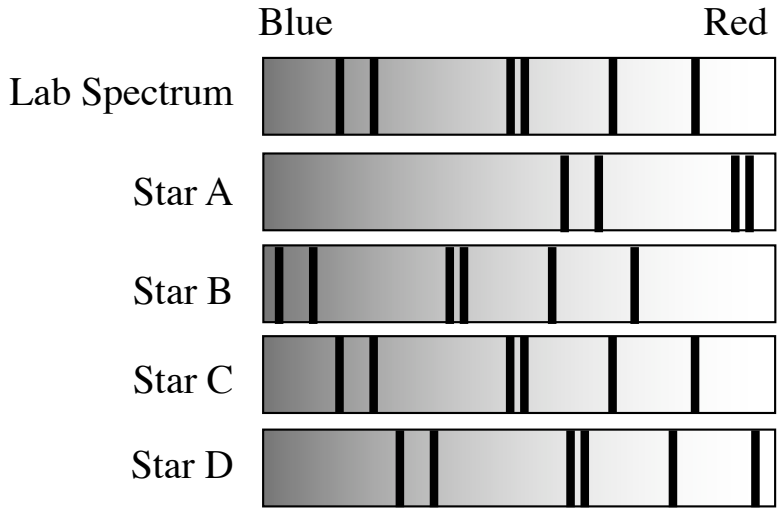
Consider the following spectra. The lab spectrum is not moving, the remainder are from stars that are either moving towards or away from us or are at rest.



Which star shows the greatest redshift?

(E = they are all the same)

Consider the following spectra. The lab spectrum is not moving, the remainder are from stars that are either moving towards or away from us or are at rest.



Which star shows the greatest blueshift?

(E = they are all the same)

A bright star is moving toward Earth. If you were to look at the spectrum of this star, what would it look like?

A. an absorption spectrum that is redshifted relative to an unmoving star
B. an emission spectrum that is redshifted relative to an unmoving star
C. a continuous spectrum that is blueshifted relative to an unmoving star
D. an absorption spectrum that is blueshifted relative to an unmoving star
E. a continuous spectrum that is redshifted relative to an unmoving star

But to look at this light....

We need to use telescopes.

Why?

Three main functions of a telescope

Most important!!

- **Gather More Light** – (bigger Is better) *making objects appear brighter*

followed by

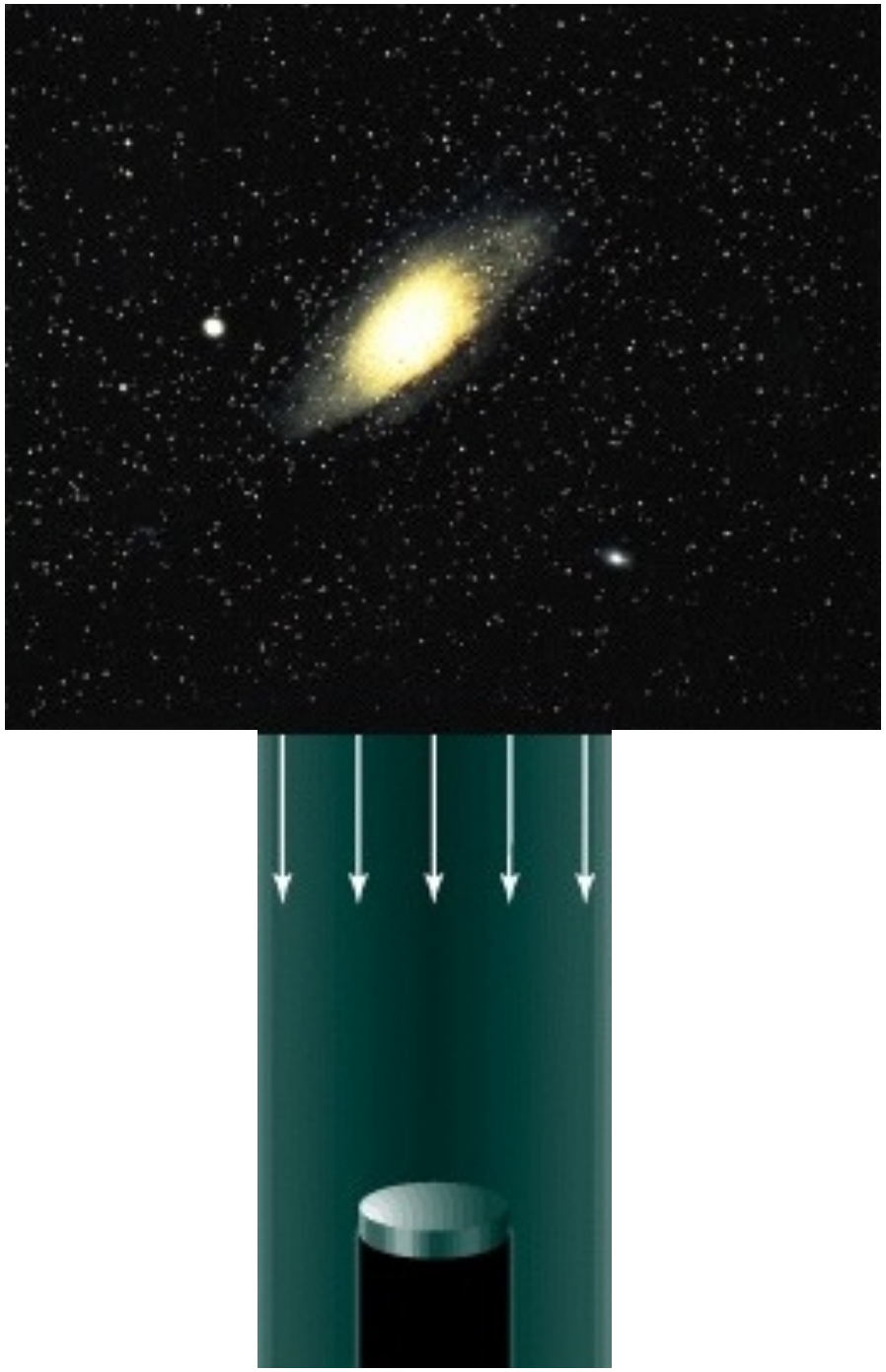
- to see fine detail

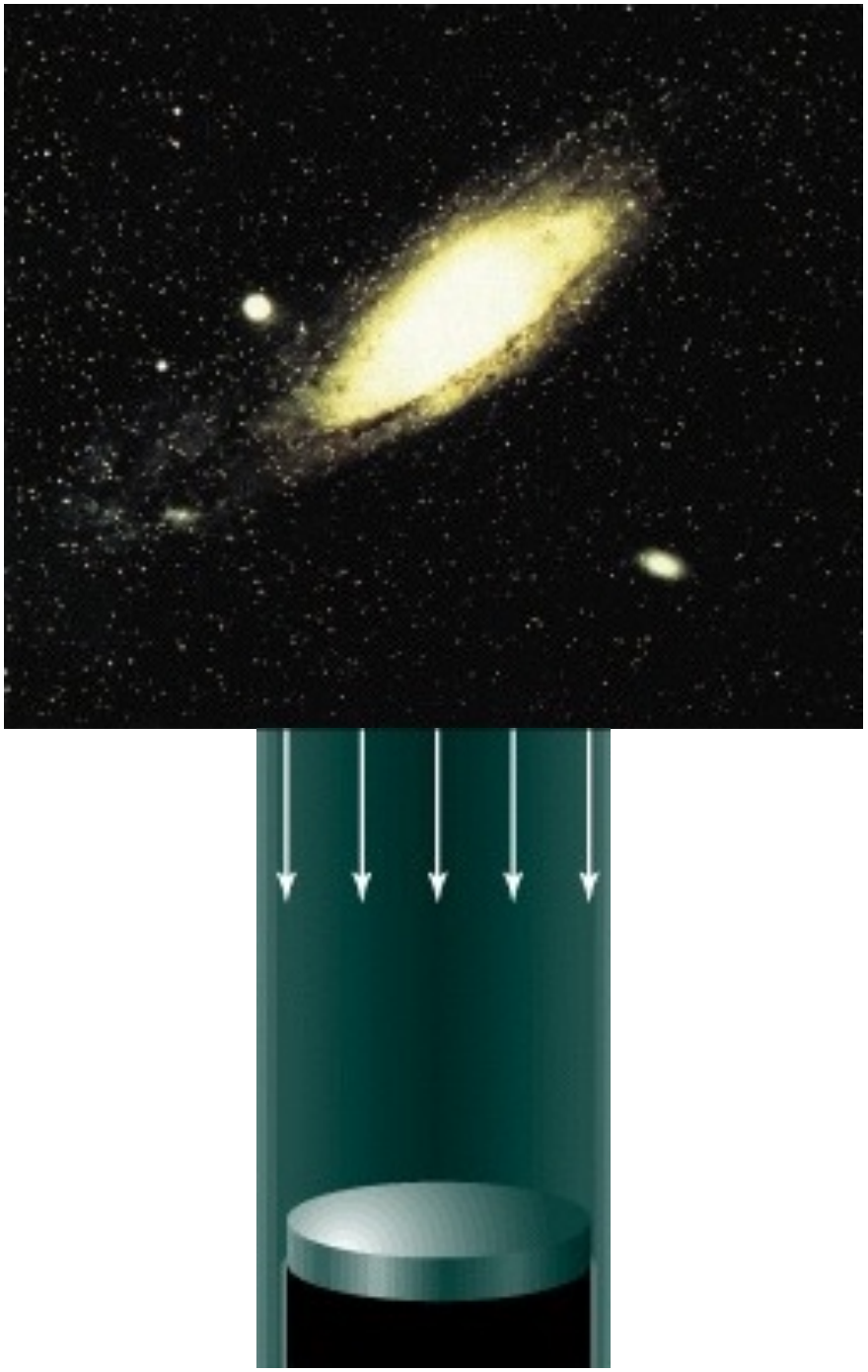
  (called resolution)

and least important,

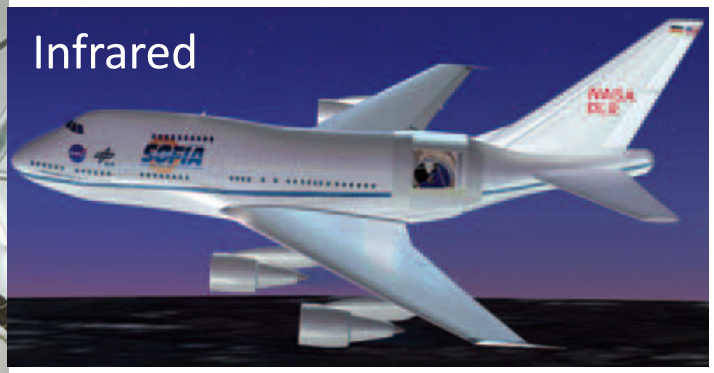
- magnify

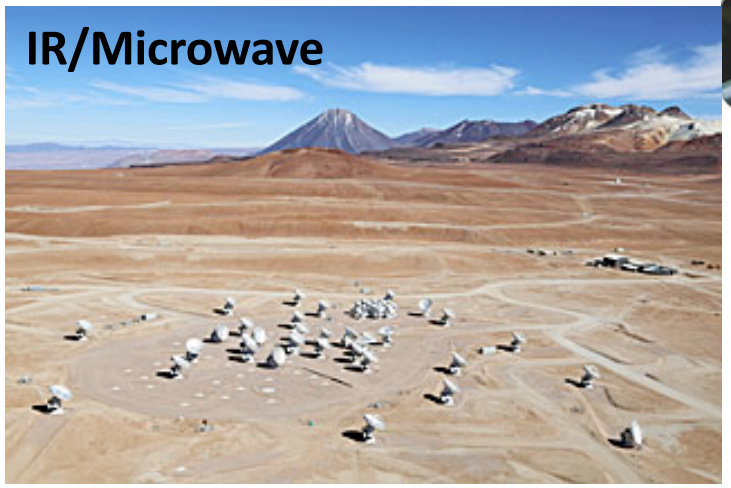
  magnification = (objective lens focal length / eyepiece lens focal length)

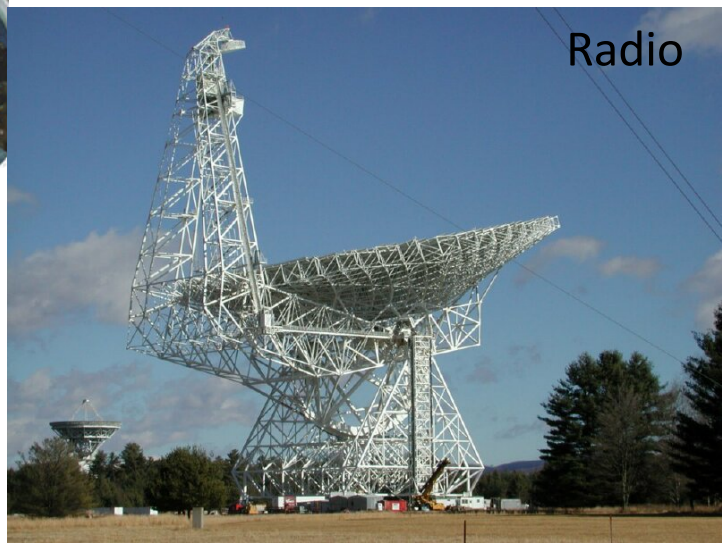




Examples of Telescopes



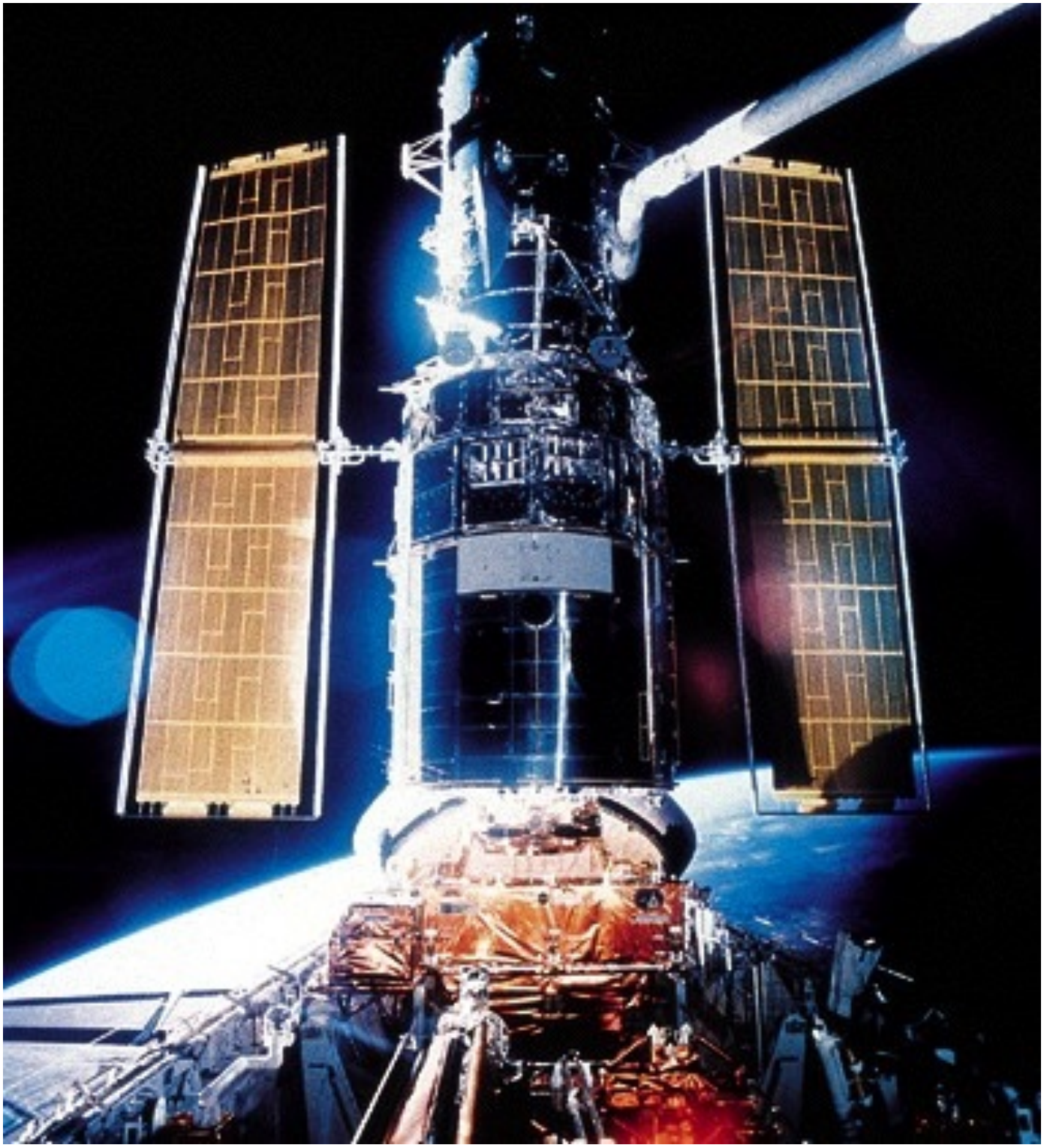




Why go into space?

To get above the atmosphere. Why?

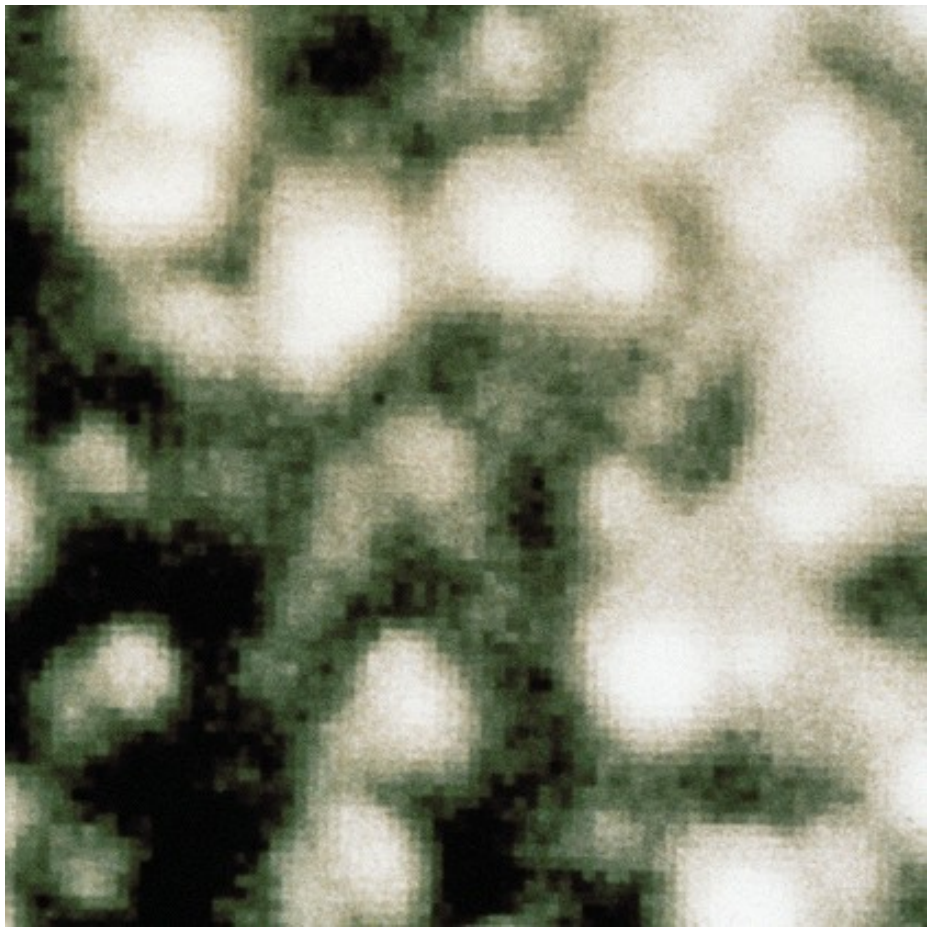
1. The atmosphere distorts some light that reaches the ground.
2. Some light does not reach the ground.



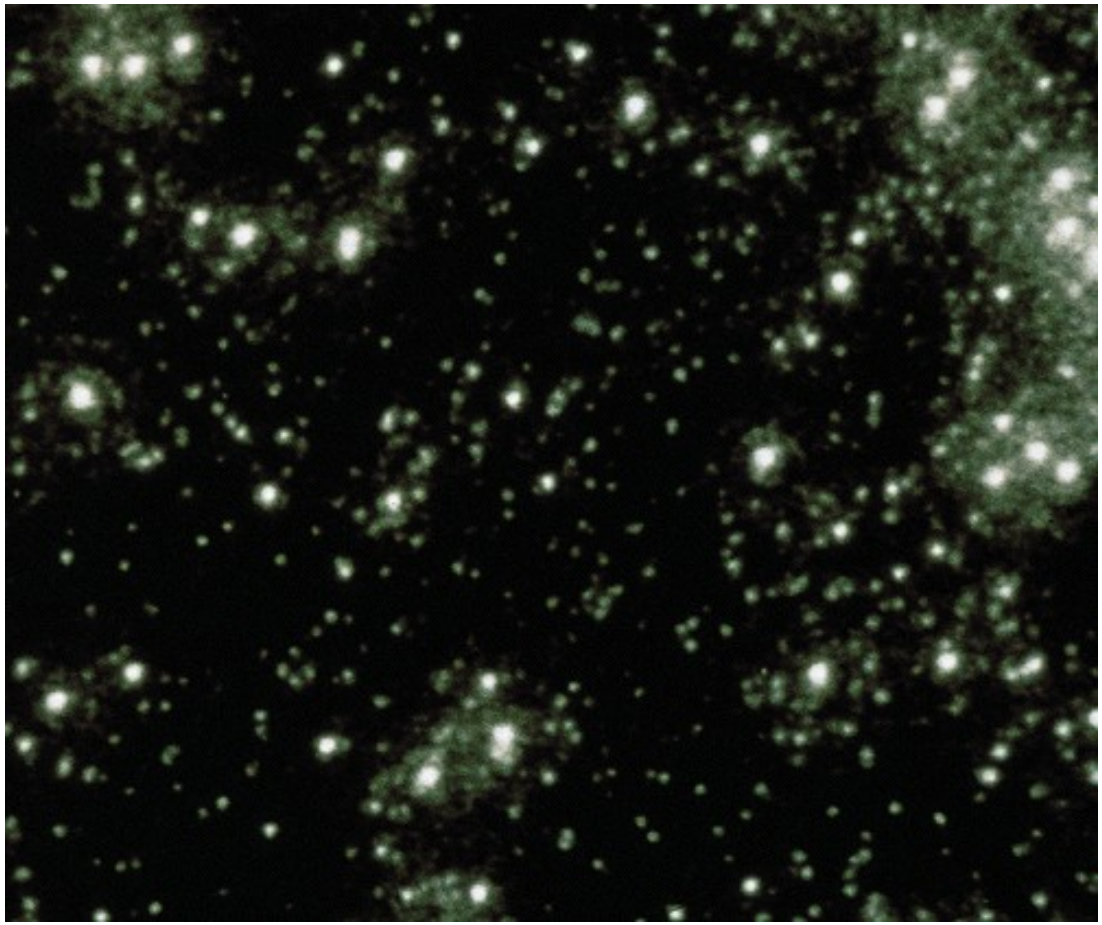
High above Earth's atmosphere, the Hubble Space Telescope provides stunning details about the universe

Earth’s atmosphere hinders astronomical research

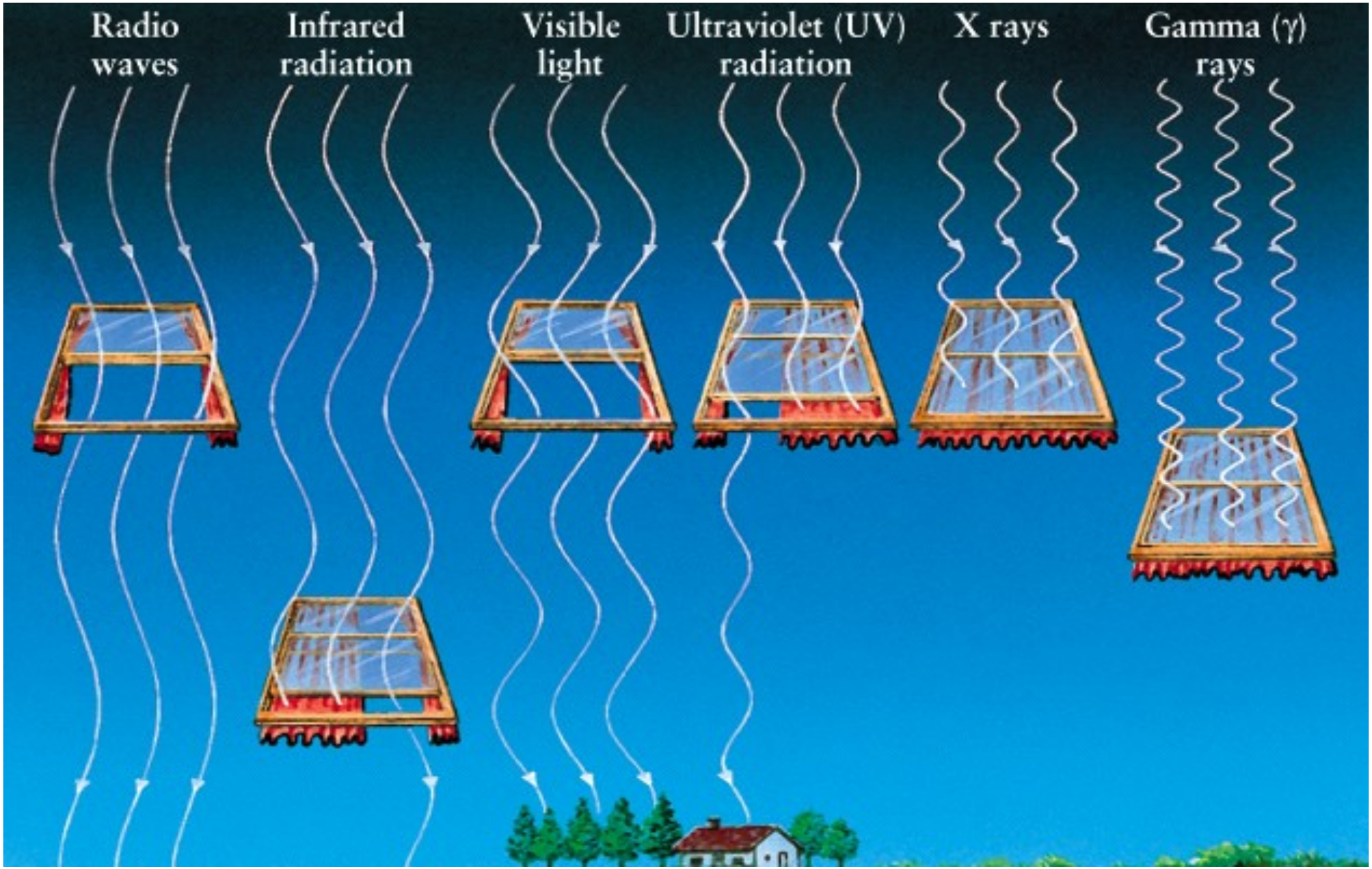
Image of stars taken with a telescope on the Earth’s surface



Same picture taken with Hubble Space Telescope high above Earth’s blurring atmosphere



Not all EM radiation can penetrate Earth's atmosphere.



Factors in locating telescopes

For visible light telescopes: good weather, stable atmosphere (good “seeing”), away from lights.

Factors in locating telescopes

For ultraviolet, x-ray, gamma-ray telescopes: the light doesn't penetrate the atmosphere, so you need to put your telescope on a balloon, an airplane, a rocket, or a satellite.

Factors in locating telescopes

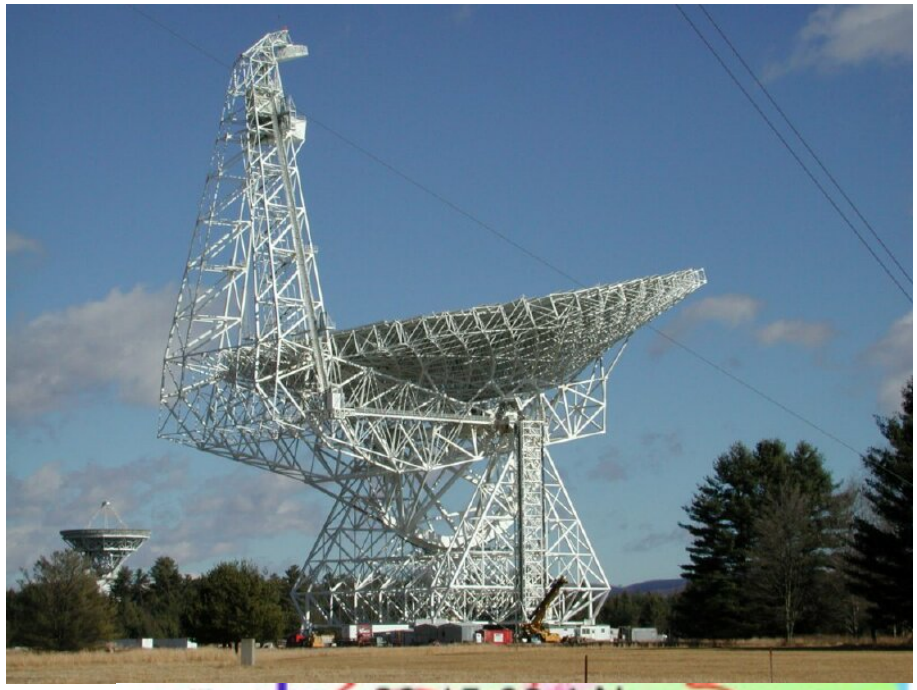
For infrared telescopes: the light is blocked by water and oxygen, so dry locations. Mountains, aircraft, satellites, the South Pole.

For microwave telescopes: the same conditions as infrared apply.

For radio telescopes: away from cellphones and radio stations, microwave ovens, cars, airplanes, people, etc…

Why put a telescope in WV?

- There are very few people.
- There is a “National Radio Quiet Zone”
- Therefore, no cellphones or radio stations near the telescopes.
- Also, no microwaves, Wii’s, wireless phones/networks, or cars with sparkplugs close to the telescopes.
- Minimizes light pollution in the form of radio frequency interference (RFI).



Imagine you're the head of a funding agency that can afford to build only one telescope. Which of the three proposed telescopes below would be best to support?

A. A gamma ray telescope in Antarctica
B. A radio telescope in orbit above the Earth
C. A visible telescope located high on a mountain in Peru
D. An ultraviolet telescope located in the Mojave desert

Stars

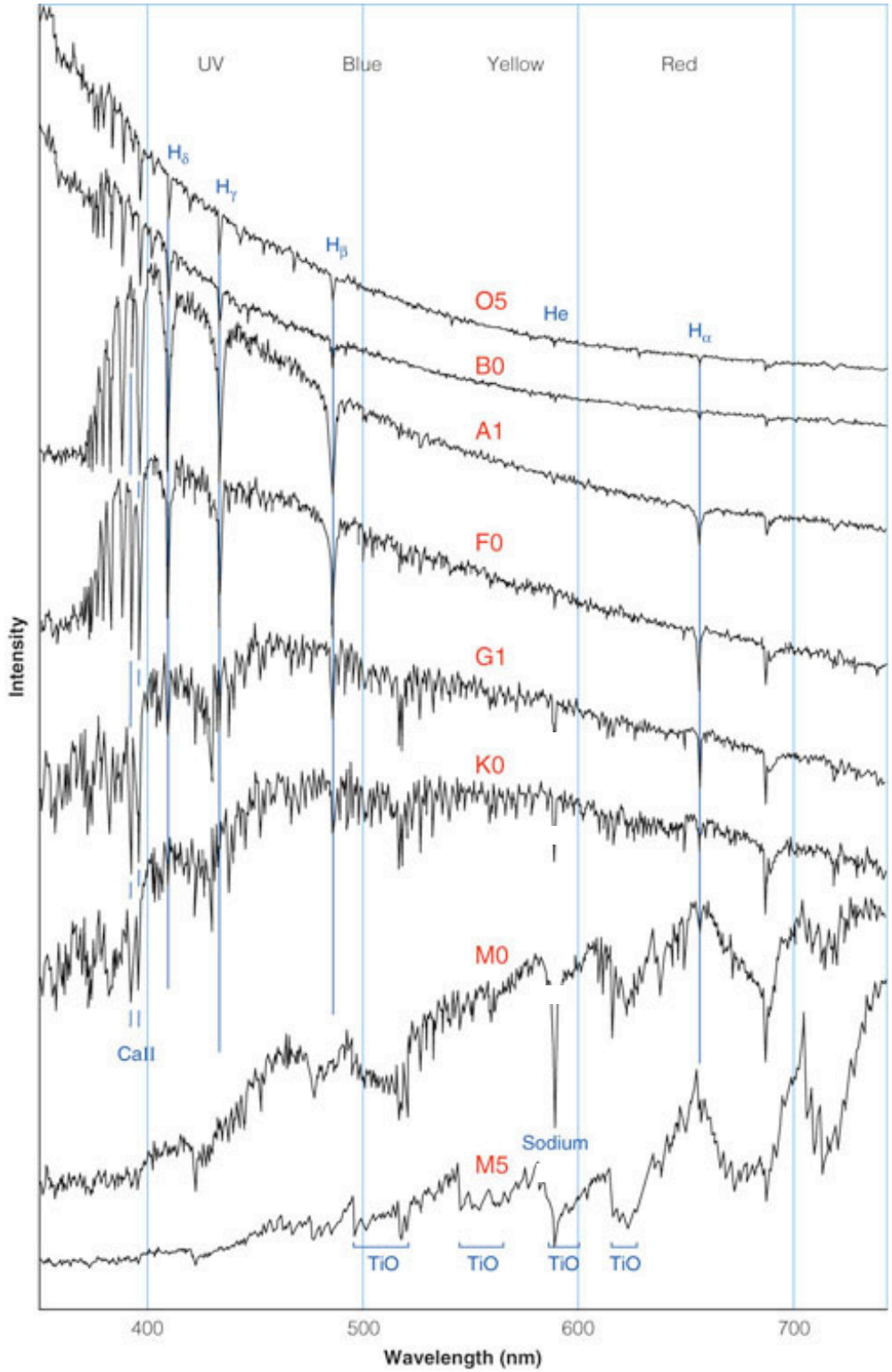
- So what do we know about stars by observing them?

Spectra of different stars
(at the same distance)

Which star is hottest?

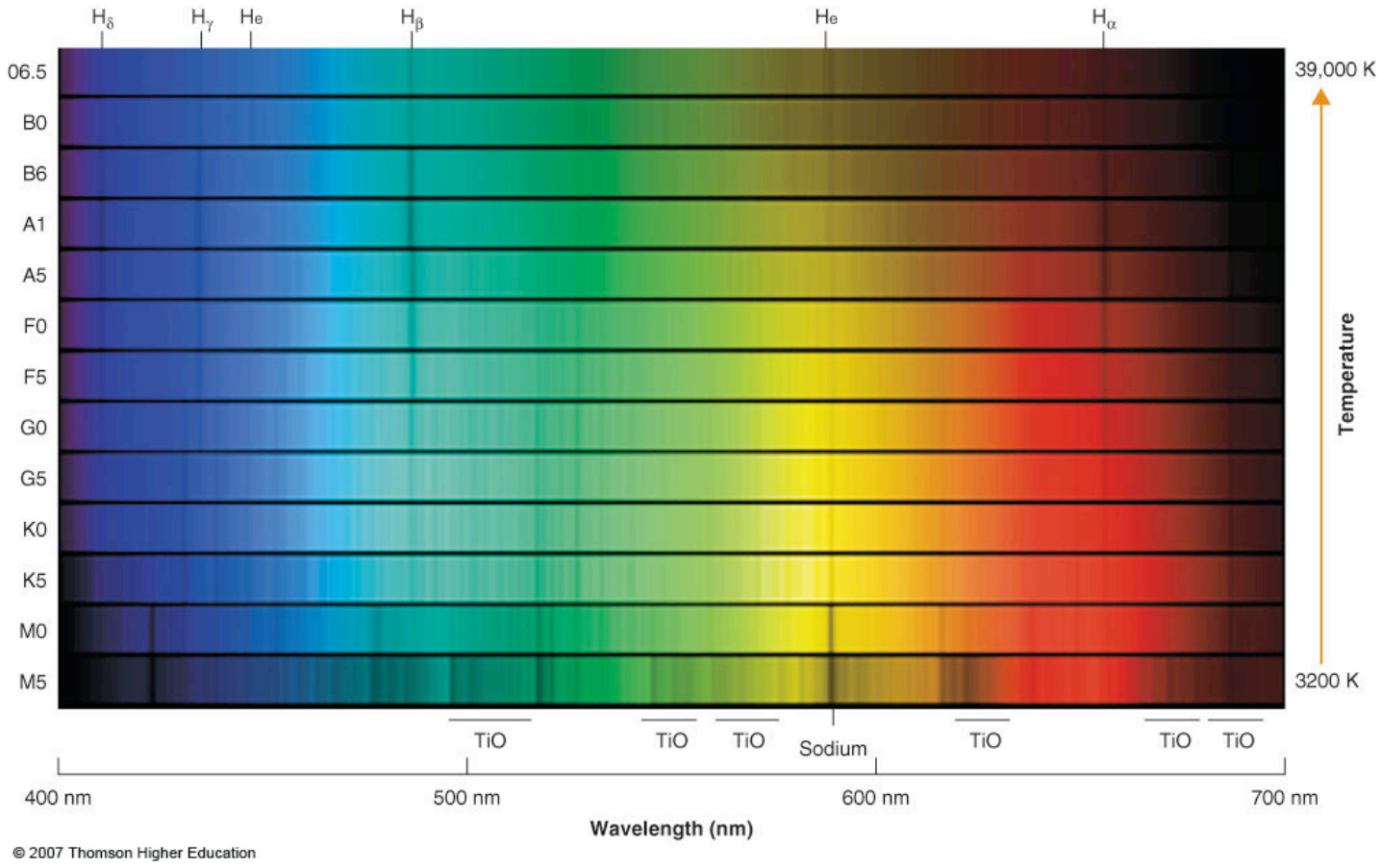
Which star is coolest?

Do you see any patterns?



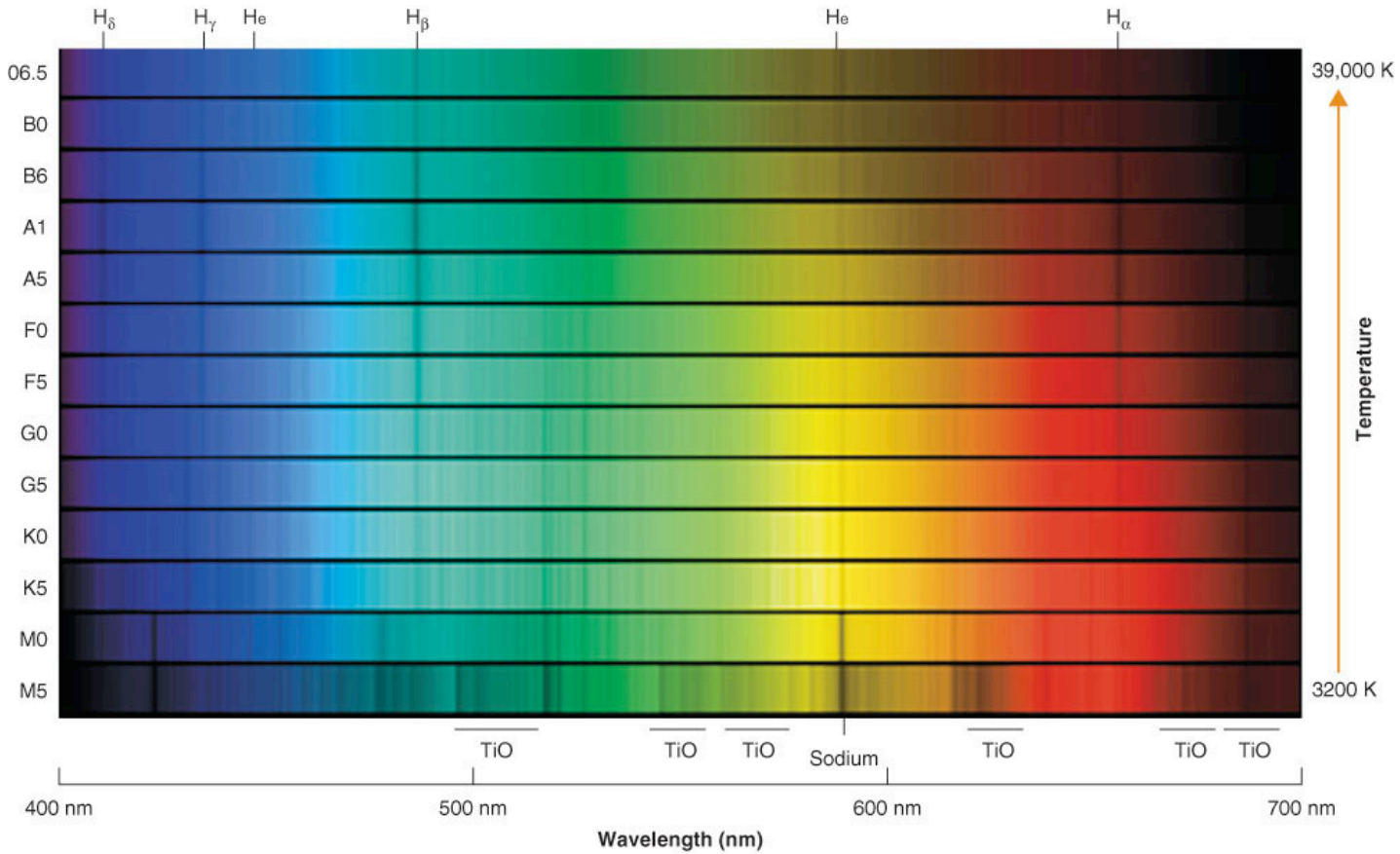
Spectral Classification

These are the same spectra in the same order you looked at them before (ordered by temperature).



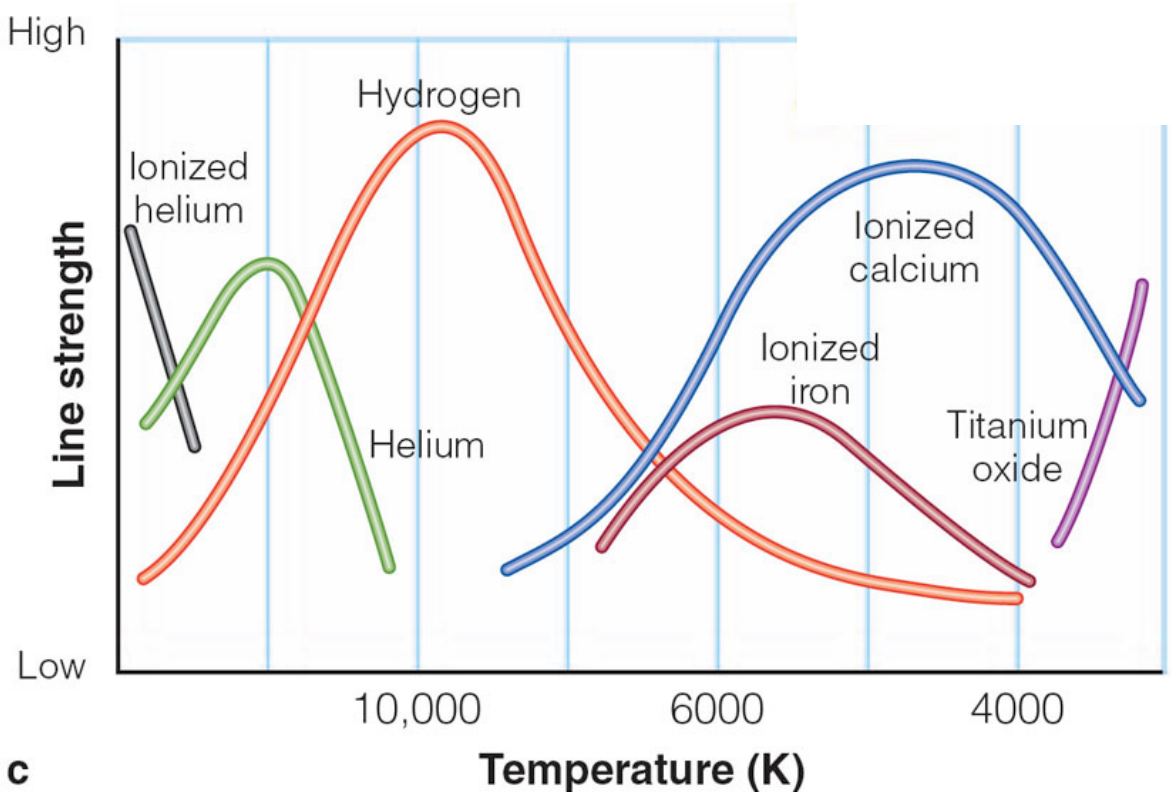
Spectral Classification

Notice that different lines appear and disappear as the temperature changes.



Spectral Classification

By measuring the relative depths of each line, we can determine the temperature of a star.



Summary of Spectral Classes

Table 6-1 | Spectral Classes

Spectral Class	Approximate Temperature (K)	Hydrogen Balmer Lines	Other Spectral Features
O	40,000	Weak	Ionized helium
B	20,000	Medium	Neutral helium
A	10,000	Strong	Ionized calcium weak
F	7,500	Medium	Ionized calcium weak
G	5,500	Weak	Ionized calcium medium
K	4,500	Very weak	Ionized calcium strong
M	3,000	Very weak	TiO strong

Stars are classified by their spectra as O, B, A, F, G, K, and M spectral types

- O B A F G K M
- hottest to coolest
- bluish to reddish
- Each class is further divided from 0-9 (e.g. A0 is hotter than A9, A9 is hotter than F0)
- An important sequence to remember:
  - Oh Be a Fine Guy (or Girl), Kiss Me
  - Overseas Broadcast - A Flash: Godzilla Kills Mothra
  - Oh, Boy, An F Grade Kills Me
  - Only Bad Astronomers Forget Generally Known Mnemonics.

For thousands of nearby stars we can find:

- the total luminosity
- the temperature (color or spectral type)
- the size (radius)
- the distance

CAN WE FIND ANY RHYME, REASON, OR RELATIONSHIPS?