Reading: Chapter 17; Chapter 19, section 19.2
Chapter 5, section 5.6; Chapter 17, section 17.4
Exam 1: Grades available on Canvas

Last time: **How does the Sun shine?**

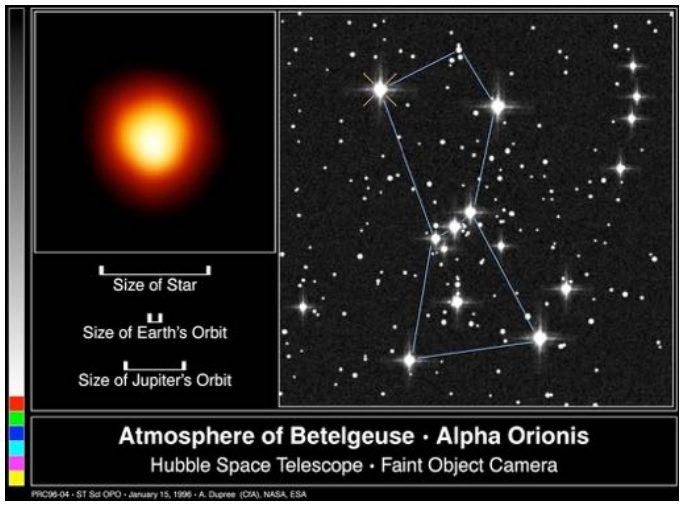
- We understand the inner workings of the Sun through our knowledge of physics.
- The Sun's interior produces huge amounts of energy that spreads from the center through to the surface in a variety of ways.
- The source of energy for the Sun is nuclear fusion.

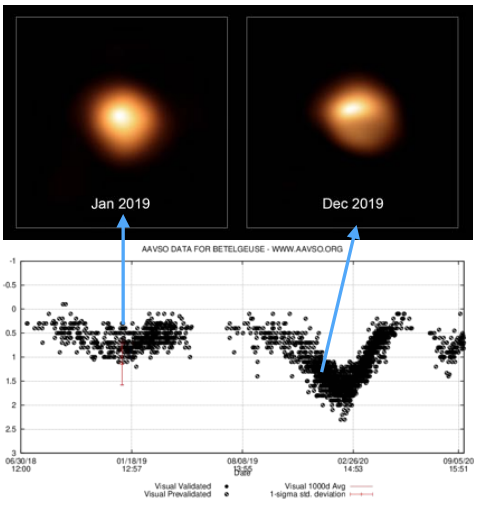
Today: **Too small to see, too bright to ignore**

- The surfaces of the stars are too small to fully resolve
- Stellar spectra display a range of features that depend on temperature and composition; **O B A F G K M**
- We measure the distances to the stars through stellar parallax

STARS!

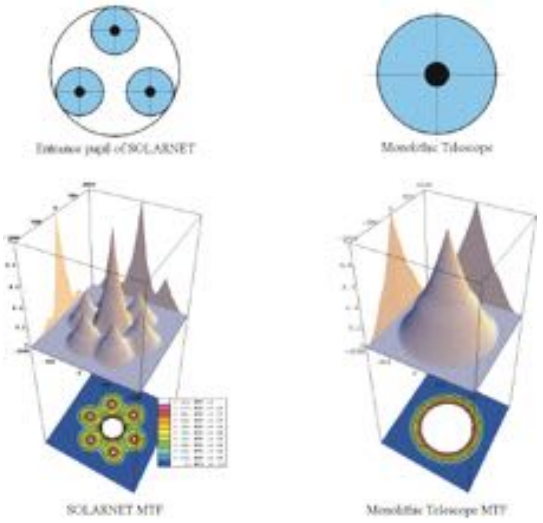
"too small to see, too bright to ignore"





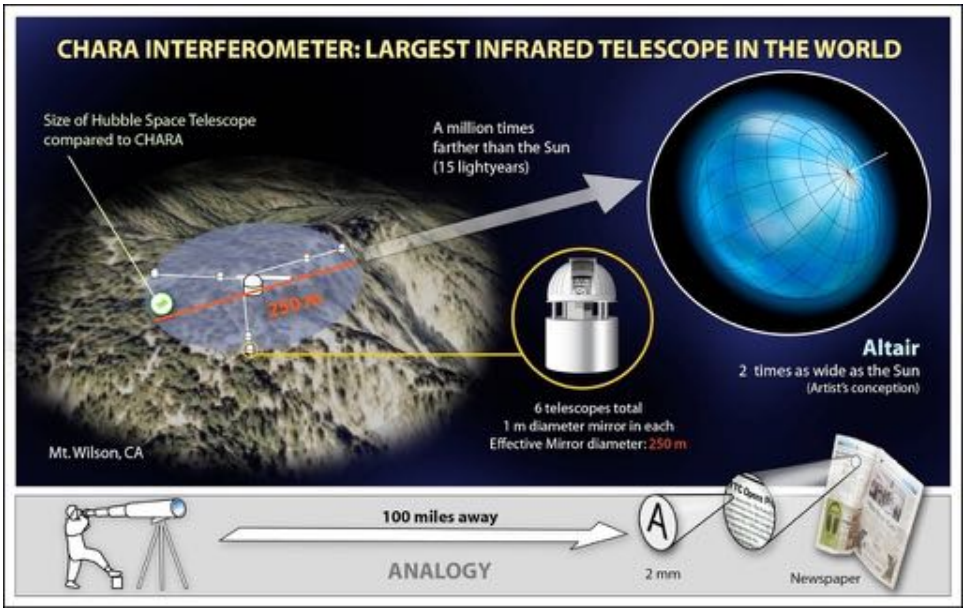
STARS!

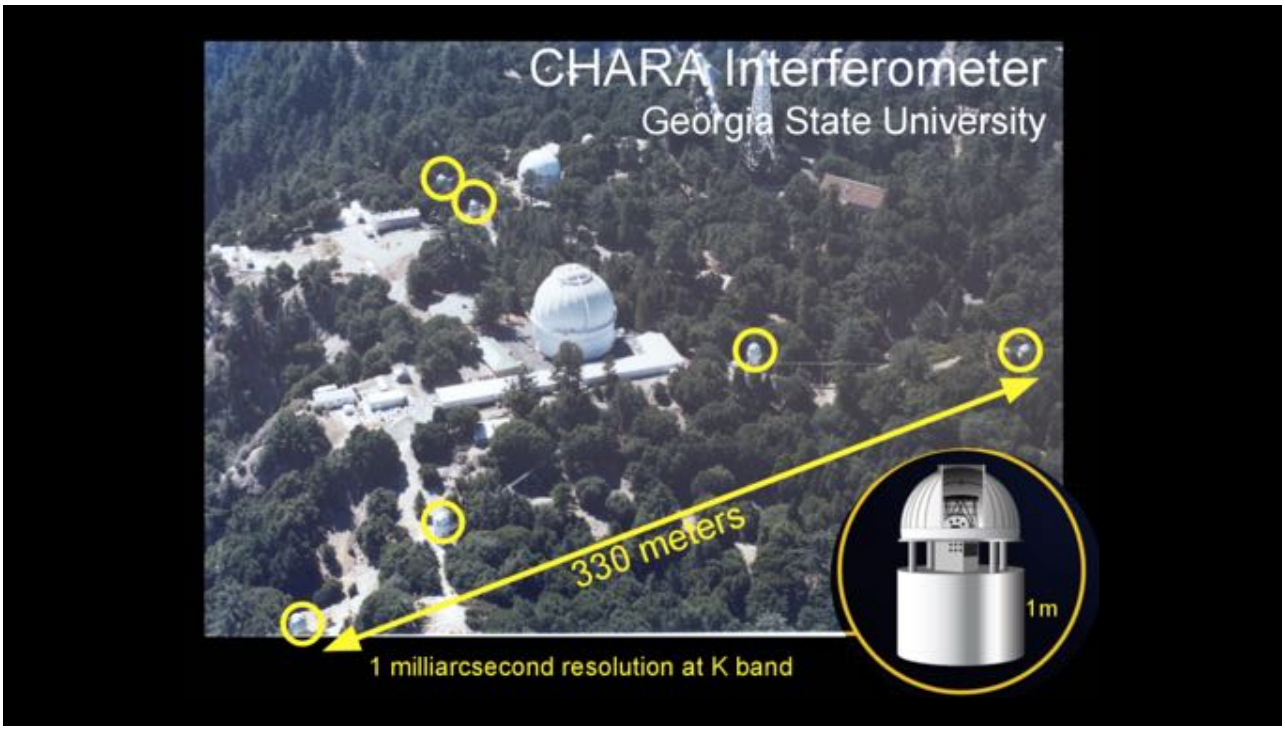
"too small to see, too bright to ignore"
without heroic effort (interferometry)



radio interferometry now "routine"

radio interferometry now “routine”

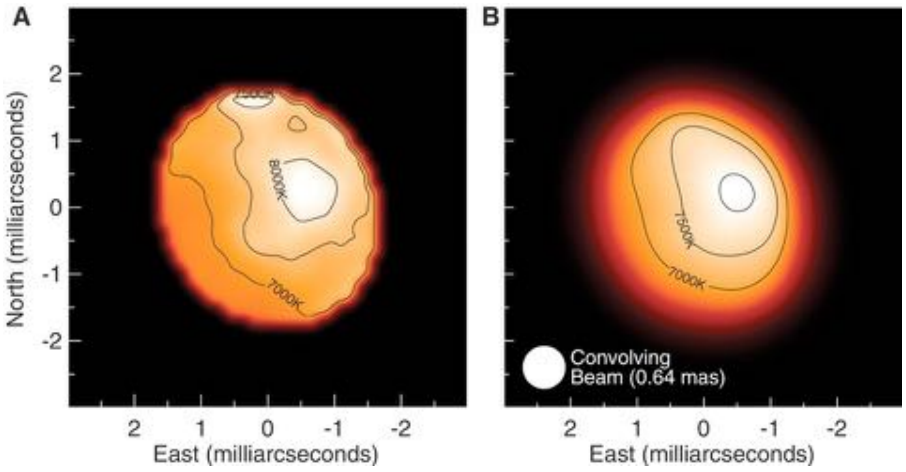




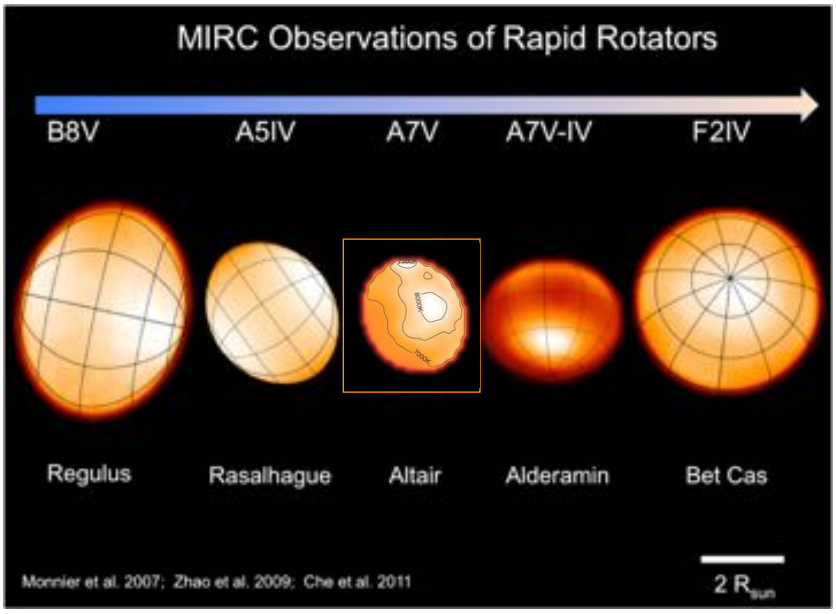
Bobcat Fire threatening Mt. Wilson

Tuesday afternoon

Altair - a rapidly rotating star imaged via interferometry



other interferometer images of stars



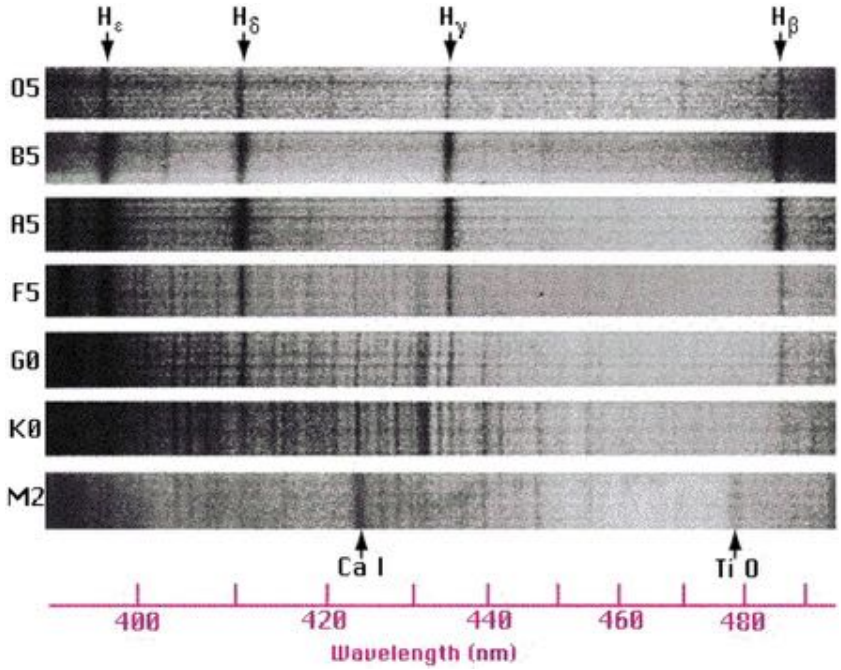
Stellar Spectra

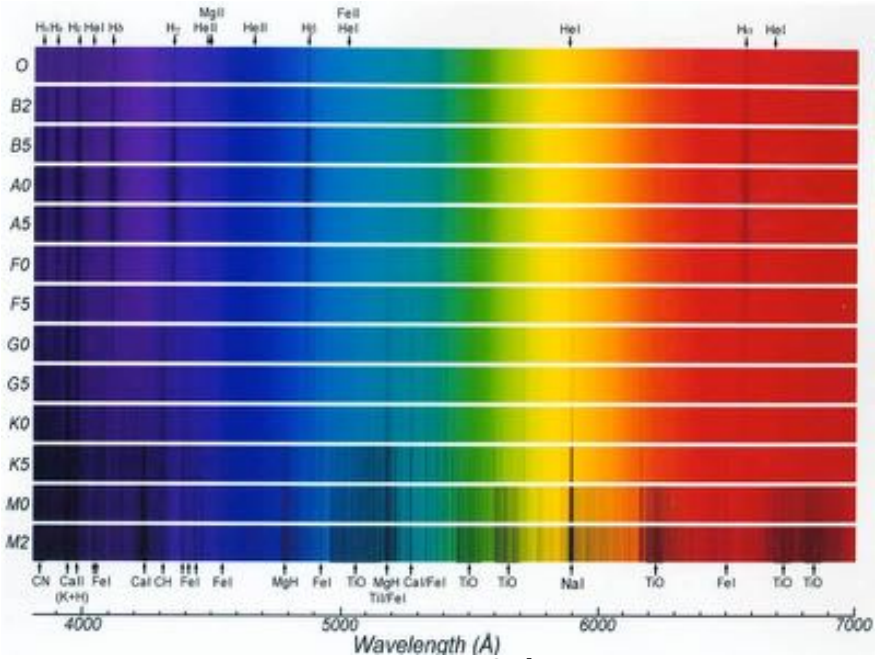
- 1872: Henry Draper: photographic survey of stellar spectra
- 1920s: Annie Jump Cannon (& crew):catalog of ~225,000 spectra

Spectral "Types": based on spectral lines

O B A F G K M

← bluer ..... redder →
← hotter ..... cooler →
← "early" type stars ..... "late" type stars →





1 nm = 10 A

The Spectral Sequence

Spectral Type	Temperature	Dominant Lines
O	> 30,000	ionized He, some H
B	18,000	neutral He, H
A	10,000	very strong H
F	7,000	modest H, some metals
G	5,500	weak H, strong ionized
K	4,000	neutral metals
M	3,000	metals, molecular bands

Oh, Be A Fine Girl, Kiss Me

-or-

Order Burgers And Fries; Get Ketchup, Mel

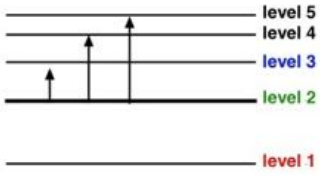
-or-

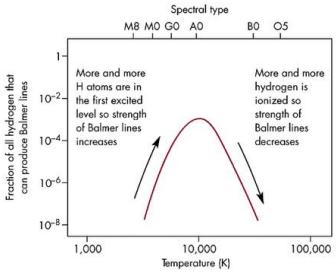
Oh! Blow Another Field Goal, Kicker Man

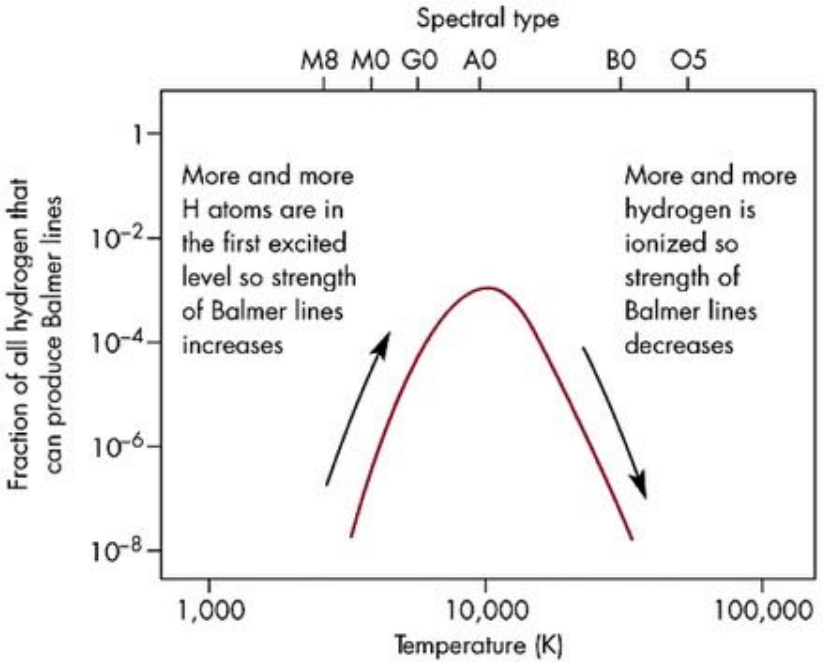
Spectral Sequence = Temperature Sequence

1925: Cecelia Payne (Gaposchkin)

- Hydrogen Balmer lines: need electron in level 2:
  - high T: most electrons in level 3 (O stars)
  - low T: most electrons in level 1 (K stars)
- Best T for hydrogen Balmer Lines:
  - **10,000K --> A stars!**
  - similar effects on other elements
- identification of lines: --> element present
- strength of lines
  - relative level populations
  - temperature *and* abundance







"undoubtedly the most brilliant Ph.D. thesis ever written in astronomy"

- **Cecilia Payne**(-Gaposchkin) - PhD, Radcliffe, 1925
- Explained the spectral sequence
- Overturned centuries-long assumption that stars are made of the same material as the Earth
- **Showed that the composition of the stars (*and therefore the Universe*) is predominantly Hydrogen and Helium**

STARS!

"too small to see, too bright to ignore"

- We observe:
  - apparent brightness
  - color
  - spectrum
  - position in sky
- Apparent brightness depends on
  - luminosity ... and...
  - distance

Is a star bright because it is close
. . . or because it is luminous?

What do we want to know about stars?

PRIMARY

- Temperature - spectroscopy
- Composition - spectroscopy
- Luminosity - brightness + distance
- Radius - brightness+temp.+distance
- Mass - binaries + distance

- Position - distance
- Velocity - distance
- Environment
- Rotation - spectroscopy
- Magnetic field - spectroscopy

DISTANCE is a pivotal quantity