# Astronomy C10: Week 6

**(Peter) Xiangyuan Ma | Sections :** 104/105/101

# Weekly Reminders

# Reminders!

**HW** 7 due at 6pm on Friday via Gradescope

**TALC** 5-7pm on Wednesday and Thursday in Campbell 131 and on Zoom

My **office hours** 9am-10am on Thursday and 4-5pm on Monday in Campbell 355

**QUIZ in 2 weeks - Oct 27th**! During section.

**This weeks plan!**

**Quiz Info** [5 mins]

**Stars Intro + Practice problems** [35-40 mins]

**Questions?** [Remaining time]

# Quiz Info

# Important: Quiz 2 next week!

Administered during section next week

20 minutes, pen-and-paper, closed book

~3 short answer questions divided into 2-4 parts each

Includes material from the first 3 HWs, emphasizing what we have covered in section

**Please submit any DSP letters as soon as possible!**

# More info:

**Topics**:
Up to lecture 22 (CS-180)

**Emphasizing material since quiz 1:** planets, Newton's laws, Kepler's laws, exoplanets, stars, stellar evolution

**When**: during section next week (October 27th)

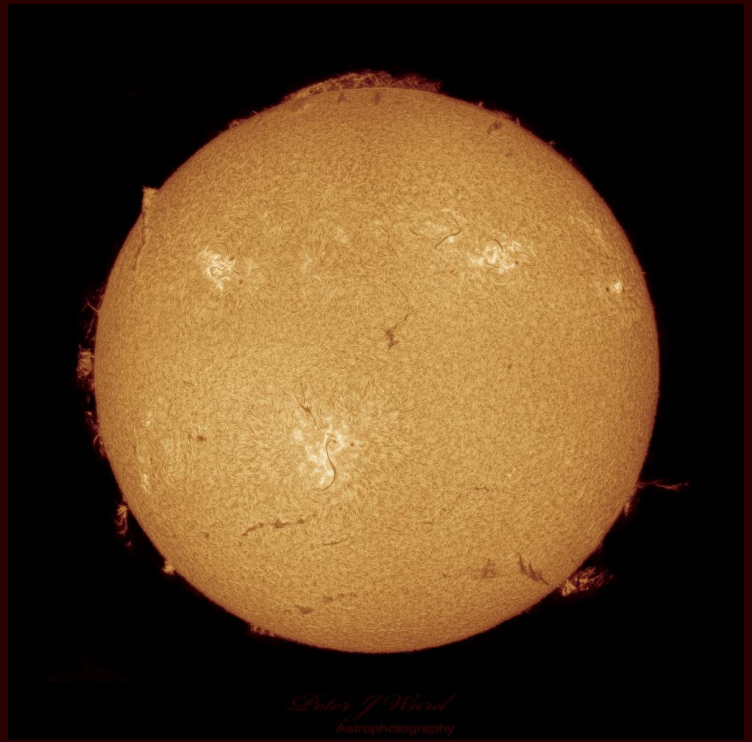
# Questions?

# Stars Intro [10 mins]

# Stellar properties

What are some properties we might want to know about stars?

What are some properties of stars we can measure directly?




Nasa APOD, Perihelion Sun 2023, https://apod.nasa.gov/apod/ap230114.html

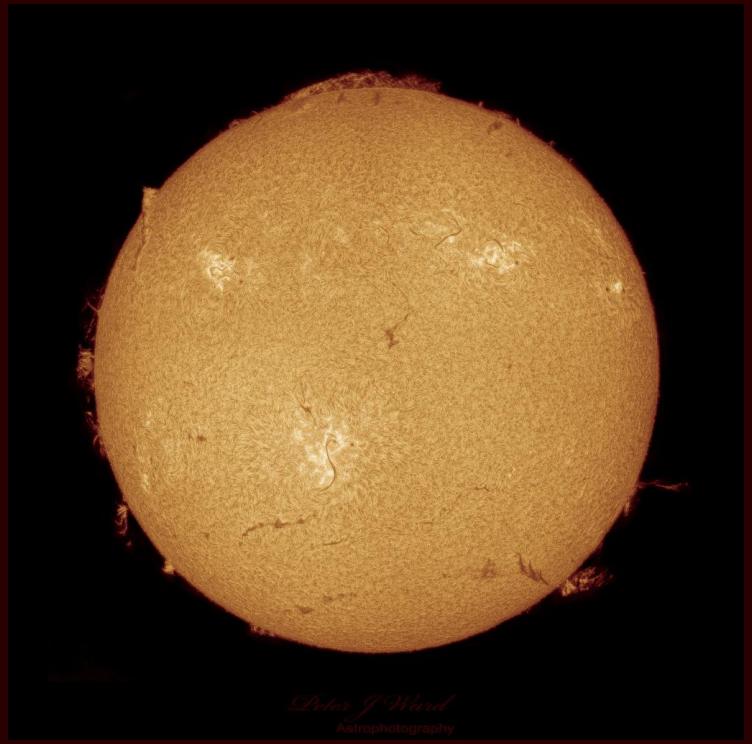
# Stellar properties

What are some properties we might want to know about stars?

Mass, temperature, radius, luminosity, brightness, composition, distance, lifetime, etc.

What are some properties of stars we can measure directly?

Brightness, spectrum, parallax

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# Goal for today

## Things we can actually see

Brightness, spectrum, parallax

## Things we want to know

Mass, temperature, radius, luminosity, brightness, composition, distance, lifetime, etc.

# Goal for today

## Things we can actually see

Brightness, spectrum, **parallax**

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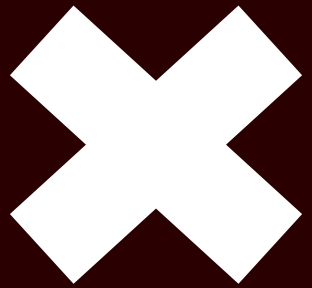
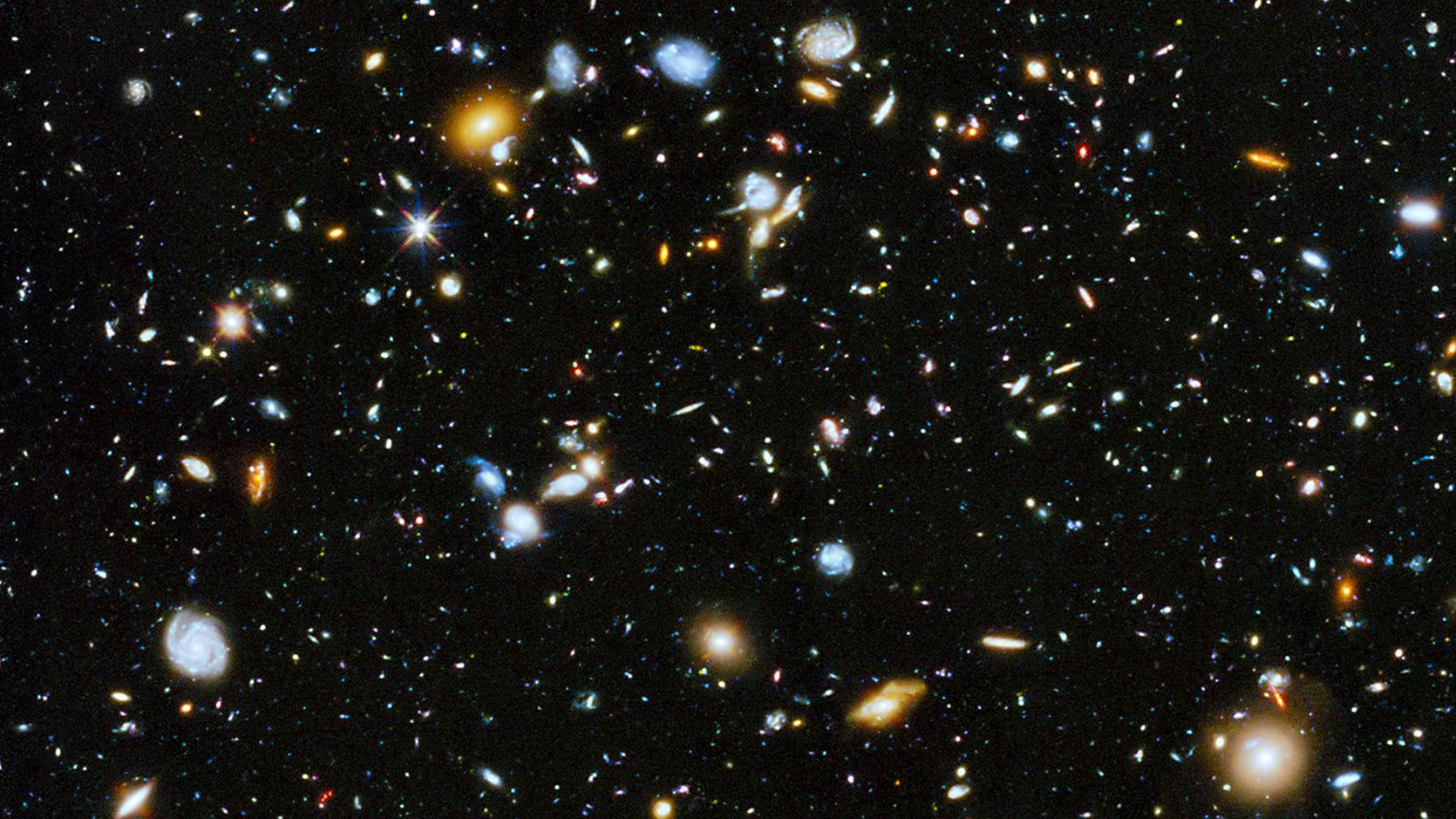
Mass, temperature, radius, luminosity, brightness, composition, **distance**, lifetime, etc.

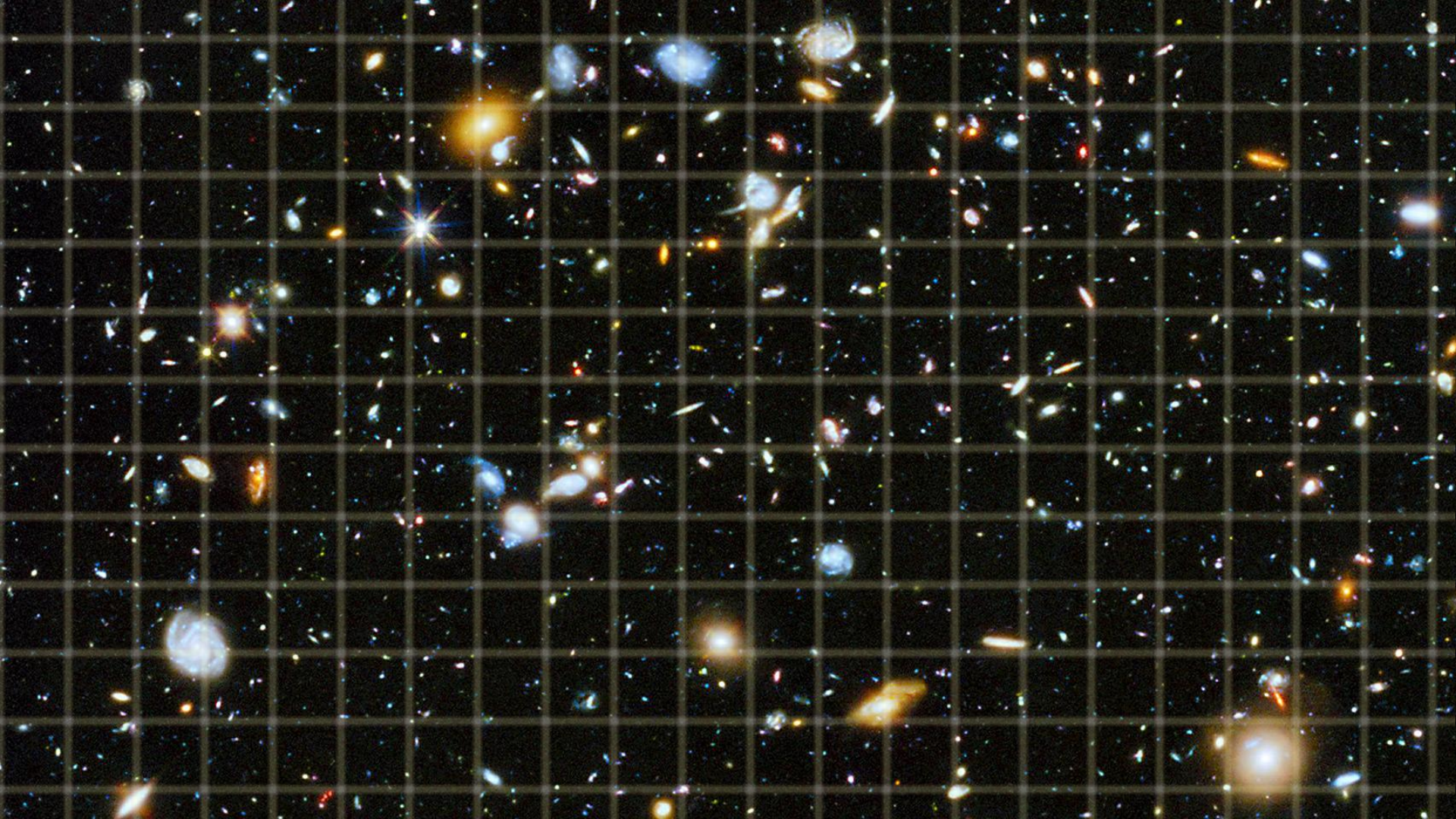
# Parallax

Try it for yourself! Close one eye and put your finger in front of the X. Then switch eyes and see what happens.

What changes if you move your finger closer to your eye? What about further away?

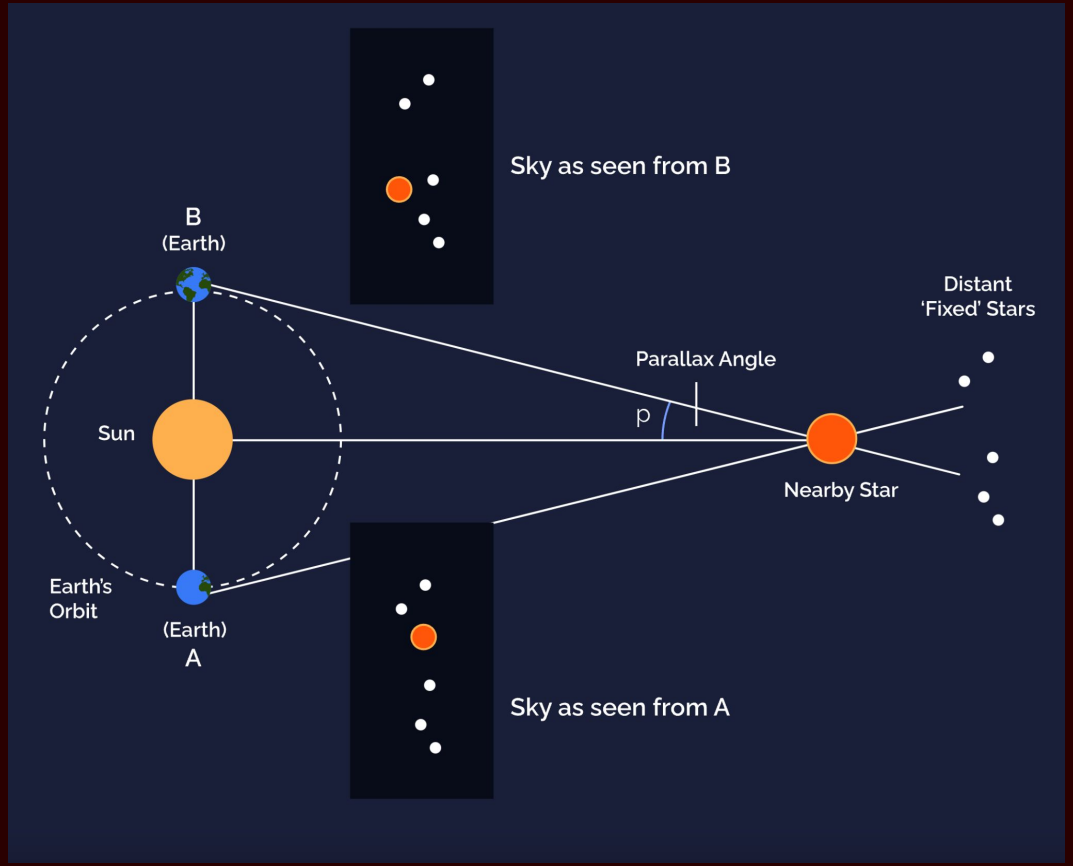




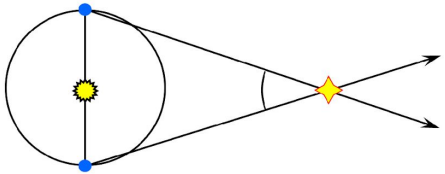


# Parallax

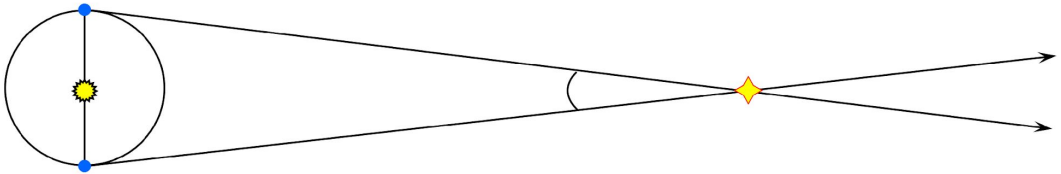
1 parsec = distance at which 1 AU baseline produces 1 arc second (1”) parallax



*Closer* stars have *larger* parallaxes:



*Distant* stars have *smaller* parallaxes:



# Parallax Key Equation:

Distance (Parsec) = 1/angle

# Parallax Problem

The star Vega has a parallax of 130 milliarcseconds. How far away is it in units of parsecs? (Recall “milli” prefix means 1/1000th)

# Goal for today

Things we can actually see

**Brightness**, spectrum, parallax

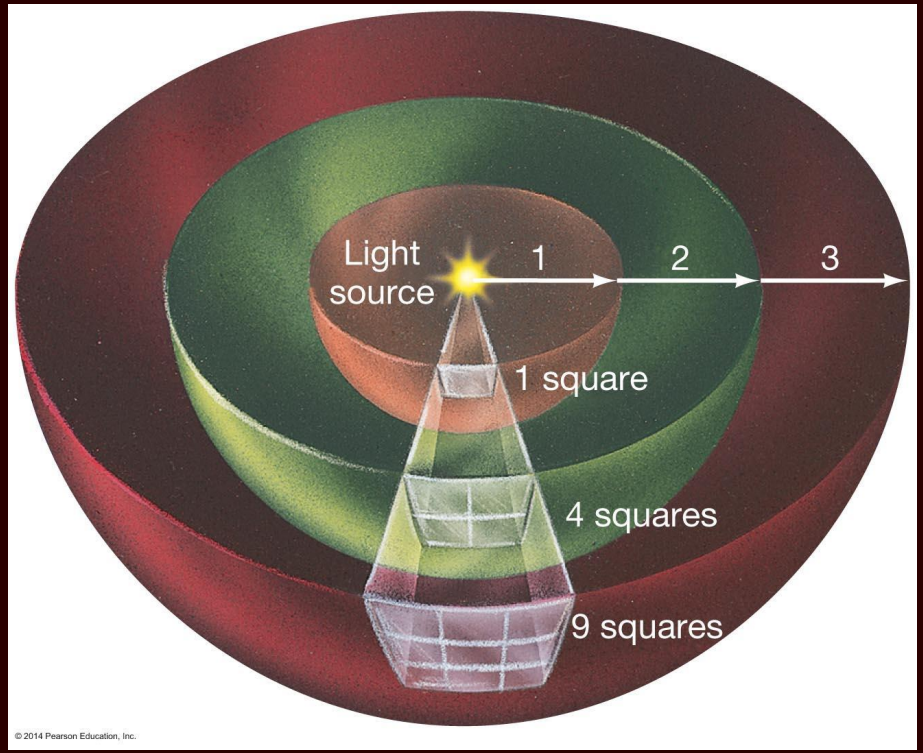
Things we want to know

Mass, temperature, radius, **luminosity**, **brightness**, composition, distance, lifetime, etc.

# Brightness and luminosity

Luminosity: energy emitted per unit time

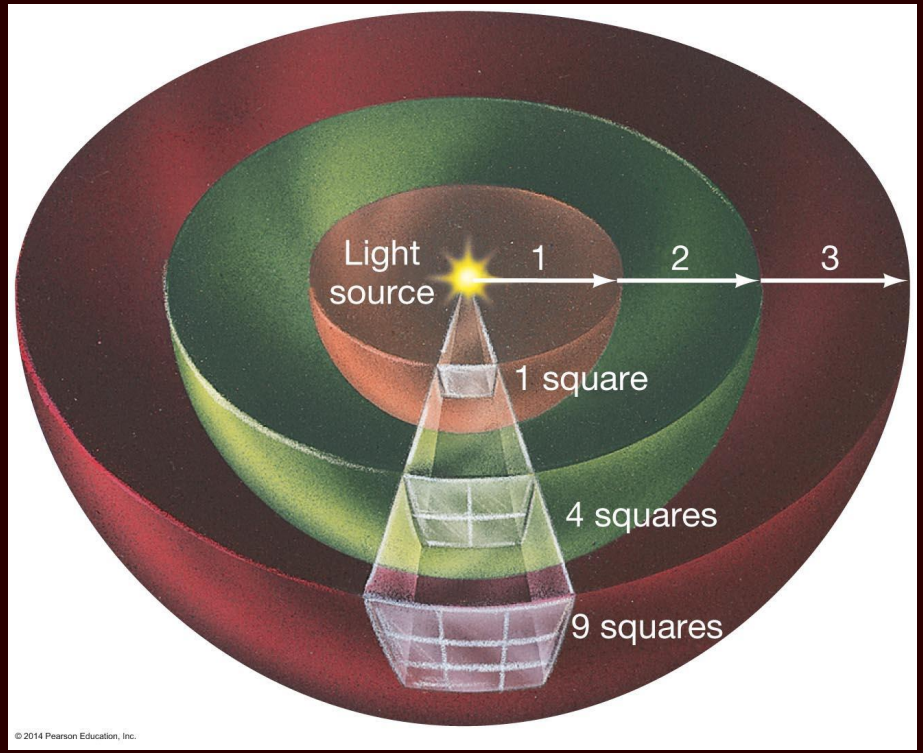
Brightness: energy received per unit time **per unit area**



# Brightness and luminosity

Star emits fixed amount of energy per second in a given direction

- When that light reaches the orange sphere (radius 1), it is spread out over 1 square
- When it reaches the green sphere (radius 2), it is spread out over 4 squares
- When it reaches the red sphere (radius 3), it is spread out over 9 squares



# Brightness and luminosity

Inverse square law of light: brightness scales with $1/d^2$

Brightness = luminosity/area = $L/(4\pi d^2)$

$$L = \frac{\text{energy}}{\text{time}} = \frac{\text{area}}{\text{area}} \cdot \frac{\text{energy}}{\text{time}} = \text{area} \cdot \frac{\text{energy}}{\text{area} \cdot \text{time}} = A \cdot B = 4\pi d^2 B$$

# Brightness and luminosity Problem

Vega has a brightness of $2.1 \times 10^{-8}$ J/(s $m^2$). What is its luminosity? You may use the fact that 1 pc = $3.086 \times 10^{16}$ m.

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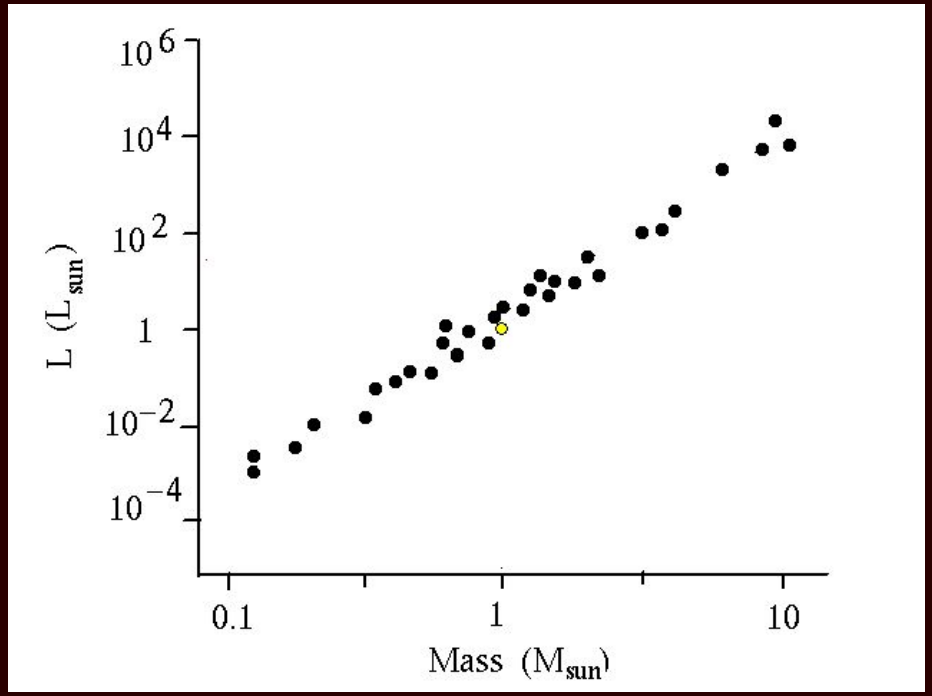
# Luminosity and mass

Plot luminosity versus mass

Log scale: increasing M by factor of 10 increases L by factor of $10^4$

Power law: L proportional to $M^4$ (main sequence stars only!)

$$\left(\frac{L}{L_{Sun}}\right) = \left(\frac{M}{M_{Sun}}\right)^4$$



# Luminosity and mass Problem

The Sun's luminosity is $3.8 \times 10^{26}$ J/s. What is the ratio of Vega's mass to the Sun's mass?

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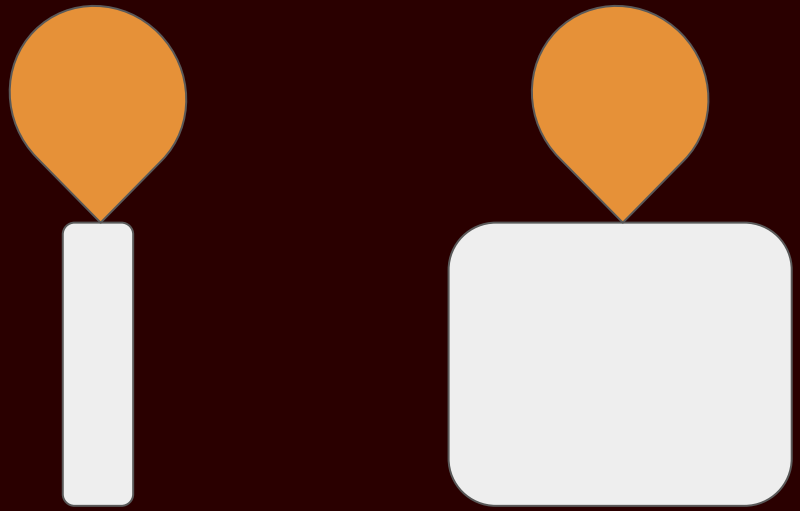
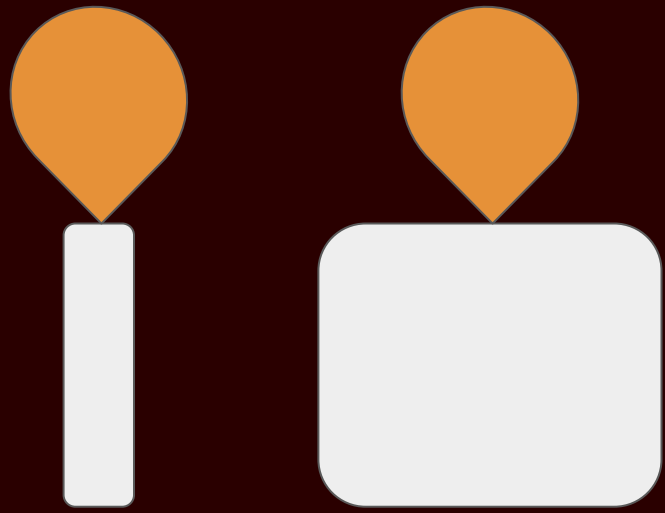
# Mass and lifetime

Which candle burns longer?



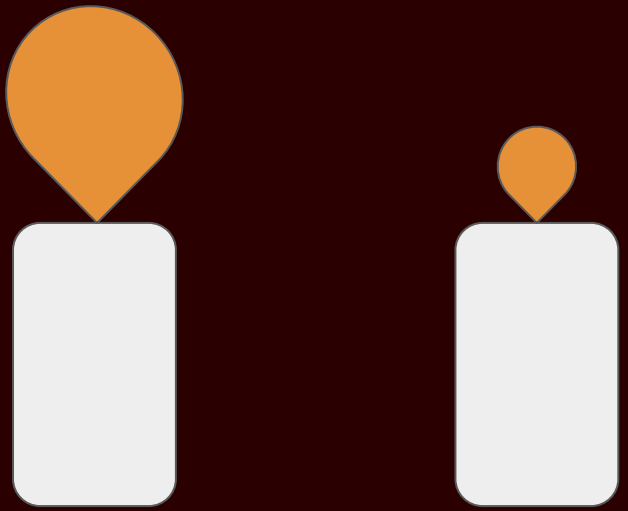
# Mass and lifetime

- A more massive candle burns longer
- A candle that is twice as massive should burn for twice as long
- Therefore, lifetime should be proportional to mass!



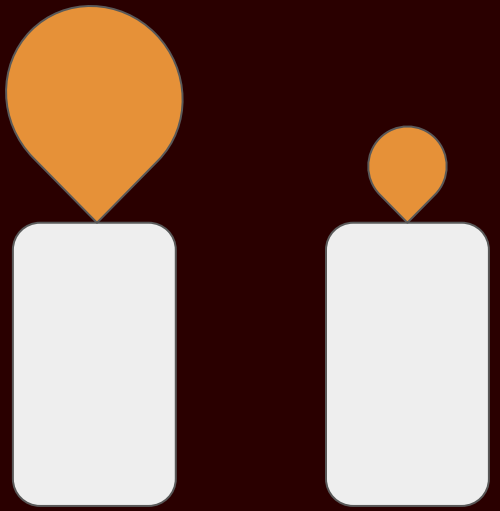
# Luminosity and lifetime

Which candle burns longer?



# Luminosity and lifetime

- A more luminous candle burns faster
- A candle that is twice as luminous should burn out twice as fast
- Therefore, lifetime is **inversely** proportional to luminosity!



# Lifetimes of stars

- We found that lifetime is proportional to mass and inversely proportional to luminosity:

$$\text{Lifetime} \propto \frac{M}{L} \propto \frac{M}{M^4} = \frac{1}{M^3}$$

- A more massive star will burn out **faster** (even though it has more fuel) because it burns through its fuel more quickly

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Things we can actually see

**Brightness**, spectrum, parallax

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Mass, temperature, **radius**, luminosity, brightness, composition, distance, lifetime, etc.

# Radius

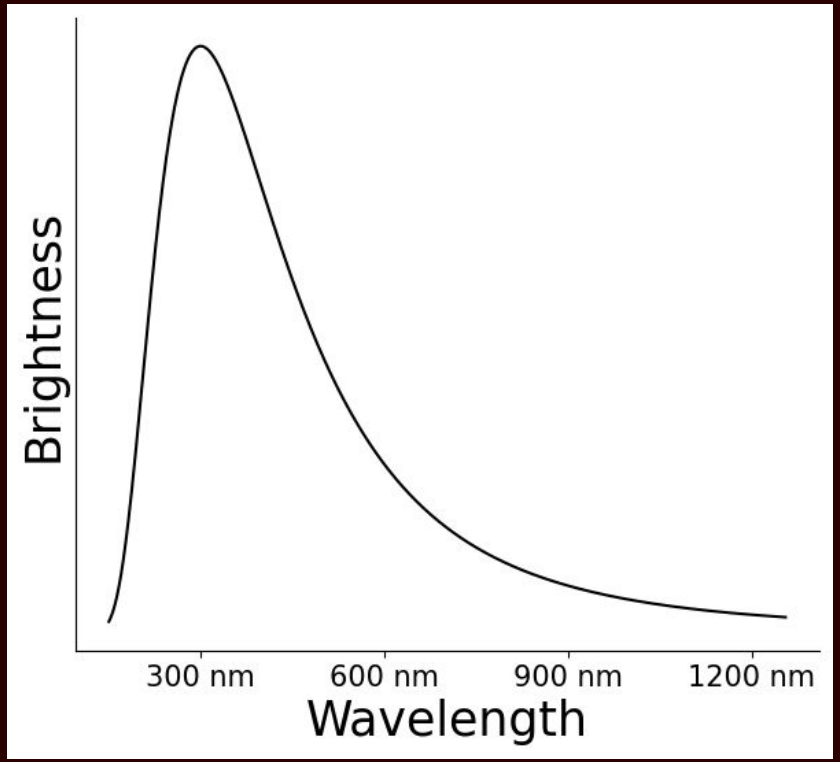
- We saw earlier in the semester that $L = 4\pi R^2 \sigma T^4$
- Find star's temperature from spectrum using Wien's law:

$$\lambda_{peak} T = 3 \cdot 10^6 \text{ nm K}$$

- Find luminosity from distance and brightness using $L = 4\pi d^2 B$
- Then we can solve for the radius R!

# Radius Problem

- If Vega has the spectrum shown at the right, what is the ratio of Vega's radius to the Sun's radius? The Sun's temperature is approximately 6,000 K.



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# HR Diagram

# Key Relationships

**Properties:**

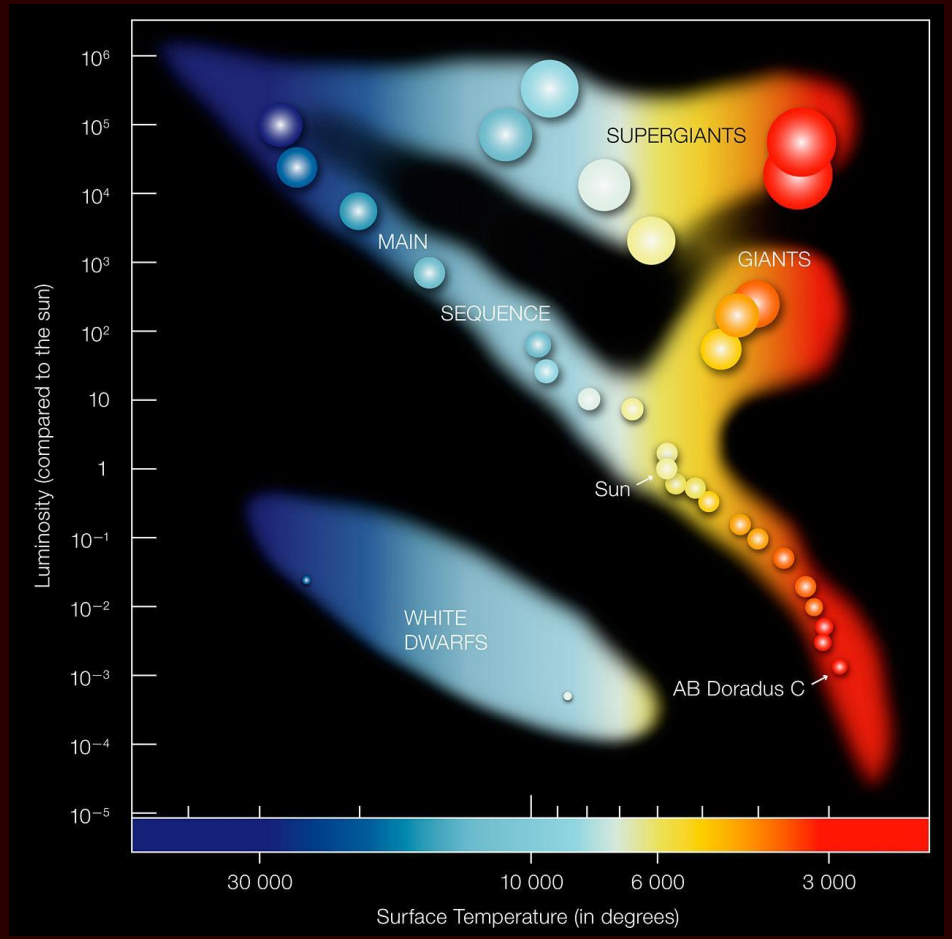
| | |
|---|---|
| Parallax | Mass |
| Luminosity | Brightness |
| Distance | Spectrum |
| Temperature | Radius |

**Relationships:**

$\lambda_{peak} T = 3 \times 10^{6}\ \text{nm K}$

$L \propto M^{4}$ $\qquad$ $D \propto 1/\theta$

$L = 4\pi R^{2} \sigma T^{4}$ $\qquad$ $B = L/4\pi D^{2}$



# Questions?

# Attendance checkout:

See ya next time!