ASTR 1020: Stars & Galaxies

September 23, 2013

- Reading: Chapter 15, section 15.1.
- Volunteer for "Astronomy in the News".
- Next naked eye observing opportunities: Sep. 24, 25.
- *Exam 1 is Friday*. Review session on Sep. 26th at 7 pm, Duane G2B47.

Exam Study Tips

- Study with a friend!
- Check PowerPoints (on class website) against your notes, homeworks- are you comfortable with the relevant concepts?
- Do more quiz and review questions in your text and in *MasteringAstronomy.*
- Check out textbook "Learning Goals" at the beginning of each textbook Chapter and Key Concepts at end of Chapter.
- Review Clicker Questions.
- Come to the review session on Thursday night.
- Exam is closed book but you may bring one sheet of paper (both sides) with notes.

Exam 1 will cover

- All material discussed in class, readings, recitations, and homeworks up through today's class.
- Textbook: Chapters 1 (Sections 1.1-1.2), Chapter 4, Chapter 5, Chapter 14, Chapter 15 (Section 15.1).
- *MasteringAstronomy* Homeworks on "Scales of the Universe", "Light and Spectroscopy", and "The Sun".

- Can you use the formula? Examples in class, homeworks, sample questions.
- You may need to "invert" the equation– for example, solve for T using the equation:

  wavelength = 2,900,000 nm / T

For numerical work- remember units!! Does your answer make sense?

(1 nm = 10^{-9} m; know cm, mm, km)

The Day of the Exam

- Bring a #2 pencil and eraser.
- Bring a calculator if you think you'll need one.
- You may bring an 8.5x11 inch, one-page (two-sided, if you like) study sheet to the exam.
- Please be prepared to get started right away at 1:00 pm!

Astronomy in the News

Mars Colony: Elon Musk's Plan To Send Humans To Red Planet

Willy Ogorzaly

Reading Clicker Question

How does the apparent brightness of a star depend on its distance from Earth?

A. The apparent brightness is independent of distance from Earth.
B. The apparent brightness is inversely proportional to distance.
C. The apparent brightness is proportional to distance.
D. The apparent brightness is inversely proportional to the square of the distance.
E. The apparent brightness is proportional to the distance squared.

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How do we measure the distances to astronomical objects?

- We'll keep asking this question again over the semester.
- Several techniques, each valid for different objects at different distances.
- We need distances to determine luminosities of stars.
- Technique #1: PARALLAX

Parallax

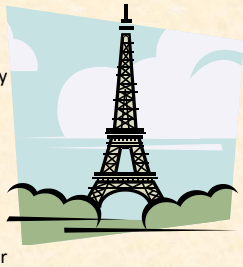
- Measure the apparent movement of stars over a year
- Movement is caused by Earth's movement around the Sun
- Closer objects will move more than farther objects

Class demo:

- Your nose is the Sun
- Your left eye is the Earth in January
- Your right eye is the Earth in June

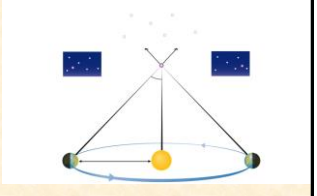
Watch the apparent motion of your thumb against a distant reference point

Which "move" more- closer or farther objects?

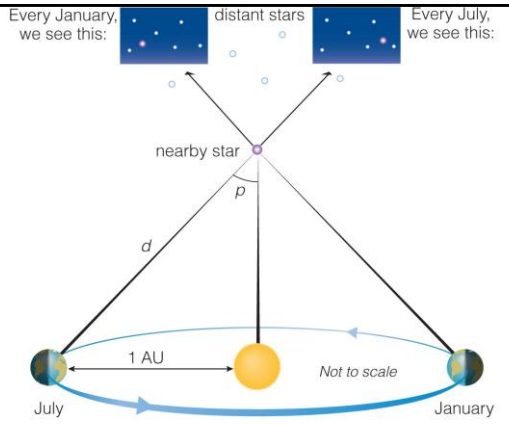


Parallax

- Parallax angle = **HALF** of the change in angular position over 6 months.
- Larger for closer objects smaller for farther objects.



Movie



How do we measure distances to stars?

Parallax and Distance

p = parallax angle

$$d\,(\text{in parsecs}) = \frac{1}{p\,(\text{in arcseconds})}$$

$$d\,(\text{in light-years}) = 3.26 \times \frac{1}{p\,(\text{in arcseconds})}$$

Remember 1 arcsecond = 1/3600 degree!

Clicker Question: The biggest ground-based telescopes with adaptive optics can measure a star's position to an accuracy of about 0.05 arcseconds. How far away could they map the positions of stars via parallax?

a) 2 pc = 6.5 light years
b) 20 pc = 65 light years
c) 200 pc = 650 light years

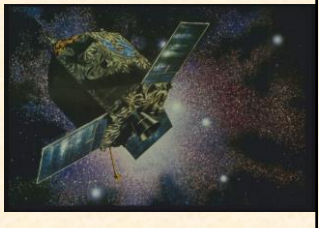
- **(B)**

maximum distance is set by the accuracy you can measure positions

Distance (pc) = 1 / 0.05 arcsec = 20 pc
= 65 ly

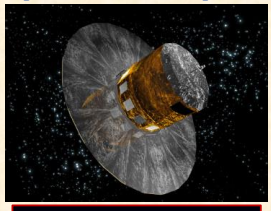
Best parallax measurer to date: Hipparcos satellite (1989-1993)

- Space measurements not affected by atmosphere
- Measurement made many times until accurate to 0.001 arcsec (→3300 light years)
- 100,000 stars mapped (2.5 million to slightly lesser accuracy)

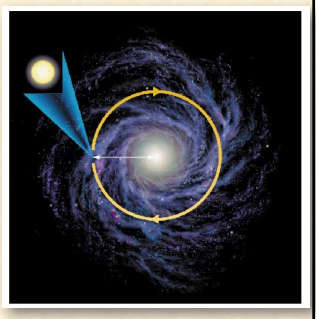


New parallax measurer: *Gaia* satellite (2013-2018)

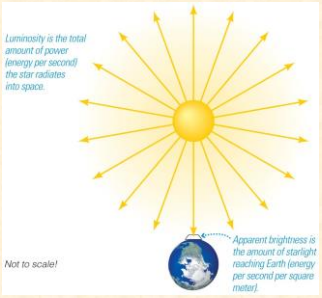
- **OBJECTIVES:** To create the largest and most precise three dimensional chart of our Galaxy by providing unprecedented positional and radial velocity measurements for about one billion stars in our Galaxy and throughout the Local Group.
- Measurement will be made with accuracies to 20 micro-arcsec (2×10^{-5} arcsec) (→50,000 parsecs = 163,000 light years)!
- Launch currently scheduled for October 25th!



- Center of the Milky Way is about 28,000 light years away
- Before Gaia, parallax worked only for nearby neighborhood
- We'll expand to other methods for more distant objects



Let's remember that:



Luminosity:

Amount of power a star radiates

(energy per second = Watts)

Apparent brightness:

Amount of starlight that reaches Earth

(energy per second per square meter)

- **Clicker Question:** Brad and Angelina are two stars that have the same apparent brightness. Brad has a larger parallax angle than Angelina. Which star is more luminous?

a) Brad
b) Angelina
c) Not enough information. Can't tell.

- Brad has a larger parallactic angle. Thus, he is closer to us.
- They both have the same APPARENT brightness, but Brad is closer
- B. Angelina must be more luminous.

Astronomer's Toolbox: What do we know how to do now?

- Measure distance: parallax, generally good to nearby stars
- Measure absolute luminosity:
  measure apparent brightness and distance, infer luminosity

Next: temperature