Announcements

- Lab 2 is graded
- Next week is the first night lab!
  - Intro to the Night Sky
  - Meet here (normal classroom) at 7:30 - Make sure to be on time, roof access is complicated right now due to construction…
  - Remember to bring your starwheel and (if desired) a red flashlight
  - Strongly recommend printing this one so you don't use your laptop/tablet on the roof
    - Also some sketches that will be a lot easier to do by hand
      - Though I will give credit for almost anything better than the AI generated ASCII art of the southern (hemisphere) sky I saw last semester
  - I will send a reminder announcement in Canvas day of

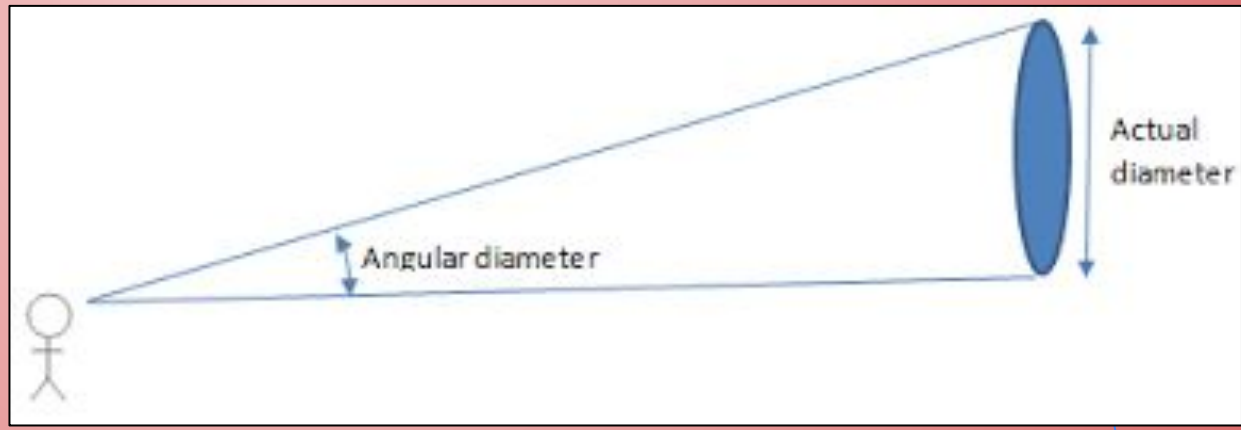
Parallax and Proper Motion

(Linear) Distance in Astronomy

- Astronomical Unit (AU) = distance between Earth and the Sun = 150 billion meters
- Lightyear (ly) = the distance light travels in one (Earth) year = 64321 AU = 9.5 quadrillion meters
  - 300 million meters per second (speed of light) times 31.5 million seconds (one year)
  - Unit of ***distance*** (or length, if you prefer)
- Parsec (pc) = 3.26 light years = 206265 AU = 30 quadrillion meters
  - Comes from parallax - part of what we are doing today
  - Name is a portmanteau of “parallax” and “arcsecond”

(Angular) Distance in Astronomy

- In astronomy, we often talk about the size of things in terms of how big they appear to be
- Think of it as yourself being one point in a triangle, the edges of the object you are looking at are the other two
  - The angle of that triangle is the angular size/distance
    - This will come up more in later labs
    - Units - degrees are broken into arcminutes and then arcseconds
    - 1 degree (°) = 60 arcminutes (‘) = 60 arcseconds (“)



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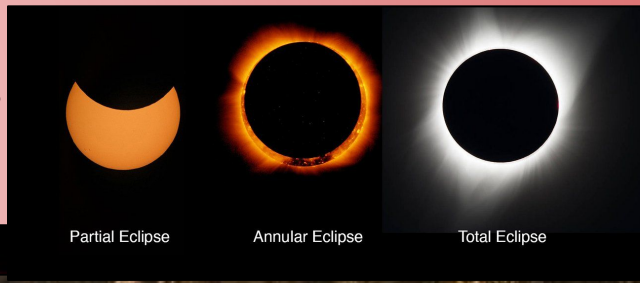
- The other way to think about this is “forced perspective”, things look smaller when they are further away
- The Sun is ~400 times wider than the Moon, it’s also ~400 times further away, so they both ***appear*** the same size



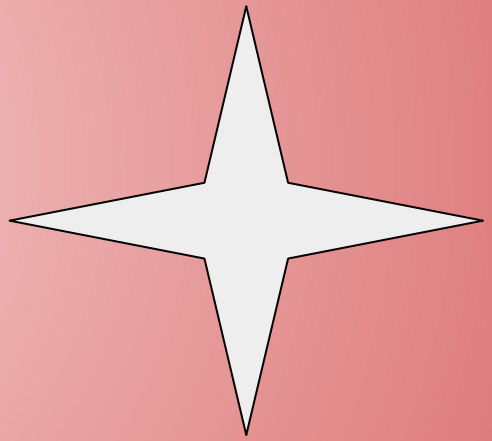
Martian Solar Eclipse

Often used in film to make certain actors or objects look bigger/smaller than they actually are

Tallest actor in the scene

Apparent Motion and Parallax

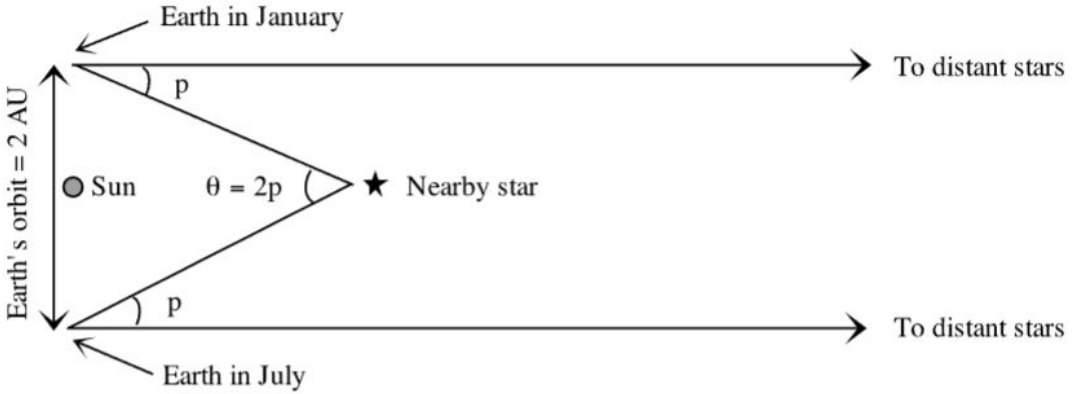
- The way something *appears* to move
  - Due to things other than its movement
- Close one eye, hold your arm out and cover the star with your thumb
- Now switch eyes
  - Still covered?
- That “apparent motion” is parallax
- Can also demonstrate with a pen or pencil held close to your face
  - With both eyes, you may or may not see double - try switching between eyes to see if it moves
- Because you have 2 eyes with a small distance between them - they don’t see quite the same things

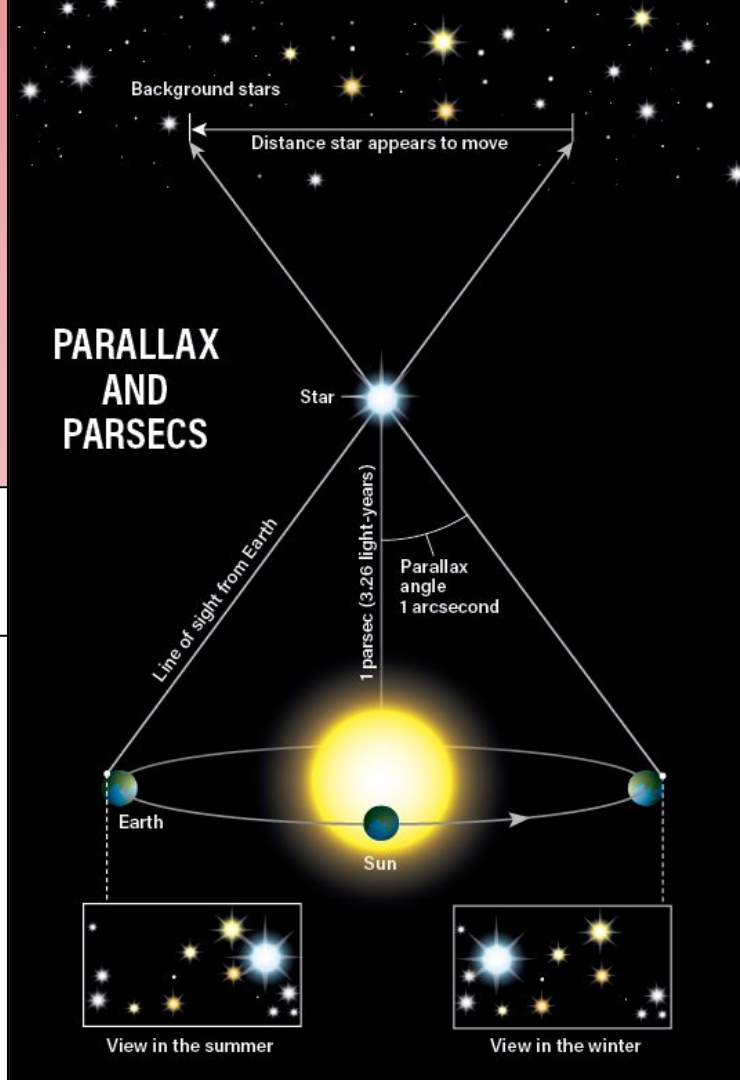


Parallax in Astronomy

- Instead of the distance between your eyes, it's the distance between two ends of Earth's orbit
  - So 2 AU instead of a few centimeters
- Closer stars "move" more than further ones
- Distance (in pc) is equal to 1 divided by the angle (in arcseconds)

$$d = \frac{1}{p}$$

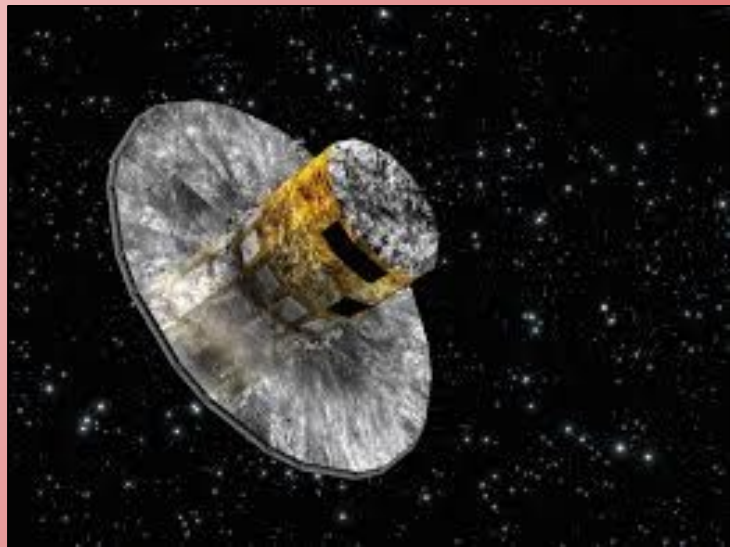




Parallax in Astronomy Cont.

- Too small to see with the naked eye
  - ↑ Why the Ancient Greeks thought the Earth didn't move (Geocentrism)
- With telescopes, we can use it to measure the distance to stars
- Max distance with current telescopes (Gaia) is about 125000 pc - hypothetically
  - ***Actually reliable distance***: ~10000 pc
  - Only a third of the Milky Way's full diameter
- In addition to telescope capabilities, baseline distance also matters *cough* Question 18 *cough*
  - 2 AU for the Earth
  - Increase in max parallax distance is ***directly proportional*** to baseline distance
  - Or trigonometry!

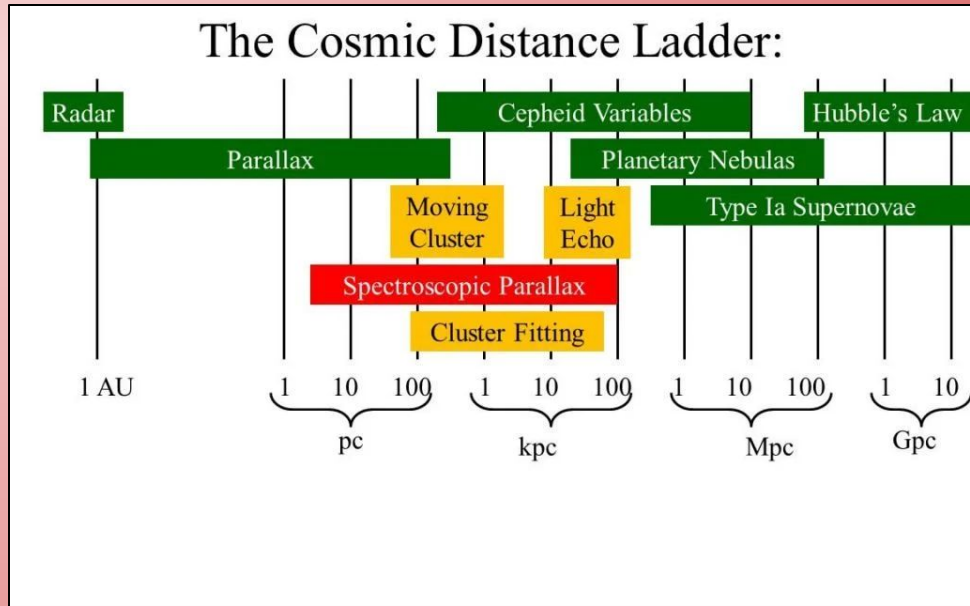
$$d = \frac{B}{2\tan(p)}$$



Gaia Space Telescope → (artist's rendition)

Cosmic Distance Ladder

- Current best parallax only gets us a third of the way across the Milky Way
  - So how to we now about the distance to things outside of it?
- Notice how the different methods overlap
  - This is how we “calibrate” each one from biggest to smallest
- Not hugely important for this lab, but we will come back to it (or something similar) for ***5*** more labs this semester
  - Magnitudes and Stellar Brightness, Variable Stars, H-R Diagrams, Open Clusters, Hubble Expansion



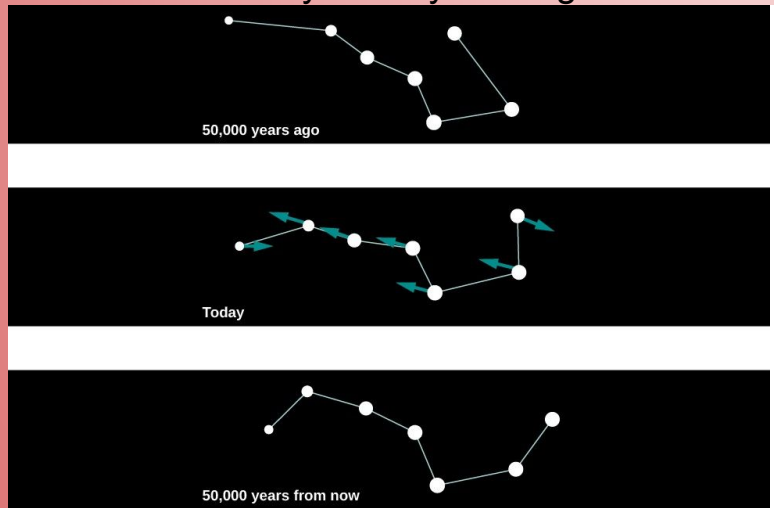
Today (Exercise 1: Parallax) (1 hour-ish?)

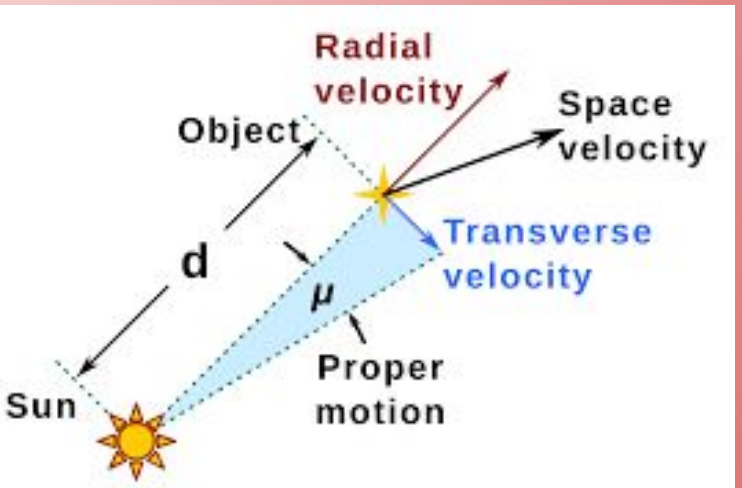
- Lots of math
  - Especially unit conversions
  - Feel free to use a calculator
  - Show work for guaranteed at least partial credit
- Question 7: Don't worry about showing work, the answer is in the definition of a parsec
- Questions 8-10: can use a ruler or just make a best estimate
- Question 12: Parallax of Alpha Centauri (Also in lab script) = .75 arcsec
- Question 18: Two ways to solve
  - Small angle approximation: $\sin(\theta) \approx \theta$ and $\tan(\theta) \approx \theta$
    - Makes trigonometry a lot easier/simpler
    - This is what the question means by "Assume small angles."
  - Proportionality (ratios)

STOP; END OF PART 1

Proper Motion

- Actual movement
  - But angles cause issues
  - We don’t actually see the full movement
  - If it’s coming straight at (or away from) you, you won’t see any movement
  - If it’s moving 90° relative to you, then you can see all the movement
  - So it’s actually usually moving faster than you can see





Starry Night and a Spreadsheet

- Follow directions in the lab script
  - Instead of a 2 degree field of view, use the box in the top right to go to 3°X1°, then zoom in slightly to get to 2°X1°
    - May need to zoom out for faster stars
- The red numbers on top of the angular separation measurement are
  - Degrees (°), arcminutes (‘), and arcseconds (“)
- Type them into the labelled yellow cells at the bottom of the spreadsheet
  - To the right of this will give a value in just arcseconds
    - This is the number you want to plug into the main spreadsheet
- Get the distance from Earth based on the blue text from hovering over the star

Today (Exercise 2: Proper Motion)

- Will need to work in pairs, maybe groups of 3
  - Not all the class computers work
- When you open Starry Night, ***do not*** update, ***do not*** register
  - This is ***old*** software, we don't want to break it
- When you open the spreadsheet, ***do not*** ask for edit access
  - Open in Google Sheets and make a copy or download it and open in Excel
- Make sure to turn in the spreadsheet
  - Can be a second file or tacked onto the end of the lab script
  - Still needs to be a PDF