Introduction: The Night Sky

- What do we see in the night sky?
  - the Moon
  - moving planets
  - occasional comets and meteors
  - against a background of randomly scattered "fixed" stars and the band of the Milky Way
- What do we see here on Earth?
  - a rocky planet with oceans and an atmosphere
  - life that has evolved for more than 3 billion years

➔ ***What has this to do with the stars and the Milky Way?***

The Stars

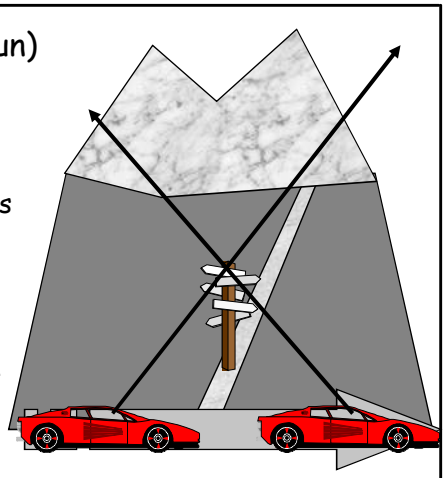
- What do we see?
  - Stars have different brightnesses
  - Stars have different colours

- What would we like to know?
  - What are the stars made of?
  - How far away are they?
  - How do they live and die?
  - How has this influenced life on Earth?

➔ ***How can we learn all this just from what we see in the night sky?***

How far away are the stars?

- Earth moves (around Sun)
  - see some stars move (against background)
  - → ***parallax***
  - → distance of nearest stars = few light years (1 l.y. ≈ 10^{16} m)
    - ⋆ first measured: 61 Cygni (Bessel, 1838), 11 l.y.
    - ⋆ closest: α Centauri, 4 l.y.



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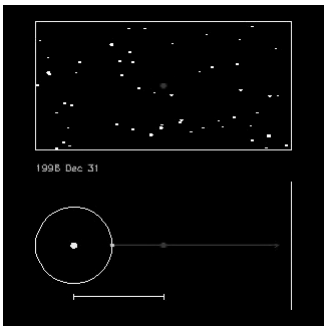
Measuring parallax

- Nearby star seen against background of fainter stars
  - motion reflects Earth's orbit
  - the closer the star, the greater the motion
  - geometry gives distance



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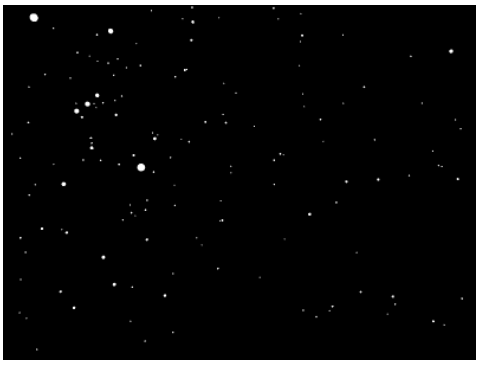
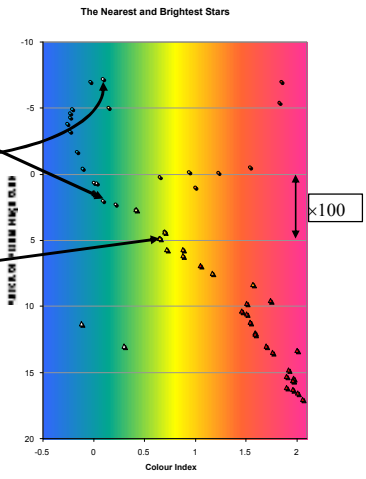
A parallax demo

- Parallax was not observed until 1838 because the stars are so far away that the effect is small
- But what if the stars were much closer (or Earth's orbit much larger)?
- Animation shows effect multiplied by one million



How bright are the stars?

- Are they all the same?
  - No!
    - the white stars Fomalhaut and Deneb appear almost equally bright, but Deneb is 1500 l.y. away whereas Fomalhaut is only 20 l.y. distant
- Are they like the Sun?
  - Sort of…
    - almost all the familiar stars are much brighter
    - almost all nearby (within 15 l.y.) stars are much fainter



The magnitude scale

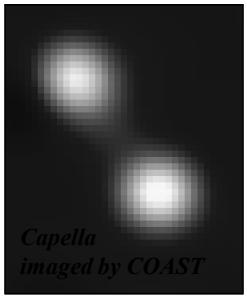
- Astronomers measure brightness in **magnitudes**:
  - **larger** magnitude = **fainter** star
  - a difference of one magnitude corresponds to a factor of 2.5 in brightness
  - **absolute** magnitude measures the **intrinsic** brightness of the star (Sun = 4.8); apparent magnitude measures the brightness of the star seen from Earth (Sun = -27)

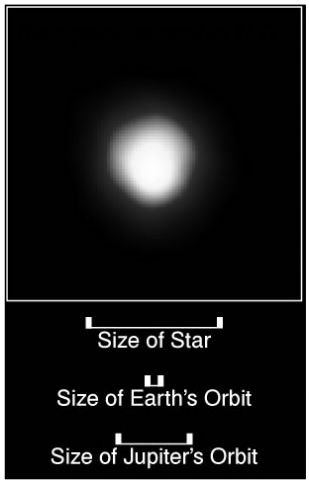
Luminosity (Sun = 1)

Absolute visual magnitude (Sun = 4.83)

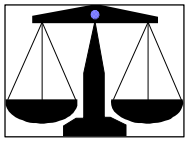
How big are the stars?

- Very few stars can be imaged as more than just points (even with HST)
- Size usually inferred from brightness
- Vary enormously, from size of small city to beyond orbit of Earth

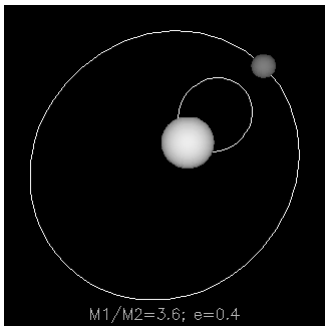




Weighing stars



- Important for our understanding of underlying physics
  - measure mass on Earth using gravity: scales and springs
  - measure mass of stars using gravity: bound pairs of binary stars (fortunately common)
- Are they like the Sun?
  - Yes…
    - familiar bright stars are a few times more massive
    - nearby stars are typically less massive



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What have we learned?

- From the motion of stars in the sky we can find:
  - their distances (if they are close)
  - their masses (if they are binaries)
- And from studying their images we get:
  - their luminosities (if we know distance)
  - their sizes (if they are large and close)
- How does the Sun compare?
  - the stars we see in the sky are much brighter and somewhat more massive
  - typical stars near us are much fainter and somewhat less massive

➔ ***the Sun is much better than average, but not a champion!***

What have we still to find out?

- "…never, by any means, will we be able to study [the stars'] chemical composition … I am of the opinion that every notion of the true mean temperature of the stars will necessarily always be concealed from us."

  Auguste Comte, French philosopher, 1835

- He was proved wrong only 25 years later by the development of spectroscopy…

  …next lecture!