2.8 Measuring the Astronomical Unit

PRE-LECTURE READING 2.8

- *Astronomy Today,* 8$^{\text{th}}$ Edition (Chaisson & McMillan)
- *Astronomy Today,* 7$^{\text{th}}$ Edition (Chaisson & McMillan)
- *Astronomy Today,* 6$^{\text{th}}$ Edition (Chaisson & McMillan)

VIDEO LECTURE

- Measuring the Astronomical Unit[1] (15:12)

SUPPLEMENTARY NOTES

Parallax

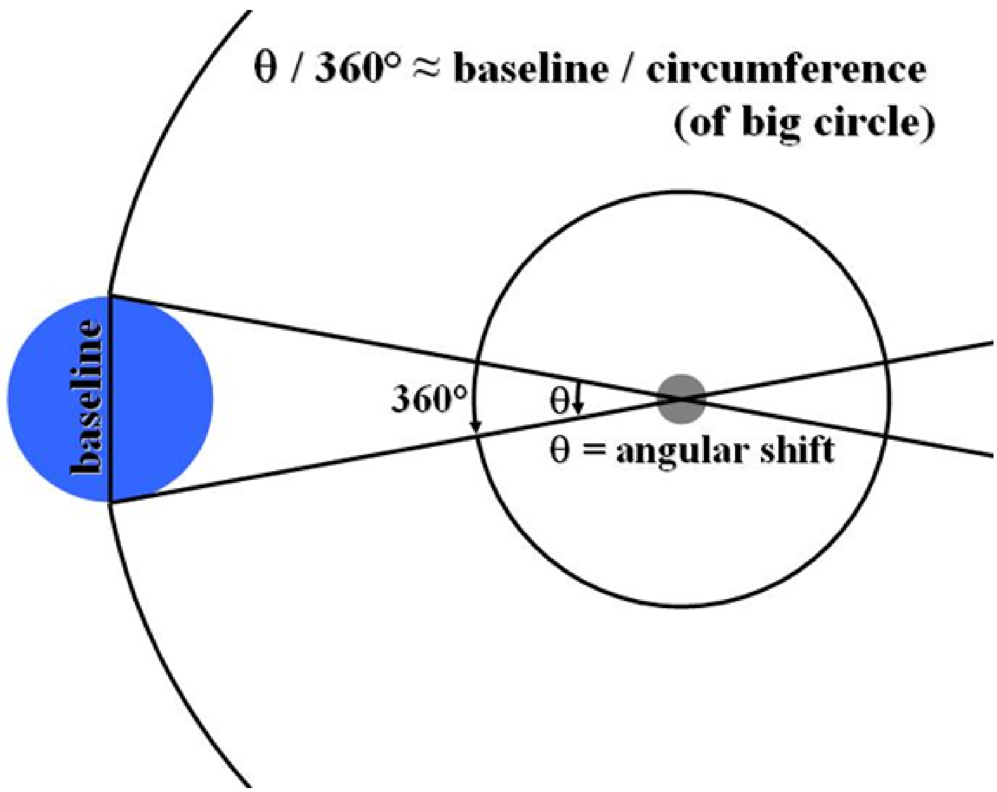

Figure 1: Earth-baseline parallax

[1]http://youtu.be/AROp4EhWnhc

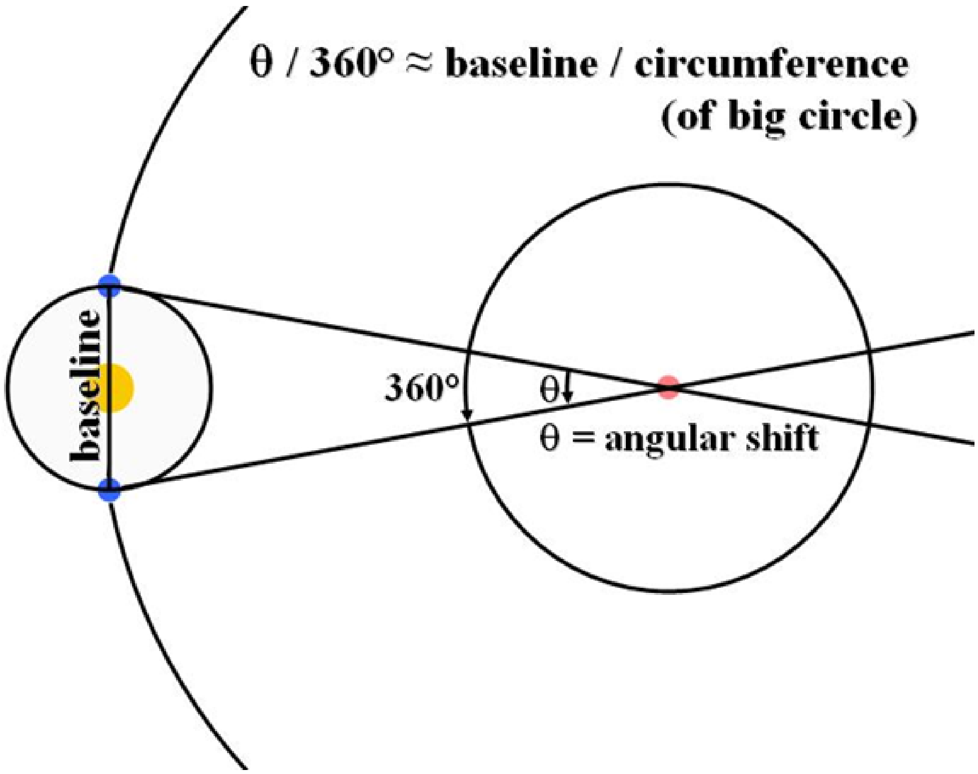

Figure 2: Stellar parallax

- In both cases:

$$\frac{\text{angular shift}}{360°} = \frac{\text{baseline}}{(2\pi \times \text{distance})} \tag{9}$$

  - angular shift = apparent shift in angular position of object when viewed from different observing points
  - baseline = distance between observing points
  - distance = distance to object

- If you know the baseline and the angular shift, solving for the distance yields:

$$\text{distance} = \left(\frac{\text{baseline}}{2\pi}\right) \times \left(\frac{360°}{\text{angular shift}}\right) \tag{10}$$

  Note: Angular shift needs to be in degrees when using this equation.

- If you know the baseline and the distance, solving for the angular shift yields:

$$\text{angular shift} = \left(\frac{360°}{2\pi}\right) \times \left(\frac{\text{baseline}}{\text{distance}}\right) \tag{11}$$

Note: Baseline and distance need to be in the same units when using this equation.

Standard astronomical baselines

- Earth-baseline parallax
    - baseline = diameter of Earth = 12,756 km
    - This is used to measure distances to objects within our solar system.
- Stellar parallax
    - baseline = diameter of Earth's orbit = 2 astronomical units (or AU)
    - 1 AU is the average distance between Earth and the sun.
    - This is used to measure distances to nearby stars.

Radar Ranging

$$2 \times \text{distance} = c \times \text{time} \tag{12}$$

- distance = distance to object
- 2 × distance = total distance that radio waves travel
- c = speed of light = speed of radio waves
- time = time that it takes for radio waves to travel to object, reflect, and travel back

Measuring the Astronomical Unit

Step 1

Venus is often the closest planet to Earth, making it a natural target for both Earth-baseline parallax and radar ranging measurements, which yield the distance to Venus in physically meaningful units, such as kilometers.

- For example, when Venus is at closest approach to Earth, Earth-baseline parallax and radar ranging both measure the distance to Venus to be approximately 4.5×10^7 km.

Step 2

Set the distance to Venus in kilometers equal to the distance to Venus in AU.

- For example, when Venus is at closest approach to Earth, the distance to Venus is approximately 1 AU – 0.7 AU = 0.3 AU.
- Hence: 0.3 AU = 4.5×10^7 km

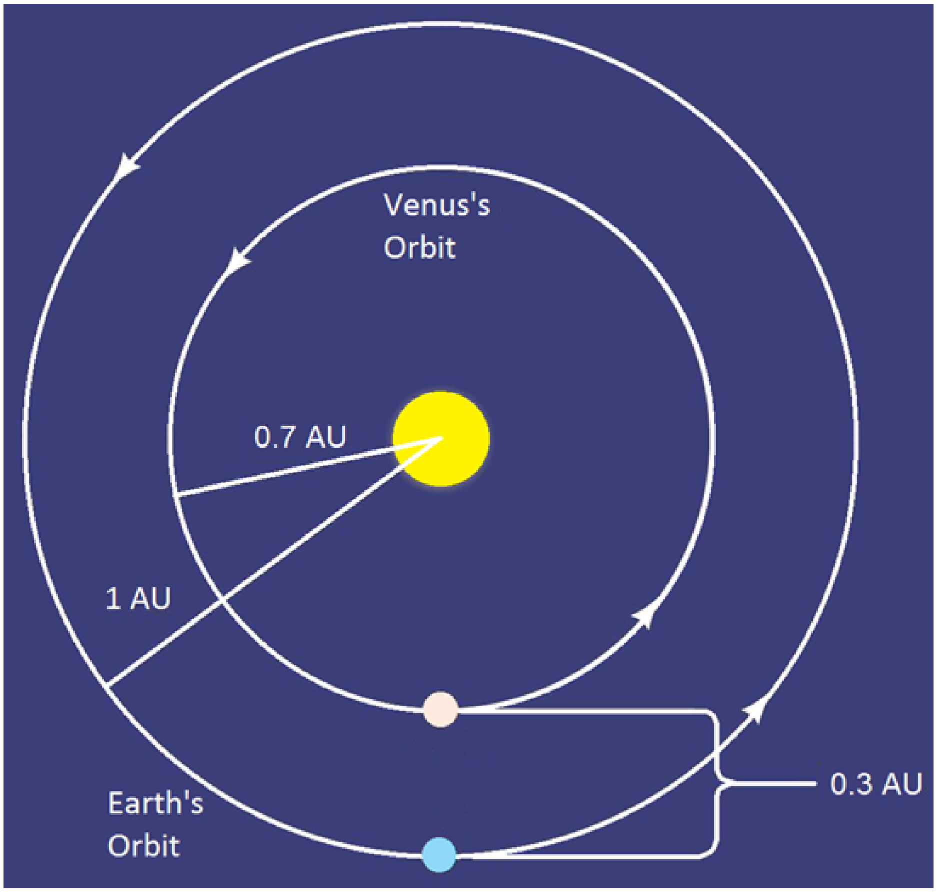

Figure 3

Step 3

Solve for 1 AU.

- For example, when Venus is at closest approach to Earth:

$$\begin{aligned} 0.3\text{AU} &= 4.5 \times 10^7\text{km} \\ \frac{0.3\text{ AU}}{0.3} &= \frac{4.5 \times 10^7\text{km}}{0.3} \\ 1\text{AU} &= 1.5 \times 10^8\text{km} \end{aligned}$$

LAB LINK

Material presented in this unit is related to material presented in Lab 4 of *Astronomy 101 Laboratory: Our Place in Space*[2].

[2] http://skynet.unc.edu/introastro/ourplaceinspace/

In *Lab 4: Cosmic Distance Ladder I: Parallax*, we:

- Use parallax to measure distances to objects on Earth.
- Use parallax and Earth's diameter to measure distances to objects within our solar system.
- Use parallax measurements of objects within our solar system to measure the astronomical unit (AU).
- Use parallax and the AU to measure distances to nearby stars.

Video Lab Summary

- Cosmic Distance Ladder I: Parallax[3] (29:27)

ASSIGNMENT 2

- Do Questions 7 and 8.

[3]http://youtu.be/FdIOAFhGYos