ASTRO 100/G – Experiment 3

Distance Modulus & Parallax

Links to Lectures 5, 6, 17, A1 and A3

Name: ID: UPI/Username:	**Grade** /10

Introduction

This lab is about measuring distances using **parallax**, **apparent magnitudes**, **absolute magnitudes** and the **distance modulus**. The first part of this lab involves coming to understand how parallax works. Then you'll use parallax to calculate the distance to a star in the night sky, then from this and the apparent magnitude you will calculate the absolute magnitude, i.e. how bright the star really is.

At the end of this lab, students will be able to:

- **Describe** what is the phenomenon of parallax and how it is used to calculate distances.
- **Explain** how parallax is used to calculate absolute magnitudes of stars.
- **Explain** how the colour and magnitude of a star are related to its temperature and distance.

Understanding Parallax

First let us look at the most basic way to measure distance to stars: parallax. Getting the distance for a star is important because without this we have no way to know how intrinsically bright the star is.

To see the effect of parallax, hold your hand out at arms length, and then look through your fingers as you close one eye then the other. You should see that what you can see between your fingers changes (as long as the background is very far away). This is because your eyes are about 10 cm apart and have a slightly different viewing angle on the gaps between your fingers. This is shown as a diagram at the top of the next page.

1. (2 marks) Fill in the table below, via the following steps:
   (a) Stand approximately two metres away from one of the scales your demonstrator has put up nearby.
   (b) Take the metre ruler, put one end just in front of your nose, and point it towards the scale.
   (c) Ask your lab partner to hold a pen halfway along the metre ruler.
   (d) Open then close one eye at a time and see how the pen moves against the scale. Use the scale to measure the relative apparent shift of the pen to the scale.
   (e) Write down your measurement on the table on the next page. Repeat this measurement with the pen 25cm away from your eye, and 1m away from your eye.
2. (1 mark) Based on your measurements above, is parallax easier to detect for objects nearer or distant to you? ________________ .
3. (1 mark) At some distance past the end of the ruler, the pen will appear to effectively be stationary. Perform an experiment to figure out what that distance is. *Hint: the person with the ruler should remain stationary.*

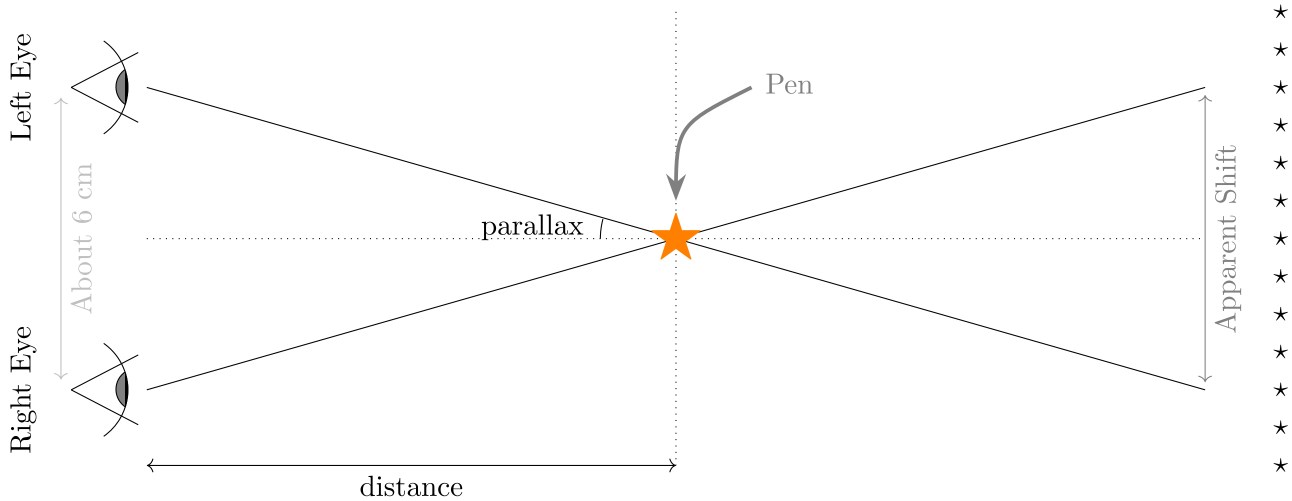
   The pen appears to be stationary at a distance of ________________ from my eyes.

Pen Distance	**Apparent Shift**
25cm	
50cm	
1m	

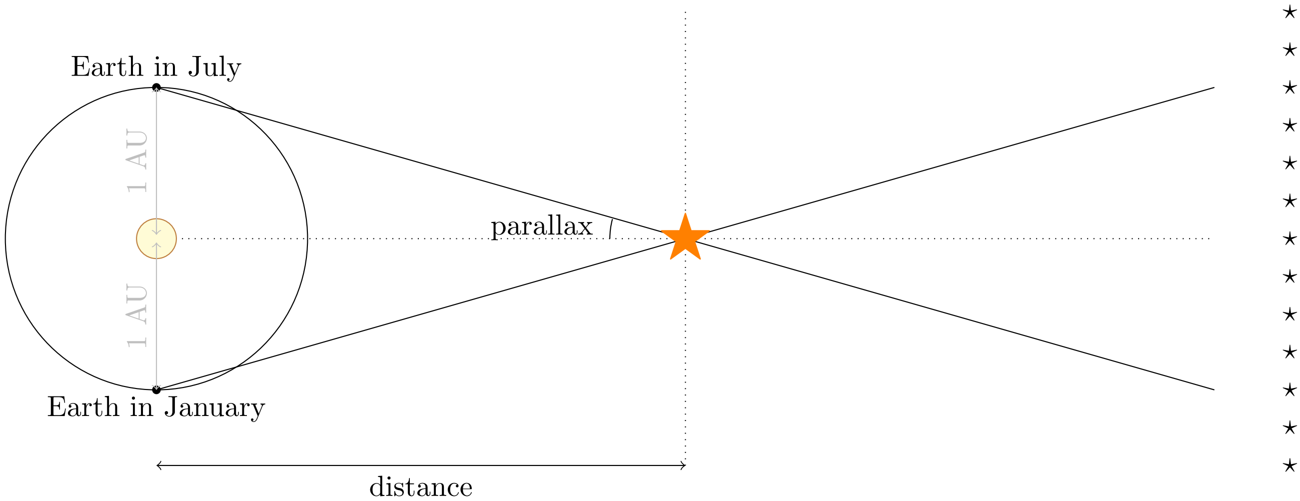
Measuring Stellar Parallax

In Question 3 you will have found a maximum distance to produce an observable parallax. This distance will be determined by your eyesight and the distance between your eyes, as shown in the picture below. As the pen gets further away, the apparent shift will shrink. The relationship between the distance between your eyes, distance to the star, and parallax, is

$$\text{distance to star} = \frac{\text{distance between eyes}}{2 \times \text{parallax}} \,.$$



But stars are much further away than this distance. Instead, the position of a star can be measured at different times in the Earth's orbit around the Sun. If we repeat the measurements of a star's position 6 months apart, during which time the Earth will have moved 2 AU from its initial position relative to the Sun, and a nearby star will appear to have moved, as shown in the picture below (not to scale – normally the distance to the star is *much* greater than the radius of the Earth's orbit). Effectively, the "distance between your eyes" is now 2 AU instead of about 6 cm.



If we measure parallax in arcseconds, then the distance in parsecs is given by

$$\text{distance} = \frac{1}{\text{parallax}} \,,$$

which is the same as the equation at the top of the page, just where the distance between eyes is 2 AU. There are 3,600 arseconds in 1 degree (which is the angular size of a thumb held at arms length away).