**Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_ Period \_\_\_\_\_\_\_\_\_\_**

**UNIT 1: Activity 13 – Practicum: Measuring Distance**

**to Asteroid 1998wt by Parallax**

**Introduction**

Earlier in this unit, we discussed the importance of discovering near earth objects (NEO) in order to have advance warning of an asteroid or comet that may strike the Earth. In activity 6, you used two image processing techniques (Stacking and Subtraction) to find asteroids in a series of images. You identified the position of an asteroid, but we did not determine how far the asteroid was from Earth. Your group may also have identified the position of a second asteroid.

On March 4, 2005, telescopes from Gettysburg College Observatory in Pennsylvania and Yerkes Observatory (24” telescope) in southern Wisconsin took simultaneous images of the asteroid called “**1998wt**”, which is the one you identified in Activity 6. When compared, the images exhibited a noticeable difference in the location of the asteroid against the background stars. In you experienced in Activity 12, astronomers can measure this **parallax shift** and use the **parallax angle** and **baseline** distance between the telescopes to calculate the distance to the asteroid in the images. The two observatories are located approximately 970 km apart.

**Images**

The images for this activity were taken simultaneously from the two observatories at 5 minute intervals. They are labelled according to observatory and time (Universal Time) taken:

Gettysburg (g) telescope: 1998wt-0245g.fit, 1998wt-0250g.fit, 1998wt-0255g.fit,.

Yerkes (y) telescope: 1998wt-0245y.fit, 1998wt-0250y.fit, 1998wt-0255y.fit

For example: 1998wt-0245y.fits was taken at Yerkes Observatory (y) at 2:45 UT.

**Procedure**

1. Open the 3 Yerkes images in SalsaJ or JS9. If you have your notes from Activity 6, you can recall the (x,y) coordinates of the asteroid in the 3 images. However, plan to use either the Stacking/Animation tool or the Subtraction tool to locate these positions as a review for use in step #3. Record the coordinates (x,y) of the asteroid for the 2:45 time in the appropriate space below.
2. Close all three images from Yerkes Observatory when finished with step #1.
3. Open the three Gettysburg images in SalsaJ. You will notice that these images have a much larger field of view compared to Yerkes, so finding the asteroid by sight is quite difficult. The “stars” in these images are also much closer together, indicating a much different Plate Scale for the Gettysburg telescope.

As with the Yerkes files, use the SalsaJ tools (Stacking/Animation and/or Subtraction) to locate the asteroid positions in these images. You may need to zoom in multiple times on the Gettysburg images to actually view the asteroid in the star field. Record the coordinates (x,y) of the asteroid for the 2:45 time (only) in the appropriate space below:

Gettysburg (x,y): Yerkes (x,y):

Now you are at the point of measuring the parallax shift of the asteroid in the images from the two observatories. If the telescopes were identical and using similar cameras with the same **plate scale**, then this process would be very simple. You would subtract the asteroid position at a given time in one of the “g” images from the same time in one of the “y” images. The parallax shift would be visual in the resulting image and would be able to measure it directly in pixels (as you did with the moon images from the three cities in Activity 12). Using the Plate Scale, you would convert the parallax shift to a parallax angle. Unfortunately, this procedure is not possible with these image since the plate scales and image sizes are different. So we must rely on another procedure.

1. Two options for converting parallax shift to parallax angle are described below. You may think of another method you would like to try. In any case, you will need just one image from each telescope to perform your measurements, so close all but the 0245” image from Gettysburg and open the “0245” image from Yerkes. You now have two images taken at the same time from the two observatories. Place them side by side and adjust them for clarity. You may want to magnify the Gettysburg image to see the asteroid in the star field. Move each image so the asteroid is located in the center of your view.

**Option 1: Using a reference star**

1. Locate a reference star, common to both images, that’s reasonably close to the asteroid. It also needs to be approximately in line with the apparent movement of the asteroid in the two images. This is similar to finding a reference “tree” in the Magnolia tree activity.
2. Measure the pixel distances (Dp) from reference star to the asteroid in each image.

Gettysburg (Dp): Yerkes (Dp):

1. Convert those pixels distances to an angle in arcsecs (⍴”) using the Plate Scale (P) specific to each image. Use these Plate Scales for each observatory: Yerkes (0.62“/pixel).; Gettysburg: 1.09 “/pixel. Keep in mind that, because of the different plate scales, the pixel measurements between any two **fixed stars** will be different, but the angular spacing will be the same. Show your work and include units.

Gettysburg (Dp):

Yerkes (Dp):

1. Use these results to calculate the parallax shift (in arcsecs) of the asteroid. Once again, the process is the same as what you did in the Magnolia Tree activity:

Parallax shift (arcseconds):

Skip to below Option 2 to the section “Calculating distance to the asteroid”.

**Option 2: Using printed images of the two asteroid fields**

1. Identify a particular field of stars near the asteroid in both images when viewed in SalsaJ or JS9. Look for a pattern of stars that appears to be a distorted pentagon with the sausage-like asteroid as one of the vertices. You may need to center the asteroid in the images and adjust the zoom to view this pattern. Locate that pattern in both images and adjust the zoom so you can see it clearly in both images. Locate which of the “stars” is actually the asteroid in each image.
2. If you examine and compare the two images now, you should be able to notice a difference in the position of the asteroid. If we use the star pentagon as a reference, then the 4 stars which are not the asteroid are very far away and show no shift or parallax. But the asteroid DOES show parallax shift. It is this shift that we can measure to determine the distance to the asteroid from the Earth.
3. Once again, if the two telescopes were identical and using the same cameras, then this process would be relatively simple. There is an electronic process we could use with SalsaJ to line up these images on top of each other and measure the parallax shift. However, that is not the case here. Another procedure is called for.
4. Obtain the two images printed on paper from your instructor. They show the views of the asteroid for Gettysburg and for Yerkes as part of the pentagon as you observed in SalsaJ or JS9. The images are printed in ***inverse-gray scale*** (sky is light and stars are black) so that lining them up is easier. The scales have been adjusted so that the four stars in the pentagon pattern match reasonably well with each other.
5. Using a pencil and a ruler, connect the four stars and the asteroid with straight lines to form the pentagon in each image. Cut between the two images to separate them. Now place the Yerkes image on top of the Gettysburg image and hold them up to the light against a window pane or piece of glass. Mark the Gettysburg asteroid position on the Yerkes image.
6. Set aside the Gettysburg image and examine the Yerkes image. You now have two different positions of the asteroid in one image--one position viewed from Yerkes and the other from Gettysburg. The difference between the two points is the parallax shift. Measure the distance between asteroid positions in mm and record your result:

parallax shift (mm):

1. To determine the distance to the asteroid we need to know the ANGLE between the two points. The scale factor that converts parallax shift from mm to arcseconds has been previously determined to be 1.5 arcsecs/mm. This is, in effect, the **Plate Scale** for this image. Use this scale factor to determine the parallax angle in arcsecs:

parallax angle (arcseconds):

**Options 1 & 2: Calculating distance to the asteroid**

Using your calculated parallax shift in arcsecs, whether obtained by Option 1 or 2, calculate the distance to asteroid1998wt using the parallax equation: **D = (AB/p") x 206,265,** where AB is the length of the baseline (970 km), p" is the parallax angle in arcsecs, and D is the distance in the same units as in same units as AB.

D =

As a last step, convert the km value above to AU. Recall that 1 AU = 1.5 x 108 km.

D (AU) =

**Conclusion**

1. If you were in charge of the fictional World Asteroid Response Team (WART), does the distance to this asteroid cause you to be concerned? Why or why not?
2. What additional information would you want to know about this asteroid before raising the alarm level?