

SIERRA COLLEGE OBSERVATIONAL ASTRONOMY LABORATORY EXERCISE		
NUMBER	III.F.a.	TITLE: ASTEROID ASTROMETRY: BLINK IDENTIFICATION
DATE-	PRINT NAME/S AND INITIAL BELOW:	GROUP <input type="checkbox"/>
DAY-		
LOCATION		

OBJECTIVE:

Use CCD images and a computer to:

- Detect an asteroid.
- Review equatorial coordinates and determine the precise RA and Dec of asteroid utilizing reference stars in the Hubble Space Telescope Guide Star Catalog (GSC)

DESCRIPTION:

Our solar system probably contains more than a million asteroids with sizes larger than 1 km. Most have orbits in the asteroid belt (between Mars and Jupiter), and so appear as point-like objects through a telescope. They can be detected because they drift against the stellar background. This motion can be seen by comparing photographs taken of the same region of sky but spaced by a few hours.

Asteroids have particular importance to us because of the concern that one might collide with the Earth. While this is extremely unlikely, even a small asteroidal collision would have devastating effects. Evidence suggests that several impacts have happened in the history of the Earth, wiping out nearly all the life on the planet each time.

In this exercise you will work with CCD (Charged Coupled Device) digital images of a small region of sky containing the asteroid 1992JB. These images were made at the National Undergraduate Research Observatory using the Lowell Observatory 0.8m f/15 telescope.

You can learn more about asteroids at: <http://ssd.jpl.nasa.gov/?asteroids>

GOALS

You have seven images of the sky to work with. The goal is to identify the asteroid in these images, and measure the asteroid's changing Right Ascension, Declination, and magnitude. You will also sketch its changing positions, and estimate its path in the sky.

PROCEDURE

First you must identify the asteroid by a method called blink-comparison. To prepare two images for blinking, you must first align them so the stars do not shift as you blink the images. After this image alignment, only the asteroid's position will shift significantly.

a. Open CLEA-Astrometry of Asteroids

> FILE > LOGIN...

(It is not necessary to enter a name; click "OK")

b. **Load Images to blink**

> FILE > LOAD IMAGE FILE > IMAGE 1

(Select 92jb05)

> FILE > LOAD IMAGE FILE > IMAGE 2

(Select 92jb07)

c. **Align images and blink**

> IMAGES > BLINK

--Image 92jb05 will appear--

(Select a first calibration star, click continue;

Select a second calibration star, click continue)

--Image 92jb07 will appear--

(Select the first calibration star—the same as you did for 92jb05, click continue;

Select the second calibration star—it is probably already selected, click continue)

> BLINK

Identify the asteroid, and compare its appearance to hot pixels. Make an accurate sketch of the star field using the box on page 4—plot the asteroid's two locations and label the dots "05" and "07," respectively.

When done, STOP the blinking, and close the window, returning to the blue file management window.

d. **GST calibration and measuring the first image**

Next you will measure the RA and Dec of the asteroid in your images. To do this, the computer must calibrate your image with a reference database of stars with known RA and Dec coordinates. The database we will use is the Hubble Space Telescope Guide Star Catalogue (GST), which contains more than 945 million stars.

We already have images 92jb05 and 92jb07 loaded in image buffers 1 and 2, so we will use those to select our GST calibration stars

> IMAGES > MEASURE > IMAGE 1

The "Observation Parameters" dialog box will appear. Verify the following values:

Date, time: 1992-05-23, 4:53:15

Replace the "Obs. ame/ID" with the image name (92jb05).

(Click OK)

Verify the values in the "Field Parameters" dialog box:

RA = 15h 30m 44.3s, Dec = 11° 15' 10.4"

Field size = 8.0 Mag = 20.0

(Click OK)

Select three stars on the left, clicking OK after each selection.

Click OK again, and when the computer asks if you want to improve your accuracy by selecting yet more stars, click NO.

Repeat the selection of the same three stars, in the same order, on the right display. (You will click OK after each star selection)

Select the target asteroid with your cursor, then click OK. The computer will ask if the image is clean: click YES.

The computer will provide you with a window full of data. Record (in your Table 1) the time of observation (specified in universal time, UT), and the asteroid's RA, Dec, and magnitude.

Click OK to accept the data, YES to record it, OK to finish data management, and then OK to return to the blue file management window.

e. **Measuring the other images**

Now we will measure the asteroid's characteristics in images (92jb07 – 92jb14). Start with image 92jb07, which is already in image buffer 2...

> IMAGES > MEASURE > IMAGE 2

Repeat all the steps as you did for 92jb05, in step "d" above. (You will not have to reselect stars in the left-hand screen, so click OK to proceed to the right-hand screen.)

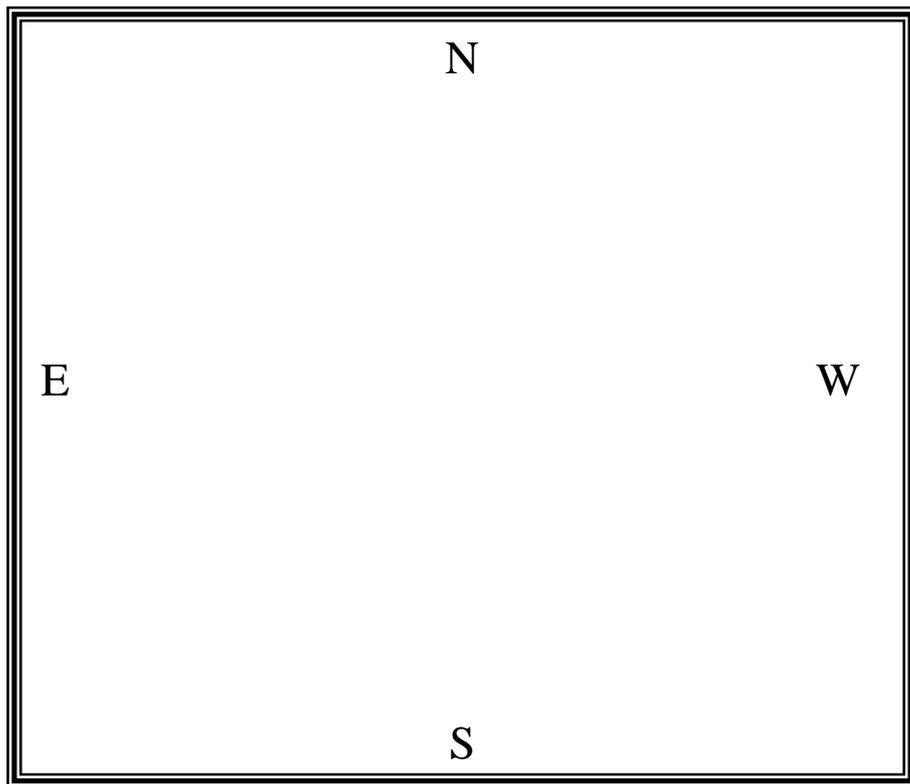
Load subsequent images into image buffer 2 to measure them. For each asteroid, record its data in Table 1. Remember that for each image you must sketch each asteroid's position, and label each position as 05, 07, 08, etc.

QUESTIONS AND ANALYSIS

1. What constellation did 1992JB occupy in these images? (Hint: Use an SC001 chart.)
2. Use a straight edge to fit the asteroid's points on your starfield sketch. In which direction (N,S,E,W, etc) was it traveling across the celestial sphere?
3. Is 1992JB visible to the unaided eye? How about in small telescope or binoculars?
4. 1992JB skipped a large distance between image 08 and image 09. Why is this the case?

TABLE 1: ASTROMETRIC DATA FOR ASTEROID 1992JB										
Image	Obs. U.T. (h, m, s)			RA			DEC			mag
							°	'	"	
92jb05	04	53	15	15 h	30 m	38.70 s				
92jb07										
92jb08										
92jb09										
92jb10										
92jb12										
92jb14										

SKETCH OF STARFIELD AND ASTEROID MOVEMENT



SIERRA COLLEGE OBSERVATIONAL ASTRONOMY LABORATORY EXERCISE		
NUMBER III.F.b.	TITLE: ASTEROID ASTROMETRY: PARALLAX	
DATE-	PRINT NAME/S AND INITIAL BELOW:	GROUP <input style="width: 40px; height: 20px;" type="text"/>
DAY-		
LOCATION		

OBJECTIVE:

Use CCD images to:

- Calculate an asteroid's proper motion.
- Observe and measure an asteroid's parallax and distance.
- Determine an asteroid's velocity in space

DESCRIPTION:

We have observed an asteroid's movement against the stars. This is called the asteroid's proper motion (μ). The size of an asteroid's proper motion is determined by its tangential velocity (V_T) and its distance (D).

We will use our images from the previous lab to determine the asteroid's proper motion. Then, we will use two images that were photographed simultaneously—one from Hamilton, NY and the other from Flagstaff, AZ—to measure the parallax effect. From the parallax and proper motion we will determine the asteroid's distance and velocity in space.

PROCEDURE:

a. Measuring East-West and North-South shifts

First, we will measure the position change of asteroid 1992JB, as recorded in images 92JB05 and 92JB14 (shown in Figures 1a and 1b, handed out in lab).

Identify asteroid 1992JB in Figures 1a and 1b. For both photographs, use the transparent overlay to measure the horizontal (East-West) distances (in arcseconds) from the asteroid to the reference star labeled "RS." Record the values as X_1 and X_2 in Table 1. Similarly record the vertical (North-South) distances from the reference star as Y_1 and Y_2 .

Next, determine the East-West shift (ΔX) and North-South shift (ΔY) of the asteroid between the two photographs by calculating $\Delta X = X_1 - X_2$ and $\Delta Y = Y_1 - Y_2$.

Finally, calculate the total angular distance ($\Delta\theta$) that the asteroid shifted, using the two component shifts (ΔX and ΔY), and the Pythagorean Theorem, shown as Equation #1:

Equation #1 $\Delta\theta = \sqrt{\Delta X^2 + \Delta Y^2}$

b. Calculating proper motion

In Lab III.F.a, you found the times the images were made (see that lab's Astrometric Data Table), in universal time, specified in hours, minutes, and seconds (h m s). Transfer the observation times for images 92JB05 and 92JB14 (UT_1 and UT_2) to Table 1.

Then, calculate the time interval (in seconds) between the two photographs, using $\Delta UT = UT_2 - UT_1$.

Finally, calculate the proper motion (angular velocity), $\mu = \Delta\theta / \Delta UT$. Do not forget to specify the correct units in your answer.

TABLE 1: CALCULATING PROPER MOTION			
92JB05	92JB14	X,Y shifts	Angular shift
X_1 (")	X_2 (")	$\Delta X = X_1 - X_2$	$\Delta\theta$ (")
Y_1 (")	Y_2 (")	$\Delta Y = Y_1 - Y_2$	
Time data			
UT_1 (h m s)	UT_2 (h m s)	$\Delta UT = UT_2 - UT_1$ (s)	
Proper Motion (μ)			
$\mu = \Delta\theta / \Delta UT$			

c. Measuring the parallax shift

Figures 2a and 2b are images of the asteroid 1992JB. These images were taken simultaneously, one from New York, and the other from Arizona. The projected baseline between these two sites is 3172 km. Notice that, because of the parallax effect, the asteroid appears to be in slightly different locations in the two images. We will measure this shift, and use it to determine the distance to the asteroid.

Examine the second transparent overlay—notice that Figure 2a and 2b are printed with a different image scale than for Figures 1a and 1b. Use the second transparency (which is scaled correctly for Figures 2a, 2b) to measure the X and Y shifts of the asteroid, just as you did for Figures 1a and 1b. Record this information in Table 2.

Calculate the ΔX and ΔY shifts, as before, and record your results in Table 2. Combine these to calculate the total angular parallax shift (p), using the Pythagorean Theorem, as before.

TABLE 2: CALCULATING PARALLAX SHIFT			
New York image	Arizona image	X,Y shifts	Parallax shift
X_1 (")	X_2 (")	$\Delta X = X_1 - X_2$	p (")
Y_1 (")	Y_2 (")	$\Delta Y = Y_1 - Y_2$	

d. **Asteroid calculations**

The asteroid's distance (D , in km) can be calculated using the parallax (p , in arcsecs), the baseline between the two observing points (B , in km), and Equation 2:

Equation #2	$D = \frac{B \times 206,265''}{p}$
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You can also calculate the tangential velocity of the asteroid (V_t), given the asteroid's distance (D) and proper motion (μ), using Equation 3:

Equation #3	$V_t = \frac{\mu \times D}{206,265''}$
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Complete the calculations for D and V_t , below. Do not omit units!

$D =$ _____

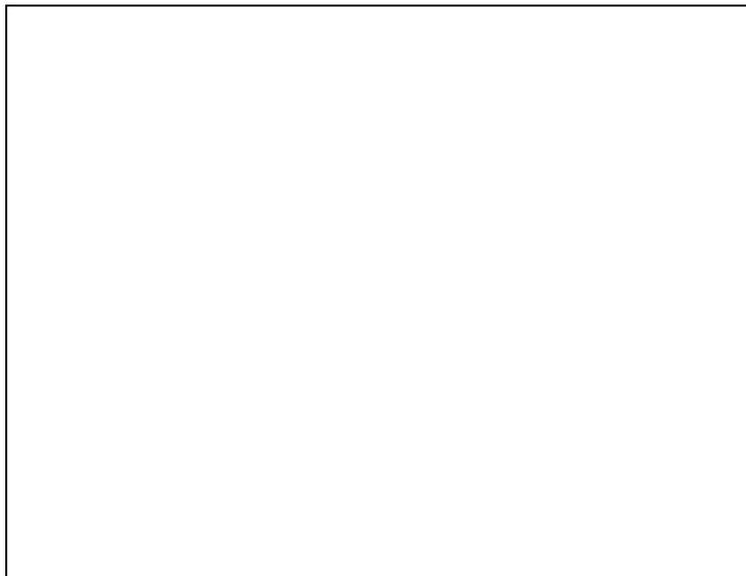
$V_t =$ _____

QUESTIONS AND ANALYSIS

1. Universal time is converted to local time by subtracting a certain number of hours (the exact number of which depends upon the time zone). To convert Universal Time to Arizona's time zone (MST), subtract 7 hours. Given that the Arizona photograph was taken on 23 May, 06:57 UT, was 1992JB on the meridian at midnight? (Hint: use a planisphere and SC001 star chart.)
2. With respect to the sun, was 1992JB near opposition, conjunction, or any other significant alignment?
3. An astronomical unit is 149,600,000 km. The average Mars-Sun distance is 227,900,000 km. The average Jupiter-Sun distance is 778,500,000 km. Complete Table 3, giving all values in astronomical units.

TABLE 3: ASTRONOMICAL DISTANCES			
Earth-Sun distance	Mars-Sun distance	Jupiter-Sun distance	Earth-1992JB distance

4. Use the box below to (carefully and neatly) sketch the orbits of the Earth, Mars, and Jupiter around the Sun. If 1992JB was near opposition at the time of the observations, sketch its location. Is 1992JB a belt asteroid?



5. Suppose that, from Doppler measurements, we determine that the radial velocity of 1992JB is 1.3 km/s. Use the Pythagorean Theorem to determine the complete space-velocity of 1992JB.