Section 3: Parts F-H *(Notes and Journal Answers)*

Part F-H explains Photometry and How it is used in Afterglow Access

Part F - Photometry

It really is helpful in this part to use the CCD poster (or smaller version) with the 9 pixels and demonstrate the information given.

Part G Photometry Methods

You be the judge of how in-depth to go with your group.

The examples listed on this sheet are not on the SJS site. You can use these to guide your students, or assign them to groups of students.

1. APERTURE PHOTOMETRY:

Again use the CCD poster (or smaller version) with the 9 pixels - it will be very helpful in explaining photometry as you go through the explanations on the SJS site. You can make rings out of anything useful (plastics lids, pipe cleaners, ribbons, etc) to help with the understanding of the aperture and annulus. The following activity can help:

Aperture Photometry Example with CCD poster (adjust the instruction for the smaller cardstock version):

The CCD poster should have two sources with background counts also.

<u>Standard star:</u>

Aperture counts of standard star: _____

(count the pins within the ring)

Annulus counts for standard star: _____

(we will not use the average annulus counts for this simulation)

Subtract the annulus counts from the aperture counts: _____

<u>Asteroid:</u>

Aperture counts for asteroid: _____

Annulus counts for asteroid: _____

(we will not use the average annulus counts for this simulation)

Subtract the annulus counts from the aperture counts: _____

You now have done the simplest form of photometry. Your answer represents the brightness measured (but not calibrated).

2. INSTRUMENTAL PHOTOMETRY (=Instrumental Magnitude)

a) This uses the counts as found in #1 above(aperture photometry). This is converted to "flux", which has a different unit. (Flux is calculated with a standard algorithm within the image processing program and becomes part of the data that is downloaded).

b) Once the flux is known, it is converted to an instrumental magnitude using the equation below(you used this if you did the optional section on calculating magnitude) - with the additional step of dividing the flux by the exposure length.

m = -2.5log(flux/exposure length), where the 'm' stands for apparent magnitude.

****NOTE: This magnitude will not match an accepted magnitude in a star catalog. It is not calibrated. However it can be used in Differential Photometry - see below

Instrumental Magnitude Example with CCD poster:
We will simply use the counts we found in the first exercise - we will not convert to flux. Use the equation to find instrumental magnitude. Show the equation with the numbers plugged in. (Use m = -2.5log(flux))
Standard Star instrumental magnitude:

Answer:_____

Asteroid instrumental magnitude:

Answer:_____

3. DIFFERENTIAL PHOTOMETRY (this is the method used in asteroid photometry)

This can also be called Differential Magnitude.

This simply uses the difference between the instrumental magnitude(type #2 above) of the object of interest and the instrumental magnitude of a standard star(recall what a standard star is from section 1).

**This allows different observations to be used. This method will agree on magnitude DIFFERENCES even if different instruments, apertures, and exposure times are used, and also, if different seeing conditions exist. YEAH!

a) After finding the instrumental magnitude of your object of interest, find a standard star in that same image.

b) Using the same equation as in #2 above, calculate the instrumental magnitude of the standard star.

c) Find the difference(subtract) between the instrumental magnitude of the object of interest and the standard star.

OR:

d) Find the ratio of the flux of the standard star to the flux of the object of interest(just divide the two!).

e) Then use that ratio in the same equation as above. Your answer IS the magnitude difference - no need to subtract!

Differential Magnitude Example with CCD poster:

Using the two instrumental magnitudes found immediately preceding this method, simply subtract them. This is the

Differential Magnitude = _____

OR

Using the counts from method #1(aperture photometry), find the
ratio of flux (we will use counts) of the standard star to the asteroid:
(just divide)

= _____

Now use this number in the equation below to find instrumental magnitude:

Differential magnitude = -2.5 log(flux ratio)

Answer: Differential Magnitude = _____

Compare the two answers: _____

##Let's try an EXAMPLE of Differential Photometry using the flux ratio method seen in letter d) above. You may use Quorum or a calculator.

Given: flux1

flux1 is found for a standard star in an image to be 8353.9 (this is converted with an algorithm in Afterglow Access - it is from the counts listed below the image on Afterglow Access)

Given: flux2

flux2 is found for the object of interest (our asteroid) to be 5962.148

Find the magnitude difference between the standard star and the asteroid by subtracting. This is delta m.

(answer should be -0.366)

**Note: Afterglow Access uses a standard algorithm from a repository(on GitHub!)of python modules made for astronomers called 'astropy'.

Calculate: -2.5 log(8353.9/5962.148)
Answer: -0.366

Also: some of the students may be more interested in the programming piece. Please have them look into astropy.

4. CALIBRATED APPARENT MAGNITUDE

a) Standard stars have their magnitudes listed in well known catalogs. Each standard star has an accepted magnitude for different filters. Recall, a filter allows only a small, well defined range of light energy through. The sample images we are using were taken with a red filter.

b) Find the difference(subtract!) between the magnitude listed in the catalog and the instrumental magnitude as calculated in #2 above.

c) This difference is called the zero point.

d) This should be done for several standard stars in the same image. Then take the average of all the differences. This average is a better zero point to use.

e) The zero point is then added (or subtracted) from the instrumental magnitude of the object of interest(an asteroid, in our case) to get the CALIBRATED magnitude. Star catalogs will become available on Afterglow Access in the future.

Have the students think about why asteroid astronomers use differential photometry. (Rotation is found by looking at how the light varies as it rotates, therefore, only the change in magnitude is important - the relative difference.

Part H - Photometry and Afterglow Access

There are a few housekeeping items to do before we use the photometry tools.
This "housekeeping" is simply for ease of keeping track of the images the students will be using for the asteroid photometry.
The next step is to load in 8 images from the first Kleopatra folder. The second Kleopatra folder has many more images (they can use these later if they would like to make a second light curve).

USING THE TOOLS:
Hopefully they have found the asteroid previously. If not, the following screenshot is of the first image with the asteroid marked. Be aware that the next images are oriented differently - but the marked asteroid position will be in the right place. This image was centered first.
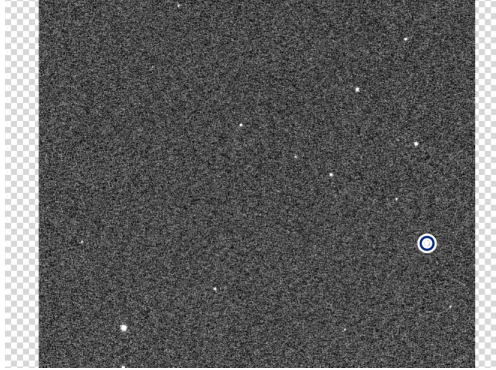
The next several steps for "merging" the asteroid images are best understood by doing them.

Here is a screen shot of the "merged" asteroid:
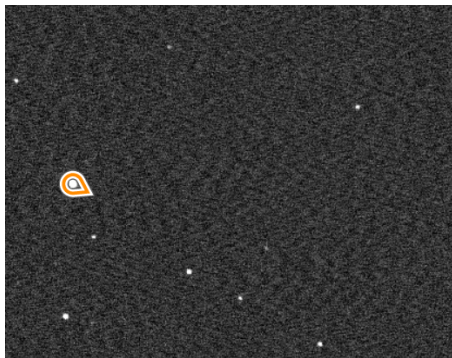
We must now mark a standard star

Mark any of the bright stars in the image. This marked star(source) will be across all the images(files) chosen.

The rest of the instructions on the SJS site in this part results in a downloaded csv file. Follow them carefully for success! Then continue to the next "Parts" on the site to analyze the data.