Lab 8 -Photometry Processing

Purpose

In this experiment we perform aperture photometry using **Maxim DL** software.
http://en.wikipedia.org/wiki/Photometry_(astronomy)#Aperture_Photometry
This involves drawing a circle around the target star, containing all pixels within that star. A second, outer annulus is drawn, and is used to measure and subtract sky background.

This procedure is also performed on non-variable *comparison* stars in the field, and on each image in the stack. We can then measure the target star's brightness, by comparing it to the non-variables, of known magnitude.

This is called differential photometry, and allows precise measurement of magnitude changes over time. These changes are calculated and graphed in **Maxim DL** for study and analysis. We can then determine transit times, or study eclipsing events and other phenomena such as novae.

Procedure

Before beginning, find the desktop location of your image files. Open an image, then go to View_File Information and note the exposure time and binning (i.e. 1min1bin). Locate the folders with the appropriate dark frames, flat fields, and bias frames for processing. *Flat fields must match the binning and date of your images (i.e. bin1flat020314). Dark frames must match the exposure and binning of your light frames. (i.e.1min1bindark).*

Start Maxim DL, choose File_Open and navigate to your folder of images. Select and open all the .fits files. These are the actual star images totaling ~ 30-60 frames. Maxim DL will load the .fits files, ready for calibration. In the main window, go to Process_Calibration Wizard, review the calibration wizard window and click Next. Make sure Regulated (for temperature) is chosen and click next. Choose Manual from the drop down menu. (We'll choose calibration frames by hand.) Hit Next.

In order of software commands, navigate one at a time to the appropriate bias, dark, and flat field folders on the desktop, to load these files. File types are also labeled in the .fits header. Read the description of each calibration frame type as you proceed, to briefly review their function:

Bias frames subtract CCD readout noise from the flat fields.
Dark frames subtract thermal noise recorded during the exposure.
Flat fields "divide" out various forms of uneven illumination in the field.

After loading the calibration frames, click Finish in the Calibration Wizard window.

Each group of calibration frames now appears in the “Set Calibration” window. Under “Combine Type” choose Median, and check Apply to All Groups. Median will discard the worst data, such as random cosmic rays (high energy particles striking the CCD.) **Maxim DL** will now create master calibration frames from each set of images. Hit OK.

In the main window, choose Process_Calibrate All and wait. Maxim now applies the 3 master calibration frames, to all images in the stack. When finished, the images will look distinctly improved, with unwanted data such as noise and “dust donuts” (round specs on the image) removed.

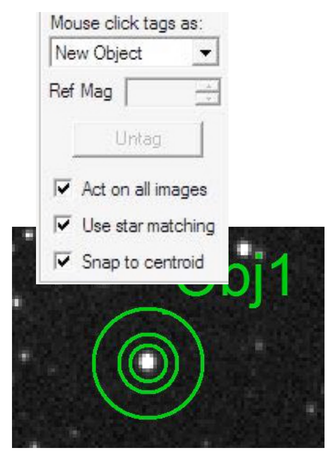
Performing the Photometry

Purpose
Next, we perform the actual photometry measurements of our target. After entering the magnitudes of our comparison stars, the target star magnitude can be determined for each image, then graphed over time. Data can also be saved as a .csv file (comma-separated values) for later analysis in Excel.

Procedure
Go to Analyse_Photometry to bring up the Photometry window and tools. Visually locate your target star in the image, using the printed AAVSO chart provided, for your star. *In the following procedures, be careful to select the correct target and comparison stars!*

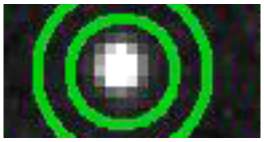
In the Photometry window, check Act on all images, Use star matching, and Snap to centroid boxes. These settings allow Maxim DL to accurately identify and measure the target star and comparison stars throughout the entire stack.

In the Photometry window, under Mouse click, tags choose New Object then click on the target star and wait for Maxim to tag that star on all images in the stack. When finished, three green circles appear around the target, now called “Obj1.” For the following steps, Obj1 (or any star) can be enlarged as needed using + and – symbols in the control window.

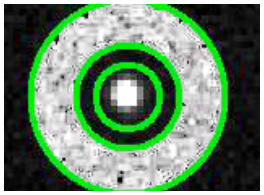


Maxim DL

These 3 apertures can be resized to mark the target star, exclude any unwanted nearby stars, and define the sky background. Right-click anywhere in the green aperture to select a new size, as needed for Aperture Radius (to select the star), Gap Width (the area between the star and the background), and Annulus Thickness (for background measurement). Gap Width is handy for isolating unwanted random stars in the field. A bit of practice quickly shows how these aperture tools are used:



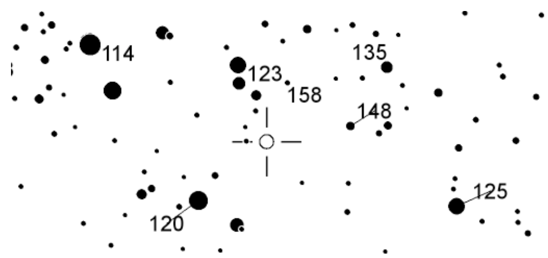
The inside aperture called “Aperture Radius” measures the star’s signal and should surround the entire star to include ALL pixels containing starlight. Even faint outer pixels are included.



The outer two green circles create the “Gap Width” and “Annulus Thickness” which is used to measure and subtract sky background. (Shown here in gray) The same gap and annulus sizes are later used with the comparison stars, for consistent background measurements.

The Photometry window also shows each image file with date and JD time, and has tools for excluding (in rare cases) images with airplanes in the field.

Under Mouse click, tags choose New Reference Star and left click on one of the numbered stars identified on the AAVSO chart. Be sure to choose the correct star in your image. This “reference” star is a non-variable comparison star, and used to calculate the target star’s magnitude. The target is identified with a crosshair, on the chart.

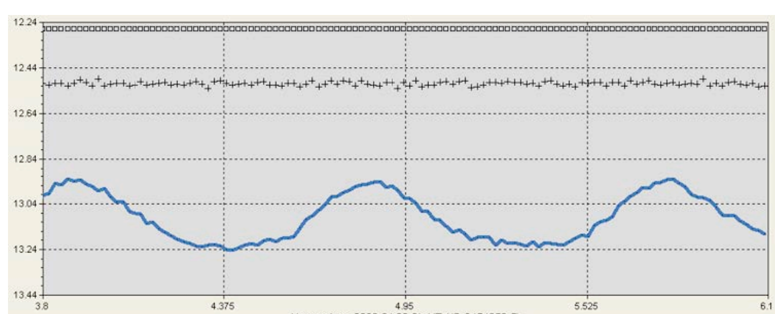


AAVSO chart

Maxim will now ask for the magnitude of the reference star just chosen, with a blinking cursor in the **Ref Mag** window. The second AAVSO sheet provided, contains magnitudes of the comparison stars. Look for “V” (visual) magnitude. Enter the V magnitude now, usually to 3 decimal pints. Go slowly and repeat this procedure for 1 or more additional comparison stars in the field.

There are now at least 3 stars tagged in the image stack: Obj1, Ref1, Ref2, etc. The reference stars’ magnitudes by nature stay the same thru the entire stack, and will be averaged together before determining the target’s magnitude.

Click View Plot at the bottom of the photometry window. The graph appears with the light curve of your variable star clearly defined. Comparison stars appear as unchanging, straight lines. The graph shows UT time and Julian Date on the X axis, and calculated magnitudes on the Y axis.



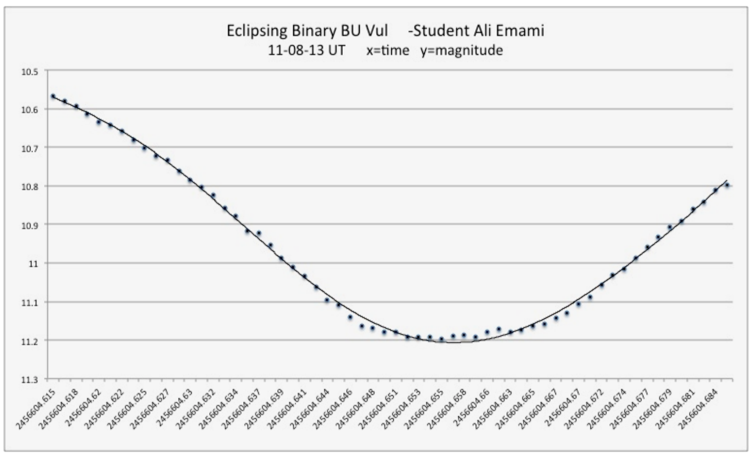
Maxim DL graph

Click Settings to make adjustments to the graph. Time axis and Magnitude numbers can be adjusted as needed for a more concise plot. This is done by unclicking auto and typing in X (time) or Y (magnitude) parameters by hand, as needed. After choosing personal preferences, hit OK. When finished hit print to print the chart as shown.

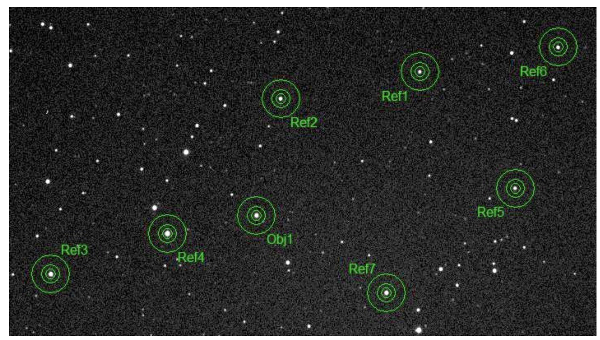
Optionally, choose Save CSV to save a .csv file for further analysis in Excel.
The .csv files are also used to submit student exoplanet data to ETD website.
http://var2.astro.cz/ETD/predictions.php

Additional Resources:
Maxim DL tutorials: http://cyanogen.com/maxim_tut.php
AAVSO Variable Star Astronomy: http://www.aavso.org/variable-star-astronomy
AAVSO Variable Star Plotter (VSP): http://www.aavso.org/vsp
NASA Julian Date Converter: http://ssd.jpl.nasa.gov/tc.cgi
Eclipsing Binary Ephemerides: http://www.as.up.krakow.pl/ephem/

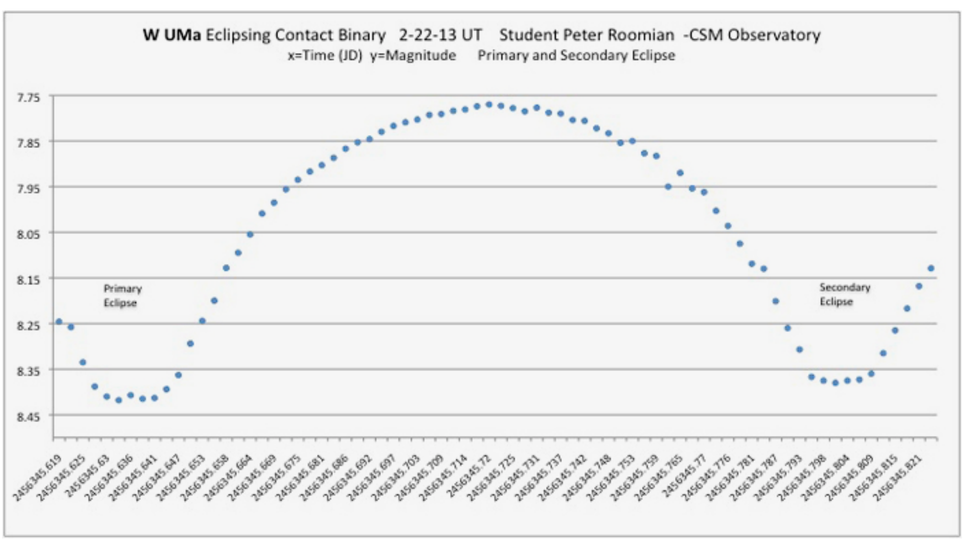
Student data taken in the observatory and processed in MaximDL.



Eclipsing Binary light curve –Student Ali Emami



Target and comparison stars, Maxim DL



Complete eclipse light curve, WUma   -Student Peter Roomian