ASTR 4100 / 6100

Observing Project - Part 2

Due Date: Friday April 3 by 5pm (in my email or in person)

Now that you have all collected your observations, it's time to reduce your images and analyze them.

Please keep in mind that, while datasets acquired at HLCO will be shared between students, **each student is required to submit his/her own project showing the results of his/her own data reduction and analysis.**

4100 students: responsible for reducing and presenting one night of V-band data (primary target), PLUS two additional nights of V-band data (secondary target)

6100 students: responsible for reducing and presenting one night of V-band data (primary target), PLUS 1 night of BVR data and 1 night of V data (secondary target)

NOTE: There is plenty of data available for everyone to complete this assignment. Make sure to get copies of data sets from other groups early if you need them to complete the project goals.

1. Logsheets

Each student should turn in printed copies of their logsheets from their own scheduled observing runs. Every logsheet should be completely filled in with all the requested information included. For example, weather conditions should be included as should seeing values (a few measurements throughout the night is fine). Some of this information can be retrieved from your images themselves after they have been analyzed, so keep this in mind. If for any reason you do not have one or more of your logsheets (observing canceled due to weather, etc), then a *brief* written explanation describing the circumstances should be submitted in place of the missing logsheet.
Note: *If you personally missed an observing trip with your group, a paragraph explaining the circumstances must be included here, and will be used to determine whether you met the full participation goals of the project.*

2. Reference Stars

To carry out the analysis of your asteroid, you will need to choose 3 reference stars in the same field of view as the asteroid on a given night. Because the asteroid is moving, you will have to choose different reference stars for each night of data. Turn in a picture of each field with your 3 reference stars clearly labeled, as well as a radial plot for each star from a single image through a single filter (make sure this information is clearly described so that I know exactly what you are showing in your plots). Good reference

stars are stars that (1) are in all your frames, (2) don't have the asteroid pass in front of them, (3) are NOT saturated in any of the frames (check several to be sure, and check all the relevant filters!), and (4) if possible, are similar in brightness to the asteroid. You will use the same reference stars for all your images of the asteroid on that particular night, and you will use the same aperture size around your stars for all of your images on a specific night (refer to the IRAF photometry handout). Be sure to include a description of the size of the radial aperture that you chose for your analysis and the inner and outer radii for the background region along with your radial plots.

3. Differential Photometry Calculations

Turn in work that clearly shows your aperture photometry calculations for the light curve plots (correcting your measured magnitudes in each frame). Be sure that it is easily apparent for me to figure out exactly what you did.

4. Light Curves

For each filter, you will need to plot the following:

- magnitude vs. HJD for asteroid
- magnitude vs. HJD for <u>each</u> of your 3 reference stars in the field of the asteroid

Be sure to include error bars on all magnitude measurements in your plots. See the helpful tips at the end of this document. If there are any of your calculated data points that should be viewed skeptically, describe them and why they might not be trusted at face value. This could be a problem with the calibrations from that night, or instrument issues, or operator error, or weather that has suddenly taken a turn for the worse, etc.

5. Analysis

Investigate your light curves and answer all of the following questions:

- How many features (minima or maxima) did you observe in each light curve of each asteroid? List the corresponding HJDs for each feature.
- What rotation periods do you estimate for the asteroids based on the full night of data? How do they compare to the expected values? (refer to Observing Project Part 1)
- What is the difference between the minimum and maximum magnitude (ΔV mag) that you measured for each asteroid based on a full night of data? How do these compare to the expected values? (refer to Observing Project Part 1)
- **6100 only:** For at least three field stars on the night of your BVR analysis, identify calibrated B, V, and R magnitudes from a reference catalog (APASS is one helpful option here). These may not be the same stars you used for your aperture photometry reference -- that is ok. Compare the calibrated magnitudes from the catalog(s) to the uncalibrated magnitudes that you measured for the stars, then use this information to calibrate your asteroid magnitudes. What are the colors (B-V and V-R) of the

asteroid? Which families of asteroids do each of them belong to based on their colors (cf. Dandy et al. 2003)?

- **6100 only:** Combine all of your V-band data for the secondary asteroid into a single file (3 columns: HJD, mag, mag error) and test out the periodogram tools at: http://exoplanetarchive.ipac.caltech.edu/cgi-bin/Pgram/nph-pgram
  Attach the periodogram that you get using the Plavchan algorithm, and provide a phased light curve using the rotation period that you think is most likely based on the available information. Describe your reasoning.

6. Take-away Lessons

With any observing run, there are many possibilities for things to go right, and for things to go wrong. Learning to be an efficient and resourceful observer takes time and practice and requires everyone to make mistakes along the way so they can learn from them. The life of an observational astronomer can be very fulfilling, but oftentimes can also be very frustrating. The goal of training as an observational astronomer is not just to learn how to take data and waste as little time as possible on a beautiful night. It is also to learn to identify the problems you can fix and to grow confident enough to fix them, but also to learn to identify the problems you cannot fix and to grow confident enough in your judgement to report those problems promptly and not make them worse.

Turn in at least one full page (12 point font, 1-inch margins, single-spaced) describing your experiences and your own personal lessons from this observing project. Some things you may want to think about and include:

- How was this observing project different from what you expected?
- What was the biggest lesson you learned?
- What was the most unexpected lesson you learned?
- If you had to do it over again with all these experiences now in hand, what would you do differently? (observations, data reduction, and/or analysis)
- What did you most enjoy?
- What did you least enjoy?
- Do you think observational astronomy is for you? (No worries if the answer is no!) Did this project change your mind one way or the other?

7. Checklist

As stated on the checklist, it also needs to be turned in with the materials described above.

Extra Helpful List of Suggestions for Observing Project Report

1. **DO** read the directions and make sure you turn in what has been requested
2. **DO** ask questions if the instructions are not clear
3. **DON'T** wait until the night before to ask questions

PLOTS

- do plot the error bars and make sure that you have propagated your errors correctly
- do make sure you include all necessary labels and they are all legible
- do consider plotting HJD-2457700 or something like this on the x-axis so that you can see the fractional time that goes with the tick marks
- do make sure that your y-axis range (Δmag) is the same for your asteroid and 3 comparison stars (something like a 1mag range, or 1.5mag range maybe)
- do NOT connect the dots in your plots

MATH

- do double check that everything is obvious from the information you have provided --- can I clearly see your work and figure out what you did?
- do ask 2 friends if they used the same logic that you did, not just 1 friend (maybe you both made the same mistake)

Example plot -- yours should look kind of like this (my error bars are smaller than most of the points, but they are there):