Astronomy 16 – Modern Astrophysics
Fall 2014
Lab 5 - instructions
Wednesday, December 3, write-up due by Thursday,
December 11 at 5pm

This document should be used in conjunction with the *Lab 5 – background* document that was posted prior to last Wednesday's lab meeting. Here I will give you some additional pointers for producing the best-possible light curve and for fitting a transit model to the light curve. I will also provide guidelines – a checklist – for what you should include in your write-up.

This is the only formal lab write-up you'll do this semester, so please take some care with it. Always ask yourself if the story you're telling is clear and if the claims you're making are supported by evidence that a skeptical or confused reader could understand.

Remember that quite a few resources are permanently linked form the right side of the class website's front page. This includes now the *Lab 5 – background* document as well as the photometry and data reduction tutorials, observation planning resources, *AstroImageJ*, and *SIMBAD* (the star information database). You should find most of the pieces of information you need there or in the headers of the data files.

Your write-ups are due by 5pm on Thursday, December 11. The regular lateness policies will apply (20% off for up to 2 days late, half off up to a week late).

Goals of the lab and write-up checklist

We are working with data I took two weeks ago, on a KELT exoplanet transit candidate host star. The ultimate goal is to determine if there is an exoplanet orbiting this star (currently referred to as KC12C033095), based on the several hours of photometry I took at the time of a predicted transit. (See the background document for information about how these candidates are identified and why most candidates turn out to not be exoplanets. And ask about this – or anything else – if you have any questions.)

And if we detect a transit or transit-like event, we also would like to determine how big the planet is (or at least put constraints on its size, as well as on several other orbital parameters).

Your lab write up should include

A short introduction describing the goals and the basic characteristics of the data and of your analysis procedure. This should include information from the background document about the host star's properties (e.g. its magnitude, but also its B-V color and thus its approximate spectral type; see *SIMBAD*).

A more quantitative description of the data, including: when it was taken (time as well as date – look in the headers of the first and last images), the exposure times, the range of airmasses, the type and number of calibration files used, the filter(s) in which the data were taken.

A brief description of the data reduction steps you applied and a representative image of the field (with the target star indicted) and then a second version of the same image, but reduced, with a

comment on the improvement in the noise properties that the reduction accomplished.

A description of the photometry (you don't have to go into detail about the mechanics, but you should include an image of the field that shows which stars were considered as comparison stars and which ones actually were used). You should also include a statement of what size apertures you used for the photometry (in pixels) and the range of radii over which the sky background was measured. (That information is generated when you plot the radial profile of a sample star prior to doing the photometry – though you can change the settings in the photometry interface, too.)

A graphical representation of the target star's light curve along (on the same plot) with any relevant comparison star light curves and the airmass trend and total comp star counts, too. You should comment on the role the changing airmass played in giving us the trends we see. (Note that the computed airmass plot is shown in the background document, too – you should comment on how the star's altitude in the sky was changing during the course of the observations.) The overall goal here is to convince the reader that you've got the most reliable possible target light curve.

A second plot of the target light curve, but zoomed in to show just it, normalized so the out-of-transit data averages to 1.00, along with the best-fit transit model. Your plot should be well labeled and should show the predicted ingress and egress times for the transit (see the Tapir output in the background document).

You should discuss the qualitative and quantitative properties of your transit light curve – how noisy are the data (how much random scatter)? Is the out-of-transit data relatively constant (as

one would expect)? Is the transit flat-bottomed or V-shaped? And what are the implications of that?

You should include a statement of the fit parameters, with an emphasis on the transit depth and the associated planet radius (ratioed to the star's). The data in this plot could be binned, if you think that improves the signal-to-noise significantly (you can try fitting your light curve twice, once binned and once not). You should report on other orbital and system properties you derive from your fit. And you should be sure to discuss relevant assumptions that you made for the fit (i.e. parameter settings in the fitting interface).

You should have a short conclusion summarizing your most important results. You should note what additional observations would give us more confidence in our conclusions.

Additional instructions for photometry and light-curve fitting with AIJ, and analysis/interpretation

Remember, there is a manual for AIJ on the AIJ website.

Note that an update of AIJ has just been released. Note also that there had been some problems with AIJ under the new Mac OS, Yosemite.

As you do your data analysis, it can't hurt to save information, including, for example, screen shots of various user interfaces.

You can draw vertical lines to mark the predicted ingress (beginning of the transit) and egress (end of the transit). The controls for this are at the top right of the "Multi-plot Main"

interface that opens up when your lightcurve is finished being plotted.

Be careful/consistent/organized with your "Norm/Mag Ref," Scale, and "then Shift" settings so you can display all your comp star light curves on the same plot as your target and see their interrelated trends.

Note that the "Norm/Mag Ref" setting that uses both or either outer-third of the light curve can be further controlled by using the "Fit and Normalization Region Selection" at the bottom center of the Multi-plot Main interface.

Use the "Bin Size" column in the "Multi-plot Y-data" interface to experiment with different binnings. Some binning is probably warranted in order to smooth out some of the noise.

In the Multi-plot Y-data interface, near the left, you can use the "Y-data" pull down menus to plot all sorts of things, including the total comp star counts and the airmass. You could then scale the airmass by a negative number so it mimics the brightness changes expected from varying airmass. You can even scale it (by trial and error) to the total comp star counts to see the extent to which the latter quantity tracks the former (places where it doesn't are likely times where there were light clouds, and so that can alert you to parts of your target light curve that might be less reliable than others).

Note that the airmass can be used to "de-trend" the target light curve. (More details about this…after I explore the capabilities a bit more.)

Do the light curve fitting simply by using the drop-down menu under the "Fit Mode" column in the Multi-plot Y-data interface. Note, among other things, that the light-curve fitting interface wants to know what the host star's spectral type is (why, do you think?). You can use the B-V colors (from SIMBAD) to estimate this (using one of the tables in the textbook appendix).

Please get in touch with me if you have any technical questions, and as we generate more useful tips, I'll update this document.