Introduction

In your first observatory practical you learned the basics of how to use the telescope; now we will use it with one of our CCD cameras to record some images and do some simple data analysis. We will record images of binary stars and the open cluster M29. We will determine the telescope's platescale and find the angular separation between pairs of stars. For the data analysis we will become familiar with two important computer programs: `ImageJ` and `fv`.

Procedure

Set up the telescope with the flip-mirror and 26 mm eyepiece. If you haven't already learned how, the observatory supervisor will show you how to set up the LPI CCD camera. Create a folder under `c:\PH2900\2007\` that indicates the date, e.g., `24oct07`. From the LPI camera's control program, set the images to be recorded in this folder.

Point the telescope to a bright star such as Vega (you can do this directly with the goto command). Centre the star in the eyepiece and synchronize the coordinates.

Unlock the primary mirror and try to focus as best you can manually, then relock the mirror. Then go to the double star Albireo. Improve the focus by using the electric focusser and the camera's focus mode.

Take several images of Albireo with different exposure settings. Save some of the images in jpeg format to show the colour information; for the rest of the practical save the images in FITS format. Also experiment with the quality control settings used by the program to decide which images to store. Ensure that the peak pixel values are not so high as to saturate the image. (See below on how to check this using the program ImageJ.)

Next go to the 'double-double' star ε-Lyrae. Get both stars on the CCD image. (For this it's useful to know whether you should move north or south; use Starry Night and check the coordinates of where you are pointing.) If the seeing conditions are good and you achieve a good focus, you can just resolve the double-star systems ε1-Lyrae and ε2-Lyrae. Record several images of ε-Lyrae, ensuring that the peak pixel value is not so high as to saturate the image.

Now go to the open cluster M29 and record several images. This will require a longer exposure time (try e.g. 16 seconds). If you have time, try taking some images of other open clusters (see e.g. Starry Night). Finally if you have time look at some globular clusters such as M13 with the eyepiece. The LPI camera is unfortunately not sensitive enough to record images of these.

Edit the logbook file to indicate the observers, targets seen, where the data are stored, and any additional comments (weather, seeing, etc.). Then zip the folder to e.g. `24oct07.zip` and copy it somewhere where you can access it later, e.g., your W or Y drive. (The folder needs to be zipped in order to be downloadable later from your W drive.) Alternatively, you can copy the data directly onto a flash memory stick.

For all of the targets you should also take a look using the eyepiece. In your report you should describe briefly your visual impressions.

Analysis

To analyze the images we will use the programs `ImageJ` and `fv`, which are already installed on the computer centre PCs. Both programs can also be freely downloaded and installed on your own computers. You should become familiar with both programs, but you can analyze your data with either one. Include at least one image from both programs in your report.

The program `ImageJ` was written by biologists to analyze photomicrographs but it has many features that make it well suited for analysis of astronomical images. More information can be found at `rsb.info.nih.gov/ij/`.

Start the program and open a fits or jpeg file. If you hold the cursor over a given pixel, the program will indicate the number of counts. Go to image $\rightarrow$ adjust $\rightarrow$ brightness/contrast and adjust the values so as to reveal the maximum amount of information (best to try this with one of the clusters such as M29).

The best method for saving images to be included in your report is probably to use alt-PrtSc to copy the image into the buffer, and then paste it into a program such as `Paint`. Then crop off the frame and save what is left as a jpg file. (If anyone comes up with a better method then they should please share it with the rest of us!)

The program `fv` ('FITS viewer') can display FITS files and provide access to all of the information contained in them. Information on `fv` can be found at `heasarc.gsfc.nasa.gov/docs/software/ftools/fv/`. Take a look at the `fv` user's guide to see how to get started. Open a FITS file and figure out how to access the header information. Display the image by clicking on 'image'. Investigate different options for the colour map, grid lines, etc.

The first goal of your analysis will be to determine the platescale of the telescope. Estimate what this should be in arcseconds per pixel by using the focal length of the telescope ($F = 3048\,\mathrm{mm}$) and the inter-pixel spacing of the LPI CCD camera ($s = 8.0\,\mu\mathrm{m}$). Use the platescale determined in this way to estimate the angular separation of ε-Lyrae. Compare your answer to a published value (check e.g. Starry Night).

In general the angular separation you determine will differ somewhat from the published value, the most likely cause being the uncertainty in the pixel separation of the CCD camera. Now use the published angular separation of ε-Lyrae to re-determine the platescale. Using this value, find the angular separation of the two stars in Albireo. Identify several of the brighter stars in M29 and for at least one pair determine the angular separation. Compare your values to published ones.

Report

In your report you should include a brief description of the procedure followed, observations, analysis, and results, following all of the guidelines that you learned in the first-year laboratory course. Include at least one image of each target observed and in addition you should provide some (brief) background information on all of the targets. The entire report should consist of around 4 pages of text not including images, tables, etc.

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