ELTE

Astronomical observational exercises at Piszkéstető

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2018

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I. Introduction

I.1. About Piszkéstető

The observatory at Piszkéstető consists of three main telescopes in different sizes. It is the biggest facility in Hungary that is capable of making astronomical measurements. The observatory due to its location and the size of the telescopes is mostly able to see brighter objects but on these long-term measurements can be executed. Photometric and spectrographic measurements are being done during our stay and even new CCD chips have been deployed to one of the telescopes.

I.2. CCDs

CCDs are semiconductor devices that are highly effective in capturing most of the incoming light and converting photons to electrons. The conversion rate is called quantum effectivity (QE) which is very high in CCDs and pretty low in digital cameras. Not only do they work effectively but also they have linear response - called gain - which is basically the number of resulting electrons per photon.

I.2..1 Image pre-processing

Due to the CCD architecture there are a number of pre-processing steps to be done before anylizing an image.

1. **overscan removal**: it is calculated by the CCD camera by the creation of extra pixels in a row, the mean value of this should be subtracted from the image and the extra row removed/trimmmed

2. **de-biasing**: subtraction of the mean pixel values that are acquired as a mean of zero exposure images

3. **dark noise correction**: taking images with the same exposure time with a closed shutter in order to be able to remove thermal noise - CCD chips are usually cooled to a low temparature, given a low enough temperature, this noise can be almost eliminated - this is also done by acquiring and averaging more images

4. **flattening**: by taking images of an evenly illuminated CCD chip one can correct for the chip's individual pixel sensitivity and also for dust particles that are stuck to the chip as well as vignetting at the edges

After having acquired the master images of bias, dark and flat we needed to substract the first two and divide by the latter which was scaled between 0-1 by *fitsh*.

During this lab the CCDs did not create overscan pixels so that step should have been skipped but we did that following three steps with a software package called *fitsh* [1] which is a C library designed for the analysis and processing of CCD images.

II. Measurements

II.1. Photometry analysis of XX Cyg cepheid

We were given archive images of a pulsar called **XX Cyg** and we did the preprocessing steps with the above mentioned package. After the images were pre-processed we run some scripts with *fitsh* to find stars over a given pixel-threshold (10000) then we used one of the measurements as reference image. This was necessary as the different images were taken in a period of time and the field of view was rotated and shifted during the process. The last step was to transform these images into the same view.

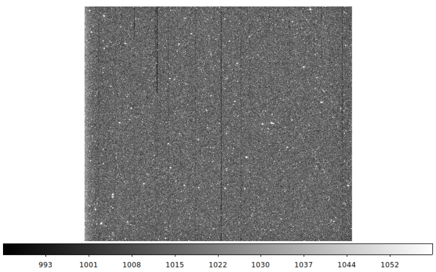

Figure 1: Before preprocessing and transformation

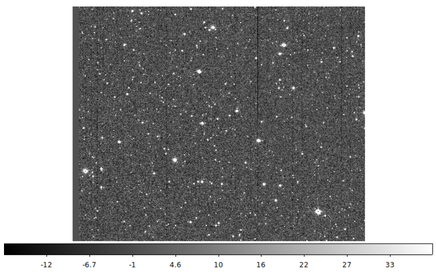

Figure 2: After preprocessing and transformation

We also had a program that visualized stars and with this we were able to select our star and the start to that we compared it with. This can be seen in the plot below:

[1] https://fitsh.net/

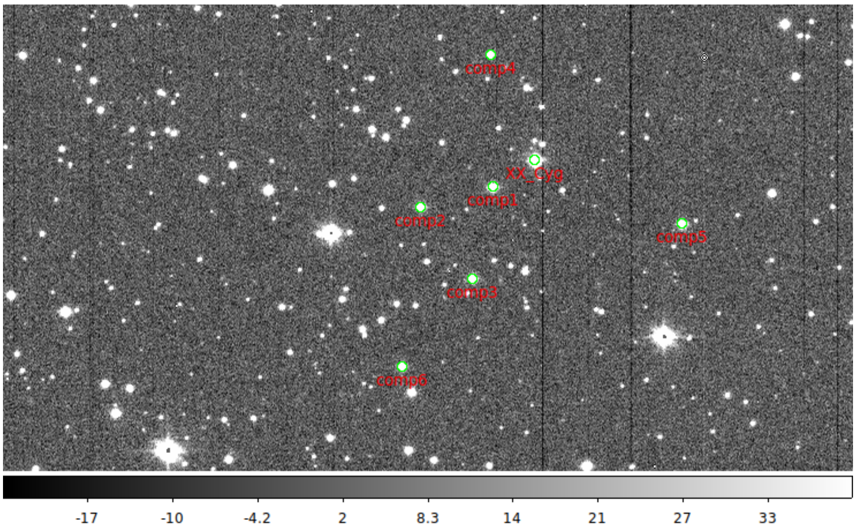

Figure 3: The target and comapring stars (XX Cyg and comp1-6)

We then extracted the photometric data with *fitsh* and created plots of the target and comparing magnitudes in filters R and V. The periodicity can be seen on the image as well as that the choosen stars for comparison were good enough since they do not vary a lot compared to each other.

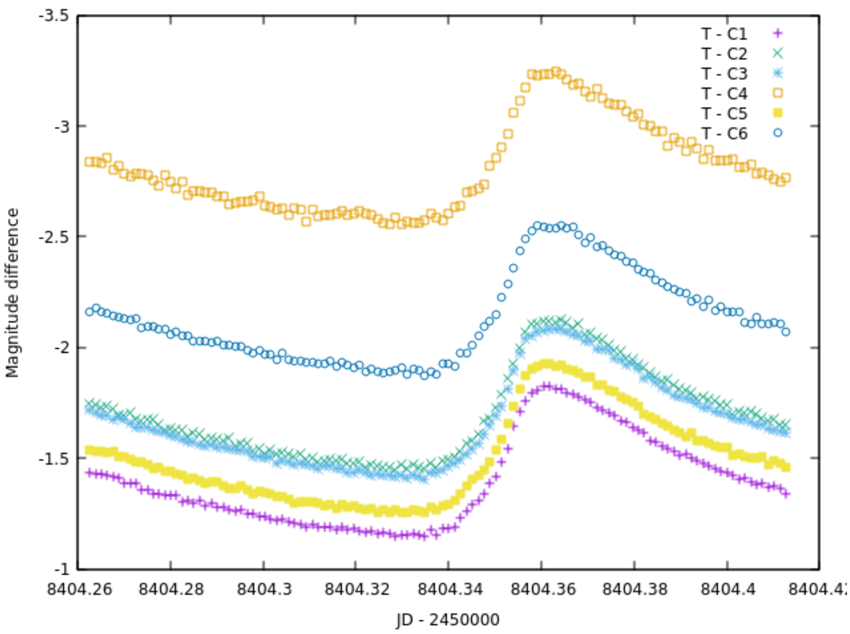

Figure 4: Magnitude difference with each comapring star given the Julian date of images

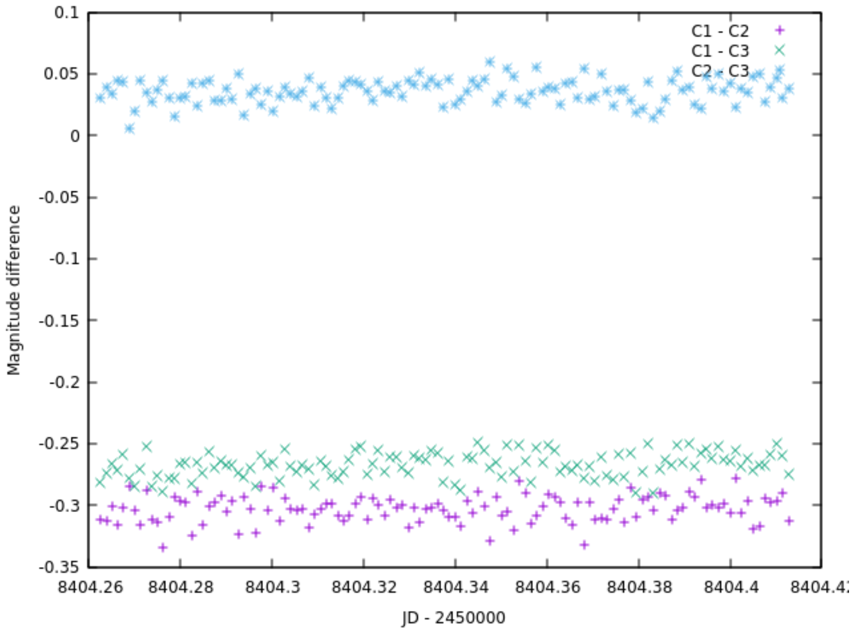

Figure 5: Magnitude difference of some comparing stars given Julian date

These measurements were done with the Schmidt-telescope in 2018/10/12. The periodic time of XX Cyg is approximately 3 h and 14 min which is $\approx$ 0.14 JD. Given 3 it can be seen that the frame is 0.16 JD and it seemingly shows around 1 period.

II.2. RGB image from RC-80 image filters

We also got images taken on 2019/02/06 on which we did the preprocessing steps and used the r, g, B filters on images of galaxy M51. We then uploaded these images to a site [2] in order to fill the header files with the appropriate celestial coordinates. These were needed for the python *aplpy* package which used *astropy* to correctly make an RGB image from the corrected r, g, B filters. After hours of unsuccessful tries we finally were able to create a pretty RGB image of the galaxy.

[2] http://nova.astrometry.net/upload

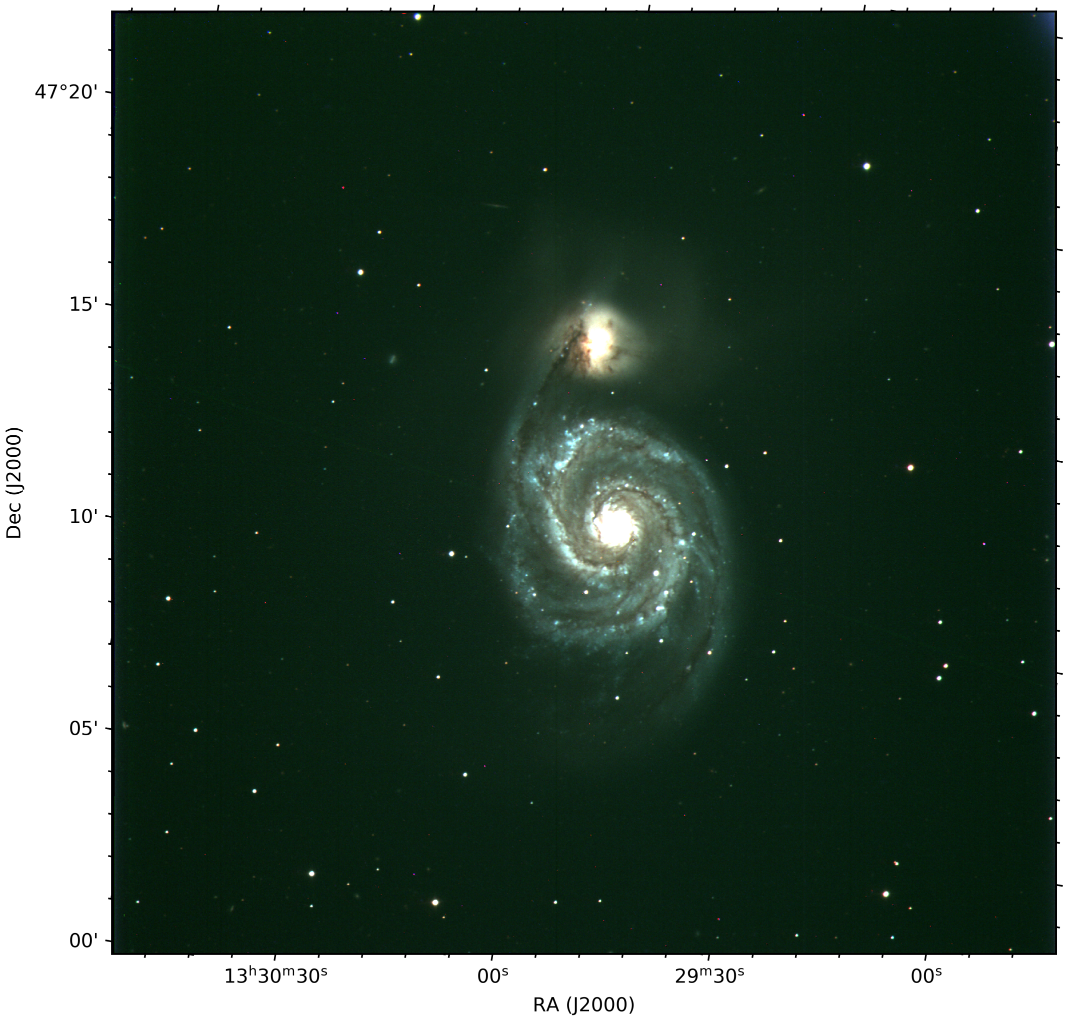

Figure 6: RGB image of galaxy M51

III. Conclusion

We had a nice weekend at Piszkéstető. We got acquainted with the experiments that are being done here and also we were shown how to process and analyse images on our own. Róbert was very helpful and patient with us and everything went smoothly during our stay. We uploaded our scripts to GitHub [3].

[3]Our scripts: https://github.com/qbeer/piszkesteto