Experimental construction of a CCD-compatible astro-spectrograph at Rozhen NAO

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Abstract. This communication is devoted to a study of the possibilities to build an astro spectrograph, capable to provide valuable data of professional quality while remaining in the limits of a very restricted budjet.

Key words: astronomical spectroscopy

Introduction

We consider the task of building a spectrograph as important since our UAGS (Universal Astronomical Grating Spectrograph) is unable to be coupled to modern cooled CCD camera. The reason is the short distance between the last surface of camera and its focal plane - 13 mm. Cooling of the CCD chip needs much greater distance from the CCD to the protective glass in order to avoid condensation of moisture on the surface of the window.

Figure 1 shows the drawing of the FLI PL09000 CCD camera used at Rozhen National Observatory. It is obvious, that the spacing from the input to the CCD chip is 30 mm ľЎS more than twice the distance available at the spectrograph.

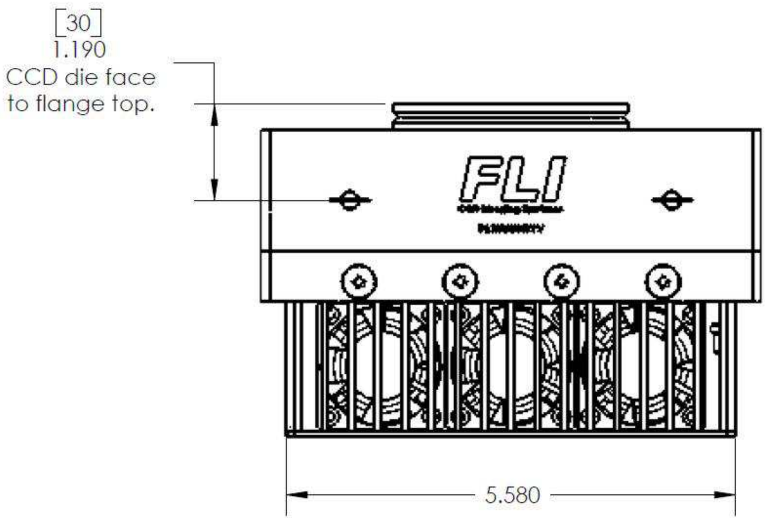

Fig. 1. Drawing of the position of the CCD chip inside the camera

As a result - medium resolition spectroscopy is practically not available at Rozhen NAO (Bonev, 2011)

Since commercially available spectrographs are either expensive or not suitable for professional application plenty of spectrographs were constructed ranging from simple design (Buil, www) to fiber feeded eshelle spectrographs (Baranowski et al., www)

Fortunately there is a favorable byproduct of the expansion of digital photo cameras in professional photography. A number of high quality optics adapted for large format photo cameras (6 x 6 or even 6 x 9 cm) are left out of service. Their field of view and large focal distance are well suited for use with astro CCD cameras. And at a very reasonable price!

1 Construction

In 2008 we started the work on the design of a spectrograph, based on transmission optics. We have 12 micron pixels of the FLI CCD and the projection of the slit on the CCD surface may not exceed 36-40 micron. If the focal length of the collimator and the camera are equal, then the slit width will be of the same value. Our 60 cm telescope has 7200 mm focal length and the scale is 27 пїЅ/mm, so 40 micron slit corresponds to 1.1 пїЅ on the sky. For 2 m telescope the situation is even worse пїЅ at 16000 mm focal length only 0.5пїЅ of the image pass through 40 micron slit. To пїЅcompressпїЅ the image of the wider slit onto the CCD surface we need to change the ratio between the focal lengths of the collimator and the camera.

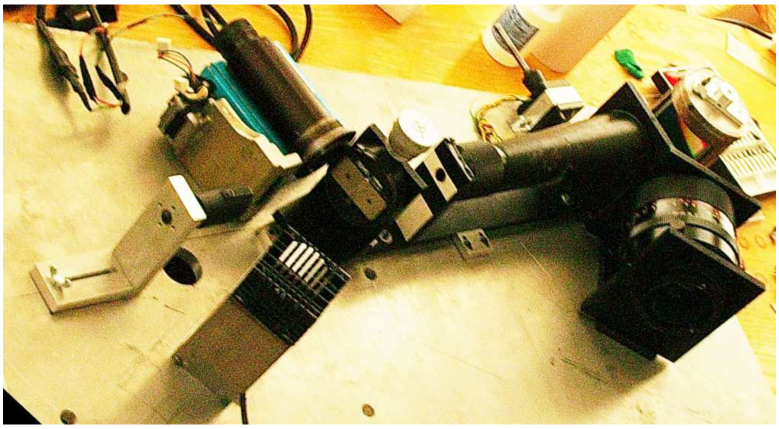

Fig. 2. Spectrograph elements transferred on the basement plate

We fixed the focal length of the camera to 180 mm, considering that with 300 grooves per mm grating and 40 degrees angle between optical axes of the collimator and camera the dispersion will be about 180 Å/mm and we can have the range of 4000 to 8000 A in the first order entirely situated in the frame. At 2.15 A per pixel we can use this grating for rough spectral classification and, using software, to estimate the B-V color.

Using a grating of 1200 grooves per mm we will have dispersion of about 47 A/mm and resolution 0.56 A per pixel. This will allow for better estimation of radial velocities, but at least two exposures and rotation of the grating will be needed to cover the same spectral range.

Fig. 3. Grating bearing

If an achromatic doublet with a focal length of 300 mm is used as a collimator, we can use 1.7 times larger slit, keeping the dimensions of the beam and the spectrograph in reasonable limits.

The image of the first spectrum was registered using the Phillips SPC900NC web cam, modified for long exposures, following Steve Chambers (Chambers, www). It has preflashed firmware to avoid nonlinearity introduced by the preprocessing of the image and black and white CCD matrix.

After the performance test, the construction was transferred to a basement plate together with deviating mirror, CCD webcam for observation of the image on the slit, comparison spectrum lamp, combined with retractable mirror designed to illuminate the slit with comparison spectrum light and stepper motors for movement of the retractable mirror and rotation of the grating. The basement plate with elements of the spectrograph mounted is shown in Fig. 2.

Testing of the construction lead to changes in the grating bearing in order to ensure the mechanical stability. This last grating bearing unit is shown in Fig. 3.

The tightening element can be seen in front of the unit which fixes the angle of the grating. The handle on the left side allows to turn the grating bearer on 180 degrees and another grating on the back is introduced into the beam.

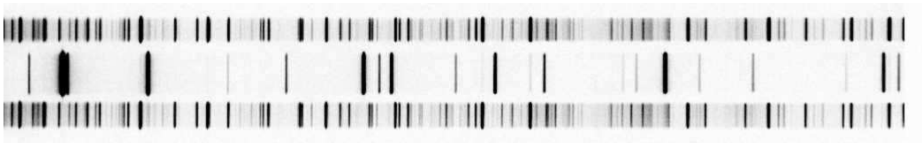

Fig. 4. Part of our comparison spectrum photographed with the Coude spectrograph

The comparison spectra is emitted from a stabilitron lamp SG3S, filled with He-Ar-Ne mixture. Its ignition voltage is 127 V and operational current is 5-40 mA. Figure 4 shows a part of the comparison spectrum photographed at the coude spectrograph. It can be seen, that our comparison spectrum is considerably less populated with lines to avoid blending at low dispersion.

Fig. 5. Experimental construction mounted on the 60 cm telescope

The spectrograph was mounted on the 600 cm telescope for tests. This is shown in Fig.5. At the lower right corner a PL9000 CCD camera can be seen.

To avoid bending of the construction an additional support rod was attached to the counterweight rail, as it is shown in Fig.6.

A spectrum of A2 class star, obtained by the spectrograph, is shown inn Fig.7. Due to the early type of the star the Balmer series can be followed up to Hη пїS 3835 A.

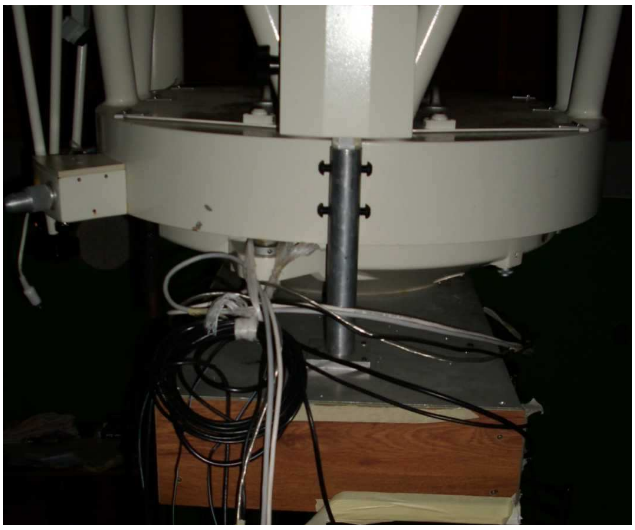

Fig. 6. Support rod attached to the construction

2 Conclusion

The accumulated experience of designing and testing allows us to establish that:

It is possible, using affordable elements, to make a spectrograph suitable for solving problems in professional astronomy.

The main problem for spectral observations at 60 cm telescope is guiding, especially for faint objects. That is why, the continuation of the work on completing the construction of the spectrograph has to be preceded by the finalization of the remote guiding system for the telescope (Popov V., Dimitrov D. 2010).

It is possible to increase efficiency of the spectrograph if a focal reducer is used. It will allow to got into the slit more light from the object. It is important, that there is no requirement for perfect image quality on the entire field of view, since the spectrograph uses only the image in the center of the field.

The identification of all the lines of the comparison spectrum is not an easy task in some spectral regions, because of blending.

Acknowledgements

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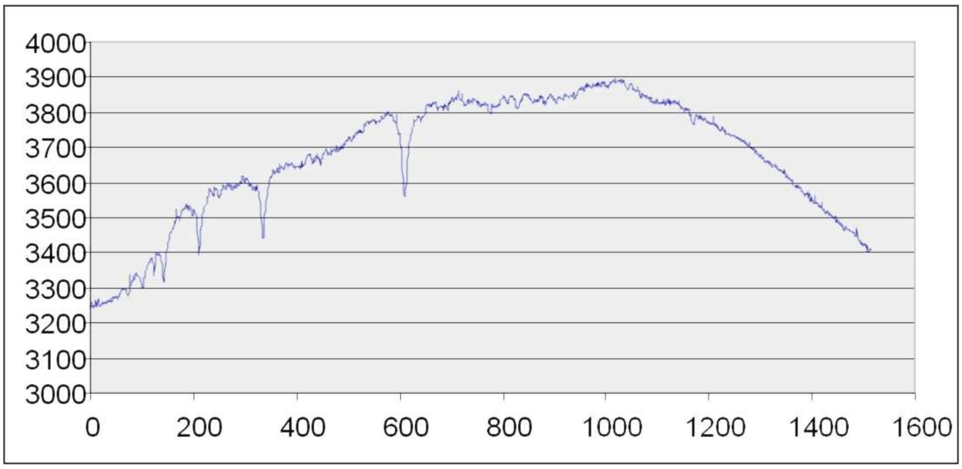

Fig. 7. First spectrum - A2 type star

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