ADAPTIVE MODE OF THE MSS BTA

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ABSTRACT. The study of instability of the Main stellar spectrograph of the 6-m Telescope together with system of registration of a spectrum by means of the CCD shows that there is a drift of a spectrum along a dispersion, corresponding to the tenth of a pixel (the hundredth part of Å) in an hour. To eliminate this drift, i.e. to keep a spectrum from displacement, the plane-parallel glass plate was installed behind a slit of the spectrograph. The angle of inclination of this plate changes depending on a mismatch of positions of the current and comparison basic spectra. A lamp of hollow cathode is used. The scheme of this device is described. The results of tests are presented. The time of correction takes about one minute that allows to keep the position of the ThAr spectrum within ±0.0006 Å.

Key words: Stars: high precision spectral measurements

Introduction

The Main stellar spectrograph (MSS) equipped by the analyzer of polarization with double slicer, serves as one of the main tools for the measurements of stellar magnetic fields on the 6-m Telescope [Vasiliev et al., 1977, Chountonov, 2004]. Besides the measurements of magnetic fields, the MSS is used also for the chemical abundance studies and the precise registration of the profiles of the hydrogen lines used for the determination of atmospheric models. It is possible to distinguish two types of instabilities of any spectrograph causing the shift of a stellar spectrum during its registration:

– the shift of a spectrum connected with the movement of the center of gravity of a stellar image at the slit of spectrograph,

– the shift caused actually by spectrograph and the CCD system.

Instability of the MSS and CCD

This work is devoted to the second type of instability. After studying behaviour of the ThAr spectrum with time, we have developed and created a system of a current spectrum stabilisation by means of comparison of its position with that of the comparison spectrum. There is an analogue of the image stabilizer applied in digital cameras. Other variants of containment, for example, by moving a slit of spectrograph or the CCD are also possible. However, they seems to us more difficult in realization. The MSS was investigated by means of visual and photographic plate methods in 70-th during commissioning time (see, review [Panchuck et al., 2007]). The both, long- and short-term drifts of a spectrum were revealed. We have carried out the instability measurements using the equipment for measurements of magnetic fields of stars: the analyzer of circular polarization with double images slicer and the CCD (2Kx2K) developed in SAO. In Figure 1 we show a typical ThAr spectrum.

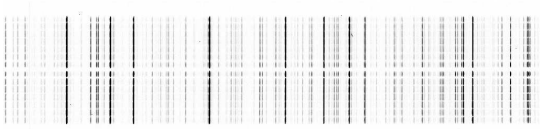

Figure 1: The ThAr spectrum registered with slicer.

In Figure 2 (a, b, c) we present the results of spectra shift measurements with time (number of exposition is on an abscissa axis and a difference of positions of current and comparison spectra is on axis of ordinates) on 1-st (a) and 14-th (b) slicers and their difference (c). A spectrum of the hollow cathode ThAr lamp was used. The light from this lamp was passed through the analyzer of polarization with double images slicer. One hundred expositions of spectra were registered with one minute exposition. The readout time of each frame was 20 sec. We can see a good correlation of spectra shifts of these two cuts which means the reliability of results. The software package in MIDAS environment, created in SAO [Najdenov et al., 2008] was used for reduction of spectra and definition of shifts. As it can be seen from the Figures, the short-term (minute) instability and drift are observed. To exclude influence of failures caused by cosmic particles, the opportunity of accumulation of several frames with the subsequent

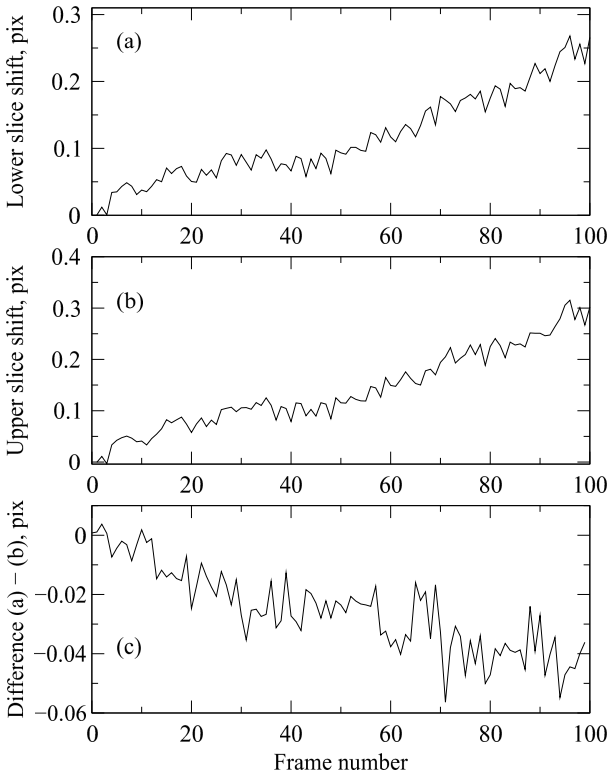

Figure 2: The position of ThAr spectrum for 1-st slice (a), 14-th slice (b) and their difference (c) with time.

clearing of cosmic particles traces was used. The MSS has won to itself glory unpromising that is located on load-bearing elements of the 6-m Telescope. Its elements are on large distances from each other and in different temperature conditions.

Main parameters of the MSS spectrum stabilizer

— a range of stabilization is about ±1 pix from the mean position of a plane-parallel plate, that is ±0.12 Å at 4500 Å

— a step of stabilization is 0.0011 pixels or 0.00014 Å

— time of correction is about one minute. For this time the spectrum drifts on 0.0006 Å.

Testing of the MSS spectrum stabilizer

The block diagram of the device for stabilization of a spectrum position for the MSS is represented on Figure 3. The computer 1 (PC1 under Windows) operates the CCD. After registration of a spectrum it copies a file with the image to the computer 2 (PC2 under LINUX). PC2 carries out an extraction of spectrum, calculates the difference of positions of current and comparison spectra, translates it into number of steps of the step motor and sends this value

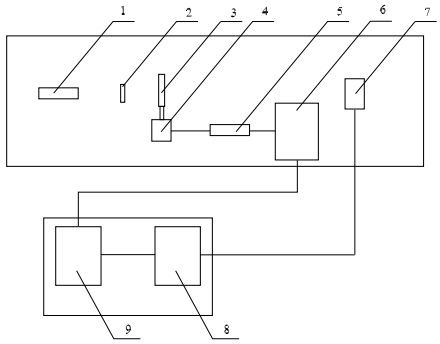

Figure 3: The block diagram of the device for stabilization of the spectrum position: 1 - ThAr lamp, 2 - slit of the MSS, 3 - plane-parallel plate, 4 - the step motor, 5 - the controller, 6 - PC3, 7 - CCD, 8 - PC1, 9 - PC2.

to computer 3 (PC3 under LINUX). PC3 turns a plane-parallel plate 3 on a necessary angle through the controller 5 and the step motor with a reducer 4. PC1 and PC2 are located in an management room, other elements on Nesmyth focus balcony. All procedure of correction can be repeated, if noncompensated value exceeds admissible value. The comparison spectrum is created preliminary in position of a plate of +1000 steps from the end contact. In this position the plate is almost perpendicular to the optical axis of the spectrograph. The relation "step/pixels" has to be about 0.0011. A plate thickness 6 mm are provided with displacement of a spectrum within the limits of not less than ±1 pix. The pixel size is 13 microns. One step corresponds to 0.00014 Å in the blue part of a spectrum.

Results of tests of the device for stabilization of a spectrum position

To check the work of the device, we have installed the additional inclined glass plate in a beam of light after the slicer. This plate causes artificial shift of a spectrum. In this condition of the device the comparison spectrum was created. On Figure 4 it corresponds to a point 1 on an abscissa axis. Then we have removed an additional plate. The position of a spectrum changed noticeably, approximately on 1.1 pixels (point 2). After that the program of shift compensation was started and the shift was compensated for three cycles.

It is possible to see from Figure 2c that a dispersion of a spectrum position about 0.005 pixels on one minute exposition. The drift during the exposition of 2 hours corresponds to 0.04 pixels. It is possible to explain that the spectrum turns with time also.

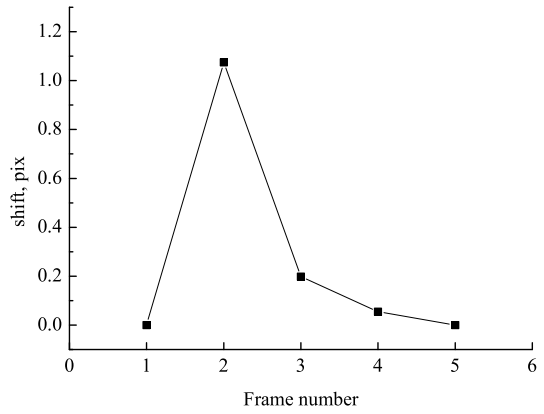

Figure 4: The compensation of an artificial shift of the spectrum.

Conclusions

The device for the MSS spectrum stabilization was created and is in trial operation on the 6-m Telescope. It allows, with an interval of one minute or often less, to carry out the correction of ThAr spectrum position with an accuracy of about 0.0006 Å. The device can be used for increasing the accuracy of radial velocity measurements of stars. It can be advanced by a principle stated in the work [Chountonov et al., 2000], by carrying out of a part of the electronic image containing a comparison spectrum, for calculation of the corrections, returning of a spectrum in a starting position and, thus, corrections of a spectrum of a star during accumulation without interruption an exposition. In the future, a fast photodetector with internal amplification EM CCD can be used for electronic correction of the image by simultaneous or consecutive registration of a star spectrum and a comparison spectrum.

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