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Digital version of the CrAO archive of spectral observations of the Sun, carried out with the KG-2 coronagraph

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With the development of computer technology a topical problem to digitize the astronomical data stored on various media, for their preservation and accessibility for further faster and more accurate processing has arisen. Creation of a digital archive of observational data obtained with the KG-2 coronagraph and stored on photographic films has been started at the Department of the Solar Physics of the Scientific Research Institute "Crimean Astrophysical Observatory". We obtained satisfactory results in comparing a part of the spectrum digitized with EPSON Expression 10000XL scanner and with the MF-2 type scanning microphotometer which was used before. This allows the scanner to be used in the future to create the archive. We also developed a special software, which speeds up the processing of scanned data, and tried to minimize and eliminate potential errors.

Key words: astronomical data bases: miscellaneous, Sun: flares

INTRODUCTION

Crimean Astrophysical Observatory (CrAO) has a large amount of observational data obtained with different telescopes and instruments. Most of this information is stored on photographic plates and photographic films, that causes a lot of difficulties with access and digital processing. Recently in CrAO we have started the project of the total photographic archive digitization in order to incorporate our observational database into the global one, and the creation of the digital version of the Sun spectral observation archive is the part of this work [3].

EQUIPMENT, INSTRUMENTS AND INITIAL TASKS

The KG-2 telescope of CrAO (see Fig. 1) is a stationary Lyot coronagraph system with the Coude focus. It has a one-lens objective with the diameter 530 mm and the focal length 8000 mm at 5500 Å. The diffraction grating has 200×250 mm in size and 600 lines per millimetre. The dispersion of the spectrograph is 1.0 Å in the second order spectrum of the second order, and 0.58 Å in the third order one. The spectral and time resolutions are 0.04 Å and 5–10 seconds[1], correspondingly.

The coronagraph is used for the spectroscopic observations in the spectral region around Hα line and study of non-stationary processes in the lower solar atmosphere. Registration of spectra is carried out with 13cm×18cm photographic plates or 35 mm photographic film.

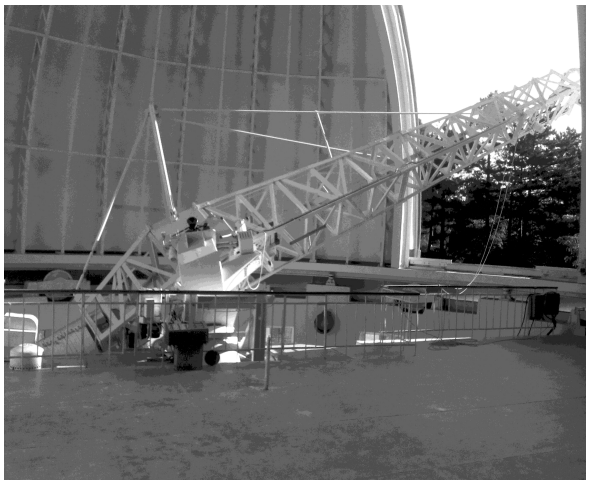

Fig. 1: Coronagraph KG-2.

Coronagraph KG-2 has operated since 1978, and observational data accumulated during this time require further digitizing and processing.

Since 2011 the EPSON Expression 10000XL[2] scanner was used for film digitizing. Previously the scanning MF-2 type microphotometer [2] had been used for that purpose. Epson Expression 10000XL scanner is designed for the high-quality scanning of materials of different sizes (up to A3) and transparent media such as slides and negative films.

The main characteristics of the scanner are the following:

- scanner resolution: 2400×4800 dpi;
- maximum scanner resolution: 12800×12800 dpi;

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[1] http://solar.crao.crimea.ua/rus/telescopes.htm#kg_2

[2] www.epson.com/cmc_upload/0/000/044/561/10000XL_CatSheet.pdf

- maximum colour depth: 48 bit;
- maximum paper size: A3;
- max optical density: 3.8D.

To find out the suitability of the scanner for announced work the prior comparison of its results with those of the microphotometer was made along with the determination of the optimal scanning parameters for films.

For comparison the observational data of the solar flare registered with KG-2 by A. Babin and A. Koval on June 7, 2011, were selected. A part of the spectrum near the Hα-line, covering the wavelength range from 6558.35 Å up to 6569.60 Å, was extracted, digitized and processed (see Fig. 2). The height of this region is 10 pixels.

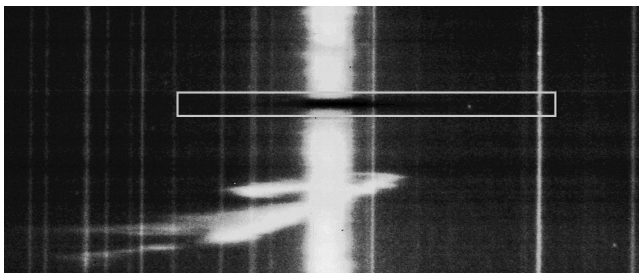

Fig. 2: Spectrum of the solar flare with a fragment that was used for comparison (the selected box height is 88 pixel).

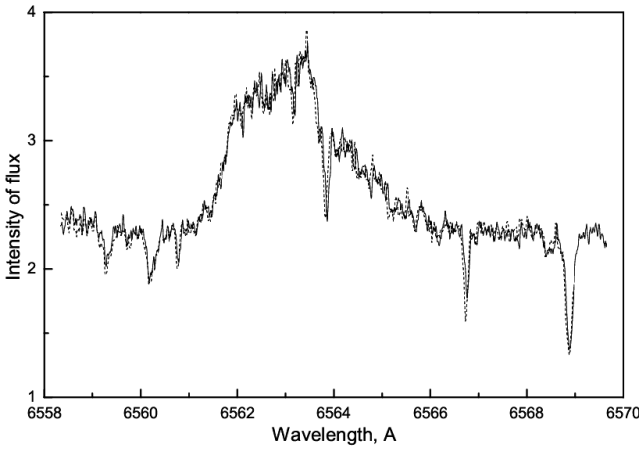

Fig. 3: The comparison of results for two scanning instruments.

To build the characteristic curve of the film a step attenuator was scanned (under the same conditions). We obtained eight photometric cuts of attenuator, that allowed us to build the third order characteristic curve. According to these data the characteristic curve of the third order was build. The approximation coefficients were used for conversion of the data, obtained with the scanner, into the flux intensity. Comparative results for both, the scanner and the microphotometer, are shown in Fig. 3. The solid and dotted lines show the data obtained with the scanner and with the microphotometer, respectively. The values of intensity are given in arbitrary units.

Fig. 4 shows the correlation of the data obtained with the microphotometer (horizontal axis) and the scanner (vertical axis). The line $X = Y$ is shown. The correlation coefficient is equal to 0.96.

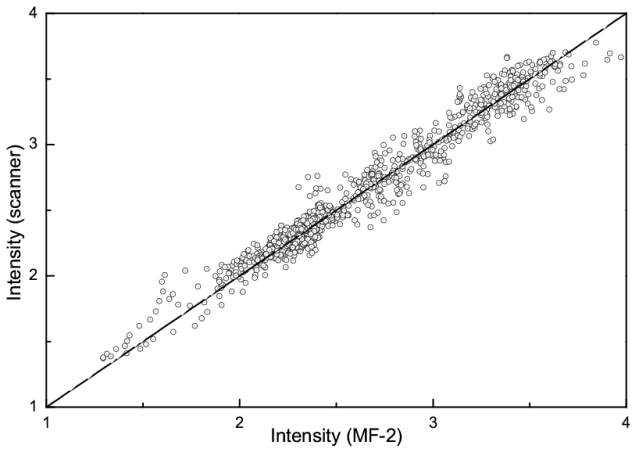

Fig. 4: Correlation graph.

RESULTS AND CONCLUSIONS

Creation of the digital archive of spectral observations of the Sun, performed with the coronagraph KG-2 of the Crimean Astrophysical Observatory is a necessary step, since the analogous treatment of other observational archives has been carried out in the observatory for several years. Digitizing of this information allows not only the data to be saved, but to be processed more effectively on the basis of the up-to-date information technologies.

The main issues that have to be resolved before the digitization of archival data start, are listed below:

1. Selection of optimal scanning parameters for films, in particular, the optical resolution (if one has a low resolution then some information will be lost; if resolution is very high then the grain structure of the film will appear).

2. Removing of optical effects that appear in areas of abrupt transition from more optically dense parts of the film to less dense ones during the scanning time. Fig. 5 shows the decrease of intensity in the spectrum near the boundary of regions with different optical density. The dashed line shows the average intensity in the unperturbed regions of the Sun. The photometric cut was obtained across the dispersion. Our task is to determine the nature of these optical effects and to eliminate them. It is obvious that this problem will be solved by the introduction of additional normalization coefficients.

3. Implementation of a reliable spectrum calibration at the selected wavelength. Here we used narrow and legible atmospheric water lines with the wavelengths 6548.621, 6552.627, 6564.200, and 6572.070 ÅÅ. The centres of these lines are determined with an accuracy within 0.075%.

4. Taking into account the presence of defects on the film surface. This factor is hard to assess, since the defects occur randomly.

5. Minimizing the impact of human factors on the final results.

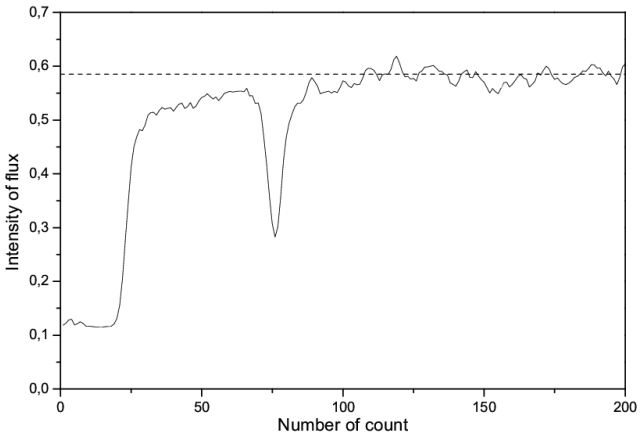

Fig. 5: Optical effects.

The last two problems can be solved by application of the specialized software that will be able to take into account all the nuances. The development of the appropriate code has already been started.

Here, we calculated radial velocities of the solar flare occurred on June 7, 2011 using the data of several scanned frames with spectra, obtained with the KG-2 coronagraph. The radial velocity was obtained by standard technique using the Doppler effect. Calibration of spectra was made with the help of the atmospheric water lines 6548.621, 6552.627, 6564.200, and 6572.070 ÅÅ. The average error of velocities was about 0.12%. The obtained values of radial velocities in the flare (58-230 km/s) are consistent with the data from other sources [1].

The digital version of the archive will provide an opportunity not only to calculate the basic characteristics of non-stationary processes in the Sun, but also to build (in some cases) long-term data series, which is a subject for further analysis.

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