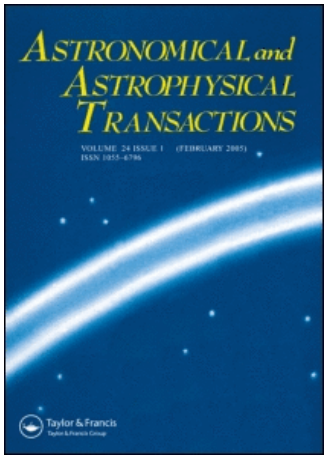

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A DIGITAL METHOD TO SEARCH FOR LONG-TERM VARIATIONS IN STELLAR BRIGHTNESS

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A quick digital method based on the PARSEC measuring complex which was developed in the Main Astronomical Observatory (Ukraine) is proposed to search for long-term variability in the brightness of red dwarfs. The capability of this scanning complex was tested earlier when it was used to digitize photographic plates successfully in the process of creating the astrometric catalogue. Application of this complex and special software to compute digitized images and to obtain photometrical data is discussed briefly.

Keywords: Photometry of active late-type stars; plate archives

1 USING PHOTOGRAPHIC ARCHIVES IN THE RESEARCH PROGRAMME ON THE ACTIVITY OF RED DWARFS

In a similar way to what occurs on the Sun, processes of interaction between convective motions, rotation and the magnetic field take place below the surface of late-type stars. As in the case of solar activity, this leads to the appearance of dark spots, flares, strengthening of ultraviolet (UV) and X-ray fluxes, etc. There exist a number of indices sensitive to variations in the magnetic field that can be used to study the activity in different layers of stellar atmospheres. Long-term observations of the behaviour of these indices indicate that the level of stellar activity varies over several years or even several decades. It is not unusual among solar-type stars that the duration of their cycles is similar to the 11 year solar cycle, but most late-type stars show cyclical variations in light on time scales of 5–60 years with peak-to-peak amplitudes of magnitude up to some tenths (Baliunas et al., 1995; Bondar', 1996, 2001). Such variations are produced owing to changes in the number and parameters of spots during their evolution on a stellar photosphere. Some stars demonstrate irregular chaotic changes in light and others exhibit slow cycles (Bondar', 1996, 2001, 2002). Samples of light curves of several red dwarfs are presented in Figure 1. The full circles indicate data obtained from the plate archive of the Sternberg Astronomical Institute (SAI) and from

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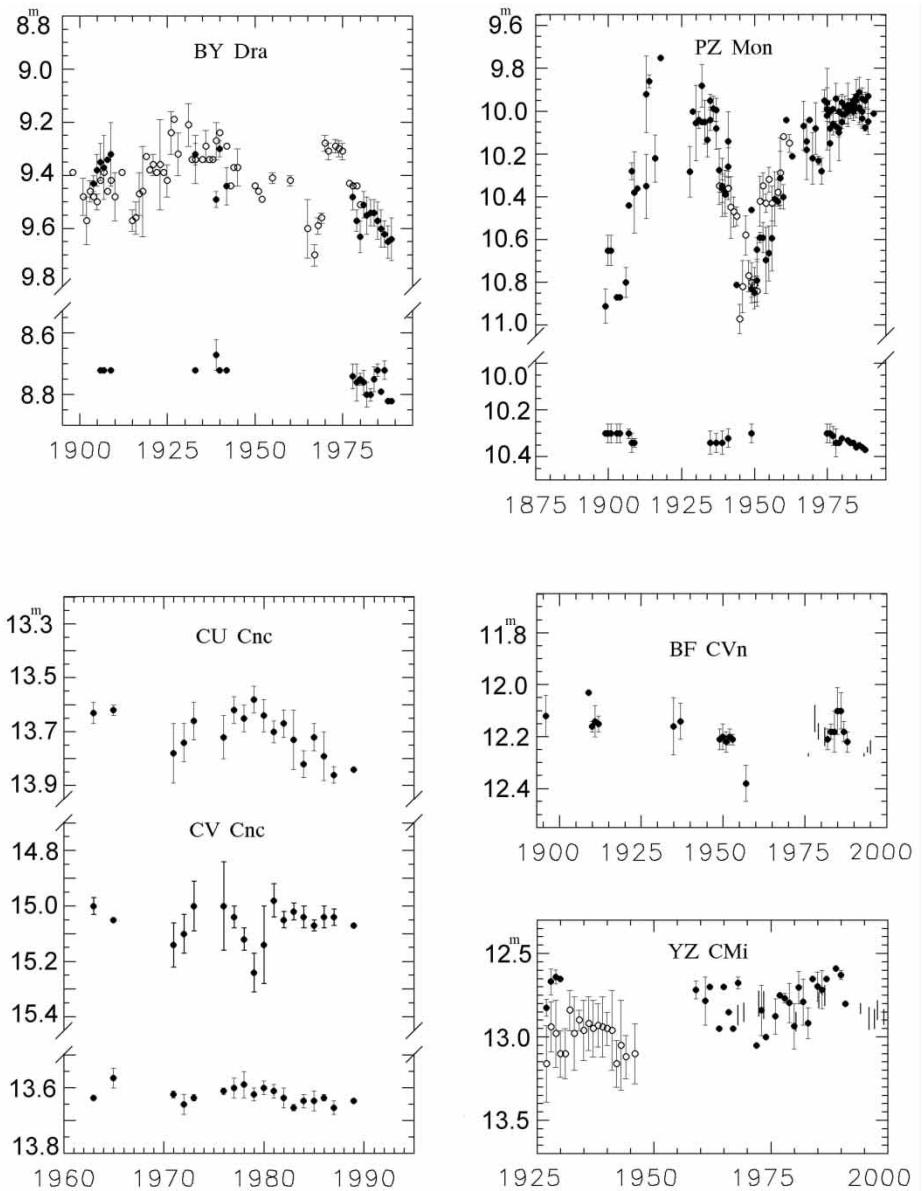

FIGURE 1 Variations in the yearly-mean magnitudes of red dwarfs.

the plate collection of Sonneberg Observatory; open circles show the published data obtained by other workers in the archives of Harvard Observatory and of Hamburg Observatory; vertical lines are photoelectric data.

The most complete information about the long-term brightness variability of stars can be obtained by measurements of photographic plates. They allow us to study the photometric behaviour of several stars on a time scale of about 100 years. As a rule, the number of measured plates in such studies reaches several thousands. For example, to construct light curves of 40 red dwarfs we measured about 6000 plates in the archives of SAI, Odessa Astronomical

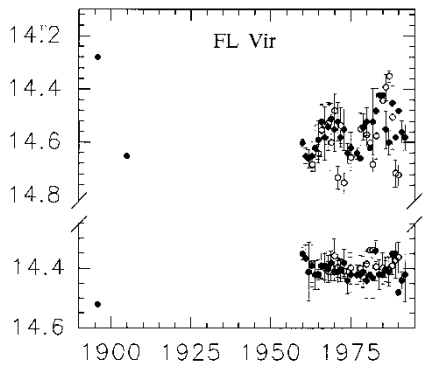

FIGURE 2 The light curve of FL Vir: •, measurements from the SAI plate collection; ○, data obtained in the archive of Sonneberg Observatory. Also light curve of comparison star are shown below.

Observatory and Sonneberg Observatory. These observations allowed us to find long-term changes in the yearly-mean light of 29 red dwarfs and to study statistical relations between several physical parameters of these stars and their activity level (Bondar', 1996, 2001, 2002). A new research programme is based on the recently created catalogue of UV Ceti flare stars and related objects by Gershberg et al. (1999), which includes data for 463 stars. Using this catalogue and information about the field size and the coordinates of centres of photographic plates in the SAI archive, about 80 dKe–dMe stars with B magnitudes brighter than 17 were selected for our programme list. Some of these stars can be investigated in other large photographic archives. It is important to use several archives to compare and check the obtained light curves. The combined light curves cover the investigated time interval more fully. If comparison stars are chosen in the vicinity of a programme star and are similar to this star in colour, we can estimate magnitudes of many programme stars with a high accuracy, even magnitudes as high as 0.05. In this case, the data obtained in different archives show good agreement (Bondar', 1996, 2001). Figure 2 shows the light curves of the active red dwarf star FL Vir obtained in two different archives. The full circles are measurements in the SAI plate collection, and the open circles indicate data obtained in the archive of Sonneberg Observatory. The light curve of the comparison star is also shown below.

As a rule the magnitudes of comparison stars must be measured preliminarily, by an iris photometer relative to photometric standard stars or photoelectrically. The described procedure of measurements of stellar images is not sufficiently effective, and currently modern scanners and software are used to extract data from photographic plates and to analyse the digitized information.

2 THE QUICK SCANNING METHOD APPLIED TO PHOTOMETRIC MEASUREMENTS OF PHOTOGRAPHIC PLATES

In order to work with plate archives, a quick scanning complex was developed at the Main Astronomical Observatory (MAO), National Academy of Science of Ukraine (Ivanov et al., 1988). The software is based on the standard package PMIS and on original modules proposed by the present authors. The scanner provides a resolution which it is not less than 1200 dpi, corresponding 20 μm for the pixel size of a digitized image. Most plates in the MAO archive were taken with the long-focal-length double astrograph and with

the wide-field double astrograph. Using the developed device to digitize these plates, we can obtain the image scale of 0.7" and 2" respectively. This is in the range of image scales of 1–2" typical of charge-coupled device detectors used in astronomy. These imaging properties allow us to determine positions and photometric values with the required accuracy by means of semi-automatic procedures. The first experience in using the digitizing method was obtained at MAO when the complex PARSEC was applied successfully to create the astrometric catalogue in the project FON-C (Bystrov et al., 1989; Kislyuk et al., 2000).

To examine the capabilities of this complex applied for photometric measurements of stellar images, two plates have been digitized by the Agfa scanner with a resolution of 600 dpi and discriminating 256 levels of grey in amplitude. Using the package PMIS, we determined magnitudes of non-crowded stars in the cluster NGC 6913 which is located in the centre of each plate. The sensitivities of both plates correspond to the Johnson B band. For 22 stars on each plate, we made three series of measurements. The B–V values of these stars are in the range from 0.19 to 1.23 and the magnitudes are from 9.71 to 15.63. The photometric values of the standard stars were taken from the work of Kazanasmas et al. (1982). Fitting the calibration curves by third-degree polynomials (Fig. 3), we found that standard errors did not exceed magnitudes of 0.13 and 0.15 for the first and the second plates respectively.

We are planning to apply this semi-automatic method to studies of long-term brightness variability of 40 red dwarfs investigated earlier by Bondar' (1996, 2001). This will allow us to examine the possibility of application of the scanning complex to photometric investigations and to provide possibilities of extended monitoring of sky monitoring plates in large photometric programmes.

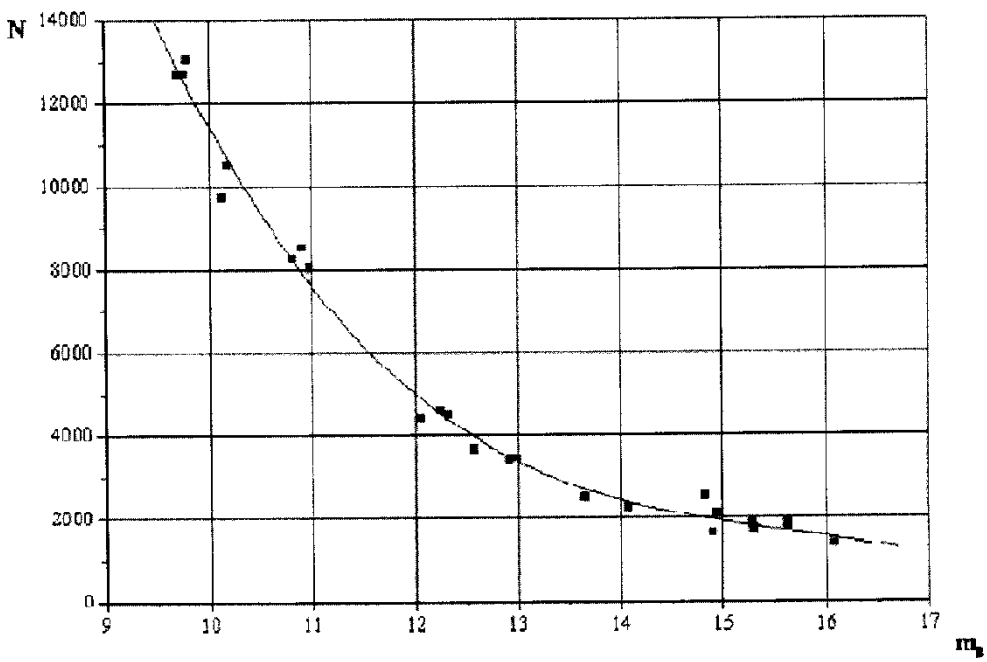

FIGURE 3 The calibration curve of the digitized plate taken with the wide-field double astrograph at MAO.

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