THE 200-CHANNEL SPECTROMETER OF THE CRIMEAN ASTROPHYSICAL OBSERVATORY

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ABSTRACT: A simple, low cost, television spectrometer has been constructed at the Crimean Astrophysical Observatory using an I-Isocon image tube for analog-digital recording of stellar spectra. High quantum efficiency (0.04) together with good accuracy (±0.3%) and repeatability are obtained.

EQUIPMENT

The 200-channel spectrometer built at the Crimean Astrophysical Observatory uses a computer controlled photometric TV system. A block schematic of the spectrometer is shown in Figure 1.

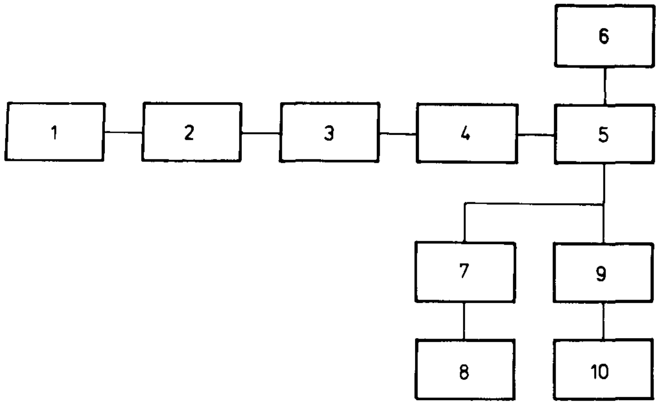

Figure 1. Block schematic of the TV spectrometer: 1, Telescope; 2, Grating spectrometer; 3, TV system; 4, 7, 9, Interfaces; 5, Computer (15 BSM-5); 6, Magnetic tape; 8, Teletype; 10, Perforator.

C. M. Humphries (ed.), Instrumentation for Astronomy with Large Optical Telescopes, 175–180.

The spectrometer uses a 600 line per mm grating for the region 3500-7000A. The detector is an Isocon image tube with a one-stage intensifier (I-Isocon: Nikonov, 1974; Prokof'eva, 1979). Its temperature is held within the range 0-5°C during observations and under such conditions the reciprocal law is obeyed up to integration times of 5-10s.

The stellar spectrum is projected on the photocathode perpendicular to the TV scan direction. Readout times for the TV system, which has non-interlaced lines, are 0.08, 2.56 or 10.24 seconds. The scan time for one line is 72ms and control and re-setting takes 0.08s. The analog TV signal is sent to interface 4 where it is digitised and then processed. The final data are recorded on magnetic tape, paper tape or a printer.

PHOTOMETRIC CHARACTERISTICS OF THE SPECTROMETER

The spectral response has been determined in the laboratory by recording many flat field spectrograms with varying numbers of summed readouts (from 2-2000). Some of these are shown in Figure 2. From each recording, the data in 40 to 100 channels were used to calculate the mean square errors of the measured intensity in each channel. The dependence of the mean square error on the number of summed readouts is shown in Figure 3.

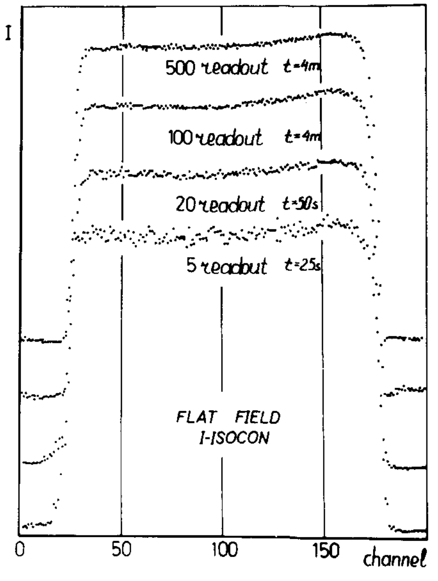

Figure 2. Examples of flat field spectrograms (the noise levels are shown at the left and right sides and the zero points on the intensity scale are arbitrarily displaced).

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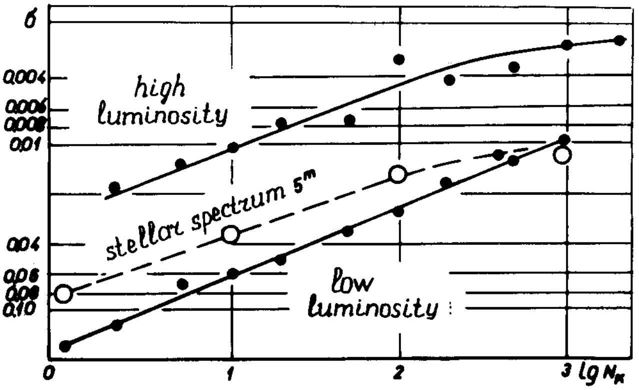

Figure 3. Mean square error of measured intensity per channel shown as a function of the number of integrated readouts. The solid curves are from laboratory measurements. The dashed curve is from the measurement of a 5^m A0 star using a 0.5m telescope.

The stability of spectral line positions is fairly good. Displacement of spectral lines does not exceed 0.3 of a channel over a period of 8 hours. Figure 4 shows the linearity of response of the system and the repeatability of the results.

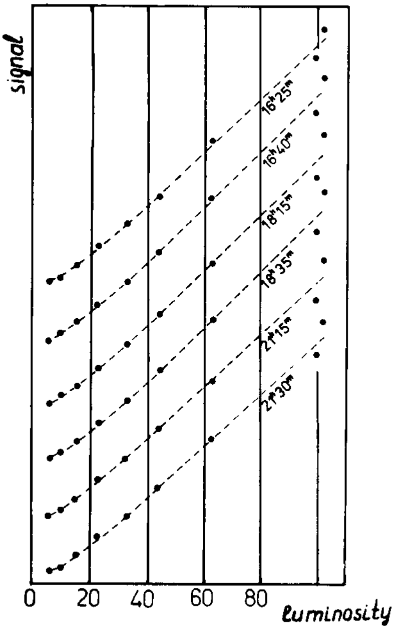

Figure 4. The signal response characteristics (zero points on the intensity scale are arbitrarily displaced).

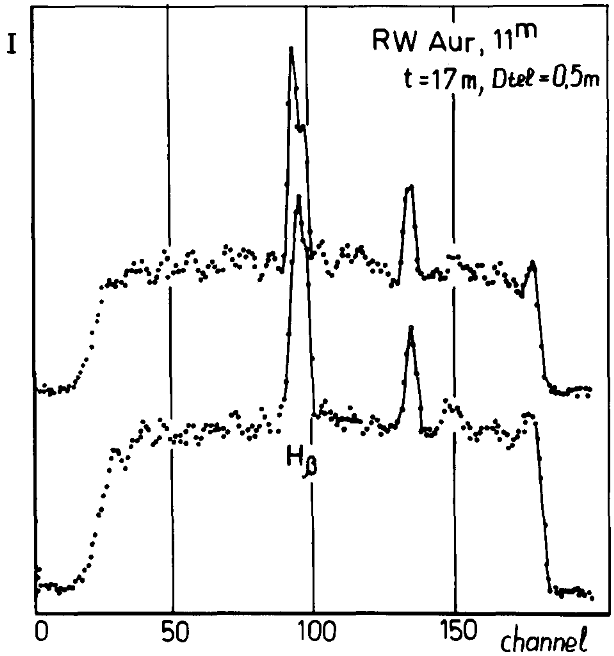

Figure 5. Two spectra of RW Aur. The signal to noise ratio in the continuum is about 20.

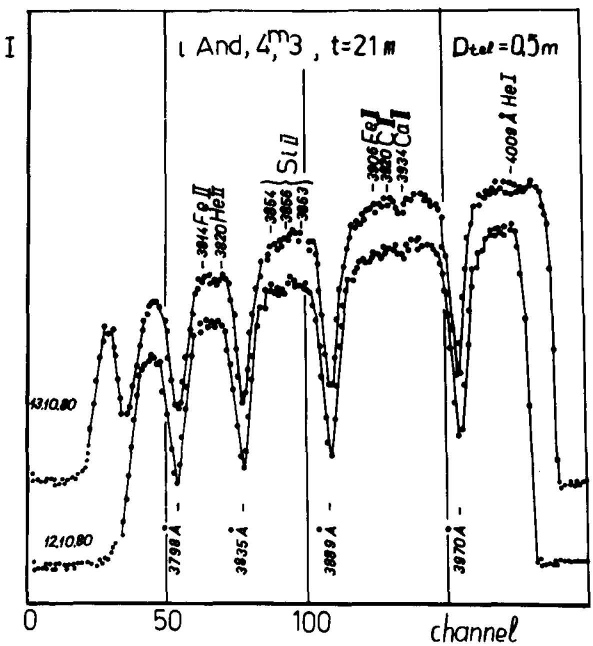

Figure 6. Two recordings of ι And obtained on different nights. The signal to noise ratio in the continuum is 100.

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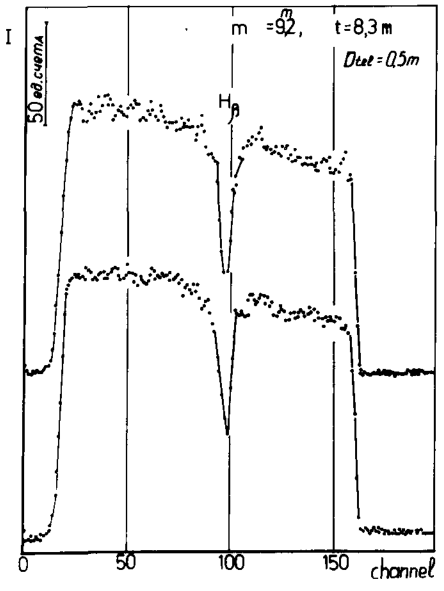

Figure 7. The spectrum of ι And obtained with a neutral filter reducing its stellar magnitude to $9^m.2$. The exposure time was 8.3m. The signal to noise ratio in the continuum is about 40. The zero points of the intensity scale are arbitrarily displaced.

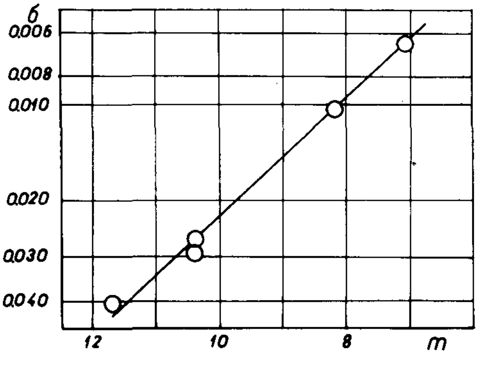

Figure 8. The mean square error of one intensity ratio measurement in the continuum as a function of stellar magnitude.

OBSERVATIONS OF STELLAR SPECTRA

Some examples of stellar spectra are shown in Figures 5-7. In each case the abscissa is the channel number and the ordinate is the intensity expressed in digital count units. All observations were obtained using a 0,5-meter meniscus telescope, f/13. The halfwidth of the

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apparatus function is about 3A and the spectral width of each channel is 1.7 A.

The accuracy of intensity ratio measurements from two channels was estimated for each stellar continuum spectrum and the average mean square errors of these values were calculated for different stars observed. The dependence of the mean square error on the stellar magnitude is shown in Figure 8. The circles represent experimental data obtained with an exposure time of 21m.

Profiles of hydrogen lines in the spectrum of Vega were obtained using a reduction in intensity of about 100. The data are shown in Figure 9. The solid curves give the results of photoelectric observations obtained at Kitt Peak Observatory with a solar telescope (Peterson, 1969). The agreement is fairly good. The detective quantum efficiency of the spectrometer was calculated from spectral observations of different stars giving an average value of 0.04 in the blue.

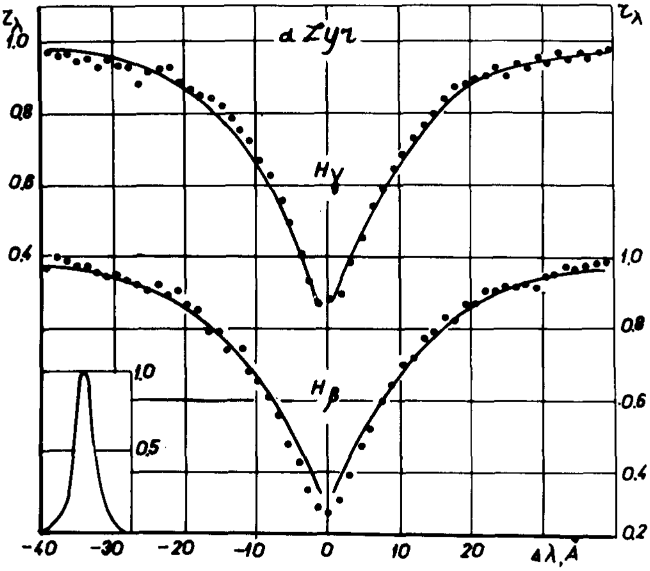

Figure 9. Profiles of Balmer lines Hγ and Hβ for Vega (500 readouts for Hγ, 200 for Hβ). The apparatus function of the spectrometer is the lower left corner.

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