Updating of the two-channel polarimeter of the 1 m telescope of SAO RAS

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Abstract. Information is presented about the updating of the standard two-channel polarimeter of the 1 m telescope of SAO RAS carried out in 1998-1999. Block diagrams of the apparatus and characteristics of the photoelectric amplifiers used are exhibited. Results of photometric testing of the polarimeter over two channels obtained in observations are given.

A two-channel polarimeter for performing fast polarimetry with the lm telescope was made by I.D. Najdenov and V.G. Efremov in 1991 as a model.[1] The device was first installed in the telescope in late 1991 and used for observing Ae/Be Herbig stars both during pilot operation and in subsequent years and appeared to be highly efficient.

However, since the polarimeter was a mock-up make, a number of optical-and-mechanical units had to be improved, most of electronic units superseded by later ones based on novel integral types of components. In addition, it turned out to be of necessity to evaluate performance capabilities of the photoelectric amplifiers all over again because they could change in the course of the 9-year performance and also to determine the limiting sensitivity of each of the channels of the polarimeter by observations of real stars in connection with the application of novel photoelectric amplifiers.

A schematic view of the two-channel polarimeter is displayed in Fig. 1. The star image is positioned in one of four diaphragms (2, 4, 6, 10 arcseconds) mounted on a rotating turret. A clear entrance opening is also available on the turret. From the diaphragm the light enters the input lens playing the part of the collimator. The parallel beam of light from the collimator passes through the electronic-optical modulator (EOM) and then through the Wollaston prism. The view can be inserted when repointing to new objects, while the insertable polaroid is used to adjust the device. The rectangular high-voltage pulses, which control the EOM polarization angle, are triggered by the signals of the control block recurring at a frequency of 1kHz. Readings of the meters to which the pulses from the photoelectric amplifiers arrive are taken in synchronism with the control block signals.

The beam of light emerging from the EOM is split into two components by the Wollaston prism. The components pass through the focusing lens, then they are reflected from the mirror prism faces and, through the Fabry lenses, fall on two different photoelectric amplifiers through two different light filters.

The polarimeter incorporates photoelectric amplifiers of the types FW-130 and EMI-9789 Å. The photoelectric amplifier of the channel "A", FW-130 has a comparatively higher sensitivity in the region from 600 to 700 nm; this is why it operates in the red spectrum region. It is also of higher quantum efficiency as compared to EMI-9789 **A,** that is used in the blue region. In Fig. 2 the quantum efficiency of the two photoelectric amplifiers is shown as a function of wavelength ($\lambda/2$).[2]

In Fig. 3 are exhibited the bandwidths of the red and blue light filters used in the polarimeter.[3]

The updating of the polarimeter caused essential changes in its vital components. The assembly of diaphragms was improved considerably, the precision of manufacturing and installation of its components was pushed up. The coaxiality of the elements, the right angles, and the parallelism of the planes were adjusted with special care. The turret was redesigned, the light blinds were improved, which reduced "dark" currents of the photoelectric amplifier through diminishing "spurious" illumination. The viewer was furnished with additional illumination which could be actuated for precise positioning of the object in the diaphragm.

The electronic equipment of the device underwent the gravest alterations. First of all, photoelectric amplifiers were replaced by new ones. The new amplifiers were designed and made on the basis of up-to-date

[1] see RF patent No.2031376 "Polarization measurement procedure"

[2] Measurements were made by V.G. Debur

[3] The measurements were done by G. Georgieva

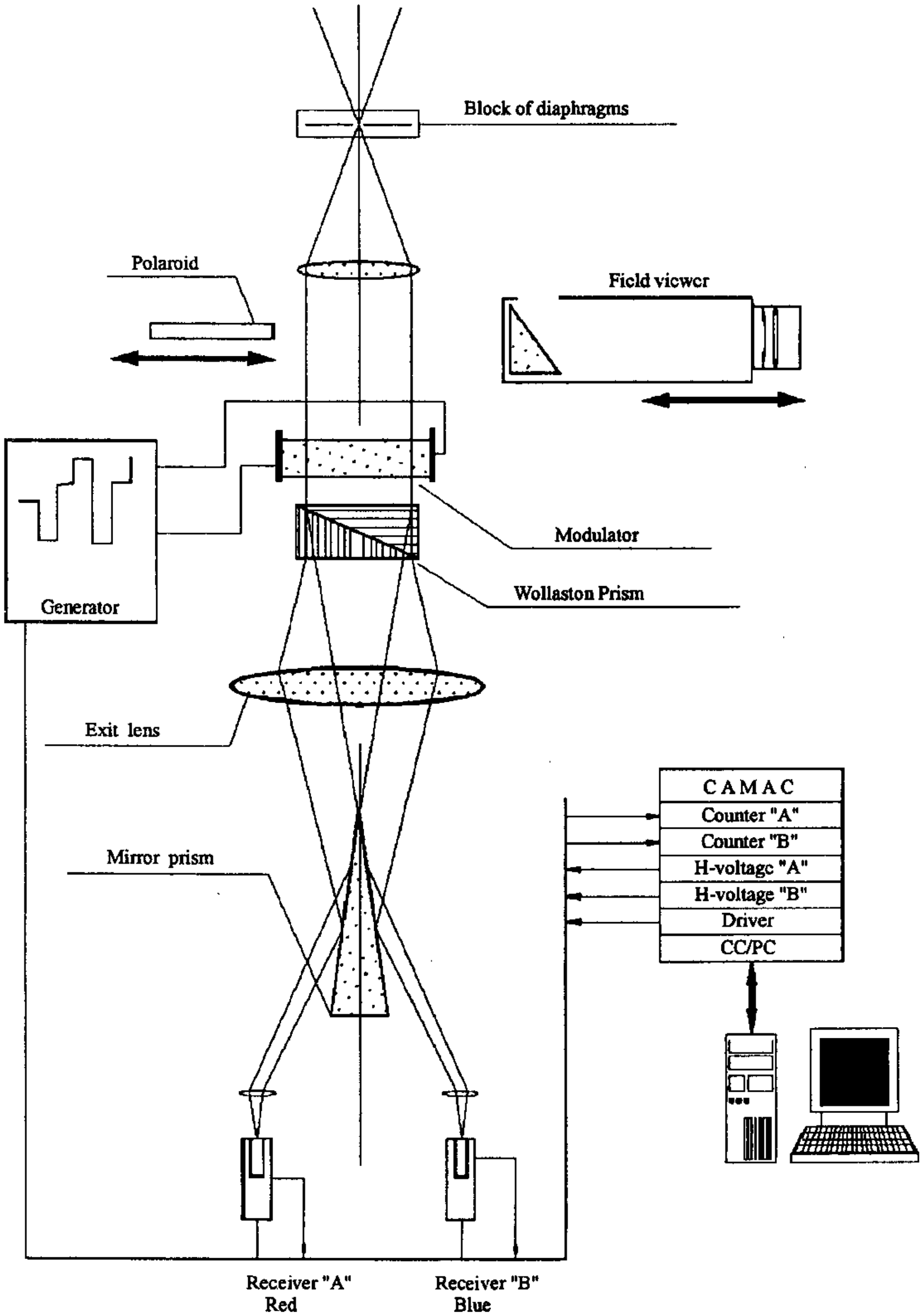

Figure 1: *The block diagram of the two-channel polarimeter of the 1 m telescope.*

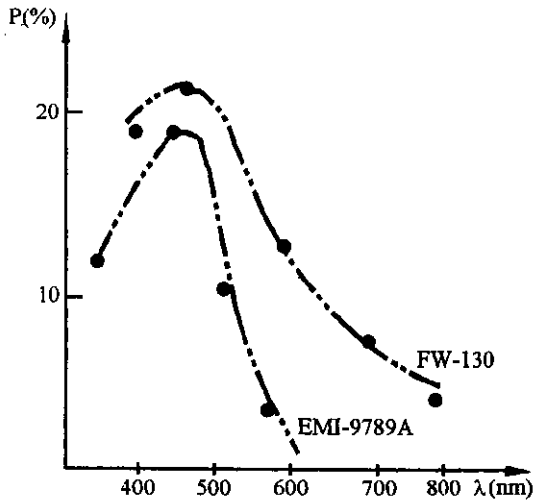

Figure 2: *The wavelength dependence of quantum efficiency of PA employed in the polarimeter.*

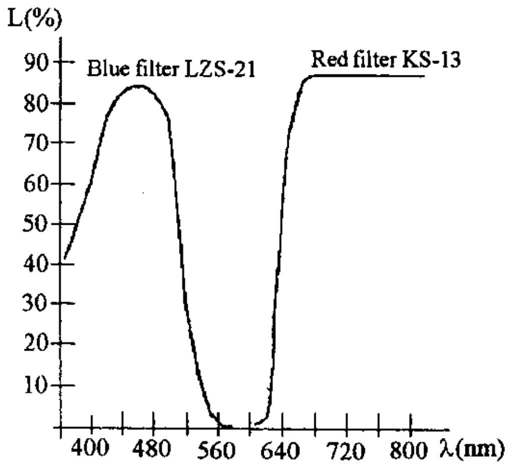

Figure 3: *The bandwidths of the filters used in the two-channel polarimeter.*

microcircuits. These display high stability, noise immunity and sensitivity. Work is under way over elaboration and manufacture of a new-design high-voltage generator for the EOM. The generator will have much better electric characteristics and be of lower weight.

The high-voltage tension modulator forms pulses of special shape, which control the phase-shifting unit of the electron-optical modulator (EOM).

The previous make of the high-voltage modulator that incorporated transformers (Najdenov, 1998) did not provide an adequate modulation depth of the EOM crystal because of insufficient steepness of the

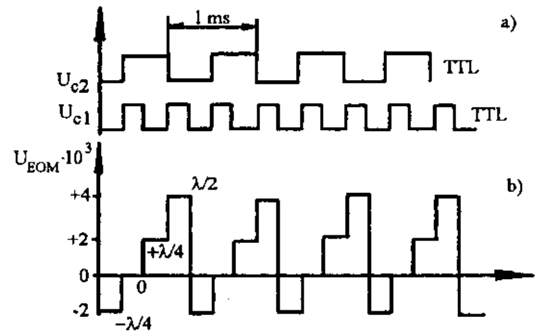

Figure 4: *Oscillograms of EOM starting pulses (a) and high-voltage pulses entering the EOM (b).*

Table 1: *Correspondence of high EOM voltage (see Fig.4 a)) to logical levels of strobe pulses* U_{s1} *and* U_{s2} *(see Fig. 4 b))*

U_{s1}	U_{s2}	U_{EOM} (kV)
0	0	-2
1	1	0
1	0	+2
0	1	+4

edges of high-voltage pulses and therefore a fair accuracy for polarization measurements. It is this situation that necessitated a search for other designs of the instrument, which resulted eventually in the construction of a novel electronic high-voltage modulator.

In Fig. 4 are shown the oscillograms of voltages which are formed by the modulator as well as their correspondence to the phase shift of the light that have passed across the modulator. High-voltage pulses are formed in synchronism with two series of strobe pulses U_{s1} and U_{s2}, arriving from the polarimetric data acquisition system. The length of the pulse of one series is 1 ms, and that of the other series is 0.5 ms. The value of high voltage depends on the sum of logical levels of two pulses of different strobe series at every moment of time in accordance with Table 1.

The new version of the high-voltage modulator provides for a steepness of the pulse edge ≈ 7 - 10μs with an amplitude of 6 kV. With flatter edges of high-voltage pulses a sufficient modulation depth of EOM is not ensured and the polarization measurement accuracy is therefore much worse.

This will make it possible to install it together with the polarimeter at the Cassegrain focus, which will ensure safety and convenience in use.

The photometric part (photoelectric amplifier — counters) was tested on June 29-30, 1999. Relation-

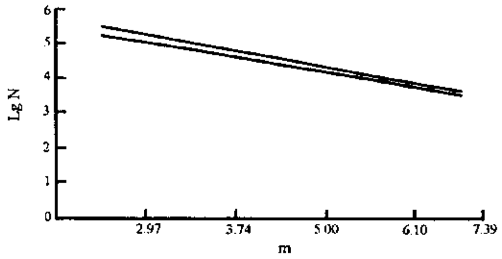

Figure 5: *The number of counts N versus stellar magnitude m of the objects.*

ships between the number of counts N and stellar magnitude m were derived. Stars of spectral class AO containing both the blue and the red components in their spectra were selected for observation. The results of measurements are presented in Table 2 and Fig. 5.

The quantity N was computed as the difference between the arithmetic mean of counts over each channel per 1 s and the background for the same period, which was on average 354 and 81 counts over the channels "A" and "B" on the night of observation,

Table 2:

Star	m	N"A"	N"B"
δ Cyg	2.97	512900	173800
γ Oph	3.74	182000	72400
14 Peg	5.00	63100	26900
UBS 8536	6.10	20900	10700
Hp 80257	7.39	6310	4000

respectively:

$$N_{A,B} = N_{mean} - N_{ph}.$$

The high background level is due not only to the fact that the observations were performed on a lunar night but also to a relatively high ambient temperature (18° C).

The observations with the two-channel polarimeter of the 1 m telescope are presumed to be recommenced in the first half of 2000.

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