

A D. C. PHOTOELECTRIC POLARIMETER

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For polarimetric observations of stationary and slow variable stars with Zeiss refractor 65/1055. cm a D. C. polarimeter, has been designed replacing the old A.C. one (Oskanjan et al. 1965).

The functional diagram of the instrument is shown in Figure 1. The polarized star light, Z, after passing the objective, O, is being modulated by a slow-

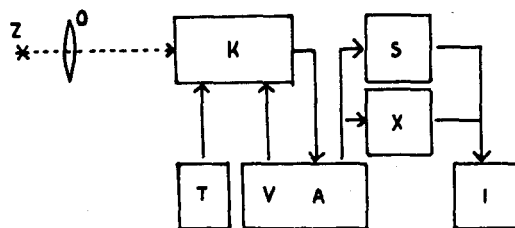


Fig. 1. Functional diagram of the polarimeter. Z = star light, O = objective, K = optical train, T = timer, V = high-voltage supply, A = amplifier, S = f(t) recorder, X = X—Y recorder, I = sine-wave comparator.

-rotating polaroid in the optical train, K. A timer, T, controls the speed of rotation of the polaroid. High voltage source, V, supplies a photomultiplier in the optical train. The photoelectric signal is being amplified in A and simultaneously recorded in the two recorders, S and X. The scaling of the record is being done in the sine-wave comparator, I.

Optical train

By the optical train, Figure 2, one controls the star radiation and, at the same time, its linearly polarized component is being modulated before it reaches the photomultiplier.

In the case of looking at the stellar image, Z, in the diaphragm, B (20' and 50'') Figure 2a, the radiation coming from the left is being reflected from a mirror, D₃, into the eyepiece, O. A light beam from a bulb X illuminates the diaphragm.

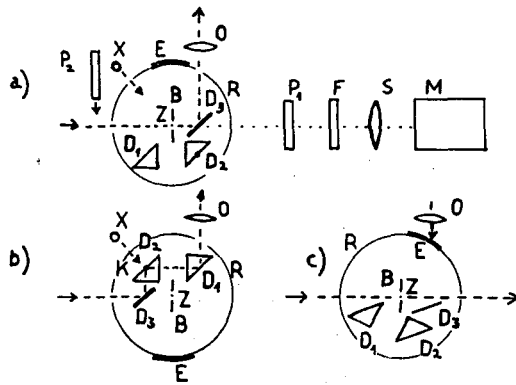


Fig. 2. Optical train of the polarimeter.

a) Controlling the stellar image Z in the diaphragm B. D₁, D₂, D₃ and E = two prisms, a mirror and a mask respectively, carried by a rotating support R. O = eyepiece, X = bulb, P₂ = a pair of crossed polaroids, P₁ = rotating polaroid, F = filters, S = Fabry lens, M = photomultiplier.

b) Controlling a wide field of view. K = illuminated cross-mark at the diagonal side of D₂.

c) Position of the rotating support, R, during photoelectric observations.

Unlike the diaphragm B, the prisms D₁, D₂, the mirror D₃ and a mask E are carried by a rotating support R. In order to get an observable field of view about 5' × 5', the support R has to be rotated by 180°, Figure 2b. Now the other side of the mirror D₃ deflects the stellar image towards an illuminated crosswire, K, at the diagonal side of D₂. The field of view is controlled through O and D₁.

During the photoelectric observations, Figure 2c, the support R is again being rotated by further 25° approximately. After the diaphragm, the light beam passes the rotating polaroid, P₁, exchangeable filters, F, (B = 2 mm GG—13 + 1 mm BG—12, V = 2 mm GG—11, and for a „red leak“ region: R = 3 mm OG—3) and a Fabry lens, S, in front of the photomultiplier, M, (EMI 9502S). At the same time the mask E covers the eyepiece O. The polaroid rotates around the optical axis with a selectable angular velocity between 0.1 and 1.0 turns per minute. For the purpose of photometric calibration a pair of partly crossed polaroids, P₂, can be introduced into the light beam.

Recording of the polarimetric signal

As a high-voltage supply and the photomultiplier current amplifier a PPI Laboratory Photometer, Model 110, has been used. It has a very useful dark current cancellation facility and gives a 10 mV output signal for the recorder.

The amplified D.C. signal is being recorded as a function of time at the recorder S, Figure 1 (Servogor RE 511). In order to obtain on-line a kind of averaged polarimetric record, the D. C. signal is at the same time led into the Y-channel of an X—Y recorder, X, Figure 1 (Philips PM 8120). The X-channel of the recorder, supplied from a stabilized D.C. source (TRS—13) through a double R—C linearized element and reset after a preselected number of half-turns of the polaroid, works as a synchronous time base.

Sine-wave comparator

Further treatment of a polarimetric record is being done with a so called sine-wave comparator, Figure 3. It consists of an oscilloscope, S, (Grundig MO

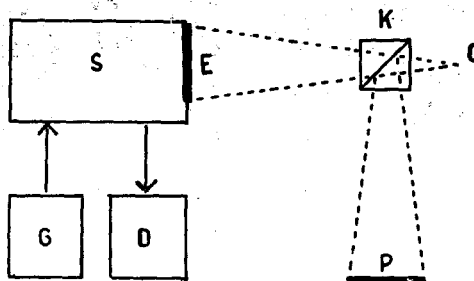


Fig. 3. Sine-wave comparator. S = oscilloscope with the screen, E, G = sine-wave generator, D = digital voltmeter, K = semireflecting cube, P = the analyzed polarimetric record, O = observer.

10/13) with the screen, E, semitransparent-semireflecting cube, K, a sine-wave generator, G, (Grundig TG 20) a digital voltmeter, D, (Hewlett—Packard 3439A/3443A) and a place, P, where the record is being kept during the measurement.

Looking from O through K the observer at the same time sees a sine-wave curve at the screen E and a polarimetric record at P. Manipulating the oscilloscope and the sine-wave generator, he finds the best fit of the polarimetric record with a sine-wave curve from the screen, Figure 4a. The D.C. level, Figure 4b, and the amplitude of the fitted sine-wave curve, Figure 4c, are readily measurable in the scale of the record. For easier reading of very small sine-wave amplitudes and more comfortable phase measurements, after fitting the sine-wave curve into the recorded signal, one can use a 10-fold vertical magnification of the oscilloscope picture (Figure 4c and 4d). Translating the sine-wave curve at the screen along the position angle axis, from the observed (Figure 4c) to an instrumental zero-position (Figure 4d) and reading at the digital voltmeter the D.C. voltage used for the shift of the oscilloscope picture, the observer measures the position angle of the polarimetric signal.

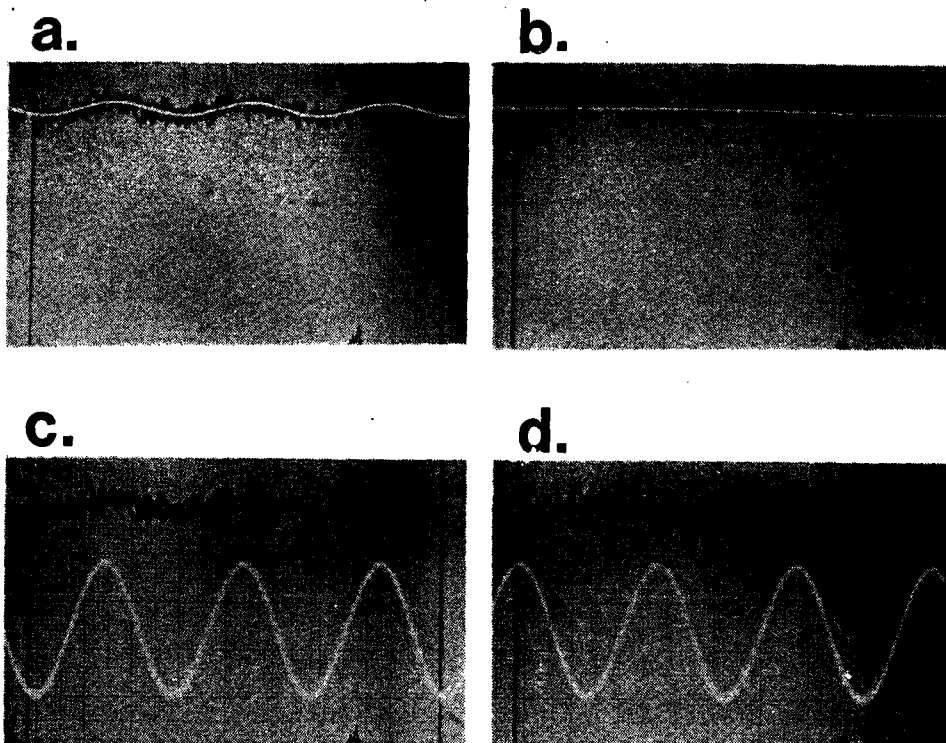


Fig. 4. Some stages of measurement with sine-wave comparator. Dark curve = polarimetric record with the zero of position angle scale at the right-hand end (vertical line). Bright curve = electronically generated comparison sine-wave curve.

- a) An approximate coincidence of the two sine-wave curves.
- b) The mean D. C. level of the polarimetric signal.
- c) The comparison curve, from Figure 4a, shifted down and amplified ten times for easier reading of the-amplitude value.
- d) The comparison curve from Figure 4c, with its nearest maximum, M , shifted to the right into the zero position, T , of position angle scale. The reading is done at the digital voltmeter.

Errors of the polarimeter

The errors of polarimetric observations are usually discussed together with the results of observations. Such an error estimation in the case of AD Leo has been given elsewhere (Arsenijević et al. 1976) and an expected error level of some tenths of one percent has been found. However, in the case of an observation of γ Cas the r.m.s. error amounted to $\pm 0.07\%$. It seems that the r.m.s. error, being about $\pm 0.07\%$ at the 3-rd magnitude, increases by about 0.04 per magnitude.

The accuracy of measurement by means of the sine-wave comparator, according to the observers who were working with it, was increasing if the shape of the record was more regular, the noises lower and the scale (magnification) of the

record larger — what was natural to expect. Repeating for many times the measurement of the same record of an average, or somewhat lower, quality, one finds an r.m.s. error of $\pm 0.08\%$ in the amount of polarization and ± 1.7 in the position angle of the plane of polarization.

The instrumental polarization has not been noticed. A depolarization effect of about 8%, found by Serkowski (1965) and attributed to the objective lens, seems still to be present and probably even increased (up to 11%) or combined with some other unknown systematic instrumental or personal effects during the measurement procedure. The effect is measured and the corresponding correction found from observations of the polarimetric standard stars (Serkowski, 1960).

Some non-sine-wave deformities of the polarimetric zero-signal have been occasionally noticed. They were probably due to a slight miscentering of the light beam with respect to the rotation axis of the polaroid (instrumental flexure) and the presence of some dust grains or other irregularities on the polaroid surface. As the period of such deformities equals that of one turn of the polaroid, the averaging of polarimetric signal in an odd number (usually 1 or 3) of polaroid half-turns diminishes this effect by a factor of about two.

A better way of eliminating the non-sine-wave effects would be to average the polarimetric signal in an even number of periods, to find out the accurate shape of the zero-signal line and to correct the observations for the found effect. But, at that level of reduction accuracy one would like to have a more proper way of averaging of polarimetric signals and an even more accurate measuring procedure. These can certainly be achieved by means of a photographic way of recording of polarimetric signals and by very accurate measurements, or by digitalizing the signal and processing it in a computer.

R E F E R E N C E S

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