

The Solid State Area Scanner Photometer

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The accuracy of the area scanning technique depends on observing conditions resulting from seeing, tracking irregularities of the telescope, photon and seeing statistics (integration time and the size of the telescope), and the atmospheric spectral dispersion of the stellar image in the spectral region used. In addition, the reduction method as well as the mechanical and optical quality of the telescope and photometer influence the accuracy of the results.

The tracking error of the telescope is usually larger than the observer believes. The amplitude of the periodic error of the worm gear is at best ± 0.5 arc sec with period length between 4 and 10 minutes, depending on the particular telescope. Figure 1 shows the tracking error for the ESO 50 cm and 100 cm telescopes. Other telescopes usually fit in between this two extremes.

The statistics of photoelectrons introduces no problem. An integration time of only one minute results in an accumulation of a very large number of photons. As opposed to photon statistics, seeing statistics has very low frequency components with significant amplitudes. An integration time of 60 s is too short to smooth out the effects of very low frequency seeing. I would suggest using two to four times that value. The best way to minimize tracking and low frequency seeing errors is to register each scan separately on discs or magnetic tape and allow the computer to add the scans together, adjusting the time coordinate to minimize the differences between corresponding ordinates for the scans. This procedure depends on good photon statistics. It works for visual binaries because, fortunately, they are almost all bright stars, (Rakos et al. 1981).

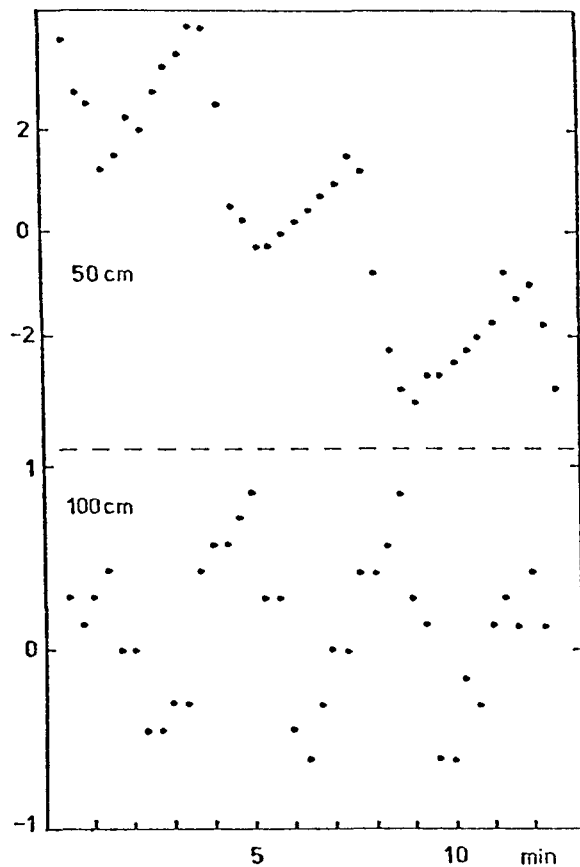


Fig. 1. Tracking error for the ESO 50 cm and 100 cm telescopes.
The amplitude is in arc sec and time in minutes.

From this point of view a good alternative solution to the use of photomultiplier and moving slit aperture would be the solid state one dimensional multidiode detector.

A linear self-scanned photodiode array has been tested for this purpose. The detector is a linear array of 128 discrete silicon photodiodes. These diodes are 2.5 mm in length and are arranged on 0.025 mm centers with effectively no dead space between adjacent diodes. The total surface of the photodetector is 2.5 mm \times 3.2 mm, equivalent to the size of the scanning area by the moving slit scanner. The peak quantum efficiency of the detector is about 80% and the dark current is typically about 5 pA per diode at 25⁰C. It can be arbitrarily reduced by lowering the temperature or by reducing the integration time. The square root of the number of electrons in the dark signal charge is responsible for the

readout noise. At room temperature and 0.01 s integration time the noise is approximately 560 electrons. Because of the exponential temperature dependence of the dark current, the noise can be reduced dramatically with a moderate amount of cooling, and an available dynamic range in excess of 10^5 is possible.

Using a 1 m telescope, integration time 1 s and a thermoelectric cooling down to -30°C double stars to the visual magnitude of 10 can be measured with a very high accuracy. Figure 2. shows a block diagram of the system I have tested. The logic section provides the array with all of the clock and control signals. The periodic start pulse initiates each scan. The corresponding video signal is converted into digital form and stored on the magnetic tape of the microcomputer PDP 11/23. A large number of scans can be collected on the tape for later processing on a larger computer. In the subsequent observing program of close visual binaries I intend to use this solid state area scanner version for further evaluation.

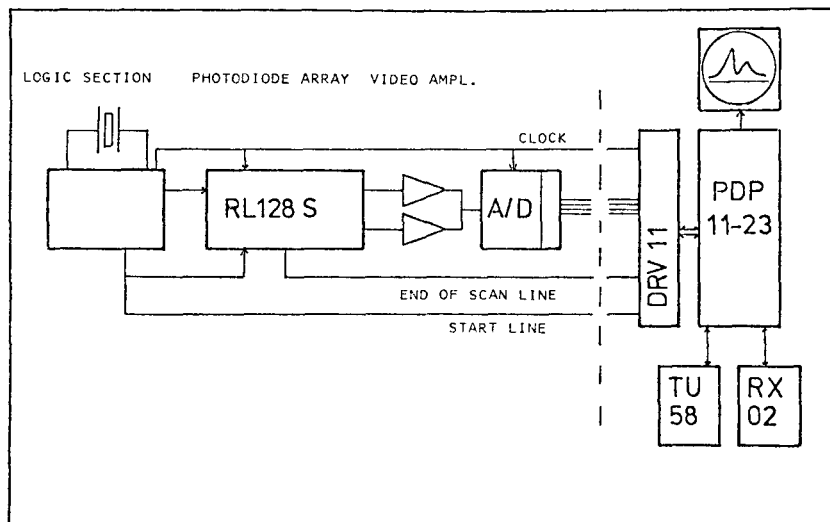


Fig. 2. Block diagram of the solid state area scanner.

Reference:

K.D. Rakos, R. Albrecht, H. Jenkner, T. Kreidl, R. Michalke, D. Oberlerchner, E. Santos, A. Schermann, A. Schnell, W. Weiss, 1981, *Astron. & Astrophys. Supp. Series*, in print.

DISCUSSION

FRANZ: What kind of array did you use, and what is its cost?

RAKOS: This is a very cheap device, a reticon 128S, and the cost is less than a thousand dollars.

ABT: An engineer at Kitt Peak named Larry Ott developed a simple device to remove the periodic error in telescopes. Between the stepping motor and worm gear he placed a connection that can be offset in angle and radius. Thus one enters a periodic error that nulls the existing error to the accuracy with which it can be measured.

RAKOS: This is very nice, but our problem is that we do not have our own telescope, so we have to use foreign telescopes for short periods of time.