Design of an Automatized Iris Photometer

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In cooperation between the European Southern Observatory and the Göttingen Observatory the design of an automatized iris photometer has been developed. The principal idea, based on the classical

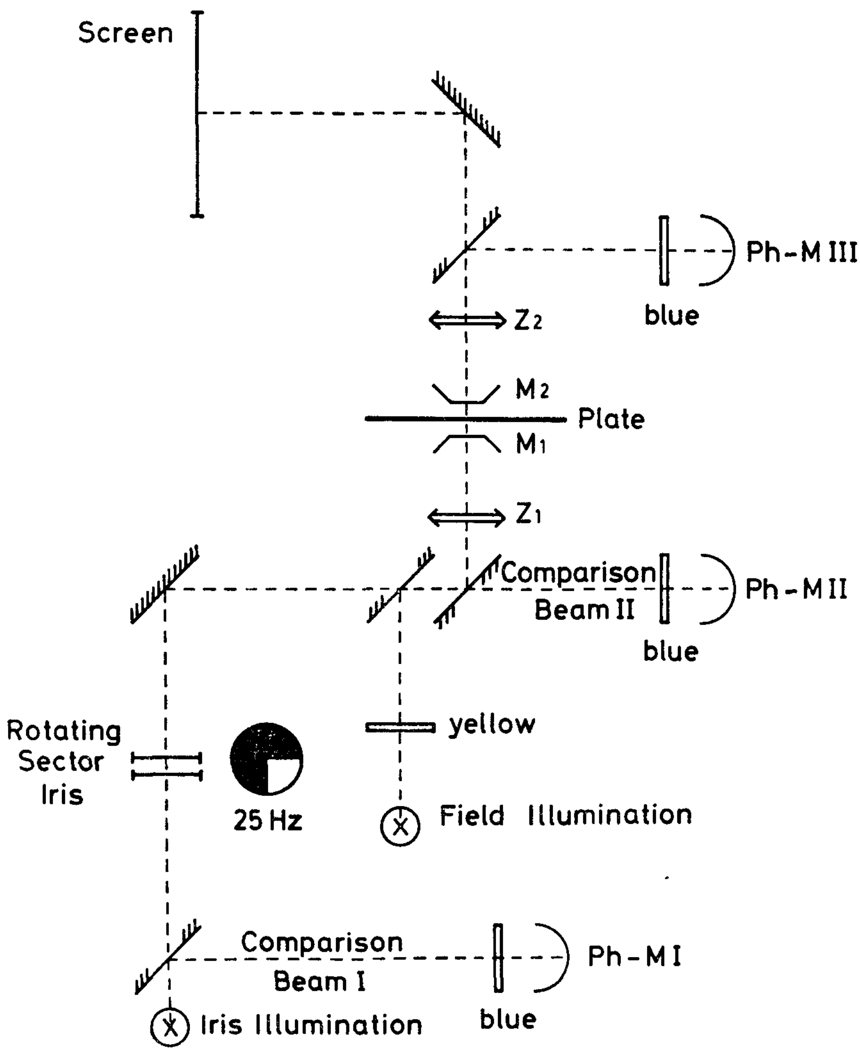

Fig. 1

iris photometer as described by Haffner (Veröff. Göttingen, Nr. 106, 1953), may be described here. (Fig. 1).

The iris is projected by a lens combination Z_1M_1 onto the photographic plate. A symmetric optical system M_2Z_2 projects the image of the iris, including the surrounding field, onto a screen, as well as the filament of the iris illumination lamp L_1 onto the cathode of a photomultiplier Ph-MIII. The projection of the surrounding field is performed partly by the same optical elements superimposed by means of semi-transparent mirrors, but mutually separated by different colour filters (yellow and blue).

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Z_1 and Z_2 are pancratic elements (zoom lenses) to cover a wide range of stellar image sizes from different types of photographic plates.

The light beam passing the iris is modulated at a frequency of 25 Hz by a rotating sector with a free aperture of 90°, in the plane of the iris (or of an intermediate image of the iris), and finally measured with photomultiplier Ph–MIII. Two comparison beams are provided. A fraction of the light coming from the main iris illumination source L_1 is projected to Ph–MI, another fraction behind the iris is projected to Ph–MII. The intensity at Ph–MI is constant and proportional to the intensity of L_1, the intensity at Ph–MII is modulated at 25 Hz, its mean value being proportional to the area of the iris in measuring position (without star image).

Comparison mode I is the standard measuring scheme of an iris photometer, comparison mode II covers a smaller range of magnitudes; however, it provides a much better signal-to-noise ratio for faint stellar images.

The output of all three multipliers is fed to a small processing computer connected with servo mechanisms to control the diameter of the iris, and the x- and y-motion of the photographic plate.

The signal of Ph–MIII is analyzed in the computer according to the coefficients of a Fourier series.

$$i = i_0 + i_1 \cos \phi + i_2 \cos 2\phi$$
$$+ j_1 \sin \phi + j_2 \sin 2\phi$$

i_0 is compared against beam I or II ($\triangle i_0$)
$\Delta i_0 \to 0$ controls the setting of the iris.
$i_1 \to 0$ controls the x-coordinate.
$j_1 \to 0$ controls the y-coordinate.
i_2 and j_2 finally give an indication of the ellipticity of the stellar image.

The setting of the iris, the coordinates x and y and the terms i_2 and j_2 are punched on tape.

The computer always keeps the terms i_2 and j_2 under observation. In the normal case, i_2 and j_2 are radial symmetric functions of

$$\sqrt{(x-x_0)^2 + (y-y_0)^2}, \; (x_0, y_0 = \text{plate center})$$

and of the density of the star image as a result of off-axis aberrations (coma, astigmatism) or linear functions of one and/or the other coordinate as a result of guiding errors or refraction. These functions are determined by the computer. Any irregular deviation indicates a double star beyond the limits of measurability or a plate error (dirt). The measurement than can be easily rejected.

DISCUSSION

J. Tinbergen: Having gone to the expense of a small computer, why have you stuck to the classical iris photometer, with its limitations in handling non-circular images? Why do you not use a raster-scan, analysing it in the computer? This would allow you to use different models of image shape on different parts of the plate.

A. Behr: That is another possibility—may I just take this as good advice?

P. J. Treanor: Can you explain more fully how the elliptical star images produce the cos 2ϕ term?

A. Behr: This is caused by the 90° rotating sector. A 180° sector would give only a constant term and the two coefficients of the first harmonic. With a 90° sector you get the first and second harmonics, the latter indicating ellipticity.

D. S. Brown: In the photometer system are two elements, the iris and the rotating sector, that have to be accurately concentric. Have you investigated the systematic errors that might be produced by lack of concentricity?

A. Behr: This may be possible, of course. But the iris is a very large thing, and the accuracy with which you can keep the centre of the rotating sector is very high. If, however, there should be a systematic deviation from the ideal centre of the iris, then the systematic error will be always the same for all stars, and it will just appear in the characteristic curve, and will not influence the measurements. If it changes, then it is dangerous, but we don't think that there is any fear that it may change during one set of measurements.