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An iris photometer of new design

Estratto dalle « Memorie della Società Astronomica Italiana »
Vol. XXXIX, fasc. 4 - 1968 - Pagg. 737 - 742

FIRENZE
TIPOGRAFIA BACCINI & CHIAPPI
1969

AN IRIS PHOTOMETER OF NEW DESIGN

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RIASSUNTO. — Si descrive un microfotometro ad iride di nuova concezione per la misura di immagini stellari. La principale variante rispetto al tipo classico consiste nel fatto che sia il fascio di misura che quello di riferimento traversano la lastra fotografica in zone adiacenti. Questo porta ad una maggiore compattezza e stabilità meccanica dello strumento ed a significativi vantaggi nell'esecuzione delle misure.

SUMMARY. — An iris microphotometer of new design for the measurement of stellar images is described. The principal difference as compared with the standard type consists into the fact that both the measurement and the reference beam traverse the plate in two neighbour regions.

This fact leads to a more compact as well as mechanically more stable design and to significant advantages in the accomplishment of measurements.

It is well known that owing to the characteristics of the atmospheric seeing, the light of a star is spread all around the diffraction image given by the telescope optic. This fact, combined with the non linear response of photographic emulsions produces, in the developed plates, stellar images which are round dark spots with fairly definite edges.

It is quite remarkable that the diameter of the image, to a fairly good approximation, is proportional to the logarithm of the intensity of the light, so that the traditional system of the stellar magnitudes, is a rather natural scale also for photographic photometry.

The first approach to photographic photometry was simply done by measuring the diameters of the stellar images with a micrometer.

Indeed very large works, such as the work of the Selected Areas (PICKERING et. al. 1918-1924) were carried on in this way.

The measurements however must have been quite an art since the borders of the images, when looked at carefully, are never perfectly sharp.

(*) Ricevuta il 29 Novembre 1968. Testo definitivo il 16 Gennaio 1969.

The approach to higher reliability was sought in impersonal ways of measuring these diameters.

The instrument that became widely adopted is the iris photometer, first proposed and built in 1947 (EICHNER et al.).

The principle of the instrument is very simple. The image of an iris diaphragm is projected on the plate and the image to be measured brought to the center of it (alternatively the plate is projected on the iris (BECKER and BIBER 1956)). The light that passes between the border of the iris and the image of the star (the measuring beam) reached a photomultiplier.

The intensity of the source of light is monitored using a « reference beam », which is detected by the same photomultiplier that detects the light in the measuring beam.

By closing the iris diaphragm around the image of the star the intensities of the lights in the measuring beam and in the reference beam are made equal. The setting of the iris diaphragm is taken as the measure of the diameter of the star image.

The original scheme of the instrument is shown in Fig. 1, adapted from EICHNER et al. (1947).

Owing to the use of the reference beam, the measurements obtained are indipendent from the brightness of the light source.

In most of these instruments, however, the path of the reference beam is rather involved, so that extreme mechanical rigidity is needed among the various parts, otherwise flexures can change the amount of light that reaches the phototube, in a different way for the measuring and reference beam, and so alter the calibration of the instrument.

The same is true for the thermal histeresis that follows the switching on of the lamp, up to the moment in which steady thermal conditions are reached in the instrument. This means that usually the lamp must be switched on at least $1 \div 2$ hours before starting the measurements.

It occurred to us to notice that if the light of the reference beam was allowed to cross the plate, a much simpler geometry could be adopted, and the need of an exceedingly stable geometric configuration could be overcome.

Of course, in doing so, the intensity of the light in the reference beam depends on the fog on the plate. This is not inconvenient if the fog is uniform. If the fog varies, a first order correction is obtained; a correction of the same kind that is used with the ordinary iris photometers, when the reading of the background is subtracted forms the reading on the star (RACINE, to be published).

The area of the plate monitored by the reference beam should be large enough, so that statistical deviations of the emulsion graininess would not introduce a significant extra error in the measurement.

The scheme we have adopted is shown in Fig. 2. The reference beam is coaxial to the measuring beam and uses the same optical elements. The switching of the beams, as well as the adjustements of the intensity of the light in the reference beam, is obtained using polaroids.

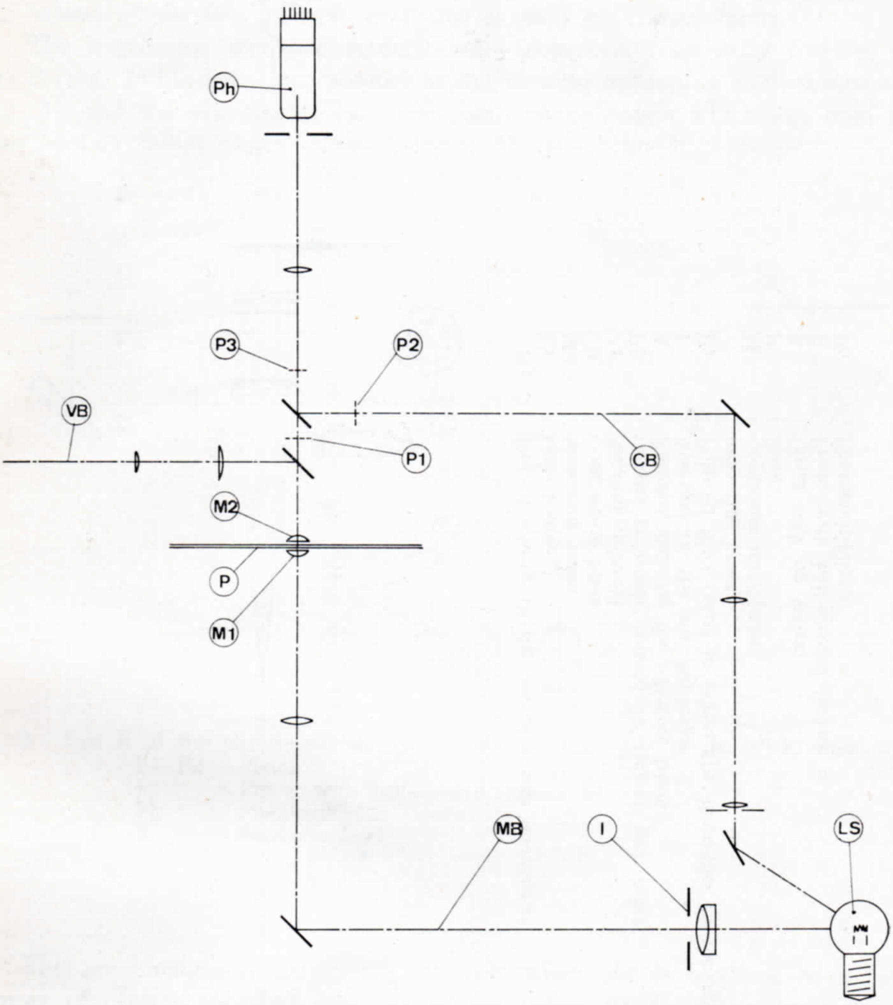

Fig. 1 - The original iris photometer, adapted from EICHNER et al. (1947).
MB - Measuring beam
CB - Comparison beam
VB - Viewing beam
LS - Light source
I - Iris diafragm
M1, M2 - Microscope objectives
P - Plate
P1, P2 - Polaroid filters
P3 - Rotating polaroid filter
Ph - Photomultiplier.

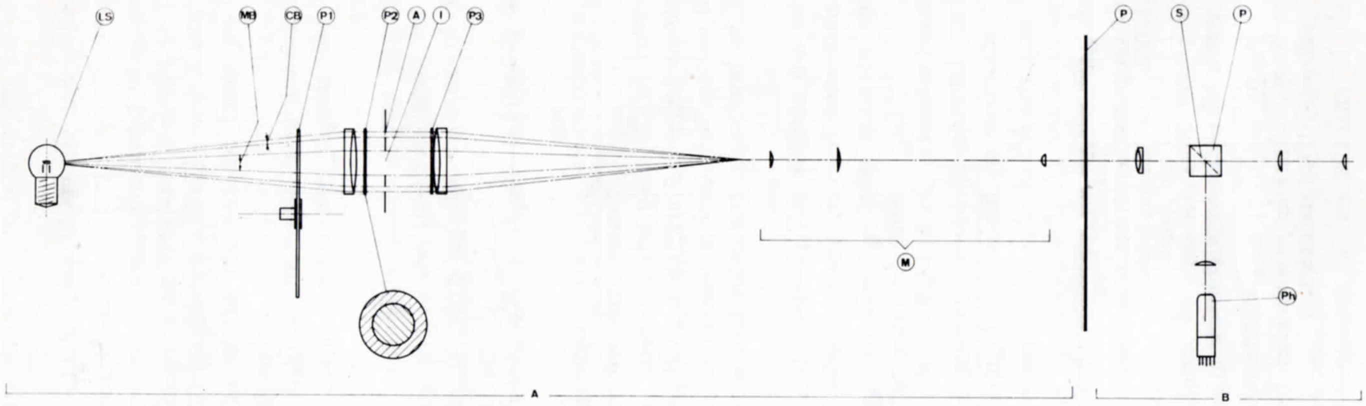

Fig. 2 - Optical scheme of the coaxial beams photometer.

LS	- Light source
MB	- Measuring beam
CB	- Comparison beam
P1	- Rotating polaroid
P2	- Coaxial polaroids, rotated 90° degree each other
A	- Annulus, defining the reference beam
I	- Aperture of the iris diaphragm
P3	- Polaroid filter, used to adjust the intensities of the reference and measuring beam
M	- Composite microscope
P	- Plate
B	- Image pick up system
P	- Prism with half-silvered surface S
Ph	- Photomultiplier.

The rotation of the polaroid that switches the two beams is monitored and used for the sincronous detection of the signal received from the phototube. The balance of the two lights is read directly on a milliamperometer.

The instrument we have actually built incorporates an extra feature, i.e. part B (Fig. 2) has been incorporated in the viewing optic of a blink comparator (Fig. 3), and the photometer has been mounted on stages which can hold the large 14 x 14 inches plates of the Palomar 48 inch Schmidt telescope.

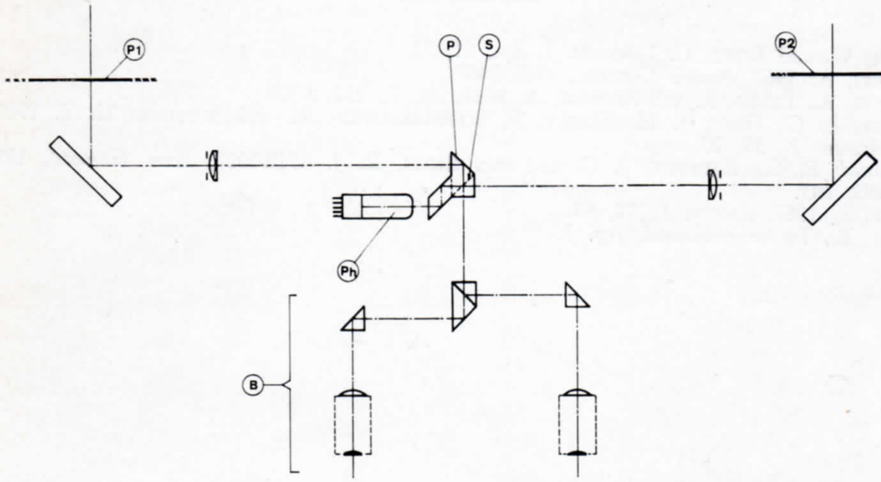

Fig. 3 - Part B of the photometer, included in the viewing optic of the blink comparator.
P1, P2 - Plates
P - Prism, with half-silvered surface S
Ph - Photomultiplier
B - Binocular head

This combination is particularly valuable when one is working on a large number of objects scattered over the whole surface of the plates (such is the case of the faint blue objects we are investigating (BRACCESI 1967; BRACCESI et al. 1968). In this case the usage of finding maps to locate the objects on the plates is rather painful. With our instrument, however, one needs only a reference plate in which the objects have been identified and marked, and the operator uses the blink comparator to locate them in the plates he has to measure with a very easy, error proof procedure.

The usage of the blink also permits to center accurately objects which are well seen on the reference plate but are barely visible on the plate under measurement (this happens quite often for the infrared images of the faint blue stars). It is known that the densest part of a barely visible image can be a fluctuation, thus centering on it gives always under-estimates of the magnitudes. The procedure of centering using the reference plate avoids this inconvenient, giving the same kind of advantage that has been found in making the photometry of very faint images on composite prints, rather than on the plates directly (RACINE 1967).

I must thank Prof. M. Ceccarelli for many useful discussions, Dr. U. Dall'Olmo and Mr. F. Bugatti for their help in building the instrument.

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