UBV photographic photometry of Schmidt Plates

J. C. Muzzio, H. G. Marraco and A. Feinstein

Observatorio Astronómico, La Plata

Resumen: Se describe el método empleado en la fotometría UBV fotográfica de placas tomadas con la cámara Curtiss-Schmidt de Cerro Tololo. La reducción se hace mediante una curva de calibración que puede ser representada mediante un polinomio. Se ejecutan correcciones por efectos de color. Los errores medios obtenidos son $\pm 0^{m}.06$ en la magnitud y $\pm 0^{m}.10$ en los índices de color. Se investigan los errores sistemáticos.

1. *Introduction*

We here used the La Plata Observatory Becker-type Askania iris photometer to measure UBV photographic plates obtained with the Curtiss-Schmidt teltscope at Cerro Tololo Inter-American Observatory.

The original iris photometer build by Askania in 1961 has been modified at La Plata Observatory. The lamp housing has been replaced by other which permits better cooling and an oscilloscope has been added to match the comparison with the measuring beam. The photometer is now similar to other iris photometers which are described in the literature (e.g. Figure 10 in Weaver (1962) changing diafragm D by a neutral wedge). The present instrument is very stable against changes in the line voltage, however the measurements are subject to some drift with time.

2. *Measurement procedure*

The excellent seeing conditions on Cerro Tololo result in high quality Schmidt plates with very small stellar images. Unfortunately such small images can be a serious handicap for deriving photographic magnitudes and colors, as one must use high magnification with the iris photometer during measuring operations. We generally employed a magnification such that a difference of one iris division corresponded to $0^{m}.2$ to $0^{m}.3$ in magnitude. The iris settings are very accurate and reproduceable within 0.1 or 0.2 units. There is a slow drift factor which amount to 0.1 units in one hour.

Each star was measured twice and an average iris reading obtained. We estimate the accuracy of the average value to be $\pm$ 0.05 of an iris division which corresponds to $\pm 0^{m}.01$ to $\pm 0^{m}.02$. However, the errors of the photographic photometry are larger than these values as we will discuss later.

Argue (1960) describes an elaborated method to determine the best position of the neutral wedge which adjusts the background setting for the photographic plate. However, we prefer a simpler approach. We note that smaller iris diameters are needed when the comparison beam is too weak, and then the star image must be accurately centered in the diaphragm. Even then, it is difficult to get reproductibility from the iris readings. On the other hand, when the comparison beam is too strong, the iris diameter versus magnitude plot becomes steep, specially for the faint magnitudes, and, beyond a certain point, precision is lost. We therefore select the wedge positions by a trial and error procedure seeking to reduce each effect without enlarging too much the other. This is a rather subjective method, but it works well, since there is a wide range of suitable wedge positions as Argue (1960) and Burkhead and Seeds (1971) find.

We find in our measurements a drift with time similar to the one that Argue (1960) mentions. Since in some cases the drift was still present when the photometer had been operational by six or seven hours before, we could not avoid it switching on three hours before measurements as Argue did. In order to compensate for it, we began our measurements one or two hours after the photometer had been turned on and used the following procedure. We divided our standard stars into five or six groups of six stars each. We started measuring the standard stars in the first group and measured about thirty or forty program stars. We then measured the second group of standard stars followed by another set of program stars. After measuring the last group of standard stars we remeasured 3 or 4 standard stars from each of the previously measured groups and noted the differences between the last measurements and those obtained earlier. These differences were used to compute the run of the drift with time. We corrected the change in iris readings with time by adding these differences to the program and standard star values. This method allowed us to compensate for the drift with an estimated accuracy of approximately $\pm 0^{m}.01$.

The measurement speed is very important in photographic photometry since it is one advantage over photoelectric photometry. According to Argue (1960) the measurement speed with Becker's iris photometer is about 300 stars per hour, while at Edimburgh they measured about 125 stars per hour reading out the measurements to a secretary (it was before the GALAXY began to work). We could only measure about 60 stars per hour, but we think it would not be difficult to double that speed provided the plate movements were improved since most of the time is lost in centering the star images in the iris.

3. *Reduction of the data*

In order to convert the iris readings into UBV magnitudes and colors a FORTRAN IV program was prepared for the IBM/360 computer at La Plata University. The reduction technique is discussed elsewhere (Marraco and Muzzio, 1973), but a short description here may be useful.

The iris readings and corresponding U, B or V magnitudes of the standard stars are used to derive the calibration curve which is represented by a polynomial expression. The order of the polynomial can be as large as five; however we find that usually a third order polynomial gives the smallest mean error for a single observation. Figure 1 shows a plot of magnitude against iris reading. We see that the mean curve is well behaved enough to be represented by a

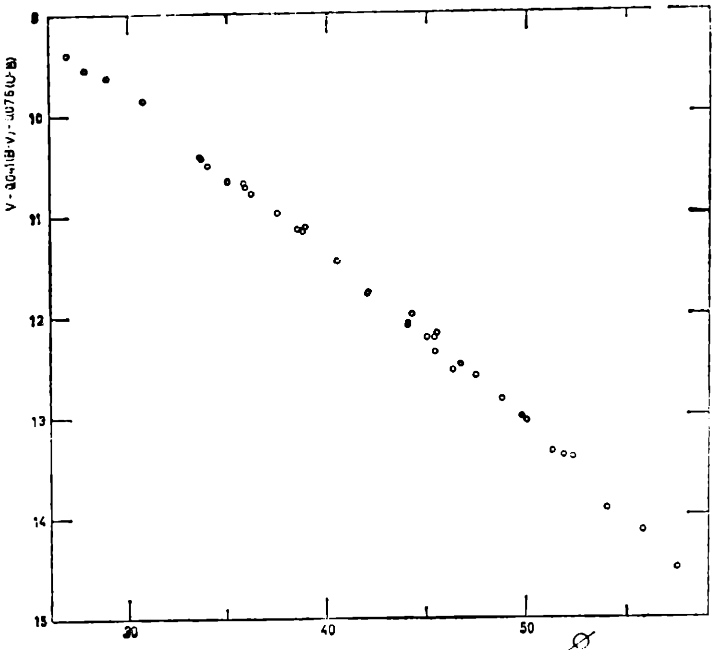

Figure 1. Corrected V magnitude versus iris reading for the standard stars of plate 71412 taken at Cerro Tololo.

low order polynomial. The program allows us to derive and apply corrections to the obtained magnitudes that are represented as linear terms in the colors B-V and U-B or to introduce them directly. As may be noted in the color-magnitude and color-color diagrams of the standard stars shown in Figures 2 and 3 they are well distributed in magnitude and in color. This should allow us to obtain good values for our coefficients in the color correction terms. A problem did occur, however, due to the fact that when the least squares method is applied, high weight is automatically assigned to those points that have extreme values of the variables: the brightest and faintest stars in our case. If these stars happen to be non randomly distributed in color, biased values of the coefficients may be derived. Accordingly, we prepared three color-magnitude diagrams for the V, B and U magnitude respectively. Inspecting them we decided what faintest and brightest magnitude cut-offs had to be introduced in order to have a good color distribution at both ends. The stars with magnitudes between the cut-off limits were then used to derive the coefficients of the color correction terms. These values were used later in the final reduction of the program stars.

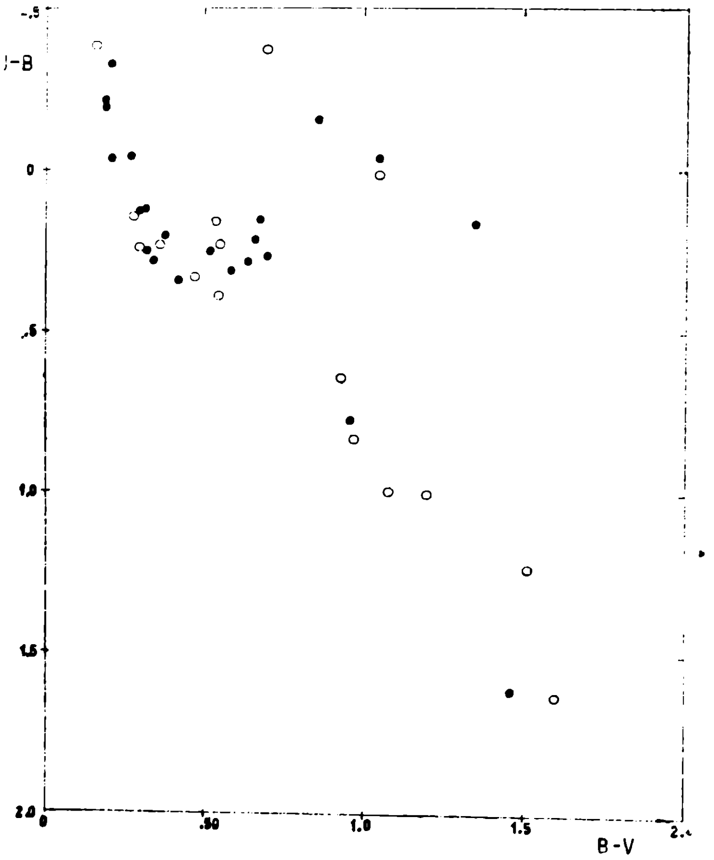

Figure 3. Color-color diagram of the standard stars.

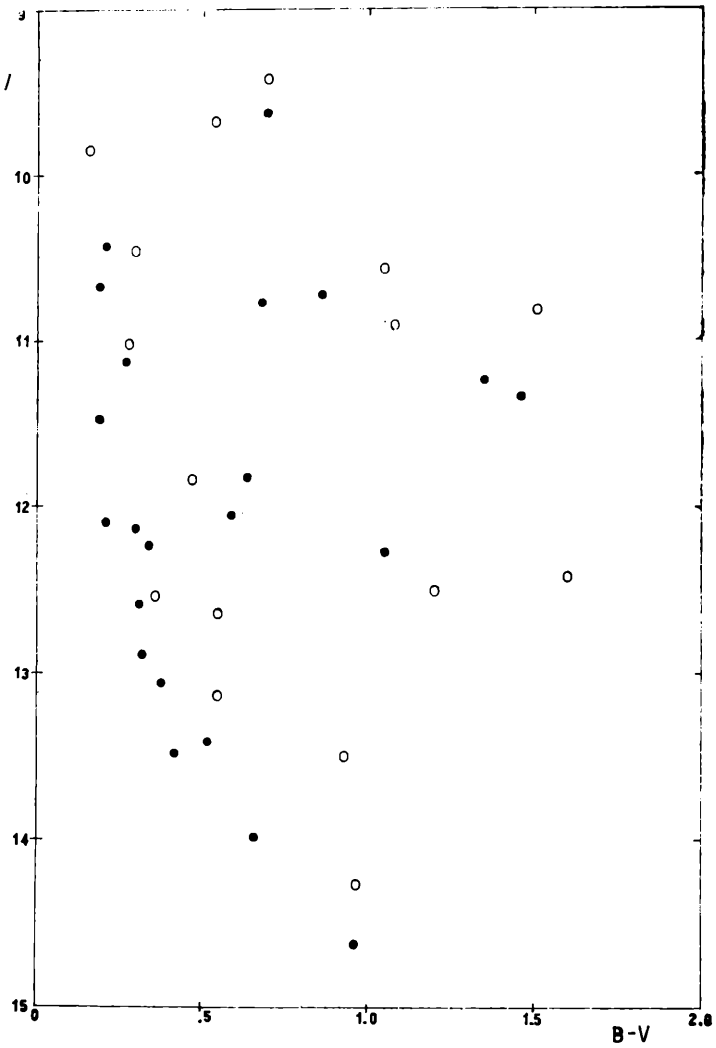

Figure 2. Color-magnitude diagram of the standard stars.

TABLE 1

Coefficients of the Color Correcting Terms

	B-V	U-B	σ
U	.07 ± .02	.07 ± .02	.06
B	.14 ± .01	.10 ± .01	.06
V	.04 ± .01	.08 ± .01	.06

Table 1 shows typical values of the coefficients of the color correcting terms as well as the mean errors of a single observation. The B magnitudes are specially affected by color effects and these effects have to be considered if is intended to give the results in the UBV system.

4. *Results*

Figure 4 shows the residuals obtained from the standard stars plotted against the corresponding iris diameter values. In the upper left hand corner of each diagram the plate number and color are indicated. The standard stars in two fields (about 40' apart) are distinguished by open and filled circles. No systematic differences are evident. The first and the second plots are derived from the same plate but measured with two different magnifications. The later magnification is about 50 % larger than the first. Although the iris diameter range is much larger in the second plot, the residuals are nearly the same for both plots. Except for the change in horizontal scale, both plots are very similar and the mean error of a single observation in both cases is about the same. This shows that, beyond a certain point, nothing is gained by using a larger magnification since the main source of error is intrinsic to the plates themselves.

The mean error as derived from two plate sets is about $\pm 0^m.06$ in the V magnitude and about $\pm 0^m.10$ in the B-V and U-B colors.

Systematic errors are more difficult to investigate. According to Figure 4, there seems to be no systematic differences between two regions near the plate center where our standard stars were located. In Figure 5 we have plotted differences in V magnitude obtained from two different plates against their own sky position. We note a large systematic difference as we move away from the plate center. However, we expect to find such systematic differences with Schmidt plates, but the lack of central symmetry in the distribution of the differences suggests emulsion variations and/or a non-uniform development (see Burkhead and Seeds, 1971) as the possible cause instead of vignetting. We believe, however, that we can obtain reasonably good magnitudes and colors from these Schmidt plates if we limit our studies to fields within 1° of the plate center, where our standard stars are also located.

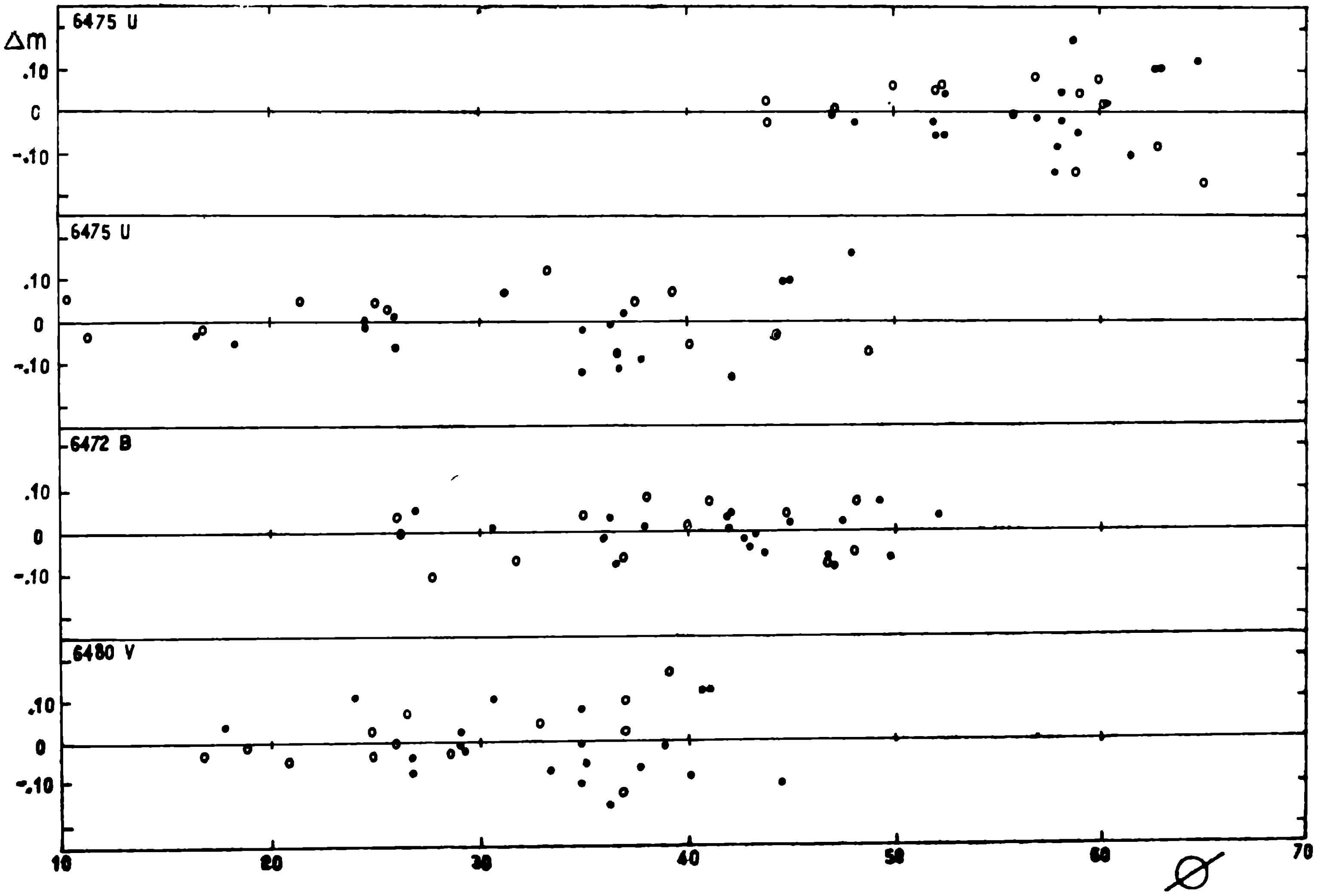

Figure 4. Residuals from the standard stars plotted against iris diameter values.

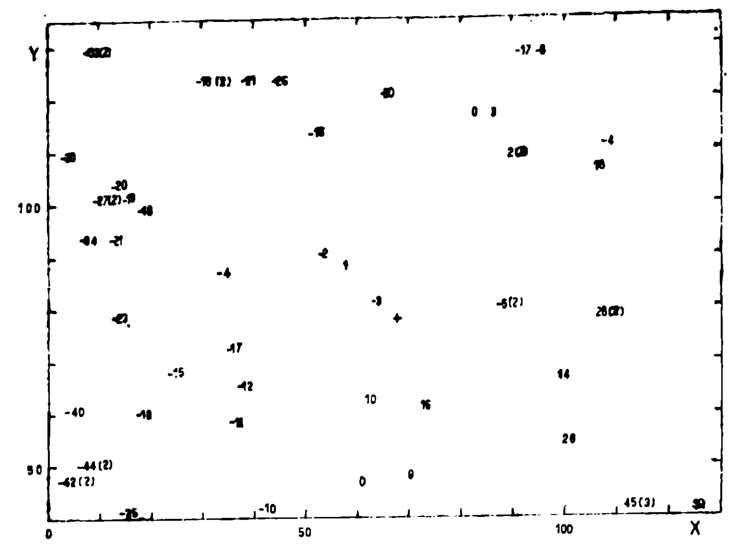

Figure 5. The V magnitude differences according to its position on the sky from two different plates. The plate center is shown by a cross and figures between parentheses indicate the number of stars contributing to the mean value given.

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Sobre la correlación entre exceso de color y luminosidad

Hugo Gustavo Marraco

Observatorio Astronómico
Universidad Nacional de La Plata
La Plata, República Argentina.

Abstract: It is found that is unnecessary to deal with circumstellar shells to explain the apparent correlation between reddening and luminosity in young stellar groups. The simple combination of the luminosity function and a color excess distribution can reproduce the observed appearence of the luminosity vs. color excess diagram of Cygnus II including the lackness of little reddened high luminosity stars.

Introducción

Blanco y Williams (1959) fueron los primeros en notar que las estrellas intrínsecamente más brillantes de la asociación Cepheus IV eran a la vez las que tenían los mayores excesos de color debidos al enrojecimiento interestelar. Notaron también el mismo efecto entre las estrellas de la asociación Cygnus II.

Después de considerar todas las posibles fuentes de error y efectos de selección Blanco y Williams concluyeron que el efecto era real y para explicarlo sugirieron que esas estrellas jóvenes mantenían aún en su derredor residuos de las nubes que les dieron origen, en forma de cáscaras circumestelares. Estas cáscaras serían más densas en torno de las estrellas más masivas, es decir las más luminosas.

Walker (1965) rechaza los argumentos de Blanco y Williams en base a que debido a un efecto observacional se produce un corte en el diagrama luminosidad versus exceso de tal manera que al faltar las estrellas más débiles y más enrojecidas, se produce una aparente correlación entre ambas coordenadas.

Finalmente Reddish (1967), en un trabajo sistemático de recopilación y análisis de este efecto, comenta acerca de las objeciones de Walker: "Aunque esto es cierto, ignora el " hecho de que todas las estrellas de alta luminosidad intrín- " seca están altamente enrojecidas, mientras que muchas de " las intrínsecamente más débiles no lo están: es la ausencia " de estrellas de alta luminosidad poco enrojecidas, no la " ausencia de estrellas intrínsecamente más débiles altamen- " te enrojecidas, lo que es el rasgo crucial de Cepheus IV y " otros ejemplos ya referidos".

Para comprobar hasta qué punto las contraobjeciones de Reddish son válidas se trató de ver mediante un experimento numérico si es posible obtener una ausencia relativa de estrellas luminosas y poco enrojecidas sin necesidad de postular la correlación entre el exceso y la luminosidad.

Elección del modelo

Se eligió como modelo para tratar de representar en la forma antedicha, la Tabla 6 del trabajo de Reddish, Lawrence y Pratt (1966) sobre la asociación Cygnus II. Esta tabla nos da la estadística de la ubicación de las estrellas en las distintas zonas del diagrama magnitud absoluta visual vs. exceso y está reproducida en la Figura 1 de Reddish (1967).

Las cifras superiores en cada compartimento son obtenidas mediante un desenrojecimiento en el diagrama color-color y las inferiores mediante la magnitud aparente corregida. La línea recta cruzada en el diagrama es el límite observacional.

A los efectos de comparar los modelos numéricos, como se verá luego, con la citada tabla se combinaron las cifras superiores e inferiores de cada compartimiento dándole peso doble a las inferiores que juzgamos más fidedignas. Debido a esto la cantidad total de estrellas en la tabla así combinada resultó ser $378\,^{3}/_{8}$.