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SOME REMARKS REGARDING PHOTOELECTRIC PHOTOMETRY

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SUMARIO

La fotometría fotoeléctrica de estrellas débiles dentro de la Nebulosa de Orión, presenta serias dificultades debido a que el brillo de la Nebulosa es intenso y varía de lugar a lugar. En el presente trabajo se describen detalladamente las técnicas que se siguieron durante las observaciones de estrellas Ráfagas, medidas en la Nebulosa de Orión. Se dan también otros datos importantes que incluyen los errores observacionales y las posiciones en que el cielo se midió.

Los resultados de las observaciones de estrellas dentro de la Nebulosa, pueden depender apreciablemente de la dirección en que las mediciones del cielo se efectúan, especialmente aquellas en luz ultravioleta. Para minimizar los efectos de la Nebulosa sobre los resultados, es necesario medir el cielo en diferentes posicions alrededor de la estrella y usar diafragmas de diferentes tamaños.

Las conclusiones principales que podemos hacer sobre las estrellas Ráfagas observadas en la Nebulosa de Orión son:

i) Los errores observacionales no son grandes.

ii) La consistencia interna de nuestra fotometría es buena.

iii) Tienen excesos infrarrojos, que no se pueden explicar como debidos solamente a la extinción interestelar.

iv) Las grandes diferencias, especialmente las del índice de color U—B, son principalmente causadas por el gran brillo de la Nebulosa que varía mucho, como función de la posición. (Se menciona en el texto que las mediciones del cielo se hicieron en diferentes lugares alrededor de la estrella y que cada valor dado, la mayoría de las veces, corresponde a una sola posición).

v) Las observaciones efectuadas en longitudes de onda larga, están menos afectadas por la presencia de la nebulosa, que las realizadas en longitudes de onda corta.

vi) Estas Ráfagas, durante nuestras observaciones, probablemente se comportaron como variables irregulares "normales".

During the past fifteen years we have made narrow, intermediate and broad band photoelectric photometry of hundreds of stars at Yerkes, McDonald, Tonantzintla, LPL (Catalina), Cerro Tololo, and La Silla observatories. These observations refer to stars distributed over the entire sky from the North to the South Pole. They also include a few faint stars imbedded in the Orion Nebula which were observed in the *UBVRIJKL*-system. These are the very observations which are subjected recently to an analysis by Haro (1969). In what follows we shall try to show that his conclusions are not entirely justifiable because some details of the observations were not given explicitly by Mendoza (1966, 1967 and 1968).

The observations have been reported or described in Paper I (Mendoza, 1966), Paper II (Mendoza, 1967), Paper III (Mendoza, 1968), and Paper IV (Mendoza, 1969). They were obtained mostly in October 1965 (see Paper III). As we describe in Paper I, the *UBVRI* photometry was made using a 28-inch telescope. It is interesting to mention, that on the very same nights other faint stars were also observed. They are given in Paper II. For instance, in October 22, 1965 a total of 33 stars were observed; 14 are faint stars in regions other than Orion; 12 are standard stars, which help to make the transformations to the *UBVRI* system and to compute the extinction for that night; 5 are bright stars; and only 2 are stars in the Orion Nebula. On the average only 15% of each night was devoted to stars imbedded in the Orion Nebula. This technique allows us to observe program stars near the meridian, to allow progress in our several extensive programs and to have a better knowledge of the observational probable errors and internal consistency. It is also important to mention that under similar circumstances we have measured *U*-magnitudes fainter than magnitude 20, (Mendoza and Johnson, 1965). This is to say that they are fainter than the *U*-magnitudes of the stars observed by us in the Orion Nebula.

We have given in Paper II (Table 18) probable errors of our multicolor photometry. They are based on more than one thousand stars. An inspection of the observations made of stars in the Orion Nebula indicates that the internal agreement is good and that the probable error of a single observation at 1.0 air mas of the *V, U—B, B—V, V—R,* and *R—I* is not larger than ± 0.05 mag. With regard to the *JKL* photometry, we can say that the values given in Papers II and III are nearly equal to those given by Iriarte (1969). Expressed otherwise, the *K* magnitude, and *J—K* and *K—L* colors have a probable error of a single observation at 1.0 air mass not larger than ± 0.2 mag.

As we pointed out in Paper I the stars imbedded in the Orion Nebula are difficult to observe because they are faint and the background is bright and variable. We also described in Paper

I the observational technique employed; namely, the use of different size of focal-plane diaphragms and sky readings in different positions around the star. (This technique was used by Johnson, 1957). We observed following the sequences *BVU*st*RI*st*IR*st*UVB* or *BVU*st*RI*st (st, corresponds to measurements made with an artificial light source; the first st, with an RCR 1P21 and the second st, with an RCA 7102). An observation with a given filter was performed following the sequence:

S sky S sky S sky S sky S . . .

where S, corresponds to the measurement of the star with the chosen size of focal-plane diaphragm; and sky, corresponds to the measurement of the sky using the same diaphragm at spots approximately, between 20 and 120 seconds of arc away from the star in one or more directions. Each S or sky measurement corresponds to 15 seconds. From 5 to 34 S-readings were made through each filter (only 2 or 3 for each st).

The observations of the stars in the Orion Nebula are mostly described in Paper I, but not in Papers II-IV because we did not have a that time additional photometry of those objects. This was unfortunate, because in Paper III we give individual values, which refer most of the time, to a single sky position. At present, we have more observations of stars imbedded in the Orion Nebula which will be described elsewhere (Mendoza, 1970). Here, to show the importance of the

TABLE 1

Magnitude and Colors of stars in the Orion Nebula as function of sky readings and size of the diaphragm

Star	*J. D. 2439000+*	*V*	*U—B*	*B—V*	*V—R*	*R—I*	*Sky*	*D(″)*
P 1353	32.956	14.18	−0.88	0.83	0.96	0.91	W	36
P 1353	34.001	14.16	−0.56	0.48	1.15	0.54	S	36
P 1353	34.913	14.35	−0.34	1.04	0.96	0.82	N	27
P 1353	63.901	14.45	+0.95	1.21	1.45	0.54	W & E	18
P 1353	63.950	14.49	*	1.2:	1.17	0.95	E	18
EZ Ori	56.863	11.68	+0.33	0.89	0.67	0.66	S	36
EZ Ori	56.875	11.71	+0.32	0.86	0.81	0.59	N	36
EZ Ori	56.889	11.71	+0.32	0.87	0.72	0.65	E	36
EZ Ori	56.905	11.71	+0.26	0.86	0.77	0.58	W	36
EZ Ori	58.896	11.76	+0.25	0.87	0.86	0.57	S	27
EZ Ori	58.924	11.75	+0.25	0.85	0.83	0.61	N	36
EZ Ori	58.951	11.77	+0.29	0.84	0.83	0.58	N	27
EZ Ori	58.978	11.76	+0.25	0.87	0.90	0.55	S	36
P 1553	65.870	12.88	+0.80	1.20	1.11	0.91	N	18
P 1553	65.913	12.89	+0.69	1.21	1.11	0.93	S	18
P 1553	65.965	13.08	−0.12	1.17	1.19	0.88	W	18
P 2078	35.925	13.81	−1.08	1.15	1.21	1.06	N	27
P 2078	63.994	13.79	+1.04	1.23	1.24	0.99	S	18
P 2172	56.979	13.94	+0.73	1.26	1.51	0.84	S	36
P 2172	61.902	13.93	+0.31	1.48	1.31	0.98	N	27
P 2172	61.953	13.93	+1.05	1.22	1.36	0.97	W & E	27
P 2172	61.999	13.89	+0.75	1.41	1.23	1.20	S	27
P 2305	57.915	13.50	+0.92	1.30	1.07	0.96	N	27
P 2305	60.959	13.54	+1.74	1.33	1.32	0.81	S	27
P 2347	61.001	13.92	+0.05	0.96	1.26	0.79	N & S	36
P 2347	64.968	14.08	+0.72	1.18	1.16	0.72	N & S	18
P 2455	59.958	14.78	+1.30	1.59	1.95	1.46	N & S	27
P 2455	62.897	14.58	+1.12	1.62	1.98	1.39	N & S	18

* The East sky in the ultraviolet is very bright, brighter than star plus sky around the star (see text.)

position of the sky readings, we select from the data published in Table 1 of Paper III, the observations given in Table 1. The columns of Table 1 contain: first, the name of the star; second, the Julian Day; third, the V magnitude; fourth through the seventh, the $U-B$, $B-V$, $V-R$, $R-I$ colors (as given in Paper III), respectively; eight, the position of sky reading; and last, the size of the diaphragm used.

We note from Table 1 the following:

Star P 1353. (P 1352 in Paper III) — The Ultraviolet sky around this star is extremely variable. A few seconds to the East of this object, the sky contained in only an area of 18″ is brighter than the star plus the sky measured with the 18″-diaphragm.

Star EZ ORI. — This T Tauri star, the brightest of the lot, so far has not been reported as a flare star. Its sky readings practically do not change either with sky position or the size of the diaphragm, most likely due to its brightness and its location in the nebula.

Star P 2347. — The Ultraviolet sky reading in the West position is very different from that at the North and South. There is practically no change in the V-magnitude and the other colors.

Star P 2078. — Around this star the Ultraviolet sky readings show large differences depending on the position and the size of the diaphragm. Practically, there is no change in the other colors.

Star P 2172. — Moderate photometric changes are largely due to different diaphragms and sky positions. However, part of the differences could be due also to intrinsic light variations.

Star P 2347. — Moderate photometric changes are due to different sky positions (see also P 2172).

Star P 2455. — Moderate ultraviolet changes are due to different diaphragms and sky position (see also P 2172).

The stars listed in Table 1 are known to be variable. Thus, small changes in the magnitude and colors can be easily due to light variability. Because of the good internal agreement of the photometric measurements, we can conclude very safely that most of the ultraviolet differences, as given by $U-B$, are caused by the bright and variable sky background in the Orion Nebula. Our data (see also Paper I) indicate that at wavelengths longer than ultraviolet light, the problems caused by the nebular background are not very important. Therefore, the color that can be most influenced by the manner in which the observations are made is $U-B$. The other colors, are not affected appreciably by the employed technique, most of the time. The correct photometry is obtained when proper allowance is made for the bright and variable background. However, to notice light variations larger than the probable errors it is not necessary to know the exact photometric values. It is enough to repeat the observations under exactly the same circumstances.

Perhaps the preliminary mean values given in Papers I, II and IV are more useful; because they take into account the size of focal-plane diaphragms used and all the different positions of the sky readings. Here, we should point out that by mistake in Tables 7 and 8 of Paper II, we give U-magnitudes instead of V-magnitudes of the stars listed in Table 1 of this paper.

We can use the above results and those given in Papers I-IV as well as new observations (Mendoza, 1970) to make final remarks about the stars listed in Table 1.

i) The observational photometric errors are not large.

ii) The internal agreement of the photometry is good.

iii) The observed flare stars have infrared excesses, unexplained by interstellar extinction alone.

iv) The very different values, especially in the $U-B$ color index, are mainly caused by the bright and very variable nebular background. (Note again that sky readings were made in different positions around each object and an individual result refers mostly to a single sky position.

v) Long wavelength measurements of the sky around the star show less scatter than short wavelength measurements.

vi) These flare stars, during our observations, probably, behaved as "normal" irregular variables.

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