NEW METHOD FOR MEASURING PHOTOGRAPHIC BINARIES

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ABSTRACT: Preliminary results of a new photographic technique applied to visual double stars are given.
This technique consists in the determination of the ρ, θ and Δm from measurements made on two pairs of trails left by the components of a binary on a photographic plate, obtained through an adequate movement of the telescope in R.A. and declination.

1. INTRODUCTION

A new photographic technique applied to the visual double stars, that consists in the determination of the angular separation ρ and the position angle θ from the measures taken on two pairs of photographic trails (fig. 1), obtained by the slow motions of the telescope, has been carried out at the Astronomical Observatory of Torino with the collaboration of the Observatory of Brera (Pannunzio and Scardia, 1980).

The telescope used in this research is the 41 inch astrometric reflector (f= 9943mm, scale value 20.744"/mm) of the Observatory of Torino (Armanelli et al., 1978).

2. TECHNIQUE OF OBSERVATION AND REDUCTION METHOD

The technique of observation can be summarized as follows:

- to operate on the slow motions of the telescope in order to obtain trails on photographic plates Kodak IIa-O (16x16 cm) as shown in figure 1, and not longer than 5 cm (in this way the effect of coma is avoided),
- to obtain a trail oriented East-West stopping the telescope drive.

16 multiple exposures on the same plate have been taken in order to compare the new method with the usual one.

All the plates were measured with a two-coordinates measuring machine of the Observatory of Torino and with a microdensitometer PDS 1010 of the Observatory of Naples.

With the measuring machine the X-Y coordinates of several points of each trail were measured in order to obtain the fundamental angles α_1, α_2, α_3 with respect the instrumental axis as shown in the fig. 1.

With the PDS the trails have been measured by means of a rectangular slit (5x200 microns) which scanned 250 sections on each pair moving perpendicularly as shown in the fig. 2.

Each single scanning, made with steps of few microns in X-scale, gave a densitometric profile of the section.

This profile can be represented analytically by the following gaussian function:

$$D_i = \sum_{j=1}^{2} A_j \, e^{-H_j^2 (X_i - \bar{X}_j)^2} + D_{s.b.}$$

(i=1,n n= numb. of steps for each transverse section)

A least-squares solution applied to the recorded density gives the separation between the two trails in that section $(\bar{X}_2 - \bar{X}_1)$.

Repeating this procedure for all sections it is possible to find the mean separation $\bar{\varrho}_1$, $\bar{\varrho}_2$ of the pairs of trails.

A generalized Carnot's formula applied to the value $\bar{\varrho}_1$, $\bar{\varrho}_2$, α_0 above computed, gives the true mean angular separation $\bar{\varrho}$ (fig. 1):

$$\bar{\varrho} = \sqrt{\frac{\bar{\varrho}_1^2 + \bar{\varrho}_2^2 - 2 \cdot \bar{\varrho}_1 \cdot \bar{\varrho}_2 \cdot \cos \alpha_0}{\sin^2 \alpha_0}}$$

The position angle θ is computed from an algebraic combination of the angles α_2, α_3, β as shown in the figure 1.

3. RESULTS

28 plates of four different double stars have been taken with this new method and with the usual one.

Table I summarizes the obtained results; the columns give:

column 1: ADS number of the double star
" 2: plate number
" 3: date of observation
" 4: time of observation in U.T.
" 5: ϱ and ε_ϱ obtained with the trails method
" 6: θ and ε_θ " " " "
" 7: ϱ and ε_ϱ obtained with the multiple exposures method

column 8: θ and ε_θ obtained with the multiple exposures method.

This new method gives also the difference of magnitude of the components, obtained provisionally by means of the curve of calibration of the plates Kodak IIa-O.

The results are:

ADS	1500	$\Delta m = 0.44 \pm 0.01$	(9 plates)
ADS	3274	$\Delta m = 0.73 \pm 0.02$	(10 plates)

All the previous results have been carried out with the computer Digital PDP 11/34 and PDP 11/10 of the Observatories of Brera and Torino.

4. CONCLUSION

From the analysis of the data we can deduce that the internal accuracy in ρ and θ obtained with this new method is increased by a factor four, with respect the usual method of the multiple exposures.

The external accuracy in ρ is always greater with this new method, particularly for double stars not too close.

On the other hand the external accuracy in the position angle is of the same order for both methods.

The main sources of systematic and accidental errors can be:

- different seeing conditions in different nights,
- differential refraction for each star depending from their colour,
- photographic effects for very close binaries,
- non adequate reduction method.

Taking into account the previous points, this new method can be optimized with improvements concerning the technique of observation and the reduction method.

REFERENCES

Armanelli L., Delgrosso A. and Pannunzio R.: 1978, Astron. and Astrophys. Suppl. Series 31, 121

Pannunzio R. and Scardia M.: 1980, Report of the Astron. Observ. of Merate N. 3/80

TABLE I

1	2	3	4	5	6	7	8
				″ ″	° °	″ ″	° °
ADS 9979	1	17-JUL-80	20:00			6.617 ± 0.019	232.85 ± 0.16
	2	4-SEP-80	20:00	6.630 ± 0.013	232.94 ± 0.10	6.601 ± 0.025	232.55 ± 0.04
	3	15-SEP-80	20:30	6.646 ± 0.006	232.44 ± 0.09	6.577 ± 0.033	232.68 ± 0.08
ADS 1500	4	1-OCT-80	24:30	3.524 ± 0.002	159.75 ± 0.06	3.546 ± 0.019	159.54 ± 0.19
	5	27-OCT-80	22:35	3.529 ± 0.003	159.87 ± 0.06	3.584 ± 0.019	158.86 ± 0.37
	6	28-OCT-80	22:30	3.480 ± 0.003	160.50 ± 0.07	3.596 ± 0.027	160.26 ± 0.31
	7	28-OCT-80	22:50	3.484 ± 0.003	160.25 ± 0.06	3.540 ∓ 0.019	159.21 ± 0.37
	8	30-OCT-80	22:30			3.589 ± 0.016	159.48 ± 0.27
	9	30-OCT-80	22:50			3.470 ± 0.035	158.40 ± 0.34
	10	9-DEC-80	20:30	3.427 ± 0.005	159.98 ± 0.13	3.528 ± 0.022	159.94 ± 0.30
	11	9-DEC-80	20:45	3.470 ± 0.005	159.01 ± 0.12	3.596 ± 0.018	160.13 ± 0.21
	12	9-DEC-80	21:10	3.445 ± 0.004	160.61 ± 0.11	3.495 ± 0.034	160.30 ± 0.42
	13	9-DEC-80	21:30	3.419 ± 0.005	156.56 ± 0.13	3.675 ± 0.029	159.38 ± 0.28
	14	17-DEC-80	20:45	3.452 ± 0.006	158.51 ± 0.17	3.492 ± 0.033	159.55 ± 0.38
	15	17-DEC-80	21:05	3.449 ± 0.009	160.25 ± 0.19	3.519 ± 0.034	159.09 ± 0.59
	16	17-DEC-80	21:25			3.479 ± 0.035	159.47 ± 0.55
ADS 3274	17	28-OCT-80	23:15	10.333 ± 0.007	309.10 ± 0.05	10.316 ± 0.020	307.98 ± 0.13
	18	30-OCT-80	23:15	10.331 ± 0.005	308.44 ± 0.04	10.290 ± 0.025	308.35 ± 0.12
	19	30-OCT-80	23:30	10.335 ± 0.005	308.32 ± 0.04	10.297 ± 0.017	308.06 ± 0.08
	20	9-DEC-80	22:00	10.323 ± 0.004	308.40 ± 0.03	10.273 ± 0.015	308.28 ± 0.11
	21	9-DEC-80	22:30	10.326 ± 0.003	308.57 ± 0.02	10.350 ± 0.035	308.17 ± 0.25
	22	9-DEC-80	22:45	10.330 ± 0.004	308.35 ± 0.03	10.313 ± 0.026	307.96 ± 0.10
	23	9-DEC-80	23:05	10.351 ± 0.004	308.59 ± 0.03	10.312 ± 0.014	308.31 ± 0.10
	24	17-DEC-80	21:50	10.307 ± 0.005	308.83 ± 0.04	10.301 ± 0.019	307.95 ± 0.09
	25	17-DEC-80	22:25	10.326 ± 0.004	308.81 ± 0.03	10.327 ± 0.024	307.84 ± 0.14
	26	17-DEC-80	22:06	10.337 ± 0.005	308.62 ± 0.04	10.328 ± 0.016	307.91 ± 0.12
ADS 4068	27	17-DEC-80	22:40	4.721 ± 0.003	207.80 ± 0.05	4.811 ± 0.022	205.62 ± 0.27
	28	17-DEC-80	22:53	4.730 ± 0.003	207.60 ± 0.06	4.799 ± 0.021	205.52 ± 0.24

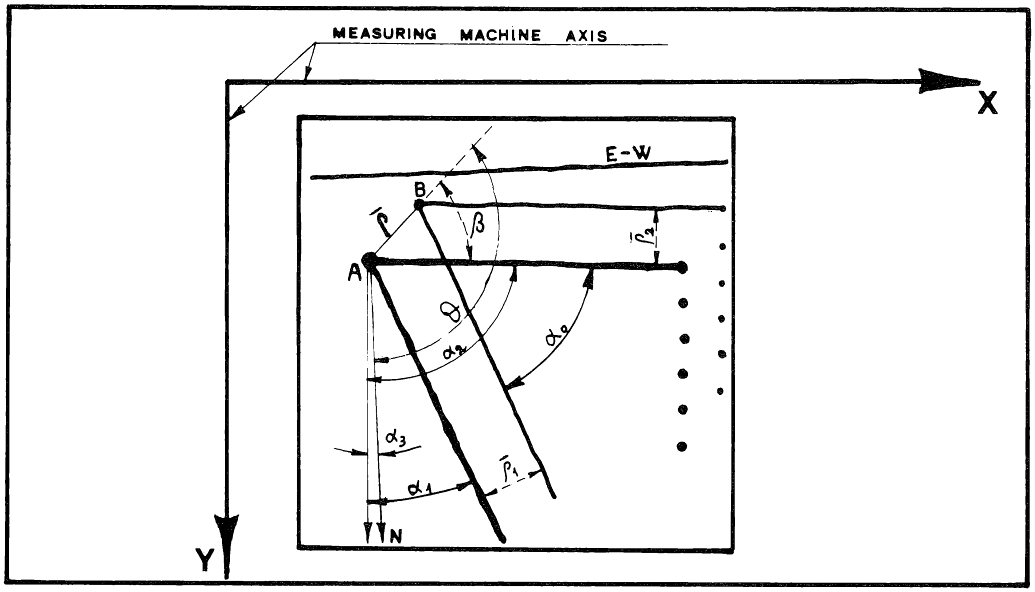
MEASURING MACHINE AXIS
X
Y
E-W
B
A
N

Fig. 1

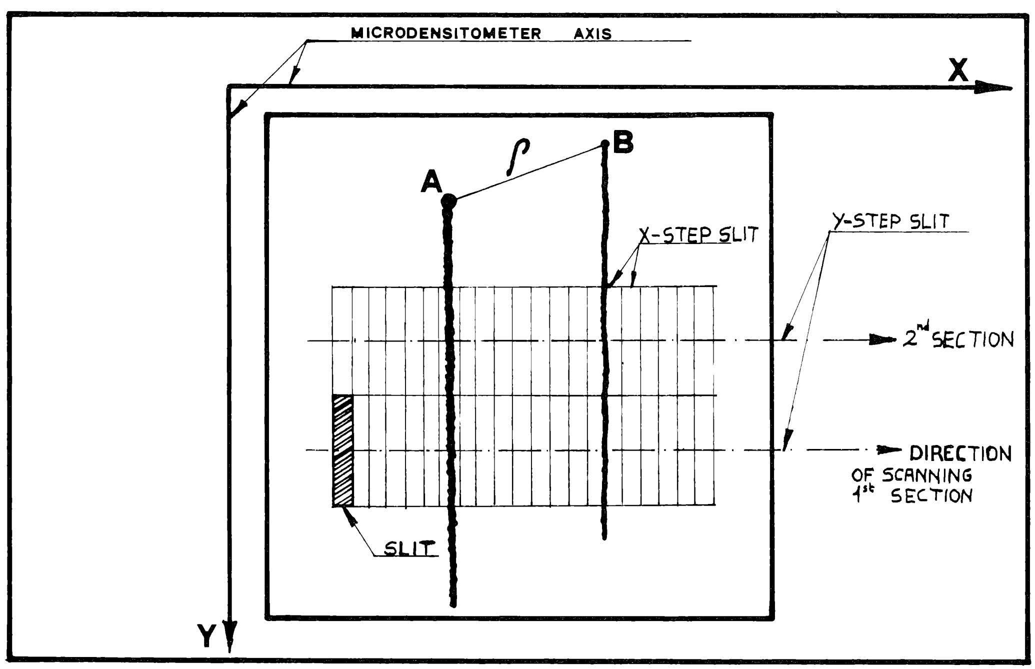
MICRODENSITOMETER AXIS
X
Y
A
B
X-STEP SLIT
Y-STEP SLIT
2nd SECTION
DIRECTION
OF SCANNING
1st SECTION
SLIT

Fig. 2