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FOCAL LENGTH OF THE BELGRADE LARGE ZEISS REFRACTOR DERIVED FROM CCD DOUBLE STAR OBSERVATIONS

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Abstract. By comparing separation of 9 visual double stars, derived from frames obtained with CCD ST–6 camera attached to our the Large Zeiss Refractor, with ephemeris separation of these same stars, the focal length of the instrument has been derived. The new focal length is $F_c = (1048.5 \pm 4.9)\,cm$, whereby the original manufacturer's focal length value is corrected by 6.5 cm, or 0.6 %

1. INTRODUCTION

The reduction of the first double star frames obtained with a CCD ST–6 camera, attached to the Large Zeiss Refractor 65/1055 cm, necessitated the knowledge of exact instrument's focal length. Therefore it was necessary to verify the original manufacturer's value $F = 1055\,cm$ and, if necessary, to correct it.

The verification of our instrument's focal length proceeded by way of comparison of the ephemeris components' separation (ρ_{eph}) of 9 selected double stars with the separations measured on frames (ρ_{CCD}) obtained with a CCD ST–6 camera attached to the instrument, not using filters. In the preliminary reduction of the frames of these 9 selected pairs the focal length $F_0 = 1050\,cm$ has been used. The values F_0 and ρ_{CCD} are connected by the following relation (Santa Barbara Instrument Group, 1992)

$$\rho_{CCD} = \frac{3600 \times 180}{\pi} \frac{\sqrt{(\Delta x\, 0.023)^2 + (\Delta y\, 0.027)^2}}{F_0} \tag{1}$$

where Δx and Δy are the measured differences of the components' positions.

The preliminary separations thus obtained could be compared with their ephemeris counterparts, ascertaining thereby whether a correction to the preliminary focal length value was necessary and if so – what was its amount.

2. OBSERVATIONS

From observational material available we selected 9 suitable pairs: 5 optical ones and 4 with known elliptical orbits. The elements of motion of all these pairs were derived anew, calculating from them the ephemeris separation values for the given epoch of

TABLE I

ADS	Epoch	θ_{eph}	ρ_{eph}	ρ_{CCD}	n_{exp}	Obs.	Description and quality (s) of traj.
48	1994.796	179 °. 86	5 ″. 976	6 ″. 148	5	POP	eliptical
				6.158	5	PAV	
				6.208	5	ZIV	
				6.171	15		(3)
56	1994.785	147.54	7.726	7.598	5	POP	eliptical
				7.770	4	PAV	
				7.638	5	ZIV	
				7.667	14		(1)
1615	1994.726	274.54	1.845	1.835	4	POP	eliptical
				1.868	5	PAV	
				1.836	5	ZIV	
				1.846	14		(2)
10329	1995.552	44.07	12.432	12.249	8	POP	rectilinear
				12.281	8	PAV	
				12.471	7	ZIV	
				12.334	23		(1)
10424	1995.541	276.27	10.530	10.566	5	POP	rectilinear
				10.918	5	PAV	
				10.640	4	ZIV	
				10.708	14		(3)
10699	1995.549	58.09	1.892	1.930	5	POP	eliptical
				1.862	5	PAV	
				1.976	5	ZIV	
				1.923	15		(2)
12727	1995.549	207.66	4.758	4.750	13	POP	rectilinear
				4.789	13	PAV	
				4.770	13	ZIV	
				4.770	39		(1)
15229	1995.552	271.63	3.146	3.155	8	POP	rectilinear
				3.137	11	PAV	
				3.220	8	ZIV	
				3.171	27		(1)
16693	1995.550	153.65	7.018	6.980	10	POP	rectilinear
				6.954	10	PAV	
				6.958	9	ZIV	
				6.964	29		(2)

Explanatio to Table 1

Column 1	– Star designation
Column 2	– Epoch of observation
Column 3, 4	– Ephemeris value of position angles and separations
Column 5	– Measured preliminary separation according to observers;
	– at bottom the mean value
Column 6	– The number of exposures
Column 7	– Authors of measurements: POP = Popović
	– PAV = Pavlović and ZIV = Živkov
Column 8	– Type of trajectory and its estimated quality

observation. It turned out that for the deriving of the ephemeris separations the rectilinear trajectory was the more convenient one.

A survey of particulars relating to the selected 9 pairs is given in Table 1.

In view of the components' separation being less than 20″ the differential refraction has been ignored.

3. ANALYSIS OF THE OBSERVATIONAL MATERIAL

The dependence between the ephemeris separation and the preliminary measured one was assumed to be linear, i.e. of the form

$$\rho_{eph} = k\,\rho_{CCD} \tag{2}$$

where k is the required coefficient. In order to take into account the trajectory quality and the number of measurements the pairs (ρ_{eph}, ρ_{CCD}) we assign the weight

$$p = (\frac{m}{M} + \frac{s}{S})\frac{1}{2} \tag{3}$$

where m is the number of measurements by all the observers (Column 6 in Table 1), M the sum of measurements of all the pairs used (in our case $M = 190$), s estimated trajectory's quality (Column 8 in Table 1), $S = \sum_{i=1}^{9} s_i = 16$. The measurements having been carried out by three observers, the total number of measurements is remarkably higher than that of the frames used. In all 67 frames have been made use of.

By employing the least–square method we obtained the coefficient $k = 1.0014 \pm 0.0047$. Since according to $\rho_{CCD} \sim 1/F_0$, a more accurate focal length is obtained from

$$F_c = \frac{F_0}{k}. \tag{4}$$

The corrected focal length is obtained as $F_c = (1048.5 \pm 4.9)\,cm$. At deriving the focal length value the error contained in the focal length as given by the manufacturer was disregarded. As expected the correction to the manufacturer's value is only $-6.5\,cm$ or 0.6%.

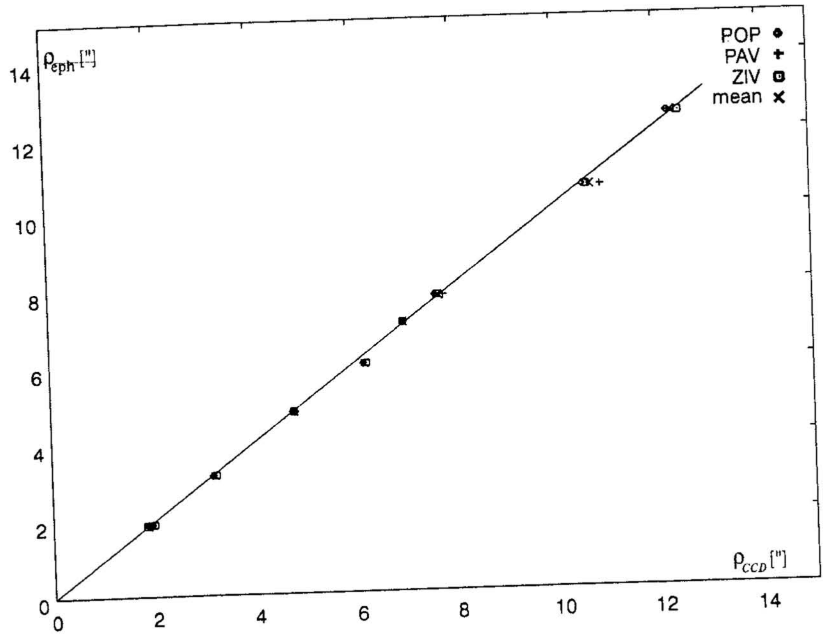

Fig. 1. $\rho_{eph} = k\, \rho_{CCD}$

4. CONCLUSION

The low standard deviation of the coefficient of transformation k is a corroboration of the highly satisfactory agreement between the ephemeris and the measured separation values.

References

Santa Barbara Instrument Group: 1992, *Model ST-6 Professional CCD Imaging Camera*, Operating Manual.