Using the Separation of Double Stars to Obtain the Plate Scale of a Telescope with a CCD Camera Attached

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Abstract: A new CCD Camera was coupled to the NURO telescope in March 2006. We used the separation of selected binary stars in the Washington Double Star Catalog to calculate the new plate scale. The value of the plate scale obtained was, within the error bar, in agreement with the design (theoretical) value. We also report the position angle and separation obtained for these selected stars.

Introduction

The calculation of the plate scale of a telescope, in arc seconds/pixel, is of utmost importance if accurate values of separation of binaries are sought. If a CCD camera is coupled to a telescope, the calculation of the plate scale is essential to obtain any astrometric data, including separation of binaries. The plate scale of a telescope with a CCD coupled is given by the equation (Muller, et al. 2003):

Plate Scale = 206265 x width of one pixel/(focal length)

assuming a square pixel. To obtain the separation of a binary system, in arc sec, is as simple as counting the pixels center to center between the two stars in the CCD image. Then,

Separation = Plate Scale x number of pixels center to center.

It is obvious from the previous equations that a new plate scale has to be calculated every time a different CCD camera is inserted in the telescope.

When the plate scale of a telescope is obtained from the stated value of the focal length a large error can be introduced in the calculations from inaccuracy in the specifications of the focal length. This is especially true if a mass produced telescope is used, since the focal length usually specified by the manufacturer is an average and could differ from the stated value by much. Celestron, in the instructions for the Micro Guide Eyepiece, states clearly the need to obtain the real focal length for mass produced telescopes if any astrometry project is to be undertaken.

Stars can be used to calculate the plate scale. From the plate scale, the focal length can be calculated if needed. For astrometric work, knowledge of the plate scale can be enough to obtain the values of interest, and one can obtain the plate scale using the separation of binary systems.

The simple scheme to obtain the plate scale of a telescope/CCD system using data from the separation of binary systems is straightforward. All we need is a target list of binaries from the Washington Double Star Catalog that show almost no change in separation in many years. The selected binaries are imaged and the images are pixelized. The value of separation of the binaries stated in the Washington Double Star Catalog is divided by the number of pixels on the image. Then:

Plate scale= separation / (number of pixels)

It is that simple. Then an average plate scale is

obtained from the sample of selected binaries. This value can be compared with the design or theoretical value for the telescope/CCD system. The position angle does not enter in the calculation but is needed to make sure that the images acquired belong to the correct binary systems.

Procedure

We use the 31 inch NURO telescope at Flagstaff, Arizona at 7200 feet over sea level, (www.NURO.nau.edu) for observing binaries, traveling twice a year to obtain the data. We usually travel in May and September to observe and gather data. The NURO telescope belongs to the Lowell Observatory and is located at Anderson Mesa, 20 miles east of Flagstaff.

We where informed, in January 2006, that a new CCD camera was going to be coupled to the telescope and that it would become operational during March 2006. The manufacturer's design (theoretical) plate scale value was .515 and the calculation of the plate scale was complicated because there was an optical reducer with a 2/1 ratio in the optical path of the telescope. The new CCD, named NASACAM, had 27 micron pixels.

We requested one night of service observing in March or April and sent a list of 25 targets to be imaged. These 25 binaries where obtained from the Washington Double Star Catalog; and we looked for binaries that would not differ much in magnitude since we wanted to image and pixelize stars of relatively close brightness.

Three of the binaries where not found and were discarded, leaving us with a sample of 22 binaries

Table 1 shows the 22 binaries. The first column shows the name of the star in the Washington Double Star (WDS) Catalog. The second column shows the separation of the pair as found in the WDS. The third

WDS name	separation ρ WDS	angle (θ) WDS	Angle (θ) measured	#pixels	Plate scale	|di|	ρ measured
STF1463	7.90	258	258.18	15.36	.514	.010	8.04
BAL1443	6.4	176	174.73	12.29	.52	.004	6.43
GRV 847	32.8	350	349.91	63.5	.517	.007	33.2
HJ 513	21.8	253	253.01	41.66	.508	.016	21.82
GRV 848	26.4	215	214.71	51.23	.515	.009	26.84
STI 738	7	38	37.8	12.48	.560	.036	6.53
STF1727	7.54	333	332.91	14.63	.513	.011	7.66
GRV 865	69.3	236	236.41	134.35	.516	.008	70.39
ARA 74	13.4	15	12.55	24.74	.542	.018	12.96
LDS1402	7	314	312	13.27	.528	.004	6.95
ARA 695	8	60	57.06	14.77	.542	.018	7.73
S 659	31.6	170	170.96	60.87	.519	.005	31.89
BAL1169	13.9	297	297.49	26.09	.533	.009	13.67
HJ 2701	12.34	37	37.18	24.12	.510	.014	12.63
POU3162	6.9	347	345.22	12.88	.536	.012	6.74
HJ 545	9.2	242	242.47	17.69	.520	.004	9.26
BAL1175	14.6	198	196.94	27.83	.525	.001	14.58
POU3193	7.6	293	295.8	14.39	.528	.004	7.54
LDS4622	14.1	40	38	26.66	.528	.004	13.96
ALI 370	13.2	148	146.47	25.28	.522	.002	13.24
POU3214	12.6	83	81.51	23.91	.526	.002	12.52
ES 627	11.9	288	286.9	22.93	.518	.006	12.01

Table 1: Measurements of double stars used in calibration

and fourth columns present, respectively, the position angle as stated in the WDS and as measured by us. The fifth column gives the number of pixels as obtained by us. The sixth column yields the division of the separation in the WDS/#pixels, thus the plate scale. The seventh column yields the deviation and the last column yields the separation calculated using the value obtained for the plate scale, .524 arc sec/ pixel.

From the table, the average value of the plate scale is $\Phi = 0.524$ arc seconds/pixel and the standard deviation value of d = .017, so our value is

Plate scale = .524 ±.017 arc seconds/pixel

It should be noted that the design value of the plate scale, .515 falls within the uncertainty of our value.

We would like to report now our measurements of position angle and separation of the 22 binaries, and for that matter we include, in the customary format, Table II. We now assume as the plate scale the value of .524 arc seconds/pixel. It should be pointed out that in the N column we indicate the number of images obtained of the binary system of interest.

Acknowledgements

We would like to thank Ed Anderson of NURO for obtaining the data we needed. We thank the Puerto Rico Space Grant Consortium for its support of our project, and the Humacao Campus MARC program for support of a student. This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.

Bibliography

Muller, R.J., Cersosimo, J.C., Benson, E., Gonzalez, R., Lind.M., 2004, The Double Star Observer **9**, 4-16

Name	RA +DEC	MAG A, B	PA (DEG)	Sep (arcsec)	Date	N
STF 1463	10 42 54.25 +46 41 25.2	9.30 10.42	258.18	8.04	2006.268	2
Bal 1443	11 08 30.9 +01 17 44	10.8 11	174.73	6.43	2006.268	2
GRV 847	11 59 33.70 +18 08 07.1	9.30 9.92	349.91	33.2	2006.271	1
HJ 513	12 00 07.63 +26 02 30.4	9.40 11.28	253.01	21.82	2006.268 2006.271	2
GRV 848	12 01 08.47 +26 43 41.2	11.8 12.6	214.71	26.84	2006.268 2006.271	2
STI 738	12 03 17.7 +59 24 05	10.1 11	37.8	6.53	2006.271	1
STF 1727	13 09 52.02 +31 22 00.3	9.81 10.99	332.91	7.66	2006.271	1
GRV 865	13 10 13.22 +14 32 52.9	10.69 11.41	236.41	70.39	2006.268 2006.271	2
ARA 74	14 01 26.4 -16 36 00	13.3 13.3	12.55	12.96	2006.271	1
LDS 1402	14 02 27.1 +15 20 33	15.1 15.5	312	6.95	2006.271	1
ARA 695	14 03 29.2 -19 32 20	12.6 12.9	57.06	7.73	2006.271	1
S 659	14 05 38.56 -18 04 20.5	8.31 8.93	170.96	31.89	2006.271	1
BAL 1169	14 08 19.3 -00 11 19	10.9 11.3	297.49	13.67	2006.271	1
HJ 2701	14 08 37.88 +06 01 41.0	9.80 9.95	37.18	12.63	2006.271	1
POU 3162	14 13 23.9 +24 24 12	11.0 12.8	345.22	6.74	2006.271	1
HJ 545	14 18 31.6 +38 37 53	11.1 11.5	242.47	9.26	2006.271	1
Bal 1175	15 00 23.7 +00 06 44	10.8 11.2	196.64	14.58	2006.271	1
Pou 3193	15 35 22 +24 08 18	13.2 13.7	295.8	7.54	2006.271	1
LDS 4622	16 01 47. -04 47 48.	13.1 17.0	38	13.96	2006.271	1
ALI 370	16 07 26.8 +35 48 29	13.7 14.1	146.47	13.24	2006.271	1
Pou 3214	16 07 48.8 +23 05 29	11.1 13.3	81.51	12.52	2006.271	1
ES 627	16 18 35.71 +51 19 51.5	9.88 10.98	286.9	12.01	2006.271	1

Table 2: Measurements of 22 double stars using the calibration constant of 0.524 a.s. / pixel.