A Report on Double Stars Observed During the Year 2015 by Students and Faculty of the Humacao University Observatory

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Abstract: We are hereby reporting on the measurements of separation and position angle of 70 binary stars. We used the NURO Telescope at the Anderson Mesa location of Lowell Observatory, 20 miles east of Flagstaff, Arizona, at an altitude of 7000 feet to obtain our data. We observed on September 26, 27, and 28 of 2015 and gathered the data using the 2K x 2K CCD camera, NASACAM, at the prime focus of the 31 inch telescope. The data was transferred and analyzed at the Humacao University Observatory of the University of Puerto Rico by undergraduate students undertaking astronomy research projects.

We report measurements of separation and position angle of 70 binary stars gathered from CCD images obtained with the NASACAM CCD at the prime focus of the National Undergraduate Research Observatory (NURO) telescope. The Humacao Campus of the University of Puerto Rico is a member of NURO, a consortium of primarily undergraduate institutions (www.nuro.nau.edu) with access to a 31-inch telescope, property of Lowell Observatory. It is located roughly 20 miles east of Flagstaff, Arizona at Anderson Mesa, at an altitude of 7200 feet. We use the NURO telescope twice a year, and at present we use it for both binary star measurements and asteroid research.

The data presented in this report was acquired on one trip to NURO on 2015, on September 26, 27 and 28. We were rained out on our May/June trip.

The NASA cam is a 2K x 2K CCD camera with 15 micron pixels. The camera does not need liquid nitrogen to cool down to -100, saving us a lot of time in the camera-telescope setup. The field of view of the old camera was 4 arc minutes by 4 arc minutes. The field of view of the new camera is 16 arc minutes by 16 arc minutes. However, an optical reducer with ratio 2:1 lies in the optical path, so the separation of binaries in the images looks almost the same as before, in a much wider field.

Procedure

As in past reports, the CCD images where analyzed by students with undergraduate astronomy research projects at our department at the University of Puerto Rico, Humacao Campus. The students used the pixelation of the CCD images to obtain the separation and position angle (Muller et al, 2003). Then various of the CCD images where analyzed a second time using the softwareAstronomical Image Processing for Windows (Berry et al, 2002). Since the software does not provide for introducing the telescope's plate scale in the computations one has to perform final number crunching with a hand calculator. The software in the program is also mirror reversed as far as position angle is concerned, so one must be very careful to figure the correct angle from the one given by the software. The design value for the plate scale with the new NASA CAM is .515 arc

seconds/pixel. We used 22 binaries with very long periods to obtain an experimental value for the plate scale. With this small sample it came to be .524 ± .009, in close agreement with the design value provided by the manufacturer. We are using our value when calculating the separation of the binaries. There is also a systematic error in position angle that occurs because the CCD camera cannot be inserted into the telescope with an absolute level. This error can be corrected by using well known binary systems and binary systems that "don't move". Binary systems that "don't move" can be found in the neglected section of the Washington Double Star catalog, as binary stars that have been measured for the last 100 years and show no change in position angle. By imaging a mix of well known binaries and fixed binaries (we use around 20 of them total) and comparing the value of position angle given in the WDS with the value obtained from our images, the systematic error in the position angle can be corrected. We call such error the offset error and are incorporated in the position angle values given in the accompanying table.

Data

The following table includes the 70 entries for the binary stars for which we obtained useful results. The table is divided with the first column containing the name of the system. The second and third columns contain the R.A. and Dec of the system, acquired from the Washington Double Star Catalog (WDS).The fourth column contain our measurement of separation and the fifth our position angle measurements. The next two columns are the visual magnitudes of the primary and secondary, obtained from the WDS. The last column is the date of the observation in fractional date. We obtained only one image per night per system. That image was pixelized and three or more copies were made of each pixelized image. Then, three students analyzed the images separately and then an average of all measures was reported as the final result.

We have gathered data for many of these binaries during many years (Muller et al., 2007 and following years) until 2014; we are putting together yearly observations of various systems to obtain information on them. Any findings will be reported in this journal.

Acknowledgements

This research has made extensive use of the Washington Double Star Catalog maintained at the U. S. Naval Observatory.We want to thank Lowell Observatory for its continuous support of this project by allowing us the use of the 31-inch NURO telescope. We also thank Ed Anderson of NURO for his efforts on behalf of our students.

References:

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Day 1: Sept 26 2015							
Star Name	**RA**	**DEC**	**Separation**	**θ**	**M1**	**M2**	**Date**
ARA 243	160106.51	-174216.7	13.21	118^0	11.7	12.1	2015.7369
AG 349	160104.36	+280642.4	12.36	227^0	9.59	10.86	2015.7369
HJ 580	160250.56	+370526.8	39.46	9^0	9.21	12.97	2015.7369
BEM 21	160258.26	+5111140.4	18.52	105^0	10.54	11.02	2015.7369
BAL1911	160320.00	+023126.8	16.36	238^0	12.19	12.7	2015.7369
STF1999 AB	160425.96	-112657.6	12.28	102.3^0	7.52	8.05	2015.7369
HJ 582	160716.96	+350741.6	22.5	234^0	11.11	13.61	2015.7369
ALI 370	160726.70	+354827.8	12.5	148^0	12.0	13.0	2015.7369
POU3214	160748.84	+230529.9	12.2	83.8^0	11.1	13.3	2015.7369
ES 627	161835.71	+511951.5	12.37	290^0	9.88	10.98	2015.7369
STF2098 AB	164543.4	+300017.2	15.5	147^0	8.77	9.61	2015.7369
BAL2429	165451.18	+031840.8	10.53	53^0	11.77	12.8	2015.7369
BAL1931	170605.4	+432857.4	17.95	189^0	12.4	13.23	2015.7369
COU 109	170627.8	+220756.7	10.34	140^0	10.01	13.1	2015.7369
AG 353	170701.3	+121321.6	9.53	250^0	9.83	11.7	2015.7369
STF2127	170704.4	+310535.1	15.17	280^0	8.7	12.3	2015.7369
SLE 9	170706.2	+202921.7	19.9	174^0	10.49	12.3	2015.7369
GRV 946	170714.1	+254434.5	20.65	43^0	10.54	11.71	2015.7369
BAL1934	171745.8	+020705.9	11.99	236^0	10.8	10.8	2015.7369
STI2366	180033.7	+584056.1	10.97	300^0	10.65	12.1	2015.7369
SLE 107	180149.8	+263123.4	13.3	207.4^0	12.45	12.6	2015.7369
HJ 1314	180705.3	+322254.6	17.25	155^0	10.33	11.09	2015.7369
SLE 110	180714.4	+271603.6	11.94	114^0	10.56	13.3	2015.7369
BAL2474	180803.4	+034312.1	16.27	284^0	10.0	11.0	2015.7369

Day 2: Sept 27 2015							
Star Name	**RA**	**DEC**	**Separation**	**θ**	**M1**	**M2**	**Date**
SLE 111	180853.96	+272456.6	14.02	317.3^{o}	10.8	12.5	2015.7397
POU3353	180855.05	+231900.4	14.97	346.1^{o}	12.26	12.4	2015.7397
STF2293	180953.83	+482405.7	12.42	85.4^{o}	8.08	10.34	2015.7397
ARA 267	180954.03	-170938.3	14.63	351^{o}	11.22	12.4	2015.7397
SEI 559	181027.80	+335555.6	11.89	174.8^{o}	11.0	11.0	2015.7397
BAL2481	181037.28	+032723.7	11.08	110^{o}	11.3	11.3	2015.7397
AG 217	181105.89	+532937.8	14.14	240^{o}	10.77	11.85	2015.7397
ALI 140	181125.14	+350645.5	14.62	251^{o}	10.97	11.79	2015.7397
BAL2483	181441.54	+034205.5	12.98	197^{o}	12.00	12.7	2015.7397
STF 2459	190722.01	+255823.9	13.68	232.7^{o}	9.12	10.07	2015.7397
SLE 931	191020.34	+024958.7	11.03	81.2^{o}	9.9	12.0	2015.7397
POU3745	191200.71	+234617.6	11.3	24.4^{o}	12.47	13.7	2015.7397
HJ 1375	191229.96	+281426.7	11.49	87^{o}	11.0	13.6	2015.7397
SLE 935	191426.85	+021204.9	8.46	222^{o}	10.5	13.1	2015.7397
ARA1175	191533.51	-195421.4	12.43	14^{o}	12.4	13.2	2015.7397
HJ 2868	191756.98	+580758.2	11.58	102^{o}	11.9	11.9	2015.7397
POU3940	193512.15	+250129.6	10.23	31^{o}	10.6	10.7	2015.7397
HJ 1421	193621.95	+353551.5	15.53	232^{o}	9.37	11.72	2015.7397
ALI 892	193720.68	+390419.2	11.27	65^{o}	10.74	12.6	2015.7397
HJ 1429	193757.45	+561405.9	8.89	239^{o}	10.6	11.0	2015.7397
SMA 101	195048.4	+444442.1	10.26	53^{o}	12.8	13.2	2015.7397
POU4178	200012.2	+242045.5	11.65	6^{o}	11.3	12.3	2015.7397

Day 3: September 28 2015							
Star Name	**RA**	**DEC**	**Separation**	**θ**	**M1**	**M2**	**Date**
BAL1230	212750.4	+010448.4	11.65	277.7^{0}	11.4	11.5	2015.7424
STI2586	214240.4	+561456.9	9.65	1.0^{0}	10.71	11.72	2015.7424
STI2720	222130.2	+583648.7	12.49	161.7^{0}	12.1	12.1	2015.7424
STI2722	222158.8	+561953.9	14.10	73.7^{0}	10.67	13.1	2015.7424
ES 837 AC	223145.7	+500424.4	12.05	241.3^{0}	9.6	12.9	2015.7424
HO 475 AC	223245.5	+262432.7	10.07	221.5^{0}	9.34	11.3	2015.7424
POU5723	223511.5	+234155.6	10.81	181.7^{0}	12.8	13.3	2015.7424
CHE 347	224037.3	+301949.0	8.03	53^{0}	13.1	13.6	2015.7424
STF2999 AD	231846.44	+051118.7	26.67	24^{0}	8.90	11.9	2015.7424
HJ 1876	232556.79	+365032.5	8.78	212.7^{0}	11.1	11.6	2015.7424
HJ 986	232707.3	+352028.2	9.85	294^{0}	11.23	12.2	2015.7424
CHE 501	233011.3	+421440.4	24.08	275^{0}	13.45	13.42	2015.7424
STF3019	233040.7	+051458.0	12.19	182^{0}	7.77	8.37	2015.7424
MLB 506	233828.6	+284456.2	8.06	239^{0}	11.1	11.6	2015.7424
STI3007	233642.8	+581948.7	8.88	123^{0}	13.2	13.2	2015.7424
ES 269 AB	234903.2	+411926.2	10.06	227.08^{0}	9.93	12.1	2015.7424
BAL1611	004318.5	255101.2	19.54	177^{0}	12.68	13.09	2015.7424
HJ 1288	161240.87	-164518.6	17.93	123^{0}	11.0	12.3	2015.7424
LDS4705	165624.44	+033029.1	13.73	56^{0}	15.2	17	2015.7424
STF2123	170657.50	+064803.0	17.5	217^{0}	9.82	9.98	2015.7424
STN 34	171642.44	-170911.5	15.96	290.3^{0}	9.57	10.58	2015.7424
HDS2441	171556.29	-132939.0	12.46	237^{0}	9.63	11.74	2015.7424
BAL1934	171745.8	+020705.9	12	239^{0}	10.8	10.8	2015.7424
BAL1952	180734.4	+022407.8	14.31	157^{0}	11.52	12.8	2015.7424