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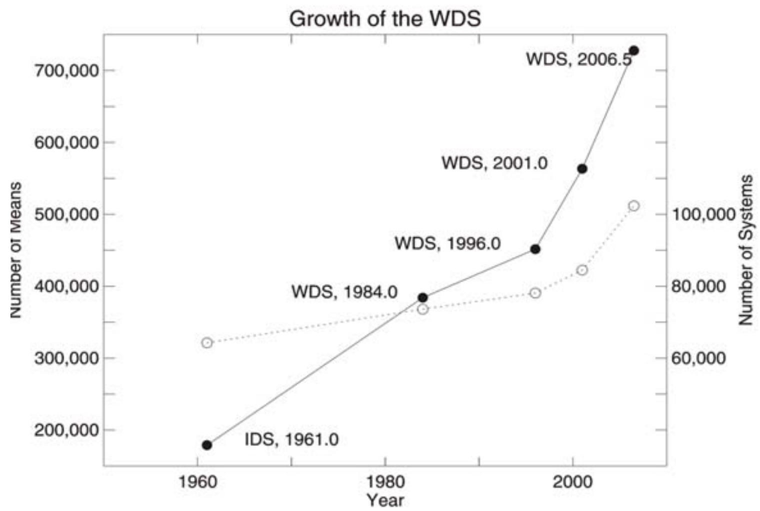
New Double Star CD

The United States Naval Observatory has released a new compact disc containing the Washington Double Star Catalog, The Sixth Catalog of Orbits of Visual Binary Stars, and other major double star catalogs. See Mason and Hartkopf's article on page 171 for a full description.



Inside this issue:

Notes on the Double Stars of Father John W. Stein, S. J.

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Abstract: Nearly half of the double stars listed in the WDS catalog have only the discovery measure. Opportunities abound for the dedicated amateur astronomer to confirm and measure these neglected pairs. This article highlights the photographic discoveries of Vatican astronomer, J W. Stein. About 18% of his pairs fit the neglecte category with the last measure averaging 90 years ago. A historical review is followed by an outline of the author's experience measuring Stein's pairs.

Brief History

In a monumental early effort to chart the entire sky to magnitude 11, the Paris Observatory developed the instrumentation and championed a program where about twenty nearly identical astrographs were built to plan and be installed by participating observatories each covering a specific declination zone. The Vatican Observatory was assigned the region +55 to +64 declination. This is generally known as the Vatican Zone of the *Astrographic Catalog*[1] *(AC)*. Over 256,000 stars were recorded for this zone alone. The Vatican photographic work began in 1895 and was completed in 1922. The deeper (14th mag) photographic charts from all zones , the *Carte du Ciel*, employed the same astrographs and contains over 12 million star images with the positions of 4.6 million measured, however, the high cost of reproduction prevented its completion and wide distribution.

Dutch born and educated, Dr. Stein (Figure 1) worked as assistant to the director of the Vatican Observatory, J. G. Hagen S.J., in the years 1906 to 1910. In 1910 he was appointed a teaching position at St. Ignatius College in Amsterdam where he taught mathematics, physics, botany and zoology During his teaching years he published many astronomical papers, most notable his section on the physics of variable stars in *Die Veränderlichen Sterne* . He always remained in close scientific collaboration with Hagen in these intervening years. Sometime after 1924 he

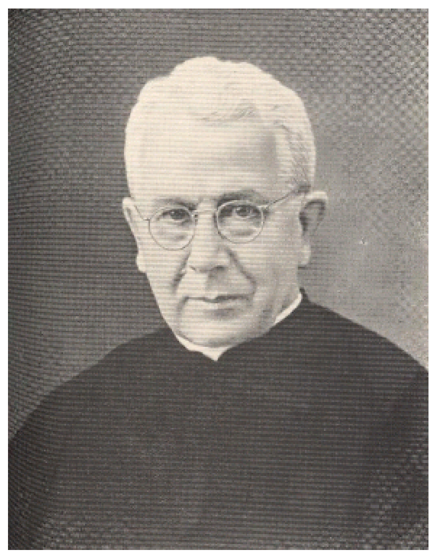

Figure 1: *Father John W. Stein, S.J. 1871 - 1951*

joined the Association of Dutch Amateur Astronomers where he contributed easily read synopses of professional astronomical literature for the association's journal and soon became its editor. In 1930 Stein was given the directorship of the Vatican observatory. The *AC* plate reduction process went on for years after the last plate was exposed in 1922 and Stein was there, off and on, through the thick of it, studying the early and recent plates to discover and measure his doubles, finally publishing his list: *Stelle doppie nel catalogo...Vaticano* (Rome, 1930). Stein was responsible for modernizing the observatory, including a new physics lab, and moving it to Castle Gandolfo just outside Rome in 1933 (see Figure 2 below). He was knighted to the Order of the Lion of the Netherlands by Queen Juliana and is also honored by the lunar crater Stein, located at 7.2 N , 179.0 E

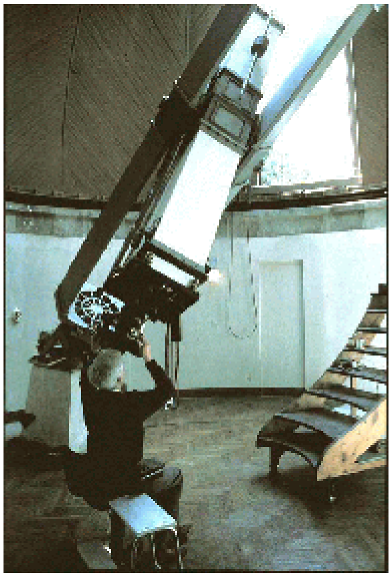

Figure 2: The Vatican's Carte du Ciel *astrograph used for zone 2 of the Astrographic Catalog. Photo courtesy Vatican Observatory web site.*

The Astrograph

Moved from the Vatican Observatory to Castle Gandolfo sometime after 1930 and dedicated in 1942, the astrograph's aperture is 13-inch (330 mm) and 135-inch (3,440 mm) focal length giving a focal ratio of 10.4. The 5-inch (130 mm) square blue sensitive glass plates covered 2 x 2 degrees of sky with a plate scale of 1 mm per minute of arc.

Color correcting the instrument for blue light (matching the blue sensitive plates) provided extraordinarily sharp images required for precise position work. An 8-inch (200 mm) aperture visually corrected, fine guiding refractor of about the same focal length as the camera is mounted co-aligned to the astrograph within the same rectangular tube, thus minimizing differential flexure. It also served as the field-centering instrument to ensure exact overlap of adjacent fields required in charting work. Operationally, two plates of each field were taken with the pointing slightly shifted for each. Generous field overlap of about 1 degree ensured complete coverage within the zone and adjacent zones.

The instrument is carried on a fine English equatorial yoke, which allows meridian passage without the usual mount flip of the more common German equatorial when working high declinations. Figure 3 shows a wonderful engraving by Poyet of the final design prototype at the Paris Observatory. Access to the pole was required for the Greenwich, England and Melbourne, Australia zones, thus a different mount arrangement was used.

Measuring Steins Doubles

Stein's (STI) discoveries, being photographic, tend to be rather faint for the visual (filar micrometer) observer, consequently about half of his pairs have only the discovery measure. Even many of those with six or eight measures can be called neglected with last measures sometimes 50 years old. The introduction of the CCD camera has changed the picture, making measurements of his doubles relatively easy. The magnitudes are mostly in the range of 9th - 14th in blue light. The accuracy of the listed B magnitudes are often quite a bit off, more than would be expected when quickly measured with a calibrated CCD in V and I-bands (B-V approximates V-I). Sometimes I find the secondary the brighter component in V-band, the accepted color for listing magnitudes. The possibility of a quadrant flip is slim with such wide and faint doubles.

Finding STI pairs visually requires a chart printout at the eyepiece and at least an 82 mm aperture finder for acquisition. I use Guide-8, a charting program from Project Pluto. The chart field is printed to

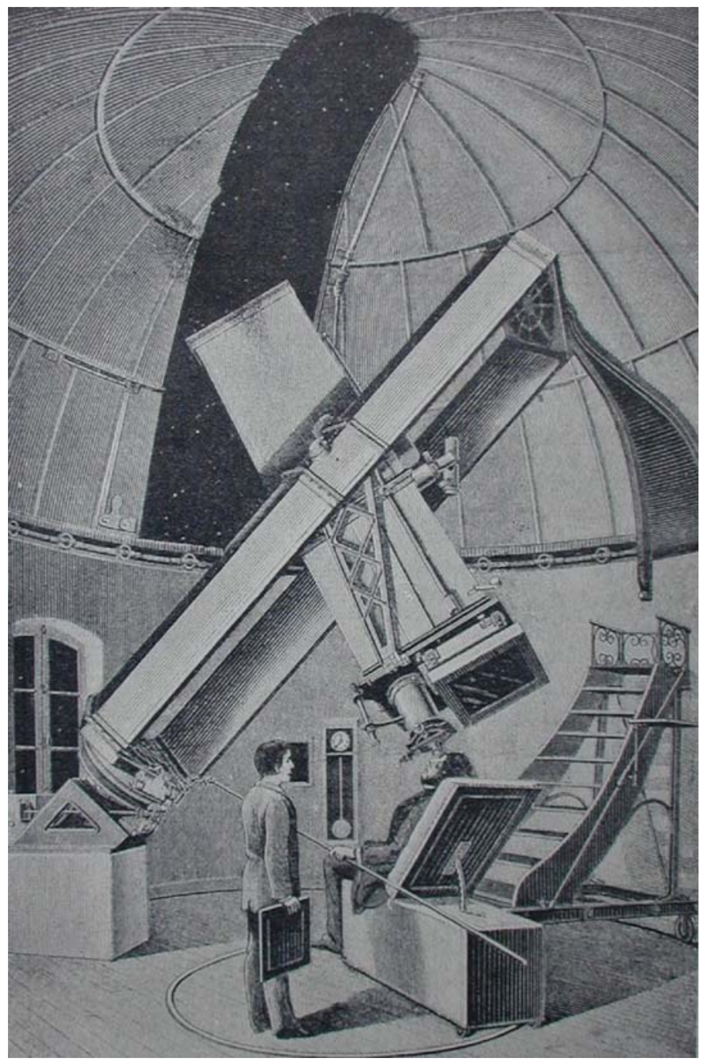

Figure 3: Early engraving of the final prototype astrograph by the Henry brothers. From "Splendors of the Heavens", vol. 2 (1925).

reflect the orientation and FOV of the finder. The separations of Stein's doubles are generally in the range of 3 to 15 arcseconds, very nice CCD objects. For LSO's 9-inch instrument, employing an ST-7 at 278-inch FL, the exposures tend to run in the range of 2 to 12 seconds unfiltered and 20 seconds and over for BVRI photometry. Pixel binning for photometric measures is preferred as long as the components are definitely separated. This keeps the exposure times reasonable. Delta m-wise, many of Steins doubles are of fairly equal magnitude, however, there are some really challenging examples where one wonders how he ever measured them photographically with the relatively short focal length of the instruments employed in the astrographic program. His precise measures stand as a testament of a careful and dedicated astronomer[2, 3].

Stein's Numbering System

Stein more or less divided his discoveries into two declination zones, essentially splitting the Vatican Astrographic zone. Doubles + 60 and higher in declination he numbered 1 through 1263 and those lower, 1364 through 3091, with both zones listed in order of right ascension. The series has many missing numbers. Due to precession since the discovery epoch, his number series no longer start close to 0 hours, beginning instead at about 0 hr 6 m (2000). Due to field overlap etc., his discoveries extend slightly outside the overall Vatican zone.

What to Expect

Photographic measures tend to be more accurate than filar work. In fact the CCD accuracy is generally comparable to photographic measures of wider pairs such as Stein's, therefore, a high confidence can be placed in detecting small relative motions. It is, of course, hard to say where the photographic and CCD measurement noise hides tiny motions. In my program to measure as many as possible of the neglected Stein doubles, I have noticed, thus far, that most show detectable relative motion where I define "detectable motion" as greater than 2-degrees in position angle and/or 0.2 seconds in separation. Naturally, for those pairs with only one previous measure, there is no way to tell if the motion is arcing concave to the primary, thus indicating physicality. Observing the colors and Δm photometrically and assuming main sequence objects can often help in this determination, however, almost nothing beats another observation, say fifty to one hundred years hence! Proper motion can also provide clues, however, these faint pairs often have no reliable data, especially for much fainter and close secondaries! Of course, if the primary is listed as having a clearly discernable proper motion and the pair's relative position has not changed much, we can assume they are traveling together through space, thus likely binary. From a "getting the job done"standpoint along with the usual time constraints, tedious analysis of most of Stein's pairs is not undertaken; just measure the position angle and separation and quickly move on to the next pair on the list! Unusual colors or delta m values are noted when encountered in hopes of returning to them another time.

Faint, well resolved double stars, other than dwarfs of spectral classes K- M, lie at tremendous distances where orbital times can be thousands of years. Studies[4] indicate that isolated main sequence doubles (especially spectral class F and G) in the range of 11th magnitude and separations of about 10 arcseconds and under have a high probability of being physical. This, shall we say, "rule of thumb" statistically includes many of Steins doubles. It is conceivable that up to 1/3 of Stein's pairs are physical! If true, it's a tremendous yield.

CCD Appearance of a Typical STI Pair

It is naturally desirable to measure such faint pairs in good seeing, but even when the images are a little blurry one can reach reasonable accuracy by av-

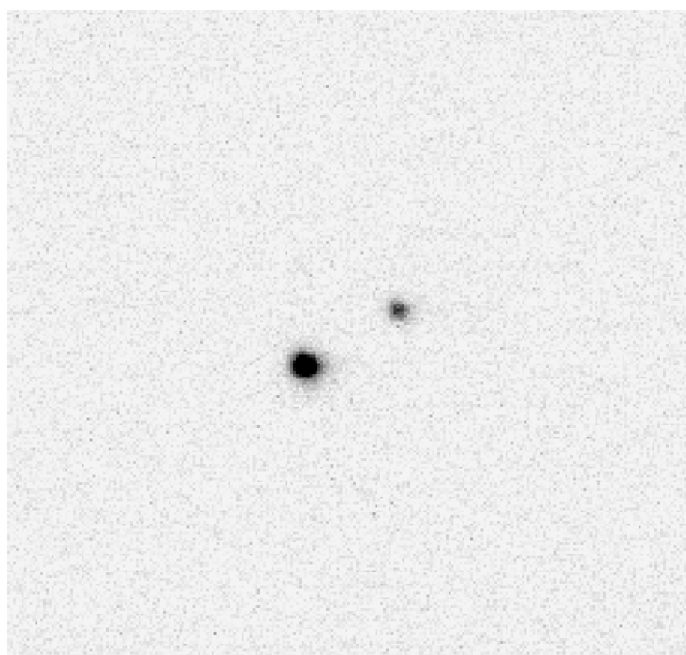

Figure 4: Cropped CCD image of STI2222. The exposure was 3 seconds, unfiltered. Separation is 10.50". No other stars recorded in the full field!

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eraging measures from at least 12 selected CCD images. If I waited to measure only on the best nights very little work would ever get done! Amazingly, with my 9-inch refractor some semblance of an Airy disk is visible most nights and only about 5 clear nights a year (neglecting windy nights) are deemed useless. Strong north-west winds, especially at high altitude, is associated with degraded seeing at my location. A southerly flow that is very light at the surface gives the best seeing. Occasionally wind off the Atlantic penetrates inland enough (70 miles) to reach LSO and this can often provide fairly good seeing as well. The image of STI 2222 in Figure 4 was taken on 2006.301 during such a "sea breeze". The WDS mags are 9.7 and 12.5. North is up east is left.

Acknowledgement

Dr. Brian Mason of the USNO was extremely helpful to me in preparing this article. I especially thank Brian for finding a picture of Stein in Kort's memoriam to him (ref. 3) where many historical details were also gleaned.

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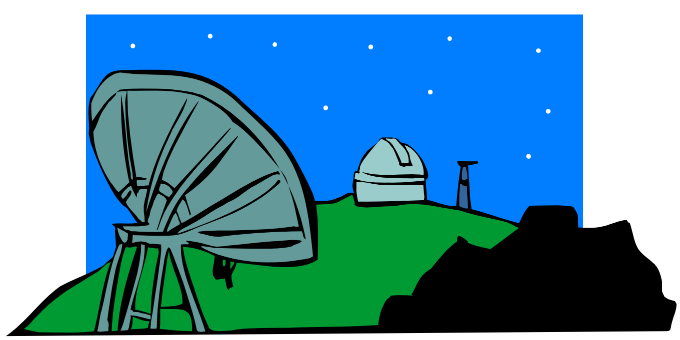
4) Wolff D. Heinz, Double Stars, section 7: Optical and Temporary Double Stars, pg 17, 1978.



A Report on the Observation of Selected Binary Stars with Ephemerides in the *Sixth Catalog of Orbits of Visual Binary Stars*

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Abstract: We observed nine binary stars with ephemerides on the Sixth Catalog of Orbits of Visual Binary Stars with the objective of corroborating the predictions on the Catalog. Our results show agreement with the predictions of separation (ρ), but found a slight difference with the predictions of position angle (Θ). Recent measurements reported in the Washington Double Star Catalog tend to agree with our observations.

Introduction

The *Sixth Catalog of Orbits of Visual Binary Stars*[1] includes close to two thousand orbits of binary stars, with numerical ephemerides included on almost all orbits. It is of interest to test the predictions, since the ultimate judgment in science rests on observations to test the predictions of a model. We selected nine binaries with ephemerides from the catalog and measured their separation and position angle. We compare our observations with the predictions and with recent measurements reported in the Washington Double Star Catalog (WDS)[2].

We obtained our observational data at the 31 inch N.U.R.O.[3] telescope, located at the Anderson Mesa near Flagstaff, Arizona, at an altitude of 7200 feet. The telescope, a Shmidt-Cassegrain, belongs to Lowell Observatory[4]. It was equipped with a 512 X 512 Tek CCD camera cooled to -110 C when we made the measurements presented in this article; the CCD has been replaced.

Method

Our methodology was detailed in an article published in the Double Star Observer[5]. Capturing images with a CCD is made simple using the properties of German Equatorial and fork mounts: with the telescope pointed to the North Pole -or as far north as possible- insert the CCD and level it as precisely as you can. North will always be either straight up or straight down in your images (assuming the CCD is not inserted using a star diagonal or a reducer/corrector in the optical path). Since a "perfect" leveling of the CCD is not possible, this procedure will introduce a systematic error that we call the offset; it can be corrected afterwards using "standard" binaries during the process of calibration of the images. The fact that our measurements of position angle of well known binaries agree with published values attests for the correctness of this simple procedure.

Our images are calibrated the usual way (master flats and master bias) plus the offset. To correct for the offset we image as many well known binaries as possible during our observing run (usually 3 nights in a row) so we end up with between 20 and 30 images of "standard" binaries. Measuring the position angle of these known binaries and comparing the measurements with values from the WDS allows us to correct for the CCD camera offset.

We use two separate procedures for the measurement of both position angle and separation. Agreement between results from those procedures ensures correct handling of the data. The first method, which we detailed in the Double Star Observer[4], basically counts the pixels in the image directly. Pixelizing the image and counting pixels directly using a well known image processing program called Photoimpact[6] allows us to measure separation and position angle with

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ease. To check the results from the aforementioned method the students use the Software AIP for Windows[7], which has a routine for the calculation of position angle and separation.

Results

Our results are summarized in the tables below. The first 3 columns of the tables show recent measurements of separation (ρ) and position angle (Θ) in the WDS. The second set of 3 columns show predictions from the Sixth Catalog of Orbits. The last four columns show our measurements. N, the number of observations, is one in all cases

We have been measuring Sigma Corona Borealis often as part of our routine observations of binary stars at the N.U.R.O. telescope but all other binaries in the table constitute first time observing for us. We have chosen to measure these pairs even though they have lots of reported measurements, because we believe there is a lot of scientific merit in making sure the "model" works properly by observing and comparing the results plus the added bonus that you are also checking if your measurements yield reasonable results.

The values in Table I seem to indicate that our ρ values are in close agreement with other observations and also in close agreement with the ephemerides, except for STF 2486 AB where we get a spurious result. However, the results for position angle Θ differ from the prediction although, in general, tend to fall closer to the other reported values in the WDS.

We have used the Data Request form of the WDS[8] to gather information of some of the stars we observed and would like to recommend this efficient service from the WDS.

The information obtained is priceless and gives the reader a clear notion of the binary system one is studying.

(Continued on page 141)

Name: STF1985 R.A.: 15:55:54 Dec. −02:10									
Recent measurements from WDS			Sixth Catalog Ephemerides			UPR at Humacao Measusrements			
year	ρ arcsc	Θ degree	year	ρ arcsc	Θ degrees	year	ρ arcsc	Θ degrees	N
2004	6.0	354							
2005	5.8	349	2005	6.24	353.4	2005.660	5.8±1	348.6±.5	1

Name: STF2032 AB (Sigma Corona Borealis) R.A. 16:14:42 Dec. 33:52									
Recent measurements from WDS			Sixth Catalog Ephemerides			UPR at Humacao Measurements			
year	ρ arcsc	Θ degree	year	ρ arcsc	Θ degrees	year	ρ arcsc	Θ degrees	No
						2001.871	6.2±1	235±.5	1
						2002.345	7.1±1	233±.5	1
						2004.391	7.4±1	237±.5	1
2004	7	236				2004.767	7.5±1	236±.5	1
2005	7.2	238	2005	7.1	236.7	2005.682	7.2±1	237.8±.5	1

Name: STF2398 AB R.A. 18:42:48 Dec. +59.38									
Recent measurements from WDS			Sixth Catalog Ephemerides			UPR at Humacao Measusrements			
year	ρ arcsc	Θ degree	year	ρ arcsc	Θ degrees	year	ρ arcsc	Θ degrees	N
2004	12.4	175							
2005	12.2	176	2005	12.2	175.5	2005.682	12.3±1	177.6±.5	1

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Name: STF2486 AB R.A. 19:12:06 Dec. +49:51									
Recent measurements from WDS			Sixth Catalog Ephemerides			UPR at Humacao Measusrements			
year	ρ arcsc	Θ degree	year	ρ arcsc	Θ degrees	year	ρ arcsc	Θ degrees	N
2004	7.3	206							
2005	7.3	206	2005	7.4	205.8	2005.682	8.7±1	204.3±.5	1

Name: STFA 46 Aa-B R.A. 19:41:48 Dec. +50:32									
Recent measurements from WDS			Sixth Catalog Ephemerides			UPR at Humacao Measusrements			
year	ρ arcsc	Θ degree	year	ρ arcsc	Θ degrees	year	ρ arcsc	Θ degrees	N
2003	39.1	134							
2005	39.5	133	2005	39.6	133.2	2005.682	39.3±1	135.5±.5	1

Name: J 838 R.A. 20:21:00 Dec. +10:28									
Recent measurements from WDS			Sixth Catalog Ephemerides			UPR at Humacao Measusrements			
year	ρ arcsc	Θ degree	year	ρ arcsc	Θ degrees	year	ρ arcsc	Θ degrees	N
2003	6.0	116							
2005	6.3	118	2005	6.1	115.4	2005.660	6.3±1	117.6±.5	1

Name: STF 2725 R.A. 20:46:12 Dec. +15:54									
Recent measurements from WDS			Sixth Catalog Ephemerides			UPR at Humacao Measusrements			
year	ρ arcsc	Θ degree	year	ρ arcsc	Θ degrees	year	ρ arcsc	Θ degrees	N
2004	6.1	10							
2005	6.1	11	2005	6.1	11.1	2005.660	6.2±1	13±.5	1

Name: STF 2727 R.A. 20:46:42 Dec. +16:07									
Recent measurements from WDS			Sixth Catalog Ephemerides			UPR at Humacao Measusrements			
year	ρ arcsc	Θ degree	year	ρ arcsc	Θ degrees	year	ρ arcsc	Θ degrees	N
2004	9.1	266							
2005	9.1	266	2005	9.2	265.6	2005.660	9.0±1	266±.5	1

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Name: STF 2758 AB R.A. 21:06:54 Dec. +38:45									
Recent measurements from WDS			Sixth Catalog Ephemerides			UPR at Humacao Measusrements			
year	ρ arcsc	Θ degree	year	ρ arcsc	Θ degrees	year	ρ arcsc	Θ degrees	N
2004	31.1	151							
2005	30.9	151	2005	31.1	150.8	2005.660	31.6±1	151±.5	1

(Continued from page 139)

Acknowledgements

This project has been partially supported by the Puerto Rico Space Grant Consortium, the Puerto Rico Alliance for Minority Participation and The Univ. of PR at Humacao MARC Program. We want to also acknowledge support from Lowell Observatory.

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2. Washington Double Star Catalog http://ad.usno.navy.mil/wds

3. N.U.R.O. North American Undergraduate Research Observatory www.nuro.nau.edu (NURO's headquarters are located at Northern Arizona University)

4. Lowell Observatory www.lowell.edu

5. Muller, Rafael, *et al.*, March/April 2003, The Double Star Observer, **9**, 4-16

6. Photoimpact can be acquired at www.Ulead.com

7. *The Handbook of Astronomical Image Processing for Windows*, Richard Berry and James Burnell, Willman-Bell, Inc, Virginia, 2000 (www.willbell.com). The Handbook includes the CD AIP for Windows.

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Dr Rafael Muller is a faculty member of the Department of Physics and Electronics and coordinator of the Humacao Campus Observatory. Dr Juan Cersosimo is the Chairman of the Department, a radio astronomer who does some optical astronomy on the side. Iliana, Desiree, Valmin, Chaim and Diana are students at Humacao who want to follow careers in astronomy.

Improving the WDS Catalog: Identifications for same double stars

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Abstract: The Double Star Section of LIADA (*Liga Iberoamericana de Astronomía*) reports identifications for same neglected double stars studied by us in 2003. Accurate astrometry and proper motions are listed. Comments about a double star with possibly two WDS-identifications are included.

Introduction

Administrators of the Washington Double Star catalog (Mason, *et al.*, 2003, hereafter WDS) have changed its format in the last year. Now the WDS lists precise coordinates for the systems and subsystems and secondary proper motions.

Coordinates which are several times more precise than the WDS identifier are now provided for the majority of WDS systems. Coordinates are obtained from several astrometric catalogs such as Hipparcos (ESA 1997), Tycho-2 (Hog E. et al. 2000), Two Micron All Sky Survey (Cutri 2000, hereafter 2MASS), UCAC-2 (Zacharias et al., 2004) or through manual inspection. The ten-digit WDS identifier is retained and will continue to be the same for all components in hierarchical systems. However, the precise coordinate will be for the primary of the subsystem. Nowadays, more than 92% of the systems have arcsecond precise coordinates. But there are many neglected or unconfirmed pairs without this precise coordinate. Systems with precise coordinates will be automatically updated by WDS administrators using future astrometric catalogs. This is why double star identification is an important contribution by an amateur, which improves the data of "our" WDS catalog.

Double Star Identification

Recently, LIADA reported on measurements made by its double star group (Rica Romero, 2006). Table I

(Continued on page 144)

(1) DOUBLE	(2) AR_2000	(3) DEC_2000	(4) PM_AR	(5) PM_DEC	(6) Source PM	(7) Note
LDS9084 B			-106	- 60	[USNO-B1.0]	
HJ 331 A	03 08 32.11	+31 00 43.9	- 4.2	- 28.8	[TYCHO-2]	
HJ 331 B			+ 11.2	- 3.1	[UCAC-2]	
HJ 28 A	04 51 20.46	-06 13 46.8	+ 3.3	+ 0.8	[UCAC-2]	
HJ 28 B			- 4.2	- 10.7	[UCAC-2]	
HJ 3306 A	08 00 14.97	+01 26 41.8	- 1.3	+ 4.7	[TYCHO-2]	
HJ 3306 B			- 1.8	- 20.7	[UCAC-2]	
B 2164 C	08 03 48.06	-31 32 55.7	- 1.8	+ 3.3	[TYCHO-2]	1)
HJ 82 A	08 11 13.64	+10 47 37.3	- 7.4	- 9.1	[UCAC-2]	
HJ 82 B			- 3.2	- 4.2	[TYCHO-2]	
HJ 84 A	08 12 32.75	+04 29 49.2				
BVD 2 A	08 12 32.75	+04 29 49.2				

Table I: Double star identifications and proper motions (continued on next page).

Improving the WDS Catalog: Identifications for Same Double Stars

(1) DOUBLE	(2) RA_2000	(3) DEC_2000	(4) PM_AR	(5) PM_DEC	(6) Source PM	(7) Note
HJ 83 A	08 12 31.13	+04 26 58.0	- 40.4	- 33.9	[UCAC-2]	
HJ 83 B			- 19.6	- 0.9	[UCAC-2]	
HJ 88 A	08 19 35.67	-00 47 21.3	- 0.7	- 20.9	[TYCHO-2]	
HJ 88 B			- 0.2	- 8.3	[UCAC-2]	
HJ 91 A	08 22 40.38	+12 04 24.2	- 7.5	- 4.2	[TYCHO-2]	2)
HJ 91 B			- 7.2	- 5.7	[TYCHO-2]	
HJ 192 A	11 51 59.06	-02 59 15.2	+ 2.2	- 53.1	[TYCHO-2]	
HJ 192 B			- 14.4	- 9.9	[UCAC-2]	
LDS 624 A	18 09 02.60	–61 54 14.6				1)
HJ 1345 A	18 46 13.83	+31 16 28.1				
HJ 2841 A	18 47 55.56	+23 35 30.8	+ 1.1	- 2.1	[TYCHO-2]	
HJ 2841 B			- 5.5	- 2.5	[UCAC-2]	
HJ 880 A	19 16 15.74	+04 39 49.1				
HJ 2864 A	19 19 10.94	+04 00 55.8	+ 4.6	- 2.9	[TYCHO-2]	
HJ 2864 B			+ 1.7	+ 4.8	[UCAC-2]	
HJ 1389 A	19 21 55.32	+30 50 00.2	- 3.9	- 6.2	[UCAC-2]	
HJ 1389 B			- 0.6	+ 13.7	[TYCHO-2]	
HJ 1637 A	21 22 33.22	+31 57 39.0	+ 10.9	- 37.9	[TYCHO-2]	
HJ 1637 B			+ 14.9	- 40.1	[UCAC-2]	
HJ 1646 A	21 27 00.86	+43 13 50.9	- 22.5	- 16.2	[TYCHO-2]	
HJ 1646 B			- 3.5	- 5.5	[UCAC-2]	
HJ 283 A	21 27 56.41	-10 48 19.5	+ 2.1	- 9.1	[UCAC-2]	
HJ 3036 A	21 33 43.21	-14 43 27.1				
HJ 5518 A	21 35 47.71	-10 23 29.8	- 0.4	- 1.7	[TYCHO-2]	
HJ 5518 B			- 70.5	-134.9	[TYCHO-2]	
HJ 3049 A	21 41 47.52	+01 44 21.8	- 0.6	- 6.6	[TYCHO-2]	
HJ 3049 B			+ 84.0	+ 17.9	[TYCHO-2]	

Table I: Double star identifications and proper motions (continued from previous page).

Notes:

1) bad WDS coordinate

2) HJ 91 is located at 08h 22m 40s387 and +12d 04' 24"19, six arcminutes West of the WDS coordinate.

ID. WDS	Designation	Epoch	N	Theta [°]	Rho [‘’]	Mag.
18462+3116	SLE 121	1982	1	350	13.7	11.6, 11.7
18464+3116	HJ 1345	1828	1	171	8.	13, 13

Table II: Visual double star with multiple identifications in the WDS.

Improving the WDS Catalog: Identifications for Same Double Stars

(Continued from page 142)

shows some of those double stars identified with their precise coordinates and gives their proper motions. Discoverer codes for the double stars are listed in column 1; precise coordinates from the 2MASS catalog are listed in columns 2 and 3. Columns 4 and 5 give individual proper motion expressed in mas/yr. The sources for proper motion are listed in column 6 and they came from Tycho-2 (Hog E. et al. 2000), UCAC-2 (Zacharias et al., 2004) and USNO-B1.0 (Monet D.G., Levine S.E., Casian B., et al., 2003) catalogs. Column 7 gives some notes.

Double Star With Two Identifications

We argue that HJ 1345 is the same double star as SLE 121. In the WDS both entries are separated by 2.6 arcminutes (see Figure 1 and Table II). In addition to a pair of stars located near the WDS position for SLE 121, there is no other pair similar to HJ 1345. Position angles for both entries are nearly equal if a quadrant correction is performed for HJ 1345. Magnitude differences in each entry are equal within a margin of error. SLE 121 is wider than HJ 1345. According to LIADA Double Star Section's results, the angular separation of unconfirmed double stars discovered by John Herschel have a large error and usually are closer by several arcseconds than the modern values.

Acknowledgements

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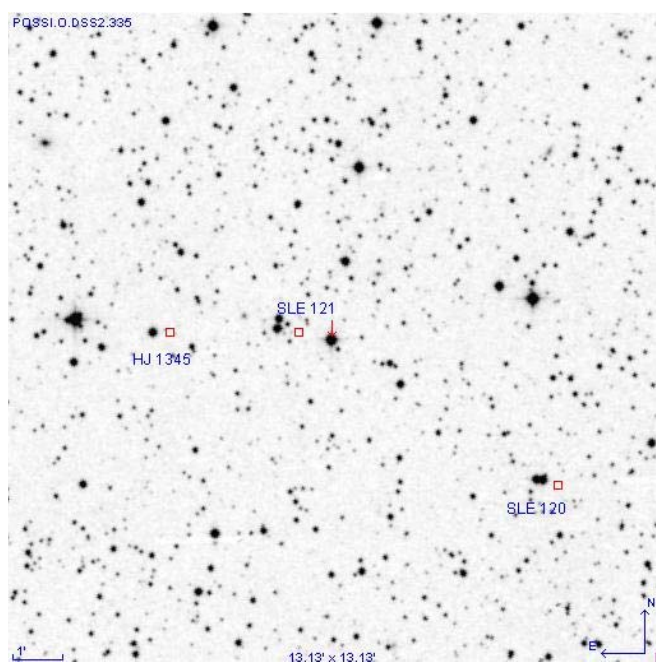

Figure 1. Part of the photographic plate from Digitized Sky Survey (POSS-I blue) taken on July 6, 1951. The field of view is of 13.1' x 13.1'. North is up and East is left. In this region are showed three WDS double stars (HJ 1345, SLE 121 and SLE 120) marked with empty red square.

Neglected Double Observations 2006 No. 1: With Notes on Use of a Robotic Telescope

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Abstract: I report the observational results for 60 "neglected doubles" found between 5hr and 10.0 hr RA and +20º and +40º DEC made with the AREO2 robotic telescope located at the RAS Observatory, Mayhill, NM, USA (http://www.remote-astronomical-society.org). In addition to theta and rho values (and standard deviations), I report the UCAC2.0 and USNO 2.0 catalogue numbers of pairs, many of which lack good positional information and proper motion values. A short discussion of the instrumentation details the advantages and some limitations of robotic observations.

Introduction and Instrumentation

I was drawn to double star research after reading articles in Argyle (2004), and in particular the paper by fellow Kansan Doug West (2004) on using CCD imaging for measuring visual doubles. A bit of investigation suggested that a fruitful avenue of research would be relatively faint visual doubles that are neglected. After some frustrating attempts to use my existing telescope/CCD combination on a non-Go-To mount to acquire these faint doubles, I began to look for alternative instrumentation. I found the solution for quickly acquiring and imaging faint doubles at the Robotic Astronomy Society (RAS) Observatory, a facility that makes various robotic instruments available by subscription. I considered their fee to be nominal given the advantages. The RAS Observatory is located near Mayhill, New Mexico, close to the National Solar Observatory.

In 2006 I embarked on a program of measuring visual doubles using one of the RAS Takahashi Mewlon 300 Dall-Kirkham cassegrainian reflectors. The instrument, with a focal reducer, works at f9.1, with an approximate focal length of 2730mm. It is equipped with a non-antiblooming ST8E CCD camera (9 micron pixels) and the combination has an approximate resolution of 0.6 arcseconds/pixel with a field of view of 11.5x17.3 arcminutes. The optical tube assembly is mounted on a Bisque Paramount 1100 German equatorial mount with quite accurate pointing capability.

There are several scientific advantages to using a robotic instrument, as at the RAS Observatory. First, the work goes very quickly. Doubles can be imaged at the rate of about 10-12 pairs per hour with 4-5 exposures per pair with careful planning. Second, reductions can be performed at leisure after the imaging session with suitable software (in my case MPO Canopus). Third, there is a permanent record of the observations in the form of a FITS image. Fourth, additional unplanned measures can always be performed. For example, I present additional "non-neglected" doubles data retrieved from images that have multiple pairs per image. Finally, weather is usually good and seeing is usually exceptional at the observatory.

There is one major limitation. One is restricted to measuring relatively wide visual pairs that lay within the capabilities of the instrument. With a subscription instrument, it is not reasonable to ask the owner of the facility to switch configurations (e.g. adding a Barlow) unless one is willing to pay a great deal more for the service. Limitations of what can be imaged will naturally vary depending on sky conditions, but pairs as close of 5 arcseconds may be successfully measured on most nights and I have attempted to measure pairs as close as 3 arcseconds, although the results are marginal, as discussed below.

Methods

This study concentrates on neglected doubles that have not been measured in 50 or more years. To insure that the pairs measured are truly neglected, I requested observing lists from Brian Mason at the USNO (Mason, 2006). I visualized each pair on the list using Carte de Ciel 2.7 (Chevalley, 2001), overlain by DSS sky survey images. Once the pair (or the likely pair) is identified on the DSS image, I gather coordinates by overlaying the USNO2.0 catalogue (Monet et al., 1998) and harvested the coordinates of the primary. Coordinates were entered into VizieR (Ochsenbein et al., 2000) and plotted. I then obtained from the Aladin server an image of the field that I downloaded and printed (usually a DSS1 image). The UCAC2.0 catalogue numbers magnitudes and proper motions were harvested from the UCAC2.0 database (Zacharias et al., 2004), when available, once the pair was confirmed by comparing coordinates, PA and SEP against the WDS catalogue. Occasionally there was no reasonable candidate pair to be found, and this observation is noted. Additional data were harvested from Simbad as appropriate. I found this procedure necessary to insure that a reasonable conclusion had been made that a particular pair was actually correlated with the WDS catalogue when positions differed, which they usually did for these particular doubles.

Imaging was straight-forward. Coordinates were entered into the instrument's Web interface and the instrument slewed to the target. Based on magnitude and separation values, an exposure was made and checked against the Aladin image to insure that the pair was in the middle of the field (Dall-Kirkham optics require good centering). If not near the center of the field, the telescope was slewed to center. (This was rarely needed as pointing is quite accurate.) Exposures were carried out with a clear filter and the initial image was checked by downloading a JPEG of the FITS image. I made the decision not to attempt photometry which permitted me to image many more pairs per session. I believe this is reasonable until such time that proper motion studies establish the nature of the pair as binary, CMP or optical. In general, pairs of 11-13 magnitude were exposed for 7-15 seconds. If the exposure looked acceptable, then a minimum of three additional images were made. If not, then exposure times were adjusted and rechecked. The images were retrieved from an ftp site provided by the RAS Observatory. MPO Canopus was used to reduce the images (Warner, 2006). It produces an astrometric solution to the image based on the UCAC 2.0 catalogue (Zacharias et al., 2004). The pair was measured using a convenient double star harvesting subroutine built into Canopus.

Results

Table 1 presents results for 60 neglected doubles not measured in the past 50+ years bounded by 5.0 hr to 10.0 hr RA and +20° to +40 ° DEC. Table 2 presents the UCAC2.0 or USNO2.0 catalogue numbers when available as well as the history of previous observations (as summarized in the WDS catalogue) and comparisons of this history with the mean measurements obtained in this study. Table 3 presents measurements and catalogue numbers for a number of pairs that are not neglected but which appeared in the images taken.

Discussion

A scatter plot of separation versus standard deviation of separation (Table 1) shows a significant (greater than 0) correlation between the separation distances and the standard deviations obtained (r^2 = 0.38; p<0.01), but not between position angles and position angle standard deviations (r^2 = 0.03, p = 0.84). The greatest variations in standard deviation among pairs of similar separation are encountered among close pairs, probably as a result of seeing causing large scatter in the resulting image and thus variations in centroid determination. However, this is a casual observation based on image quality and should be confirmed with careful records of FWHM (full width at half maximum) values that can be obtained at the RAS Observatory facility.

Comparisons with the historical record (Table 2) demonstrates that the measurements obtained are reasonable and thus in most cases refer to the neglected double in question. Doubts can be addressed through the catalogue numbers provided. Anomalies are annotated in Notes.

Comparison of recently measured doubles (Table 3) with published records in the Washington Double Star Catalogue (Mason et al., 2001 et seq.) demonstrate that this rapid and easy method of obtaining measures is sufficiently accurate to enable a large number of neglected doubles to be located and measured with a minimum of instrument time so long as the pairs are picked with due regard to the capabilities of the instrument and seeing conditions. The RAS Observatory supports active research programs, such as mine,

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WDS ID	Discovr.	Mags	PA	PAsd	SEP	SEPsd	Epoch	N	Notes
05066+2321	POU 543	13.08, 12.46	247.9	0.69	14.87	0.07	2006.16	5	1,2
05135+2451	POU 587	12.65, 11.67	175.7	0.61	9.24	0.12	2006.16	4	1,3
?05157+3738	SEI 125 AB ?	13.0,13**	317.8	0.43	23.40	0.23	2006.16	7	1
?05157+3738	SEI 125 BC ?	13**, unk	344.	2.0	4.32	0.53	2006.16	6	1,4
05175+2446	POU 637	11.8, 11.5**	202.9	na	1.73	na	2006.16	1	1
05210+3728	SEI 203 AB	11.25, 13.47	251.9	0.63	21.49	0.03	2006.16	4	1
05307+3725	SEI 311 AB	10.58, 11.58	357.3	0.11	22.67	0.07	2006.16	4	1,5
05325+2818	HJ 704	10.56, 11.64	93.6	0.23	13.42	0.09	2006.16	7	1
05345+3727	SEI 330-1895	10.56, 13.29	141.9	0.67	7.34	0.64	2006.16	5	1,6
05345+3727	SEI 330-1930	10.32, 12.17	196.4	0.56	8.31	0.07	2006.16	4	1,6
05403+3757	SEI 367	10.46, 12.30	348.3	0.37	11.93	0.04	2006.16	4	1,7
05421+3245	HJ 3695	10.91, 12.28	326.2	0.93	15.29	0.11	2006.16	4	1
05423+3247	HJ 370	11.19, 11.21	259.1	0.21	12.74	0.13	2006.16	5	1
05485+2451	POU 782	12.37, 13.18*	307.	1.1	11.14	0.20	2006.16	5	1
05498+3127	SEI 392	11.5, 12.29*	309.4	0.56	8.69	0.07	2006.16	4	1
05524+2428	POU 799	12.48, 13.O3	68.0	0.86	13.08	0.23	2006.16	5	1
06009+2424	POU 842	12.02, 12.8**	130.	1.3	3.99	0.22	2006.19	4	1
06022+2440	POU 849 AB	11.88, 10.10	358.4	0.29	21.15	0.15	2006.16	4	1
06022+2440	POU 850 AC	11.88, 13.22	91.	1.3	7.04	0.33	2006.16	4	1
06090+2416	POU1030	8.38, 13.3**	132.5	0.75	10.78	0.17	2006.19	4	1
06092+2418	POU1037	11.7, 14.35	234.	1.00	13.57	0.15	2006.19	4	1
06280+2415	HJ 390	10.82, 11.36	227.6	0.18	14.12	0.05	2006.18	4	1,8
06353+2252	POU1528	11.96, 12.66	294.3	0.53	8.97	0.11	2006.18	5	1
06537+2450	POU2106	12.43, 13.38	194	0.73	13.12	0.10	2006.18	4	1
06549+3503	ALI 98	11.71, 11.56	286.7	0.21	13.30	0.08	2006.18	4	1
06598+2303	POU2236	10.87, 13.24	309.0	0.46	11.05	0.13	2006.18	4	1
07046+2117	J 1989 AB	9.76, 10.67	255.5	0.13	37.33	0.15	2006.18	5	1
07186+2255	POU2669-1909	13.15*, 13.69	73.6	0.57	11.01	0.09	2006.18	6	1,9
07186+2255	POU 2669-1954	13.89, 13.07	81.9	0.71	16.22	0.07	2006.18	6	1,9
07202+2336	POU2695	9.3, 13.8**	180.7	0.37	14.54	0.201	2006.18	5	1
07204+2344	POU2698	10.68, 11.40	180.5	0.48	9.20	0.08	2006.18	6	1
07258+2413	POU2763	12.89, 12.8**	188.9	0.33	12.52	0.048	2006.18	4	1
07310+2435	POU2820	13.86, 15.05	316.1	na	10.21	na	2006.18	1	1,10
07331+2255	POU2828	10.42, 13.36	18.2	0.29	20.02	0.10	2006.18	3	1
07378+2324	POU2848	11.72, 13.15	328.2	0.72	16.19	0.065	2006.19	6	1
07395+2449	POU2857	10.48, 12.72	58.8	0.40	12.73	0.14	2006.18	5	1
07407+2350	POU2863	12.89, 13.45*	168.4	1.55	5.84	0.61	2006.18	4	1,11
08026+2028	DOO 47	11.9, 11.72	120.4	0.15	23.34	0.048	2006.26	4	1
08034+2305	POU2921	10.30, 11.4**	219.6	2.59	3.91	0.388	2006.19	5	1,11
?08036+2303	POU2923-1898?	13.72, 14.51	272.1	0.55	13.5	0.167	2006.26	4	1,12
?08036+2303	POU2923-1950?	13.47, 13.72	306.7	0.22	21.83	0.083	2006.26	4	1,12

Table 1. Summary data for neglected doubles reported. WDS ID and Discovr. Are Washington Doubles Star Catalogue identifiers and discoverer codes. Magnitudes (Mags) are UCAC 2.0 approximate magnitudes except for some WDS (*) and some instrument (**) approximate magnitudes. PAsd and SEPsd refer to standard deviations of the respective angle (PA) and separation (SEP) based on N images measured. *continued on next page*

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WDS ID	Discovr.	Mags	PA	PAsd	SEP	SEPsd	Epoch	N	Notes
08042+3136	HJ 438	9.79, 11.85	128.2	0.07	24.64	0.031	2006.26	5	1
08067+2245	POU2930	10.87, 12.15	180.2	0.91	8.31	0.186	2006.19	4	1
08100+2329	HJ 440	10.61, 11.07	122	0.1	15.58	0.023	2006.19	5	1
08136+2543	FOX 13 BC	10.74, 12.23	67.2	0.1	24.46	0.068	2006.19	5	1
08136+2543	HJ 441 AC	10.74, 12.23	67.1	0.11	24.45	0.064	2006.26	5	1
08139+2747	HO 38 CD	12.24, 13.3	214.3	0.52	11.29	0.123	2006.26	5	1
08291+3245	SEI 501	12.44, 13.64	215.5	0.32	6.73	0.058	2006.26	5	1,13
?09015+3604	ALI 354? (1)	13.84, 14.83	268.9	0.6	16.1	0.151	2006.21	5	1,14
?09015+3604	ALI 354? (2)	12.86, 13.09	231.20	0.14	21.85	0.039	2006.21	5	1,14
09044+3914	ALI1085	12.41, 12.74	220.2	0.13	16.25	0.139	2006.23	4	1
09052+2314	POU3024	12.1, 14.65	36.2	0.39	16.93	0.211	2006.26	6	1
09058+2358	POU3027	11.14, 12.95	310.7	0.3	14.43	0.016	2006.21	4	1
09061+3537	ALI 355	12.01, 12.28	255.7	0.12	32.06	0.038	2006.21	5	1
09104+2916	BOH 1	10.95, 11.33	147.8	0.16	10.95	0.03	2006.26	4	1,15
09287+2307	POU3045	12.41, 13.97	214.9	0.54	14.09	0.116	2006.23	4	1
09319+3430	ES 299 AB	9.52, 12.02	288.6	0.03	63.55	0.044	2006.26	4	1
09431+3824	ALI 846	11.76, 12.30	94.9	0.26	19.76	0.074	2006.23	4	1
09488+2424	POU3059	11.85, 13.28*	66.6	0.66	7.85	0.065	2006.21	4	1
09537+2239	POU3061	12.4**,13.4**	264.9	0.33	20.58	0.05	2006.23	4	1

Table 1. *continued from previous page.* Summary data for neglected doubles reported. WDS ID and Discovr. Are Washington Doubles Star Catalogue identifiers and discoverer codes. Magnitudes (Mags) are UCAC 2.0 approximate magnitudes except for some WDS (*) and some instrument (**) approximate magnitudes. PAsd and SEPsd refer to standard deviations of the respective angle (PA) and separation (SEP) based on N images measured.

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with inexpensive subscription rates and high quality equipment. I would especially recommend the facility to those who are disabled, live in large cities, or who, like myself, lack the instrumentation to carry out such programs but wish to engage in an active research program. RAS Observatory is a research affiliate of Global Rent-A-Scope (http://www.global-rent-a-scope.com)

Acknowledgements

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Name	UCAC2/p	UCAC2/s	1st obs	Last obs	N Obs	PA1	PA last	PA obs.	SEP1	SEP last	SEP obs	Notes
POU 543	39975736	39975739	1897	1955	2	249	249	247.9	15.8	16.4	14.87	1,2
POU 587	40475510	40475512	1897	1951	3	178	175	175.7	8.4	10	9.24	1,3
SEI 125 AB	44971144	1275-04592925*	1895	1895	2	317	309	317.8	23.5	19.3	23.40	1
SEI 125 BC?	1275-04592925	uncat						344.0			4.32	1,4
POU 637	40476260	uncat	1898	1951	2	219	214	202.9	13.6	11.4	1.73	1
SEI 203 AB	44804115	44804110	1895	1929	2	251	251	251.9	21.9	21.5	21.49	1
SEI 311 AB	44806409	44806407	1895	1928	2	355	357	357.3	23.4	40	22.67	1,5
HJ 704	41675085	41675089	1897	1899	2	92	94	93.6	13.8	13.9	13.42	1
SEI 330-1895	44807090	44807093	1895	1895	1	135	135	141.9	8.7	8.7	7.34	1,6
SEI 330-1930	44807099	44807098	1930	1930	1	195	195	196.4	9.2	9.2	8.31	1,6
SEI 367	44976912	44976911	1895	1929	2	350	349	348.3	12.2	12.2	11.93	1,7
HJ 369	43243500	43243496	1895	1933	3	327	327	326.2	15.1	15.1	15.29	1
HJ 370	43243521	43243516	1894	1998	7	261	259	259.1	11.2	12.6	12.74	1
POU 782	40481728	1125-02839021	1906	1951	2	297	203	307.0	9.4	17.4	11.14	1
SEI 392	42727626	1200-03870477	1899	1933	3	307	308	309.4	8.6	9.7	8.69	1
POU 799	40317010	40317004	1906	1951	2	68	67	68.0	13.5	13.7	13.08	1
POU 842	40319359	uncat	1902	1954	2	141	213	130.4	4.8	7	3.99	1
POU 849 AB	40485807	40485805	1994	1954	4	353	0	358.4	20.9	21.7	21.15	1
POU 850 AC	40485807	40485808	1902	1954	4	96	89	91.2	7.0	8.6	7.04	1
POU1030	40322106	uncat	1926	1926	1	131	131	132.5	10.6	10.6	10.78	1
POU1037	40322200	40322195	1926	1998	2	234	234	234.4	13.0	13.6	13.57	1
HJ 390	40328213	40328211	1895	1925	5	227	47	227.6	12.7	14	14.12	1,8
POU1528	39824581	39824578	1894	1906	2	294	296	294.3	11.2	10.7	8.97	1
POU2106	40500663	40500659	1905	1907	2	196	191	194.0	11.3	10.5	13.12	1
ALI 98	44123226	44123222	1928	1948	2	286	286	286.7	13	13.5	13.30	1
POU2236	40004315	40004311	1892	1908	3	308	307	309.0	11.5	11.3	11.05	1
J 1989 AB	39300018	39300004	1893	1941	4	258	260	255.5	29.2	20	37.33	1
POU2669-1909	1125-05020665*	39836646	1909	1909	1	81	81	73.6	11.3	11.3	11.01	1,9

Table 2: Catalog numbers for neglected doubles reported in Table 1, with comparison of previous observations. UCAC2/p and /s are USCA2 catalog numbers of primary and secondary. Hyphenated numbers are USNO V2.0 numbers, "uncat" refers to stars not found in either catalog. Dates, number of observations and reported values for PA and SEP for previous observations are taken from the WDS catalog. PA obs and SEP obs refer to mean PA and SEP as reported in Table 1 and are included for comparison. *continued on next page.*

Name	UCAC2/p	UCAC2/s	1st obs	Last obs	N Obs	PA1	PA last	PA obs.	SEP1	SEP last	SEP obs	Notes
POU2669-1954	39836618	39836621	1954	1954	1	83	83	81.9	16.2	16.2	16.22	1,9
POU2695	40185381	uncat	1909	1954	2	175	173	180.7	15.3	16.3	14.54	1
POU2698	40175393	40175392	1892	1954	5	199	192	180.5	9.9	11.6	9.20	1
POU2763	40178311	1125-05117058	1905	1954	3	193	198	188.9	14.2	18.7	12.52	1
POU2820	40507554	40507552	1902	1954	2	315	318	316.1	9.2	9.3	10.21	1,10
POU2828	39838950	39838951	1892	1954	2	16	18	18.2	19.8	20.4	20.02	1
POU2848	40011135	40011134	1892	1954	3	329	326	328.2	16.7	16.6	16.19	1
POU2857	40508663	40508668	1893	1954	3	57	28	58.8	12.6	13.9	12.73	1
POU2863	40178311	uncat	1899	1954	2	161	146	168.4	8	10.2	5.84	1,11
DOO 47	38967880	38967883	1911	1911	1	1911	1911	120.4	25.1	25.1	23.34	1
POU2921	40013932	uncat	1893	1950	3	224	217	219.6	6	8.1	3.91	1,11
POU2923_1-2	40013949	40013947	1898	1950?	2?	265	268	272.1	12.9	20.2	13.5	1,12
POU2923_3-1?	40013950	40013949		1950?	1?			306.7			21.83	1,12
HJ 438	42922138	42922141	1820	1820	1	135	135	128.2	20.0	20.0	24.64	1
POU2930	39842468	39842467	1893	1898	3	189	184	180.2	10.9	10.7	8.31	1
HJ 440	40014549	40014552	1892	1911	4	110	112	122.0	14.9	11.2	15.58	1
FOX 13 BC	40850819	40850822	1915	1927	2	66	66	67.2	21.9	21.2	24.46	1
HJ 441 AC	40850818	40850822	1914	1914	1	68	68	67.1	21.9	21.9	24.45	1
HO 38 CD	41535968	uncat	1904	1904	1	219	219	214.3	7.4	7.4	11.29	1
SEI 501	43268405	43268402	1894	1894	1	43/223	43/223	215.5	8.1	8.1	6.73	1,13
ALI 354-1?	44483502	44483500	1932	1932	1	55/235	55/235	268.9	9.1	9.1	16.1	1,14
ALI 354-2?	44483492	44483495	1932	1932	1	55/235	55/235	231.2	9.1	9.1	21.85	1,14
ALI1085	45503726	45503725	1928	1928	1	219	219	220.2	13.0	13.0	16.25	1
POU3024	40018195	40018196	1899	1899	1	65	65	36.2	9.2	9.2	16.93	1
POU3027	40184791	40184790	1899	1899	1	227	227	310.7	16.4	16.4	14.43	1

Table 2: *(continued from previous page)* Catalog numbers for neglected doubles reported in Table 1, with comparison of previous observations. UCAC2/p and /s are USCA2 catalog numbers of primary and secondary. Hyphenated numbers are USNO V2.0 numbers, "uncat" refers to stars not found in either catalog. Dates, number of observations and reported values for PA and SEP for previous observations are taken from the WDS catalog. PA obs and SEP obs refer to mean PA and SEP as reported in Table 1 and are included for comparison. *continued on next page.*

Name	UCAC2/p	UCAC2/s	1st obs	Last obs	N Obs	PA1	PA last	PA obs.	SEP1	SEP last	SEP obs	Notes
ALI 355	44306650	44306651	1933	1933	1	175	175	255.7	14.2	14.2	32.06	1
BOH 1	42058936	42058937	1915	1915	1	309	309	147.8	5.3	5.3	10.95	1
POU3045	40019236	40019235	1905	1905	1	243	243	214.9	12.1	12.1	14.09	1,15
ES 299 AB	43960415	43960410	1906	1906	1	0	0	288.6	55.9	55.9	63.55	1
ALI 846	45169780	45169785	1929	1929	1	95	95	94.9	13.6	13.6	19.76	1
POU3059	40351319	uncat	1907	1907	1	55	55	66.6	8.1	8.1	7.85	1
POU3061	1125-06003148	1125-06003084	1909	1909	1	272	272	264.9	7.2	7.2	20.58	1

Table 2: *(continued from previous page)* Catalog numbers for neglected doubles reported in Table 1, with comparison of previous observations. UCAC2/p and /s are USCA2 catalog numbers of primary and secondary. Hyphenated numbers are USNO V2.0 numbers, "uncat" refers to stars not found in either catalog. Dates, number of observations and reported values for PA and SEP for previous observations are taken from the WDS catalog. PA obs and SEP obs refer to mean PA and SEP as reported in Table 1 and are included for comparison.

WDS ID	Discovr.	Mags	PA	PAsd	SEP	SEPsd	Epoch	No Obs	UCAC2/p	UCAC2/s
05206+3727	SEI 200	12.17, 13.17	209.70	0.56	10.06	0.16	2006.159	4	44804013	44804012
06091+2416	POU1032	10.73, 12.30	173.1	0.14	19.42	0.08	2006.192	4	40322156	40322160
06093+2417	POU1046	11.86, 12.8**	196.4	0.39	11.10	0.18	2006.192	4	40322246	uncat
06093+2418	POU1045	11.96, 11.86	137.6	0.28	10.67	0.07	2006.192	4	40322250	40322256
06094+2420	BRT 140	11.21, 11.9**	151.5	2.23	3.37	0.22	2006.192	4	40322330	uncat
07308+2437	POU2817	12.23, 14.1**	304.5	0.65	12.77	0.21	2006.176	4	40507533	1125-05177944
07309+2441	HJ 424AB	11.08,11.76	113.60	0.11	16.59	0.08	2006.176	4	40507553	40507558

Table 3. Summary data for recently measured doubles re-measured in this paper. PAsd and SEPsd refer to standard deviations of the respective measure. N is the number of CCD images measured, UCAC2/p and -/s are the J2000 positions of the primary and secondary reported in the UCAC2.0 catalogue as returned in VizieR. The USNO catalogue number (hyphenated)r is used for the secondary of POU 2817. Some secondary do not appear in either catalogue as returned by VizieR (uncat.).

Neglected Double Observations 2006 No. 1: With Notes on Use of a Robotic Telescope

Notes

1. 300mm Cassegrainian reflector, F9.1, CCD camera image analyzed using the astrometric/ photometric program MPO Canopus.
2. POU 543 is CCDM J05065+2331AB.
3. POU 587 is probably switched and is reported herein with A to north.
4. Is SEI 125BC a double? Note the high standard deviation for separation. The images were partly merged and the measurements are probably unreliable.
5. SEI 311AB. There is a wide discrepancy in the 1928 separation measure compared to 1895 and that reported here. I suspect that the 1928 measure was in error. It might refer to Tycho 2415-00915-1 and USNO 1200-03407262 located north and west of the pair measured in 1895, with the "primary" and "secondary" switched.
6. SEI 330. First and last measurements reported in the WDS refer to two different pairs, as noted by the date attached. Both were measured by Scheiner in 1895. SEI 330-1 of PA 242.2º taken by Scheiner in 1895.2 and re-measured in 1929 and 1930 (present PA = 196.4 º) will retain the designation SEI 330. SEI "330"-2 also taken by Scheiner in 1895 (first PA = 134.9º; PA reported herein = 141.9 º) will become SEI 332 in an update of the WDS (G. Wycoff, USNO, Pers. Comm., 28 March 2006).
7. SEI 367. The 1895 measure is the inverse of the 1929 and the present measure, based on magnitudes of primary and secondary.
8. HJ 390. The apparent anomalies in the 1895 and 1925 measures are caused by switching primary and secondary.
9. POU 2669-09, -54. Although the measures of 1909 and 1954 look reasonable, I suspect that they refer to two different pairs, as reflected in the UCAC2.0 numbers in Table 2. This should be checked.
10. POU 2820. Only a single image was acceptable, reported for position.
11. POU 2863 and POU2921 represent attempts to explore the limits of resolution under average seeing conditions at the RAS Observatory. Note very high standard deviations caused by partial merging of the images. Measurements must be considered crude and these pairs should be re-measured for more reliable PA and SEP.
12. POU 2923 is a curious "pair." Although 1898 measurement and 1950 measurements, while agrees in angle are widely divergent in separation. I believe that examination of the UCAC2.0 catalogue will show that the measurements refer to different pairs that form a triplet (of unknown status) in the field
13. The 1894 measure is inverted given measured magnitudes.
14. ALI 354 (1, 2). There are two candidates for this entry. "ALI 354(1)" is closest to the WDS reported position, but "ALI 354(2)" is a better match, with primary and secondary switched (PA=50.9º compared to the last reported of 52 º if the pair is switched).
15. BOH 1. Primary and secondary switched based on magnitudes.

(Continued from page 148)

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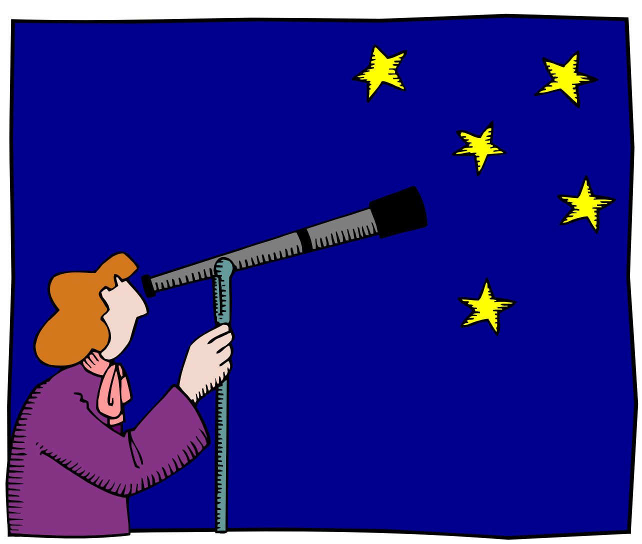

33 Double Star Measures Using a CCD Camera in Corona Borealis

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Abstract: I report on my first experience using a CCD camera to measure double stars in light polluted skies near New York City.

Introduction

Following are some recent double star measures made with a CCD camera from my home in Larchmont, NY. Larchmont is situated just 17 miles east from New York City, along the Long Island Sound. While the waters of the Sound tend to keep the skies fairly steady, the proximity to one of the world's largest (and brightest) metropolitan areas means considerable light pollution. My initial attempts at measuring doubles were done using a filar micrometer from Retel, Ltd., in the U.K., but due to the light pollution, the dimmer magnitudes were difficult to see and measure on most nights. After reading several accounts of amateur astronomers using software and CCD cameras to measure doubles, including Bob Argyle's book, "Observing and Measuring Double Stars", I decided to change my setup to utilize CCD imaging techniques and to learn how to use the software to perform astrometric measurements.

Setup and Image Capture

My method is fairly straightforward. I use a Celestron 9.25" (23.5cm) Schmidt-Cassegrain telescope mounted on a Takahashi NJP Temma 2 Goto German equatorial mount. My camera is a Santa Barbara Instruments Group ST2000XM, with 7.4 x 7.4 micron pixels. I image at F/10, yielding a plate scale of .68 arcseconds per pixel. I image on 4 or 5 consecutive clear nights and average the results. Exposures are 20-30 seconds, to obtain a good signal to noise ratio.

The camera is controlled for imaging by CCDSoft v.5, by Software Bisque. Image reduction uses CCDSoft, and astrometric solutions utilize Software Bisque's theSky 6 Pro. The computers I use are an IBM ThinkPad T20 750Mhz PIII, running Microsoft XP pro operating system, outside with the telescope; and a Sony VAIO laptop 3.2Ghz Pentium IV laptop inside the house. They connect using the WIN XP's remote assistance software over a wireless LAN connection.

Targets are chosen using Paul Rodman's Astroplanner software, which has all of the main catalogues for double star work. I primarily use the WDS and the WDS Neglected lists, which I organize by constellation for convenience. I arrange lists of targets that are appropriate to my telescope and camera, by magnitude and separation as defined by my previous experience, so that on any good night, I can obtain images.

Once a target list is chosen, I utilize another Bisque software product, Orchestrate, which is a scripting software that allows me to get the most efficient use of the equipment. Orchestrate sets up commands that control the telescope, pointing it at successive targets; pauses on the target to allow the mount to settle and begin tracking; activates the camera to capture an image of the target for a set exposure; and then proceeds to the next target. Once started, this automated sequence can run for long periods without any intervention; but in practice, I usually attend the computer on each imaging run, though I do so from inside my house about 25 yards from the telescope. I periodically check on the telescope to make sure that no wires have become tangled or equipment loosened, but generally I don't have to intervene during a run. I can capture up to 100 images per evening utilizing Orchestrate – my previous manual imaging run yielded about 25 good images! So Orchestrate has

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provided a very efficient use of my limited (mostly due to weather) observing time.

I also utilize Bisque's Tpoint software, which refines the pointing accuracy of my mount, placing the targets on the center of the imaging chip after an initial setup runoff as few as ten stars.

Image Reduction

Once the images are downloaded and the telescope is put away, the images are reduced using CCDSoft and theSky6 Pro. TheSky's image link function links my CCD images to the Sky's software, which automatically provides a plate solution for the image. Measurements of separation and position angle are obtained; clean separations provide the most reliable results, so the targets are scaled to the capabilities of the telescope/imager combinations, based on my previous experience. Exposures of 30 seconds provide images of stars to mag. 15, depending on sky conditions, thus allowing many more doubles to be targeted than with my visual setup.

Results of the measures are entered back into Astroplanner, manually, and the measures for each target are combined and averaged.

REDUC

A new development reflected in 3 results in the table of my measures below is a software program developed by Florent Losse, a French double star observer. REDUC allows me to analyze tighter doubles, using a "webcam" technique of image capture. I take 20, 2 second exposures of the target, using a 2x AP Barlow, resulting in a plate scale of .38"/pixel. REDUC reduces and averages the results in PA and Sep. Although all measurements were taken on the same night, N = 20 was entered into the table of measurements to reflect the number of images used by REDUC to determine the position angle and separation. The three pairs thus measured are labeled REDUC in the notes field of Table 1.

Measurements

With the technique just described, position angle and separation measurements were made for 33 double stars in the constellation Corona Borealis. These measurement are given in Table 1.

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Observing and Measuring Double Stars, Robert Argyle, Springer-Verlag, 2004.

Florent Losse,, REDUC software; http://www.astrosurf.com/hfosaf/

Brian Mason, et al., USNO WDS 2001 and Neglected Doubles lists

Paul Rodman, Astroplanner program; http://www.ilanga.com

Software Bisque, suite of astronomy programs: CCDSoft v.5, theSky 6 Professional version, Tpoint, Orchestrate; http://www.bisque.com

Name	RA	Dec	Mags	PA	SEP	N	Date	Notes
KZA81	15h 21.1m	+31° 02'	10.5, 11.0	171.2	8.3	6	2006.384	
KZA82	15h 21.2m	+30° 49'	10.5, 11.5	93.1	13.4	4	2006.384	
KZA83	15h 21.6m	+30° 59'	10.5, 11.0	44.2	12.2	6	2006.384	
KZA87	15h 24.8m	+29° 34'	12.0, 12.5	358.9	11.6	4	2006.384	
KZA90	15h 27.4m	+31° 02'	12.5, 13.0	297.3	19.6	3	2006.384	
KZA94	15h 31.1m	+39° 25'	9.5, 11.5	256.2	15.8	4	2006.384	
HJ2786	15h 33.3m	+38° 27'	8.3, 11.7	169.4	26.6	4	2006.384	
BRT252	15h 37.8m	+30° 26'	12.1, 12.3	216.9	4.7	20	2006.386	REDUC
ALI862	15h 38.6m	+38° 26'	12.8, 13.2	0	0	3	2006.386	not there
HJ572	15h 44.0m	+35° 26'	9.2, 11.7	275.3	21.6	4	2006.384	

Table 1: Double Star Measures. *Continued on next page*

33 Double Star Measures Using a CCD Camera in Corona Borealis

Name	RA	Dec	Mags	PA	SEP	N	Date	Notes
HJ2791	15h 44.8m	+38° 34'	10.7, 14.2	129	11.4	4	2006.384	
ALI369	15h 50.1m	+36° 39'	11.9, 11.9	337.8	8.2	4	2006.384	
HJ2792	15h 50.3m	+31° 14'	11.0, 12.0	351.7	26.7	4	2006.384	
HJ574	15h 50.3m	+32° 24'	9.3, 10.9	96.4	76.5	4	2006.384	
HJ574AB	15h 50.3m	+32° 24'	9.3, 11.3	93.5	15.8	4	2006.384	
HJ2795	15h 52.3m	+31° 19'	11.0, 11.0	29.2	12.4	4	2006.384	
HJ1280	15h 53.0m	+39° 13'	9.9, 12.9	0.7	32.3	4	2006.384	
HJ258	15h 56.9m	+36° 13'	9.8, 10.8	86.7	25.6	4	2006.384	
HJ2800	15h 57.3m	+30° 05'	9.7, 11.7	279.7	14.3	4	2006.384	
VKI23	16h 00.0m	+36° 50'	11.2, 13.2	349.6	4.2	20	2006.386	REDUC
AG349	16h 01.1m	+28° 08'	9.1, 10.1	227.0	11.7	4	2006.384	
HJ580	16h 02.8m	+37° 05'	9.2, 12.2	7.3	40.6	4	2006.384	
HJ581	16h 04.5m	+32° 26'	10.3, 11.4	55.8	21.0	4	2006.384	same as GYL 14?
HJ582	16h 07.1m	+35° 07'	9.7, 12.0	232.0	22.3	4	2006.384	
ALI370	16h 07.6m	+35° 48'	13.7, 14.1	146.4	13.1	8	2006.384	same as HJ259?
COU1276	16h 08.9m	+37° 58'	10.0, 12.0	54.7	2.7	20	2006.386	REDUC
HJ1289	16h 10.6m	+39° 28'	12.5, 13.4	238.5	11.3	4	2006.384	
HJ260	16h 11.8m	+37° 25'	10.0, 11.0	27.1	19.9	4	2006.384	
HO551	16h 12.4m	+26° 26'	8.3, 12.8	78.6	7.1	4	2006.384	
STF2032AB	16h 14.7m	+33° 52'	5.2, 6.3	240.2	8.0	4	2006.384	
COU980AC	16h 17.2m	+33° 41'	10.1, 10.5	81.3	39.4	4	2006.384	
HJ584	16h 17.7m	+39° 14'	10.3, 11.5	203.3	15.2	4	2006.384	

Table 1: Double Star Measures. *Continued from previous page*

Double Star Measurements for First Half of the Year 2006

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Abstract: This semi annual report contains 116 measurements, 1 of which is a new discovery, of neglected double stars from the WDS Northern List. The instrumentation utilized was a 12-inch RCX400 at f8 and a CCD camera to record the images. Data reduction was done using Reduc software.

Telescope

The telescope is a Meade RCX400 of 12" aperture with a 38% central obstruction by diameter. The telescope is mounted in Alt/Az and therefore each binary system that is imaged must contain a drift image to determine the correct PA orientation. Calibration of the PA and Sep was determined by imaging a known Calibration Candidate from the Sixth Catalog of Orbits of Visual Binary Stars. Images are taken without any additional amplification at a focal length of 2438 mm providing 0.71 arc seconds per pixel at the CCD detector.

CCD Detector

The CCD detector is a Meade DSI Pro II. The Pixel size is 8.6x8.3 arranged in a 752x582 array on a Sony ICX429ALL image sensor. No binning was employed. The shutter is electronic and there is no cooling used.

Data Reduction

All double star images were reduced using Reduc software kindly provided by Florent Losse. With careful technique it was possible to generate highly accurate and repeatable values for PA and Sep. To ensure the accuracy of the measurements, I utilized an initial Calibration Candidate from the Sixth Catalog of Orbits of Visual Binary Stars to calibrate the system and followed up with 3 blind Calibration Candidates, which were listed in the WDS Neglected Doubles List.

General Information

Data is presented with the top row providing from left to right, the discoverer designation, WDS Epoch 2000 RA & Dec, WDS magnitudes, WO measured position angle in degrees, WO measured separation in arc seconds, Decimal date, and number of nights ob-

(Continued on page 162)

Discoverer Des.	WDS (2000)	WDS Mags	Theta (deg)	Rho (arcsec)	Date	n	Notes
STF2300 AB	18093+5945	9.00/10.30	42.61	13.868	2006.4365	1	
SEI 559	18104+3356	11.00/11.00	169.22	12.391	2006.4365	1	
SEI 563	18175+3403	9.40/10.70	92.12	13.872	2006.4365	1	
KU 117	18276+2509	10.28/11.30	14.95	20.347	2006.4365	1	
HJ 1326	18292+3220	10.00/10.00	4.25	11.819	2006.4365	1	
ES 2668	18343+4511	9.20/11.00	224.85	12.180	2006.4365	1	
SLE 220	18371+3201	10.10/10.90	236.73	18.376	2006.4365	1	
SLE 101	18394+3000	9.80/10.40	234.49	20.018	2006.4365	1	

Double Star Measurements for First Half of the Year 2006

Discoverer Des.	WDS (2000)	WDS Mags	Theta (deg)	Rho (arcsec)	Date	n	Notes
SLE 94	18413+4102	10.40/10.40	102.75	16.793	2006.4365	1	
STF2398 AB	18428+5938	9.11/ 9.96	175.99	12.186	2006.4365	1	Note 1 Calibration Star
SEI 574	18457+3218	9.00/11.00	262.93	18.952	2006.4365	1	
HJ 1349	18488+3319	8.30/10.70	91.08	30.731	2006.4365	1	
HJ 1352	18501+2949	7.80/10.00	251.76	13.603	2006.4365	1	
HJ 1355	18541+2718	10.00/10.50	40.20	12.066	2006.4365	1	Note 2
SEI 554	18019+3123	10.20/11.00	47.16	24.941	2006.5233	1	
SEI 555	18020+3153	9.80/10.70	110.44	19.770	2006.5233	1	
SLE 131 AB	18054+3029	10.29/11.69	202.82	55.485	2006.5233	1	
SLE 187	18310+3857	9.70/10.80	207.66	24.242	2006.5233	1	
HJ 1332	18387+2439	8.16/10.36	231.14	27.995	2006.5233	1	
SLE 232	18387+5300	10.80/10.90	220.97	15.122	2006.5233	1	
SEI 572	18430+3445	11.00/11.00	52.38	22.802	2006.5233	1	
HJ 1348 AB	18474+4606	10.38/11.66	294.23	73.538	2006.5233	1	
ES 2569	18107+3903	9.50/10.00	275.91	9.636	2006.5315	1	
ES 1420 AB	18156+4417	9.60/10.80	67.44	9.330	2006.5315	1	
ES 2664	18157+3723	10.00/10.10	83.86	9.609	2006.5315	1	
HJ 1321	18213+3920	10.00/11.00	76.84	10.369	2006.5315	1	
MLB 648	18270+2832	9.70/11.00	21.42	10.840	2006.5315	1	
ES 475	18280+2708	9.60/10.60	219.83	10.907	2006.5315	1	
J 2913 AC	18293+2144	10.00/10.00	161.05	15.553	2006.5315	1	
SLE 182	18298+3930	9.80/10.10	253.80	11.602	2006.5315	1	
SLE 209	18339+3208	9.10/10.20	16.16	10.199	2006.5315	1	
SLE 211	18347+3158	10.60/11.00	270.50	9.539	2006.5315	1	
STI2380	18380+5722	9.80/10.80	3.17	10.449	2006.5315	1	

Double Star Measurements for First Half of the Year 2006

Discoverer Des.	WDS (2000)	WDS Mags	Theta (deg)	Rho (arcsec)	Date	n	Notes
ES 478	18436+4237	10.30/10.80	183.32	9.847	2006.5315	1	
HJ 1354	18530+3621	9.70/ 9.80	5.66	10.702	2006.5315	1	
ES 2669	18550+6143	10.20/10.60	166.95	12.147	2006.5315	1	
MLB 852	18159+3840	11.42/12.10	40.09	9.846	2006.5343	1	
STI 865	18519+5948	10.40/10.90	178.53	3.154	2006.5343	1	
ES 2018	18077+3904	10.13/11.15	233.47	5.731	2006.5397	1	
MLB1078	18189+3918	12.70/12.70	136.59	6.753	2006.5397	1	
ES 2110	18210+3630	9.30/10.80	99.68	6.735	2006.5397	1	
ES 21	18332+4200	10.50/10.50	109.02	7.283	2006.5397	1	
SLE 362	18408+2703	11.00/11.00	100.83	7.158	2006.5397	1	
ES 1912	18494+6528	9.40/11.00	21.16	7.819	2006.5397	1	
MLB 857	18573+3925	9.80/10.00	341.73	5.078	2006.5397	1	
ES 1417 AB	18092+4314	9.50/10.40	208.05	13.507	2006.5452	1	
ES 2480	18101+3713	10.50/11.00	357.31	3.969	2006.5452	1	
SLE 141	18123+3106	10.50/10.90	23.39	6.446	2006.5452	1	
STF2305 AB	18162+5120	9.16/10.81	339.11	4.945	2006.5452	1	
BRT1915	18186+4104	10.00/10.90	15.51	5.343	2006.5452	1	
ES 2418	18267+3211	9.60/10.50	77.92	5.513	2006.5452	1	
MLB 854	18272+3847	11.80/12.00	12.23	6.871	2006.5452	1	
SLE 114	18409+3044	10.90/10.90	147.47	3.585	2006.5452	1	
ES 2482	18445+3733	10.00/10.50	161.34	11.858	2006.5452	1	
ES 2483	18449+3651	10.50/11.00	264.47	5.106	2006.5452	1	
STF2427 BC	18581+3813	9.93/10.20	79.52	7.248	2006.5452	1	
AG 367	18582+2924	9.90/10.90	301.27	5.147	2006.5452	1	
MLB 757	18590+3235	13.00/13.40	124.43	4.924	2006.5452	1	

Double Star Measurements for First Half of the Year 2006

Discoverer Des.	WDS (2000)	WDS Mags	Theta (deg)	Rho (arcsec)	Date	n	Notes
STF2486 AB	19121+4951	6.54/ 6.67	204.89	7.741	2006.5452	1	Note 3 Calibration Star
J 756	18004+4611	12.31/12.31	182.29	3.742	2006.5507	1	
J 757	18031+3805	9.60/10.00	320.84	3.616	2006.5507	1	
ES 2109	18056+3727	9.00/11.00	141.25	4.313	2006.5507	1	
BRT1914	18072+4430	10.60/10.80	154.99	4.699	2006.5507	1	
AG 361	18251+2654	10.65/10.97	14.08	3.866	2006.5507	1	
J 2913 AB	18293+2144	10.00/10.30	115.51	3.150	2006.5507	1	
ES 2419	18343+3205	11.00/11.00	158.49	4.231	2006.5507	1	
BRT2448	18425+2116	10.60/11.00	296.06	4.009	2006.5507	1	
J 1208	18491+2834	9.50/10.00	333.32	4.964	2006.5507	1	
BRT2449	18498+2149	9.80/10.80	229.49	3.913	2006.5507	1	
BRT1922	18509+4259	11.29/11.85	294.23	3.377	2006.5507	1	
WFC 215	18549+6911	10.10/10.22	254.11	3.926	2006.5507	1	
ES 1657	18554+4052	10.40/11.00	352.57	3.892	2006.5507	1	
POP 194	18569+3505	12.00/13.00	125.63	3.567	2006.5507	1	
AG 349	16011+2808	9.59/10.86	226.78	12.289	2006.5562	1	
PKO 13	16065+6028	10.50/10.80	305.27	11.246	2006.5562	1	
HJ 260	16118+3725	11.00/10.00	26.79	20.509	2006.5562	1	
STF2032 AB	16147+3352	5.62/ 6.49	236.84	7.220	2006.5562	1	Note 4 Calibration Star
ES 1253	16185+4510	10.00/11.00	230.95	7.001	2006.5562	1	
ES 627	16186+5120	9.88/10.98	287.45	12.351	2006.5562	1	
HJ 261	16284+3724	10.00/11.43	100.60	21.927	2006.5562	1	
SEI 539	16358+3219	9.00/10.50	233.14	10.928	2006.5562	1	
KU 54	16430+4355	9.20/10.70	97.28	9.720	2006.5562	1	
ROE 49	16456+3705	9.50/11.00	79.71	11.303	2006.5562	1	

Double Star Measurements for First Half of the Year 2006

Discoverer Des.	WDS (2000)	WDS Mags	Theta (deg)	Rho (arcsec)	Date	n	Notes
KZA 117	16509+4601	10.50/10.50	325.28	8.526	2006.5562	1	
KZA 120	16534+4601	10.50/10.50	78.74	11.038	2006.5562	1	
ES 1090	17005+4817	10.60/10.60	274.89	4.918	2006.7369	1	
BRT 340	16494+4127	10.20/10.80	201.61	3.484	2006.5644	1	
ES 344	17573+3351	9.70/10.20	30.55	9.311	2006.5644	1	
ES 1259	17521+4657	9.00/ 9.80	219.69	6.582	2006.5644	1	
ES 1414	17298+4334	10.40/10.80	227.66	7.157	2006.5644	1	
ES 1556	16010+4338	9.50/11.20	229.92	10.586	2006.5644	1	
ES 2169	17496+3649	10.10/10.40	336.30	8.735	2006.5644	1	
ES 2478	17595+3803	10.50/11.00	235.37	4.691	2006.5644	1	
ES 2567	17496+3756	11.00/11.00	194.77	5.661	2006.5644	1	
ES 2660	17372+4309	10.16/10.16	151.36	9.526	2006.5644	1	
ES 2663	17536+4313	10.60/10.90	332.70	10.273	2006.5644	1	
GYL 5 AC	17120+3158	11.34/12.36	320.26	17.142	2006.5644	1	
HEI 14 AB	17158+3829	9.60/11.00	313.03	7.530	2006.5644	1	
SOO 1	17158+3829	9.21/12.16	356.29	4.814	2006.5644	1	Discovery Note 1
HO 64	16308+2744	11.65/11.59	106.20	4.334	2006.5644	1	
HO 558	17105+6322	9.50/10.00	207.61	8.396	2006.5644	1	
J 1124	16415+4007	10.20/10.80	276.60	3.332	2006.5644	1	
MLB 850	17145+3833	14.00/14.20	187.00	5.872	2006.5644	1	
MLR 351	16304+7930	9.90/10.20	95.05	3.824	2006.5644	1	
PKO 14	16067+6000	10.50/10.60	143.26	2.109	2006.5644	1	
PTT 17	17167+3752	9.50/10.00	190.02	10.209	2006.5644	1	
SEI 545	17400+3144	10.30/10.30	148.31	11.876	2006.5644	1	
SEI 547	17460+3206	10.00/11.00	242.30	8.873	2006.5644	1	
SEI 549	17535+3240	11.00/11.00	131.98	12.613	2006.5644	1	

Double Star Measurements for First Half of the Year 2006

Discoverer Des.	WDS (2000)	WDS Mags	Theta (deg)	Rho (arcsec)	Date	n	Notes
SEI 553	17569+3252	10.00/10.20	27.86	9.887	2006.5644	1	
SLE 11	17118+2906	10.10/11.00	284.74	9.528	2006.5644	1	
STF2225 AB	17452+5157	8.70/10.90	357.78	5.459	2006.5644	1	
STF2225 CD	17452+5157	10.20/10.56	318.25	8.751	2006.5644	1	
STF2229	17459+5011	8.30/10.30	337.58	6.612	2006.5644	1	
STI2357	17462+5613	10.20/10.60	171.62	12.155	2006.5644	1	
WFC 196	17352+2545	9.93/10.48	101.53	8.003	2006.5644	1	

2006 Notes

1) Comparative results of this blind calibration are as follows:
18428+5938 STF2398AB 2006.00 175.9 12.113 (WDS Sixth Catalogue)
2006.4365 175.99 12.186 (WO)

2) Primary and Secondary need to be reversed to get Theta reading in keeping with previous observations of this system.

3) Comparative results of this blind calibration are as follows:
19121+4951 STF2486AB 2006.00 205.6 7.405 (WDS Sixth Catalogue)
2006.5452 204.89 7.741 (WO)

4) Comparative results of this blind calibration are as follows:
16147+3352 STF2032AB 2006.00 236.9 7.123 (WDS Sixth Catalogue)
2006.5562 236.84 7.220 (WO)

(Continued from page 157)

ject was observed. A notes column follows each row to expand on any peculiarities noted in the double star observation.

Discovery Notes

SOO 1 – 17hr 15m 48.00s +38deg 51' 60.00". Found while imaging HEI 14. This is a third fainter component, which I have measured in relation to the primary star in HEI 14. Positioning and magnitudes were confirmed by accessing online The Two Micron All Sky Survey (2MASS) images using the Aladin sky atlas. Image of this system is shown in Figure 1.

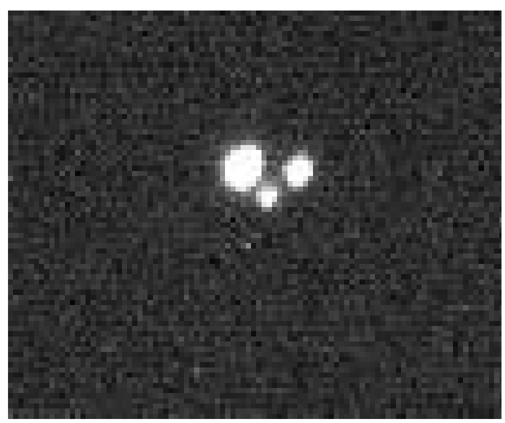

Figure 1: *Image of HEI 14 showing newly discovered third component.*

References

1. "This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/ California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation."
2. The Washington Double Star Catalog

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Abstract: This report contains theta/rho measurements obtained using a 20-cm Schmidt-Cassegrain telescope and an illuminated reticle micrometer. 105 different double star systems were measured. The time period spans from 2005.696 to 2005.871. This report represents a portion of the work that is currently being conducted in double star astronomy at Divinus Lux Observatory in Flagstaff, Arizona.

The double star measuring program that has been ongoing, at Divinus Lux Observatory, has evolved to the point in which tenth magnitude pairs have been a primary emphasis for the past several months. Admittedly, measuring such pairs with a 20-cm telescope and an illuminated reticle micrometer pushes this type of instrumentation to the limit. In essence, when working at the practical limit of measurability, one tenth of a magnitude can become significantly noticeable. In the present case, companion stars can be measured down to about magnitude +10.7, but it becomes almost impossible to make measurements at about magnitude +10.8, or fainter, with a reasonable degree of accuracy.

One may wonder why such instrumentation should be consistently pushed to the limit when there are so many brighter pairs that would be easier to measure. The principal reason for this attention is because it is these fainter pairs that most frequently show up on the "neglected doubles" list. Because the mission of the observatory is to provide double star measurements that are in great need, the rationale for this emphasis becomes obvious. In addition, since increased expertise naturally evolves when the researcher uses the same instrumentation for several years, the time eventually comes when one should exploit this to the fullest for the benefit of science.

As has been mentioned in a previous article, nights with good seeing and transparency are usually essential when working at the limits of one's equipment, but the satisfaction that can be derived from such a focus is incalculable. Providing double star measurements that are needed the most is certainly one element. Furthermore, I have detected enough errors from sky survey data to state that the visual measuring of double stars has not been rendered obsolete, but rather, such measurements can help to confirm the accuracy of this information. Hence, an appeal is being made, in this report, for others to give greater attention to the visual measuring of neglected double stars.

As has been done in previous articles, the selected double star systems, which appear in this report, have been taken from the 2001.0 version of the WASHINGTON DOUBLE STAR CATALOG, with published measurements that are no more recent than ten years ago. There are also some noteworthy items that are discussed pertaining to the following table.

To begin with, there are several double stars that have displayed significant theta/rho shifts, during the past several years, because of proper motion by one or both of the components. HJ 2153 is one such pair. Since 1912, the year of the last published measurements, the rho value has decreased by about 7.5% as a result of proper motion by the reference point star. Proper motion by the reference point star is also responsible for a 7.2" decrease in the rho value and a 3 degrees increase in the theta value, since 1902, for HJ 3246 AC. BAL 2995 has also displayed significant theta/rho shifts. Since 1991, the theta value has decreased by about 2.5 degrees and the rho value has decreased by 3% because of proper motion by the reference point star.

Two additional double stars that have dated pub-

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lished measurements might be mentioned as well. GAL 375 has had only one previous set of published measurements, and these were done in 1904. Consequently, with such a large passage of time, a 9 degrees increase in the theta value and a 5.7" increase in the rho value are being reported for this system. Proper motion by both component stars is responsible for these shifts. Secondly, AG 88 Aa-B is a neglected system with the last published measurements appearing in 1914. It is noted that the 1914 theta measurements may be anomalous for unknown reasons, since the 1902 measurements and current measurements suggest a value of 286 degrees, rather than the 289 degrees value reported in 1914. What these results suggest is that several of these "neglected" systems need measurement verifications by other researchers.

It is noted in this report that the rho measurements in the table for BAL 2691 AB more closely match those published in 1910, rather than the ones published in 1982. A 3.2% difference exists with the 1982 rho measurements, while only an 0.8% difference exists with the 1910 measurements. Since only 2 sets of measurements were published in 1982, this double star needs additional study in order to determine the rho value more accurately.

Regarding STF 404 AB, one may notice that the companion star is listed as being at magnitude +11.3, which seems to contradict what was mentioned in the opening remarks for this report. However, while magnitude +11.3 is indicated in the Hipparcos/Tycho data for this star, this component was noticeably brighter when measurements for "AB" were done. Excellent seeing conditions were probably not responsible because the "D" component, which is listed with a similar magnitude, was definitely not bright enough for theta/rho measurements to be performed. Since the mission of the observatory emphasizes astrometry instead of photometry, a direct measurement of the magnitude for the "B" component was not made. Nevertheless, a visual estimate of +10.8 has been noted in the records of the observatory. In addition, because the USNO DOUBLE STAR CD 2001.0 indicates that "AB" has not had published measurements since 1911, obtaining measurements for this common proper motion pair was of vital importance.

Two double stars, labeled with the "ARN" prefix, appear in the table because these pairs, which might share a common proper motion, do not appear to have been previously cataloged. Hence, ARN 84 (05262+0048) and ARN 85 (05472+5631) have been included in this report. ARN 85 is located near STI 2108.

Finally, this report notes an error for one of the published measurements in the WDS catalog. Regarding ES 1310AD (03131+4440), the listed measurements for "AD" are actually measurements for the "BD" components. The table below reflects updated measurements for the AD components, which lists a theta value that is 13 degrees less than what appears in the catalog.

Name	RA DEC	Mags	PA	Sep	Date	N	Notes
A 2324 AC	02007+0456	10.2, 10.3	130.1	71.10	2005.696	1n	1
A 2324 DC	02007+0456	10.2, 10.3	20.8	87.89	2005.696	1n	1
GAL 317	02021-1321	10.0, 10.6	59.0	41.48	2005.696	1n	2
GAL 319	02070-1017	10.0, 10.5	85.1	28.14	2005.696	1n	3
ES 1306	02234+4441	10.3, 10.5	274.8	9.38	2005.696	1n	4
KU 76	02235+2623	9.8, 10.4	349.7	32.09	2005.696	1n	5
MLB1061 AC	02324+3905	10.0, 10.7	311.3	24.19	2005.696	1n	6
HJ 2153	02388+1729	10.6, 10.7	350.8	19.26	2005.734	1n	7
BU 1374 AB	02516+6033	9.7, 10.1	195.8	21.23	2005.808	1n	8
HJ 2162 AB	02548+4332	10.5, 10.7	40.2	11.85	2005.696	1n	9
AG 305	03063+5100	10.2, 10.3	99.9	11.36	2005.696	1n	10

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Name	RA DEC	Mags	PA	Sep	Date	N	Notes
ES 1310 AD	03131+4440	10.4, 9.0#	234.8	96.78	2005.696	1n	11
HJ 3246 AC	03207+1736	9.9, 9.9	141.1	172.82	2005.808	1n	12
BAL2995	03212+0523	10.6, 10.7	187.6	11.36	2005.808	1n	13
ES 464	03213+4743	10.1, 10.6	67.3	7.41	2005.696	1n	14
KU 80	03232+2412	10.2, 10.4	181.1	27.65	2005.715	1n	15
STF 404 AB	03314+2148	9.7, 11.3	202.2	28.64	2005.715	1n	16
STF 404 AC	03314+2148	9.7, 8.8#	49.7	120.48	2005.715	1n	16
AG 69	03332+0409	10.0, 10.3	353.6	6.42	2005.808	1n	17
HJ 3583	03377-2028	10.2, 10.5	86.8	11.85	2005.808	1n	18
SMA 38	03348+4408	10.2, 10.7	68.1	21.23	2005.696	1n	19
KU 81	03451+3425	9.9, 10.5	282.6	41.48	2005.715	1n	20
ES 167	03474+3521	10.3, 10.5	314.3	7.41	2005.715	1n	21
ES 770 AB	03494+5214	10.2, 10.4	232.2	70.11	2005.715	1n	22
WFC 33	04077+5258	10.4, 10.5	185.7	8.39	2005.734	1n	23
STF 494	04089+2306	7.5, 7.6	187.3	5.43	2005.734	1n	24
AG 78	04104+3618	10.0, 10.5	198.1	17.78	2005.734	1n	25
STI2036	04105+5717	10.4, 10.7	55.2	8.89	2005.808	1n	26
HJ 673	04170+3048	9.6, 10.4	197.2	20.74	2005.734	1n	27
GAL 371	04283-1400	10.1, 10.5	184.7	20.24	2005.808	1n	28
STF 550 AB	04320+5355	5.8, 6.8	308.4	10.37	2005.734	1n	29
AG 81	04427+0630	10.6, 10.7	279.9	38.51	2005.808	1n	30
A 3006 AC	04441+0205	9.9, 10.0	250.2	52.34	2005.808	1n	31
HJ 27	04455-0512	10.1, 10.1	51.4	39.50	2005.808	1n	32
WHC 1	05036-2029	10.0, 10.7	83.0	8.89	2005.811	1n	33
GAL 375	05047-0925	10.2, 9.9#	257.0	16.79	2005.811	1n	34
AG 88 Aa-B	05049+3054	10.0, 10.2	286.3	12.84	2005.811	1n	35
HJ 3265 AB	05080+3703	10.3, 10.2#	137.3	14.81	2005.811	1n	36
VBS 10 AC	05103+3718	6.8, 10.4	192.2	72.09	2005.827	1n	37
BU 1006 AC	05123-0212	9.3, 10.0	178.4	51.84	2005.811	1n	38

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Name	RA DEC	Mags	PA	Sep	Date	N	Notes
HJ 3270	05127+1629	10.4, 10.6	331.3	13.83	2005.811	1n	39
AG 92 AB	05154+3020	10.1, 10.7	334.9	24.69	2005.811	1n	40
HJ 2260 AB	05177-1041	10.3, 10.5	1.9	31.11	2005.811	1n	41
ES 574 AB	05178+4720	10.1, 10.7	67.0	34.56	2005.811	1n	42
STF 679	05197+2511	10.0, 10.2	317.0	20.24	2005.811	1n	43
SMA 54	05206+3939	9.9, 10.6	268.1	15.80	2005.816	1n	44
HJ 364	05242+2208	10.1, 10.5	143.2	10.86	2005.816	1n	45
HDS 713	05261+2250	9.9, 10.1	129.3	24.19	2005.816	1n	46
ARN 84 ##	05262+0048	8.3, 9.9	275.9	35.55	2005.830	1n	47
STF 705	05266+3524	10.2, 10.7	12.3	18.27	2005.816	1n	48
WEB 4	05290-0442	10.0, 9.8#	52.7	47.89	2005.816	1n	49
STF 748 AB	05353-0523	6.6, 7.5	32.4	8.89	2005.830	1n	50
STF 748 AC	05353-0523	6.6, 5.1#	132.5	12.84	2005.830	1n	50
STF 748 AD	05353-0523	6.6, 6.4#	96.0	21.73	2005.830	1n	50
AG 316	05395+5352	10.0, 10.1	212.3	9.88	2005.816	1n	51
STD 771 AB	05418+1933	10.2, 10.3	54.6	21.73	2005.816	1n	52
STF 777	05434+2213	9.3, 9.8	84.5	4.94	2005.830	1n	53
HJ 5539	05456+1737	10.0, 10.2	281.7	27.16	2005.816	1n	54
STI2108	05461+5623	10.4, 10.7	139.2	10.86	2005.830	1n	55
ARN 85 ##	05472+5631	10.0, 10.5	271.1	75.05	2005.830	1n	56
HJ 2279	05502+5450	10.6, 10.7	21.6	15.80	2005.816	1n	57
SEI 394	05514+3506	10.0, 10.7	325.5	14.32	2005.816	1n	58
SEI 404	05521+3235	10.5, 10.7	167.3	16.79	2005.816	1n	59
SEI 410	05522+3235	10.6, 10.7	121.9	17.28	2005.816	1n	60
SEI 428	05528+3233	10.0, 10.0	334.2	23.21	2005.816	1n	61
SEI 434 AE	05545+3109	10.1, 10.0#	82.4	26.17	2005.816	1n	62
STF 852 AC	06086+0722	9.9, 10.5	30.0	44.93	2005.833	1n	63
SCA 37	06099+2032	10.5, 10.6	94.3	24.69	2005.833	1n	64
AG 106 AC	06110+3302	9.9, 10.1	218.4	27.65	2005.833	1n	65

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Name	RA DEC	Mags	PA	Sep	Date	N	Notes
OPI 8	06119+0051	10.5, 10.7	143.5	34.07	2005.833	1n	66
GAL 225	06192-1151	10.3, 10.4	165.4	7.90	2005.833	1n	67
HJ 2312	06194-0516	10.4, 10.5	197.2	9.38	2005.833	1n	68
ES 2617	06219+5459	10.3, 10.3	26.4	9.88	2005.833	1n	69
J 595 AC	06264+1128	10.7, 10.6#	245.0	43.94	2005.833	1n	70
AG 113	06284+3116	10.0, 10.2	315.4	11.36	2005.833	1n	71
STF 908	06310+5351	10.6, 10.6	359.8	8.89	2005.833	1n	72
BAL2671	06342+0420	10.2, 10.7	213.4	19.26	2005.836	1n	73
GYL 80 AB	06402+3342	10.2, 10.3	117.1	28.64	2005.836	1n	74
BAL2691 AB	06422+0409	9.8, 10.3	63.7	22.71	2005.836	1n	75
ES 2098 AB	06435+3929	10.6, 10.5#	203.2	30.61	2005.836	1n	76
BAL1350	06521+0146	10.4, 10.5	29.7	18.27	2005.836	1n	77
HJ 3902 AB	06574-1821	10.1, 10.2	236.2	14.81	2005.836	1n	78
SEI 479	07269+3054	10.6, 10.7	41.5	15.31	2005.863	1n	79
HJ 2386	07283+0345	10.3, 10.5	249.3	6.91	2005.863	1n	80
D 13 AC	07330-1250	10.3, 10.6	288.1	11.85	2005.863	1n	81
STF1098	07348+5933	10.2, 10.5	289.3	27.16	2005.863	1n	82
KU 93	07414+0149	9.9, 10.7	15.1	49.38	2005.863	1n	83
HJ 2418	07506+2001	10.1, 10.1	217.2	21.73	2005.863	1n	84
STF1153	07526+1201	10.1, 10.3	357.6	19.75	2005.863	1n	85
SEI 483	07530+3138	10.4, 10.6	150.9	22.71	2005.863	1n	86
AG 148	08059-0146	10.2, 10.3	176.6	6.91	2005.866	1n	87
CHE 88	08137+0833	10.2, 10.7	110.5	45.43	2005.866	1n	88
AG 151	08138+3346	10.2, 10.5	148.9	6.42	2005.866	1n	89
BHA 56	08233-1804	9.9, 10.4	271.0	18.76	2005.866	1n	90
HJ 93	08285+1212	10.5, 10.6	99.1	19.26	2005.866	1n	91
HJ 3314	08504-0002	10.2, 10.7	133.4	16.29	2005.866	1n	92
AG 156	08508+3418	10.2, 10.4	249.8	10.86	2005.866	1n	93
STF1288	08527+2827	10.1, 10.1	258.9	7.90	2005.866	1n	94

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Name	RA DEC	Mags	PA	Sep	Date	N	Notes
SCJ 12	09078-0013	10.2, 10.2	260.7	6.42	2005.871	1n	95
POU3029	09082+2353	10.0, 10.3	315.5	7.90	2005.871	1n	96
HJ 122	09137+1109	10.2, 10.4	91.3	9.88	2005.871	1n	97
HJ 2490	09150+1253	10.2, 10.5	68.0	21.73	2005.871	1n	98
HJ 810 AC	09212+2728	10.4, 10.7	26.2	22.22	2005.871	1n	99
HJ 137	09297+0433	10.0, 10.3	354.7	18.76	2005.871	1n	100
KU 98	09404+1936	10.2, 10.4	341.1	56.78	2005.871	1n	101
HJ 820	09434+0858	10.0, 10.2	253.3	12.84	2005.871	1n	102
HJ 2503	09445+4830	10.4, 10.7	158.4	37.03	2005.871	1n	103
HJ 470	09448+1940	10.1, 10.3	211.5	22.22	2005.871	1n	104
KR 34	09578+5815	10.0, 10.6	65.5	33.08	2005.871	1n	105

Companion star is the brighter component.
Not in WDS catalog

Notes

1. In Pisces. AC= sep. increasing. DC = sep. decreasing. Spect. F8, K2, K5.
2. In Cetus. Relatively fixed.
3. In Cetus. Relatively fixed.
4. In Andromeda. Position angle decreasing.
5. In Aries. Sep. & p.a. decreasing. Spect. A5, F5.
6. In Andromeda. Sep. increasing; p.a. decreasing. Spect. G3V.
7. In Aries. Sep. & p.a. decreasing. Spect. A2.
8. In Cassiopeia. Slight p.a. increase. Spect. B1V, B.
9. In Perseus. Separation decreasing. Position angle increasing.
10. In Perseus. Relatively fixed. Common proper motion. Spect. F2, F2.
11. In Perseus. Sep. increasing; p.a. decreasing. Spect. K0.
12. In Aries. Separation decreasing. Position angle increasing.
13. In Cetus. Sep. & p.a. decreasing. Spect. G0, G0.
14. In Perseus. Relatively fixed. Common proper motion.
15. In Aries. Relatively fixed. Common proper motion. Spect. G5, G5.
16. In Taurus. AB = relfix; cpm. AC = sep. dec.; p.a. inc. Spect. AC = K0, F2.
17. In Taurus. Relatively fixed. Common proper motion. Spect. F8.
18. In Eridanus. Common proper motion; p.a. decreasing. Spect. F5.
19. In Perseus. Relatively fixed. Common proper motion.
20. In Perseus. Position angle slightly increasing. Spect. A2.
21. In Perseus. Sep. increasing; p.a. decreasing. Spect. G0.
22. In Perseus. Position angle slightly increasing.
23. In Camelopardus. Relatively fixed. Common proper motion.
24. In Taurus. Common proper motion. Spect. A8IV, A8IV.

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25. In Perseus. Relatively fixed. Spect. A0.
26. In Camelopardus. Sep. & p.a. decreasing.
27. In Taurus. Sep. decreasing; p.a. increasing. Spect. G0.
28. In Eridanus. Sep. decreasing; p.a. increasing. Spect. G0.
29. 1 Camelopardi. Common proper motion. Spect. B0III, B0III.
30. In Taurus. Sep. increasing; p.a. decreasing. Spect. F8, F8.
31. In Orion. Relatively fixed. Spect. F8, F0.
32. In Eridanus. Relatively fixed. Common proper motion.
33. In Lepus. Relatively fixed. Spect. A0.
34. In Eridanus. Sep. & p.a. increasing. Spect. G5.
35. In Auriga. Relatively fixed. Spect. A2.
36. In NGC 1778 (Auriga). Relfixed. Common proper motion. Spect. B8, B8.
37. In Auriga. Part of STF 644 system. Sep. & p.a. decreasing. Spect. B2.
38. In Orion. Relatively fixed. Common proper motion. Spect. F2V.
39. In Taurus. Position angle increasing. Spect. A0.
40. In Auriga. Separation increasing. Spect. G0.
41. In Orion. Relatively fixed. Common proper motion. Spect. B, B.
42. In Auriga. Sep. & p.a. increasing.
43. In Taurus. Relatively fixed. Common proper motion. Spect. G0, G0.
44. In Auriga. Relatively fixed. Spect. B8
45. In Taurus. Relatively fixed. Spect. F2, F5.
46. In Taurus. Relatively fixed. Common proper motion. Spect. G0, F8.
47. In Orion. Possible common proper motion. Spect. B9, A2.
48. In Auriga. Relatively fixed. Spect. F8.
49. In Orion. Sep. & p.a. increasing. Spect. M, M.
50. In Orion. Trapezium. All components relfixed. Spect. O7, B1V, O6, B0.
51. In Auriga. Position angle decreasing. Spect. A0, A2.
52. In Taurus. Separation decreasing. Spect. A0.
53. In Taurus. Relatively fixed. Spect. A0, A0.
54. In Taurus. Relatively fixed. Spect. A0.
55. In Camelopardus. Relatively fixed.
56. In Camelopardus. Near STI 2108. Possible common proper motion. Spect. G5.
57. In Auriga. Relatively fixed. Common proper motion.
58. In Auriga. Relatively fixed.
59. In Auriga. In M37 open cluster. Relatively fixed. Common proper motion.
60. In Auriga. In M37 open cluster. Sep. & p.a. decreasing.
61. In Auriga. In M37 open cluster. Sep. & p.a. increasing. Spect. F5.
62. In Auriga. Separation decreasing. Spect. A0.
63. In Orion. Sep. & p.a. slightly increasing. Spect. F5.
64. In Orion. Sep. & p.a. slightly decreasing. Spect. F0.
65. In Auriga. Position angle increasing. Spect. G0.
66. In Orion. Sep. & p.a. slightly increasing. Spect. G0.
67. In Canis Major. Position angle increasing. Spect. G0.
68. In Monoceros. Relatively fixed.
69. In Lynx. Relatively fixed. Common proper motion. Spect. A, A.
70. In Monoceros. Relatively fixed.
71. In Auriga. Common proper motion. Sep. slightly increasing. Spect. G5, G5.
72. In Auriga. Common proper motion. Slight increase in p.a.
73. In Monoceros. Relatively fixed. Spect. A0, A.
74. In Auriga. Sep. increasing; p.a. decreasing. Spect. G0, G0.
75. In Monoceros. Sep. & p.a. increasing. Spect. A5.

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76. In Auriga. Separation increasing.
77. In Monoceros. Sep. & p.a. slightly decreasing.
78. In Canis Major. Sep. & p.a. increasing. Spect. A2.
79. In Gemini. Sep. increasing; p.a. decreasing.
80. In Canis Minor. Common proper motion. Position angle increasing.
81. In Puppis. Separation slightly increasing.
82. In Lynx. Sep. & p.a. increasing. Spect. K0, F8.
83. In Canis Minor. Relatively fixed. Spect. A2.
84. In Gemini. Relatively fixed. Common proper motion. Spect. A0, F2.
85. In Canis Minor. Relatively fixed. Spect. F8, F5.
86. In Gemini. Sep. & p.a. slightly increasing. Spect. K0.
87. In Monoceros. Sep. & p.a. slightly decreasing. Spect. A5, A5.
88. In Cancer. Sep. & p.a. increasing.
89. In Lynx. Common proper motion; p.a. increasing.
90. In Puppis. Sep. slightly increasing. Spect. F5.
91. In Cancer. Sep. increasing; p.a. decreasing.
92. In Hydra. Relatively fixed. Common proper motion. Spect. F8.
93. In Lynx. Slight decrease in p.a. Spect. G0, G0.
94. In Cancer. Relatively fixed. Common proper motion. Spect. G0.
95. In Hydra. Sep. decreasing; p.a. increasing. Spect. K2, K2.
96. In Cancer. Relatively fixed. Common proper motion. Spect. F5, F5.
97. In Cancer. Separation increasing. Spect. A5, F.
98. In Cancer. Relatively fixed. Common proper motion. Spect. K0, K.
99. In Cancer. Sep. increasing; p.a. decreasing. Spect. K0, F5.
100. In Hydra. Sep. & p.a. decreasing. Spect. G0.
101. In Leo. Separation increasing. Spect. G5, G5.
102. In Leo. Relatively fixed. Common proper motion. Spect. F2, F2.
103. In Ursa Major. Sep. decreasing; p.a. increasing. Spect. K0, F8.
104. In Leo. Relatively fixed. Common proper motion.
105. In Ursa Major. Sep. decreasing; p.a. increasing. Spect. M4.

The US Naval Observatory Double Star CD, 2006.5

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Abstract: The United States Naval Observatory has recently released its second CDROM of double star catalogs. This article describes the contents of the CD and how to obtain a copy.

The U.S. Naval Observatory has produced its second CDROM of double star catalogs. This successor to the 2001.0 CDROM will include the latest versions (30 June 2006) of four major double star catalogs maintained at the USNO:

- Washington Double Star Catalog (WDS),
- Second Photometric Magnitude Difference Catalog,
- Fourth Catalog of Interferometric Measurements of Binary Stars, and
- Sixth Catalog of Orbits of Visual Binary Stars.

Each of these catalogs had seen significant changes during the past six years; for example, the WDS has grown by over 150,000 measures and the number of systems in the Interferometric Catalog has nearly doubled. Other improvements include precise coordinates for the vast majority of systems, as well as new observing lists for tens of thousands of "neglected" doubles.

Also included on this CDROM is a Catalog of Linear Elements for several hundred optical pairs. These elements should prove useful for improving the components' proper motions, as well as providing scale calibration out to several tens of arcseconds. Another item included on the CD is a history of double star work at the US Naval Observatory.

Each of these is described in some detail below.

Washington Double Star Catalog, 2006.5

The WDS summary catalog is a listing of 102,387 systems based on 727,726 mean positions. In addition to the summary data we also provide precise positions, proper motions, as well as cross reference identifications. We also provide more detailed notes as well as indicating when systems are also in other datasets. The WDS is the successor to Index Catalog of Double Stars (IDS) and has gone through three major releases (1984, 1996, 2001), is under continual growth (Figure 1) and is updated nightly.

The WDS has been matched with astrometric catalogs, primarily those used for the determination of proper motion for Tycho-2. These catalogs have significantly improved the identification of pairs with their precise position such that 97% of them have at least arcsecond-precise positions. Also the proper motion of the secondary is now provided for 38% of all

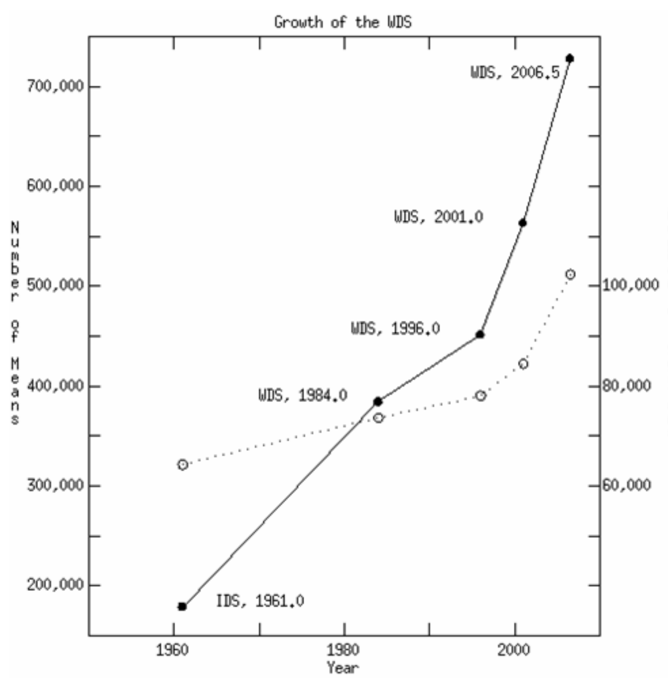

***Figure 1:** Growth of Washington Double Star Catalog*

pairs, aiding in the identification of common proper motion binaries and optical doubles. Pairs having common or mutually exclusive parallaxes are also indicated.

As well as providing a DM cross-reference, the WDS also provides cross-references to Hipparcos, Tycho-2, and historical double star catalogs (ADS & BDS). New lists of "Neglected Doubles" are provided. Pairs are classified as neglected if they are unconfirmed or infrequently observed. Observation of these pairs by amateurs has significantly improved the database. Amateurs have also provided arcsecond-precise coordinates for pairs too faint, or unmatched, with astrometric catalogs. Unpublished measures of doubles from various sources are included, as well as lists of verified single stars.

While the mean number of measures per system is 7.1, the median is only 3. (Figure 2) Some 1522 have orbits of varying quality, 354 have common parallax, and an unknown number have common proper motion. Others are certainly optical: 1163 have published rectilinear solutions and 174 show mutually exclusive parallax. With only a few percent even approximately described kinematically, there still remains much work to be done.

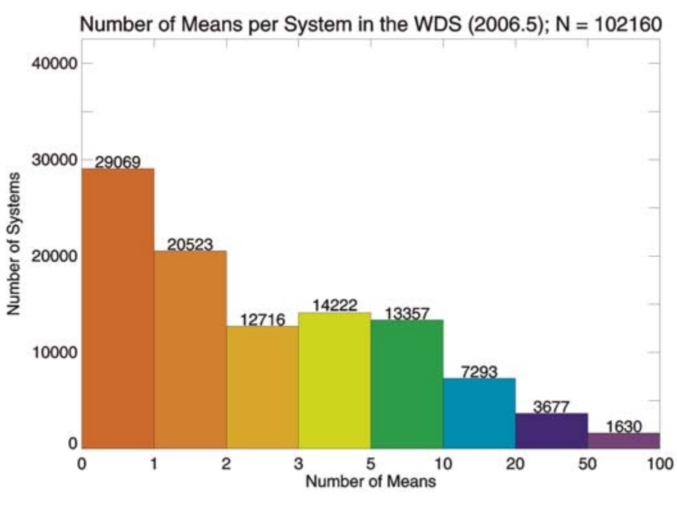

Figure 2: *Distribution of mean number of measures per system.*

Sixth Catalog of Orbits of Visual Binary Stars

The Sixth Catalog of Orbits of Visual Binary Stars continues the series of compilations of visual binary star orbits published by William Finsen, Charles Worley, and Wulff Heintz from the 1930's to the 1980's. As of 30 June 2006, the new catalog included 2,024 orbits of 1,888 systems. All orbits have been graded as in earlier catalogs, although the grading scheme was modified as of the Fifth Catalog to be more objective.

Nominally a single "best" orbit is given for each system; however, a second solution is occasionally given in cases of two very different orbits of similar quality or instances of quadrant ambiguity. Ephemerides are given for all orbits with complete elements, as are plots including all associated data in the Washington Double Star (WDS) database. Examples of these figures are shown below. Notes are given for many systems, and a subset of orbits potentially useful for scale calibration is also presented.

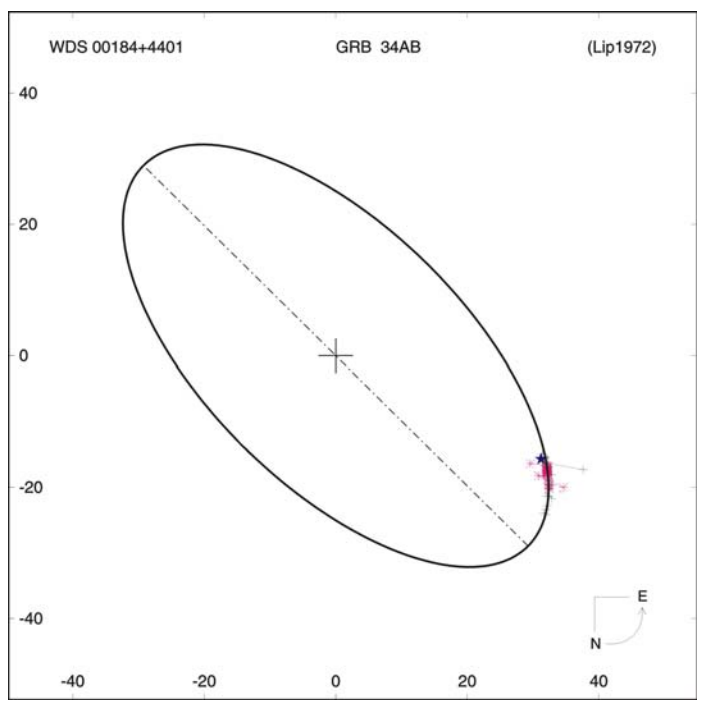

Figure 3: *The "Grade 5" indeterminate orbit for GRB 34. While residuals are small, and the ephemeris quite accurate for many years to come, the orbital coverage is slight and calculated astrophysical parameters would have large errors.*

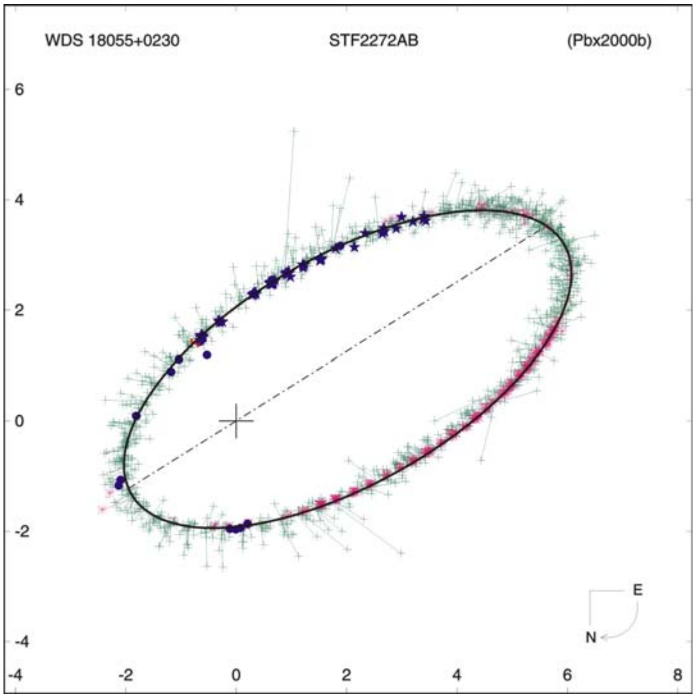

***Figure 4**: The "Grade 1" (definitive) orbit for STF2272AB. Small residuals and excellent orbital coverage makes this among the best. The submotion seen in STF2272AS (see Figure 8) is due to the approximate 88 year orbit of this pair.*

Fourth Catalog of Interferometric Measurements of Binary Stars

The Fourth Catalog of Interferometric Measurements of Binary Stars includes 104,618 published measures of binary and multiple star systems obtained by high-resolution techniques (speckle interferometry, photoelectric occultation timings, etc.), as well

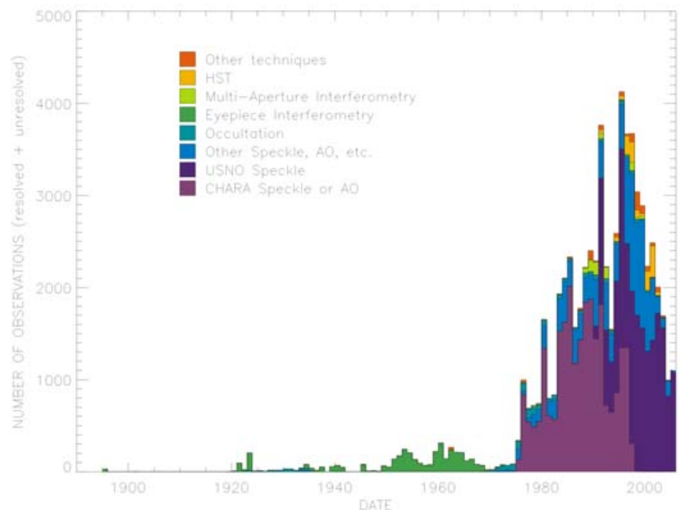

***Figure 5**: Distribution of measures with time. Barely visible are the 1895 observations of Schwarzschild & Villiger, followed two decades later by the 1919-1921 data obtained using the famous 20-foot beam interferometer with the Mount Wilson 100-inch Hooker Telescope by Anderson and Merrill.*

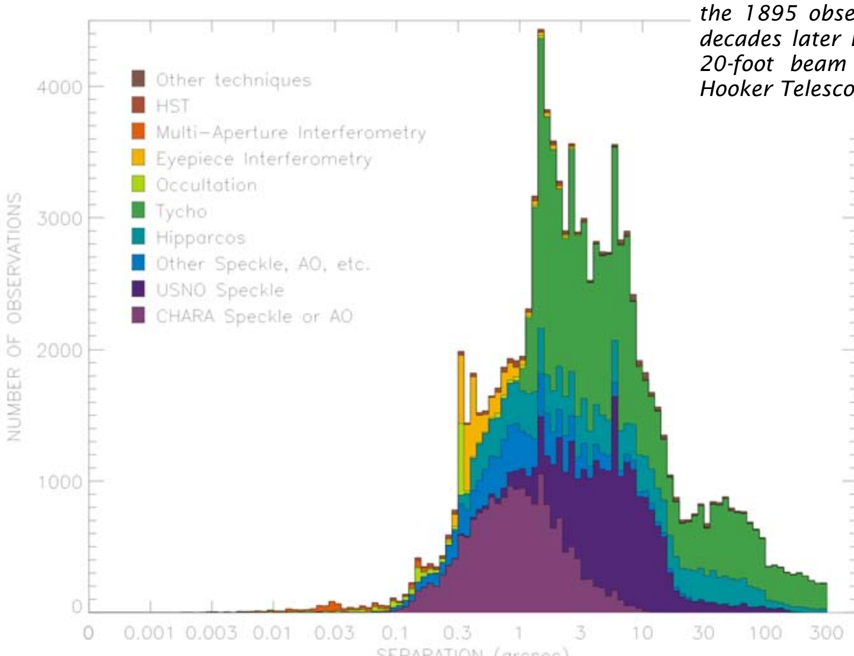

***Figure 6**: Distribution of measures with separation, from the closest measures by long-baseline interferometry to the widest Tycho pairs..*

as 30,956 negative examinations for duplicity.

Second Photometric Magnitude Difference Catalog

The Second Photometric Magnitude Difference Catalog is a collection of magnitude difference measures for double stars and serves as a repository for double star observations where no astrometry is given. It is ten times larger than the First Catalog and consists of 209,365 measures of 63,643 systems with a mean Delta-m of 1.49. The most significant addition since the last version of this catalog is due to matching the WDS with the 2MASS catalog. Delta-m determinations in J, H, and K bands are now listed for the 42,009 systems matched with WDS pairs. A brief summary and statistical analysis of the contents of the catalog are presented.

Catalog of Rectilinear Elements of Visual Double Stars

This is new on the Second Double Star CD. Many systems in the Washington Double Star Catalog have shown significant relative motion since their discovery. The Catalog of Rectilinear Elements provides linear fits for those systems whose motion does not appear to be Keplerian. While a few of these may in fact be very long-period physical pairs whose orbital motion is not yet apparent, most are probably optical pairs (i.e., chance alignments of unrelated stars). These linear fits, then, just describe the relative proper motions between these pairs of stars.

The purposes of this catalog are threefold. First, the very well-defined motions of some of these systems means they may prove useful for scale calibration for imaging systems such as CCDs or photographic cameras. Also, these differential proper motions may allow us to improve upon proper motions of individual

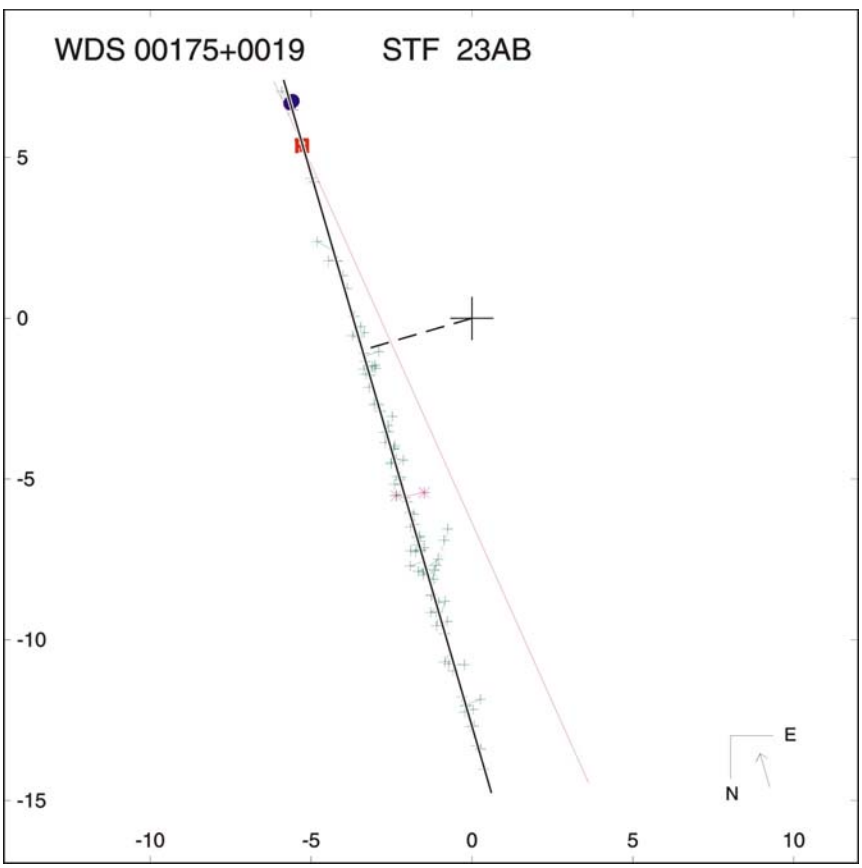

Figure 7: *STF 23, whose 170+ years' worth of data illustrate a clear deviation from the published relative proper motion (red line). For this class of objects, the long timebase of double star measures may yield better proper motions than traditional techniques.*

The US Naval Observatory Double Star CD, 2006.5

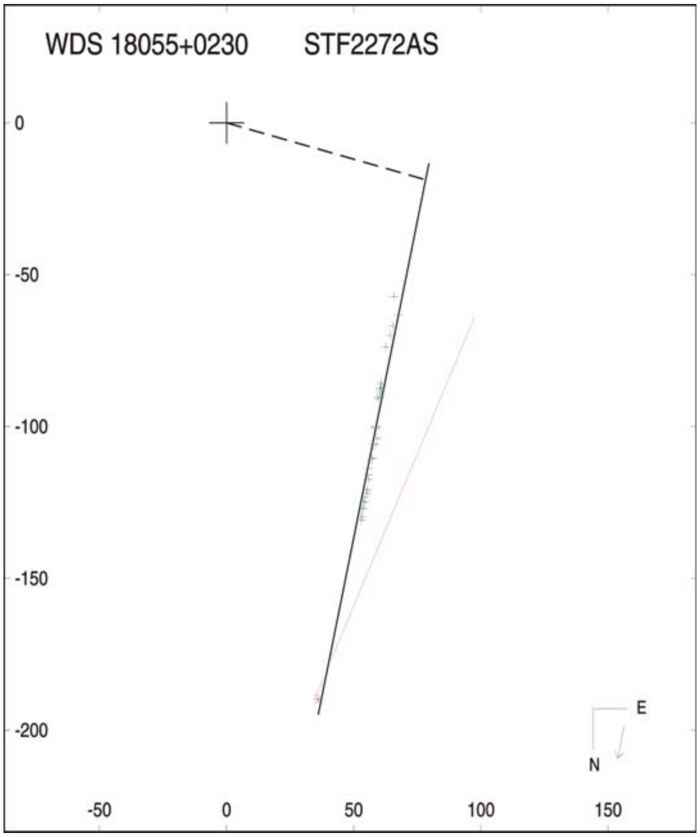

Figure 8: STF2272AS, a distant pair exhibiting a "wobble" in its motion due to the orbit of a closer pair.

components. Finally, these linear fits, especially in comparison with Hipparcos proper motions, may be useful in searches for submotions due to closer components. These investigations are underway.

As shown in Figure 8, Fourier analysis of residuals to linear fits may indicate the presence of unseen companions as well.

Double Star Astronomy at the US Naval Observatory

The U.S. Naval Observatory has, for well over a hundred years, been involved in various programs related to the observation of double stars. Highlights of these efforts, using the three observing techniques of visual filar micrometry, photography, and speckle interferometry, are given, along with many historic photographs, some of which are shown below.

How do I get one?

Copies of the US Naval Observatory Double Star CD, 2006.5 are available. Simply fill out the web form at http://ad.usno.navy.mil/wds/cd_request.html.

Figure 9: The 26" in 1911.

The US Naval Observatory Double Star CD, 2006.5

Figure 10: *Ejnar Hertzsprung visiting the USNO, seen with Scientific Director, Kaj Strand.*

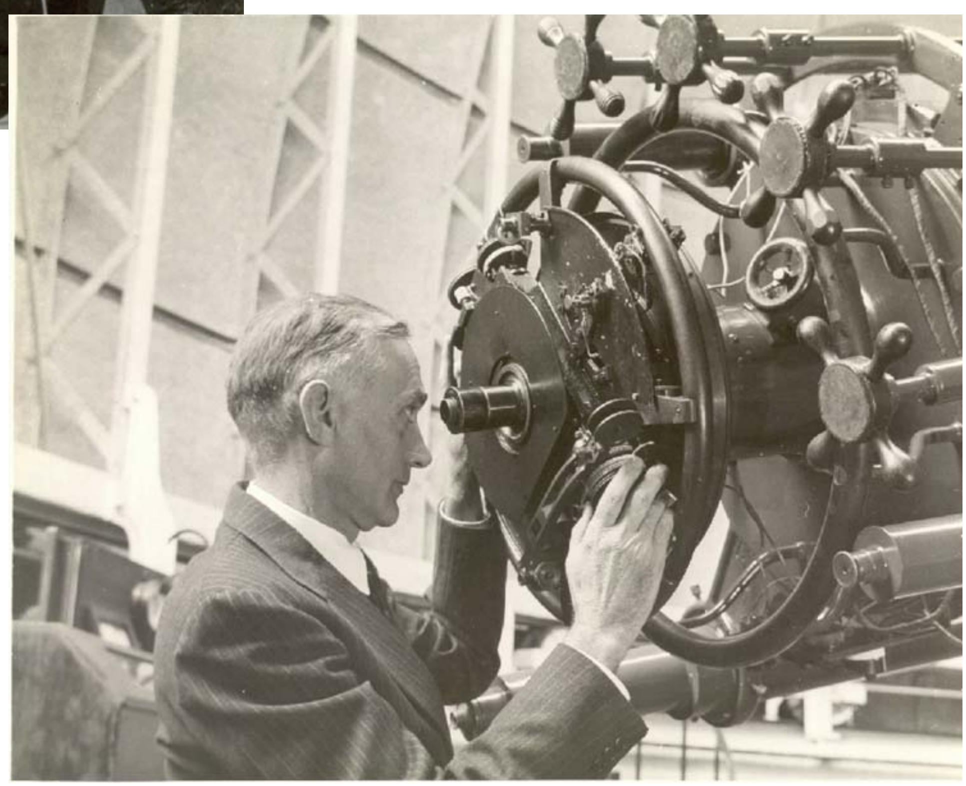

Figure 11: *U.S. Lyons with a micrometer on the 26".*

BOOK REVIEW

Observing and Measuring Visual Double Stars

Bob Argyle, ed. New York: Springer, 2004. Paperback. 326 pages + cd-rom. $39.95 (paper) ISBN 1-85233-558-0.

This book contains 25 chapters of material written by editor Bob Argyle and ten other contributors from the field of double star astronomy. An effort is made to present the subject in such a way that both novices and "seasoned veterans" will find information that can be of great value. In the process, a comprehensive review of the aspects of observing and measuring visual double stars is presented.

At the basic level, the book discusses the nature and different types of double stars, and why they should be observed. Optical concepts, and the advantages and disadvantages of different types of telescopes for doing double star work, are also explored. Chapters are also included on the use of binoculars and binary star formation.

Chapters in the book of a more advanced nature include discussions of the orbital elements of a visual binary star and how orbits are computed. Various measuring techniques are also covered, such as the use of different types of micrometers, the CCD camera, and speckle interferometry.

The last section of the book highlights what amateurs can contribute to this field, and lists some useful formulae, star atlases, software, and catalogues. The final chapter discusses how to publish the results of one's work.

A CD-ROM is also included that I have utilized on many occasions. Some of the resources on the CD-ROM include the *Washington Double Star Catalog*, the *Fourth Catalog of Interferometric Measurement of Binary Stars*, the *Sixth Catalog of Orbits of Visual Binary Stars*, the *Tycho-2 Catalog*, and the *WDS Photoelectric Difference Magnitude Catalog*. There is also a software section that allows for the instant computation of such parameters as precession, combined magnitudes of component stars, position angle and separation from inputted orbital elements, and micrometer calibration.

In summary, I will state that some parts of this book may seem too advanced for those who are just starting out as double star researchers, and the more advanced researcher may find some of the early chapters to be rather elementary. However, I believe that anyone who is seriously interested in the study of visual double stars would want to add this book to his or her library. Personally, I have utilized this book as a reference on several occasions over the past 3 years.

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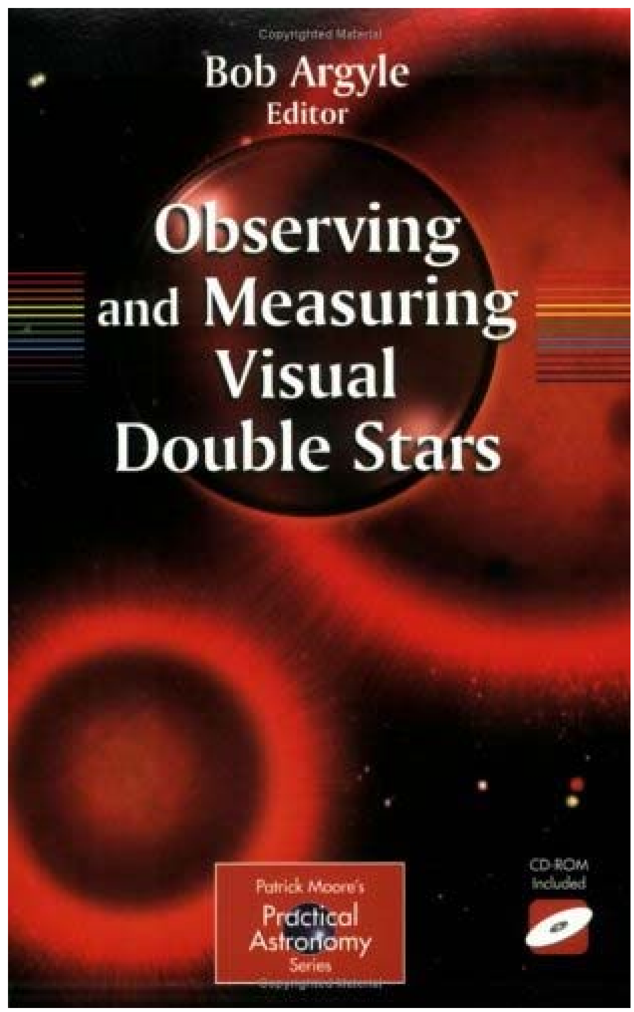
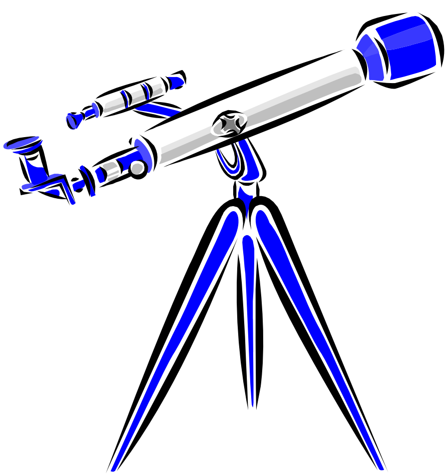


Journal of Double Star Observations

Fall 2006
Volume 2, Number 4

The *Journal of Double Star Observations* is an electronic journal published quarterly by the University of South Alabama. Copies can be freely downloaded from http://www.jdso.org.

Questions, comments, or submissions may be directed to rkentclark@jaguar1.usouthal.edu or to rmollise@bellsouth.net



The *Journal of Double Star Observations* (*JDSO*) publishes articles on any and all aspects of astronomy involving double and binary stars. The *JDSO* is especially interested in observations made by amateur astronomers. Submitted articles announcing measurements, discoveries, or conclusions about double or binary stars may undergo a peer review. This means that a paper submitted by an amateur astronomer will be reviewed by other amateur astronomers doing similar work.

Not all articles will undergo a peer-review. Articles that are of more general interest but that have little new scientific content such as articles generally describing double stars, observing sessions, star parties, etc. will not be refereed.

Submitted manuscripts must be original, unpublished material and written in English. They should contain an abstract and a short description or biography (2 or 3 sentences) of the author(s). For more information about format of submitted articles, please see our web site at www.jdso.org

Submissions should be made electronically via e-mail to rclark@jaguar1.usouthal.edu or to rmollise@bellsouth.net. Articles should be attached to the email in Microsoft Word, Word Perfect, Open Office, or text format. All images should be in jpg or fits format.

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