Neglected Double Star Observations Conducted at Kitt Peak Advanced Observer Program

Frank Smith

20 Coburn Way
Jaffrey, NH 03452

E-mail: fhasmith@myfairpoint.net

Abstract: I report 76 measures of double stars (27 of them "neglected" doubles) found between 2219.0 and 2221.1 RA and +51 to +60 DEC. The observations were conducted with a 20in f/8.4 Ritchey-Chretien reflector. Eight new doubles found in the same CCD field as a neglected double are reported. The observing run was conducted at the National Optical Observatory at Kitt Peak Visitor's Center Advanced Observer Program. Information about instrumentation, methodology, results and notes is included.

Introduction and Instrumentation

For some time I had been interested in using the Advanced Observer Program (AOP) [noao.edu] run by the Visitors Center of the National Optical Observatory located at Kitt Peak, Arizona to measure neglected double stars. To that end, I reserved two nights, September 30th and October 1st, 2008 for my observing run. The first night was rained out.

The Kitt Peak AOP has equipment not usually available to amateurs. The telescope used for the observations was a RC Optical Systems 20in f/8.4 Ritchey-Chretien carbon truss reflector on a Paramount ME German equatorial mount. The CCD camera was a SBIG STL-6303E non-ABG. No filter was used. This instrumentation gave an effective focal length of 4,103 mm and a field of view of 22 X 15 arcminutes and a plate scale of 0.45 arcseconds/pixel. Telescope control and CCD imaging were managed by MaximDL software.

I was assisted by AOP guides who operated the telescope and the CCD imaging software during most of the duration of my observing run. For the safety of the equipment, the guides retain primary control of the telescope.

The combination of the location on Kitt Peak, the 20 in telescope and the wide CCD field of the camera made for a productive session. Nearly every CCD image of a neglected double included several other Washington Double Star Catalog (WDS) doubles.

Methods

The target list of neglected doubles was provided by Dr. Brian Mason of the U.S. Naval Observatory (USNO).

As a "sanity" check, the imaging session started with several doubles that had recent high quality measures [Daley, 2006]. A quick review of the data obtained at the start of the observing session indicated excellent agreement with the published measures.

An unguided CCD exposure of 10 seconds gave good S/N and little trailing. For each neglected double the telescope was slewed to reported position and between three and seven images of the star field were taken. This procedure was repeated until dawn. Twenty-two star fields were imaged, resulting in more than 75 doubles being available for measurement. The total observing run produced almost 2 GB of data.

Back at home, each CCD image was examined and any sub-par image was discarded. Any image that the plate reduction software could not reach a plate solution was also excluded. MOP Canopus [Warner, 2006] was the primary measurement and plate solution software. Canopus produces a plate solution and raw instrumental magnitudes based on its internal catalogs (USNO-V2.0 and Tycho 2 datasets)[Monet, 1998, Schwekendiek, 2000]. All the CCD images were copied to archival CD-ROM disks and are available from the author by request. The first and last CCD image from each star field were blinked to determine

if they held anything else of interest (asteroids, etc). Nothing of note was found.

Results

Table 1 shows the results from the double stars measured. It includes the WDS designation, discoverer, WDS magnitudes, arithmetic means of the measured separations and position angles, the epoch, number of measures, standard deviations of the measurements, the date of previous measures, number of previous measures and a reference note number if applicable.

In the notes and tables I report the RA and DEC and raw instrumental magnitudes of some stars. Neither the positions nor magnitudes should be considered precision astrometry or photometry. The Canopus software attempts to derive a useful estimate of star image magnitudes by comparing the CCD images to its internal catalogs. Correlation between the computed raw instrumental values and catalog values was usually within .5 magnitude. Of course, the raw instrumental values and the catalogs have numerous systematic errors.

I report the raw instrumental magnitudes of some new, and faint secondaries of known doubles. It has long been known that when doubles are about the same magnitude, they are generally of the same color. With doubles of unequal brightness, color differences increase [Aitken, 1935]. Therefore, the reported raw instrumental magnitudes of those faint companions are likely to be even less accurate.

Stein double stars were originally measured on blue sensitive photographic plates. It is not uncommon for the primary and secondary to be reversed in CCD and visual observations [Daley, 2006]. I report several of those here.

New Doubles

Table 2 lists eight new doubles discovered during the observing run. All the new doubles reported here are in the same CCD field as a known neglected double. The author is well aware that the WDS catalog is not in need of additional doubles. However, it seemed wasteful not to measure the new doubles when high quality data was available

The CCD images taken with the 20in from Kitt Peak easily reach 17.5 magnitude and show dozens, if not scores, of close and faint doubles. The criteria used to select the reported eight new doubles included magnitude and separation. All new doubles are in the same 10-13 magnitude range of the neglected doubles that were the reason for the CCD image and have separations of 10 arcseconds or less. As an example, Figure 1 shows one of the new doubles, listed as double number 1 in Table 2. Probability theory indicates that the eight new doubles are likely to be physical systems [Romero, 2007]. The pairs should be easy CCD targets for future measurements. The USNO team can add the new doubles to the WDS catalog --- or not, at their discretion.

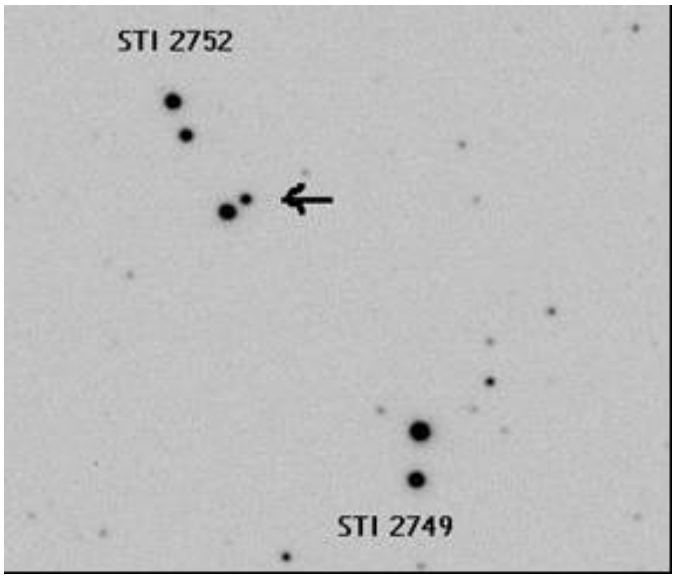

Figure 1: New double in the same CCD field as two WDS binaries.

Acknowledgments

Thanks to Dr. Brian Mason of the USNO for encouragement and for observing lists. Special thanks to Jim Daley for allowing me to sit in on one of his double star measuring sessions and for providing me with his expert advice. Thanks also to telescope operators/ guides Kevin Bays and Roy Lorenz of the Kitt Peak Advanced Observers Program, who took a personal interest in my attempt to do some science.

References

Aitken, R.G. "The Binary Stars", Dover Publications, New York 1963, pg 16.

Daley, J. "Notes on the Double Stars of Father John W. Stein", JDSO 2:134:137.

Daley, J. "Double Star measures for 2006", JDSO 3:68-76.

(Continued on page 140)

Neglected Double Star Observations Conducted at Kitt Peak Advanced Observer Program

Table 1: Summary data for doubles measured at Kitt Peak AOP are reported. WDS ID and Discovr. are Washington Double Star Catalog identifiers and discoverer codes. PAsd and SEPsd refer to standard deviations of the respective angle (PA) and separation (SEP) based on (No.) of CCD images measured followed by date of last measure, total number of previous measures, and the number of associated note.

WDS ID	Discovr.	WDS mags	PA	SEP	Epoch	No.	PAsd	SEPsd	Last	Prev.	Notes
22019+5506	ABH 157AD	11.1, 14.2	269.6	11.70	2008.75	3	0.11	0.012	1987	1	
22019+5506	ABH 157AG	11.1, 14.3	348.2	38.72	2008.75	3	0.04	0.067	1999	2	
22019+5506	ABH 157AL	11.1, 15.7	146.5	66.35	2008.75	3	0.03	0.072	1999	2	
22019+5506	ABH 157AI	11.1, 14.6	280.7	30.88	2008.75	3	0.03	0.059	1999	2	
22019+5506	ABH 157AH	11.3, 14.3	321.8	32.74	2008.75	3	0.1	0.071	1999	2	
22019+5506	ABH 157AF	11.1, 14.7	95.4	14.62	2008.75	3	0.16	0.014	1999	2	
22019+5506	ABH 157AK	11.1, 13.9	225.9	40.78	2008.75	3	0.04	0.050	1999	2	
22019+5506	ABH 157AJ	11.1, 13.9	239.0	47.88	2008.75	3	0.06	0.031	1999	2	
22019+5506	ABH 157AM	11.1, 15.2	282.3	68.57	2008.75	3	0.04	0.054	1999	2	
22019+5506	ABH 157AE	11.1, 12.6	144.6	31.03	2008.75	3	0.04	0.025	1999	3	
22019+5506	HJ 1718AB	10.4, 11.3	219.0	9.33	2008.75	3	0.11	0.054	1999	5	
22019+5506	HJ 1718BC	11.3, 12.4	301.0	12.65	2008.75	3	0.05	0.038	1999	4	
22019+5506	HJ 1718AC	10.4, 12.4	267.7	16.72	2008.75	3	0.17	0.009	1999	3	
	HJ 1718B-D		83.3	5.05	2008.75	3	0.48	0.025	New		1
22029+5512	STI2608	12.7, 12.7	41.3	7.20	2008.75	3	0.08	0.012	2006	2	2
22158+5519	STI2668	11.2, 11.8	211.9	15.30	2008.75	7	0.14	0.039	1999	4	
22161+5453	STI2673	12.1, 12.4	199.1	7.98	2008.75	5	0.31	0.038	1999	3	
22164+5454	STI2675	13.1, 13.1	339.7	3.89	2008.75	5	0.61	0.037	1917	1	3
22164+5525	STI2674	13.1, 13.1	141.9	4.87	2008.75	7	0.27	0.024	1999	2	
22170+5515	STI2677	13.1, 13.1	76.2	10.82	2008.75	7	0.08	0.013	1999	2	
22170+5526	STI2678	11.3, 13.1	284.0	14.52	2008.75	7	0.08	0.031	1999	2	
22177+5444	STI2681	12.5, 12.5	104.8	7.79	2008.75	5	0.17	0.026	1917	1	4
22178+5452	STI2685	13.1, 13.1	61.6	8.44	2008.75	5	0.1	0.056	1917	1	5
22182+5523	STI2686	12.5, 13.1	130.2	1.11	2008.75	7	1.94	0.066	1917	1	
22185+5525	STI2688	13.1, 13.1	4.2	8.24	2008.75	7	0.12	0.010	1917	1	6
22185+5526	STI2687	9.5, 12.2	139.6	11.83	2008.75	7	0.19	0.043	2000	4	
22187+5521	STI2691	11.6, 13.1	168.5	4.17	2008.75	7	0.45	0.014	2000	2	
	A 1461AG		304.7	2.96	2008.75	6	2.95	0.397	New		7
22191+5607	HJ 1751AC	10.2, 10.5	267.7	16.72	2008.75	3	0.17	0.009	1999	9	
22191+5607	HJ 1751AD	10.3, 13.6	75.9	24.81	2008.75	7	0.11	0.079	2000	6	
22191+5607	HJ 1751CF	11.0, 13.0	32.6	8.74	2008.75	7	0.29	0.029	1987	2	
22191+5607	HJ 1751DF	13.6, 13.0	250.8	10.03	2008.75	7	0.17	0.037	2000	2	
22191+5607	HJ 1751AE	10.3, 13.6	27.1	25.60	2008.75	7	0.16	0.053	2000	4	
22192+5603	STI2696	12.4, 12.8	267.8	5.67	2008.75	6	0.2	0.034	2000	3	
22192+5605	STI2697	12.1, 13.1	354.2	7.74	2008.75	7	0.22	0.015	2000	2	
22200+5115	HU 980	8.5, 14.1	40.7	0.92	2008.75	7	5.11	0.216	1945	3	

Table continues on next page.

Neglected Double Star Observations Conducted at Kitt Peak Advanced Observer Program

Table 1 (continued): Summary data for doubles measured at Kitt Peak AOP ...

WDS ID	Discovr.	WDS mags	PA	SEP	Epoch	No.	PAsd	SEPsd	Last	Prev.	Notes
22200+5603	STI2706	13.2, 13.8	80.4	13.56	2008.75	7	0.23	0.046	1917	1	8
22203+5607	STI2708	9.8, 13.0	253.4	9.84	2008.75	7	0.23	0.046	1917	3	
22207+5606	STI2711	12.5, 13.1	91.2	12.39	2008.75	7	0.1	0.031	1917	1	
22213+5109	VBS 36AC	11.0, 11.4	103.0	47.02	2008.75	7	0.1	0.058	1998	3	
22213+5109	VBS 36AB	11.1, 12.5	8.0	12.19	2008.75	7	0.08	0.042	1998	2	
22217+5112	HJ 1757	10, 12							1828	1	9
22223+5657	STI2730	13.4, 13.4	155.3	6.71	2008.75	7	0.26	0.035	1917	1	
22237+5514	STI2744	12.1, 12.5	207.0	15.26	2008.75	7	0.12	0.022	2000	2	10
22239+5739	STI2749	11.4, 11.6	178.7	10.11	2008.75	7	3.7	2.762	2000	3	
22240+5740	STI2752	12.5, 13.1	22.9	8.31	2008.75	6	0.24	0.063	1920	1	11
22241+5523	STI2750	12.5, 13.1	175.5	4.04	2008.75	7	0.48	0.035	1917	1	
22247+5516	STI2759	12.5, 13.1	43.4	11.49	2008.75	7	0.25	0.044	2000	2	
22248+5518	STI2761	13.1, 13.1	2.1	11.77	2008.75	7	0.01	0.027	1917	1	
22249+5738	STI2762	11.1, 12.1	187.2	3.10	2008.75	6	1.31	0.282	2003	2	
22279+5600	STI2786AB	12.5, 13.1	48.8	18.90	2008.75	7	0.06	0.029	1917	1	
	STI2786AC		187.0	4.07	2008.75	7	0.32	0.123	New		12
	STI2786AD		96.9	6.55	2008.75	7	0.17	0.035	New		12
22282+5603	STI2790	11.6, 12.6	13.3	5.95	2008.75	7	0.13	0.037	1999	3	
22353+6025	STI1114	12.4, 12.4	35.1	14.64	2008.75	7	0.05	0.046	1907	1	
22388+5244	SMA 176AB	11.0, 12.0	19.0	17.26	2008.75	6	0.15	0.033	1911	1	
	SMA 176AC		295.0	7.17	2008.75	4	0.4	0.050	New		13
	SMA 176BD		110.7	6.83	2008.75	4	0.5	0.042	New		13
22395+5236	SMA 177AB	11.0, 12.0	76.1	10.88	2008.75	6	0.21	0.038	1911	1	
22410+5541	STI2841	14.1, 14.1	59.8	12.27	2008.75	7	0.12	0.047	1917	1	
22421+5445	ES 1027AB	10.0, 13.0	226.9	5.71	2008.75	7	0.75	0.115	1910	1	
22421+5445	ES 1027AC	9.0, N/A	170.3	8.29	2008.75	7	0.44	0.030	1910	1	14
22427+5446	STI2846	13.2, 14.7	23.6	15.83	2008.75	7	0.09	0.044	1917	1	
22437+5451	ES 1029	9.5, 14.2	86.6	5.83	2008.75	7	0.6	0.245	1910	1	
22469+5637	STI2857	11.1, 12.6	156.6	7.77	2008.75	7	0.43	0.039	1917	1	
22482+5704	STI2861	12.6, 12.6	162.3	6.66	2008.75	6	0.76	0.048	2000	2	
	STI2865AC		332.7	10.15	2008.75	5	0.36	0.044	New		15
22496+5656	STI2865AB	12.0, 12.6	23.0	8.67	2008.75	6	0.51	0.047	1917	1	
22501+5621	STI2869	9.0, 12.6	250.4	13.98	2008.75	7	0.29	0.062	2000	2	
22503+5652	STI2871	11.3, 11.7	9.0	4.42	2008.75	5	0.19	0.030	2003	3	
22514+5619	STI2876	12.6, 12.6	59.0	12.38	2008.75	7	0.39	0.087	1917	1	
22519+5620	STI2877AB	12.6, 12.6	28.7	11.96	2008.75	7	0.35	0.089	2000	2	
22519+5620	STI2877BC	12.6, 12.6	83.8	3.74	2008.75	7	0.73	0.155	2000	2	
22538+5459	STI2895	12.2, 12.6	137.6	12.28	2008.75	7	0.23	0.035	1917	1	
22543+5747	STI2897	12.3, 12.3	163.4	14.08	2008.75	6	0.13	0.073	1904	1	

Neglected Double Star Observations Conducted at Kitt Peak Advanced Observer Program

Table 1 Notes:

1. The HJ 1718AB and ABH 157 group appear in the CCD images to perhaps be a coarse open cluster. It looks as if there are two actual doubles: HJ 1718AB and the pair no one measured until now, HJ1718BD. See Figure 2.
2. STI 2608. Check star. J. Daley reported PA 40.6 and SEP 7.23 on 2006.860. *JDSO* **3**:75
3. STI 2675 "A" is USNO 2150/29353.
4. STI 2681. CCD image shows "A" and "B" reversed. Raw instrumental mags; A 13.77, B 12.69.
5. STI 2685. Listed position in WDS appears to be USNO 2150/35297, which is not a member of the pair. STI 2685 "B" is USNO 2150/35139, catalog position 22:17:52.75 + 54:51:50.0. Canopus plate solution gives "A" at 22:17:52.36 +54:51:47.6, "B"at 22:17:53.16 +54:51:51.2
6. STI 2688. Listed position in WDS appears to be USNO 2006/23241, catalog position 22:18:22.18 +55:25:39.0, which is not a member of the pair. Canopus plate solution gives "A" at 22:18:31.5 +55:24:38.5. "B" at 22:18:31.0 +55:24:46.6.
7. A1461. AB pair was too close to measure. "A" has a 13.88 (raw instrumental magnitude) companion measured here. See Figure 3.
8. STI 2706. "A" and "B" reversed in CCD image. "A" is USNO 2007/160, catalog mag 14.66, "B" is USNO 2007/251, catalog mag 11.69.
9. HJ 1757. Not found at listed position. No obvious candidates near that location. In the CCD image, there are a number of nearby doubles, but none are even close to the reported PA and SEP.
10. STI 2744. "A" and "B" reversed in CCD image. "A" is USNO 2007/12060, catalog mag 13.35. Canopus reports "B" raw instrumental mag 12.26.
11. STI 2752. "A" and "B" reversed in CCD image. "B" is USNO 2007/13317 catalog mag 11.41. Canopus give "A" raw instrumental mag 12.11.
12. STI 2786. CCD image shows "A" has two companions "C" and "D". Raw instrumental mags are 16.29 and 16.44 respectively. See Figure 4.
13. SMA 176. "A" is USNO 2152/29837. Both "A" and "B" components have companions. "C" and "D" have raw instrumental mags of 16.40 and 16.13 respectively. See Figure 5.
14. ES1027 AC. "C" magnitude is not listed in WDS. Canopus gives raw instrumental magnitude of 14.93
15. STI 2865 "B" has companion "C" . Canopus gives raw instrumental mag of 14.73. See Figure 6.

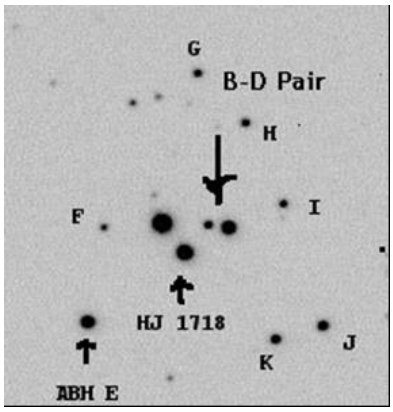

Figure 2: HJ 1718AB and BD pair. ABH157 E through K also marked.

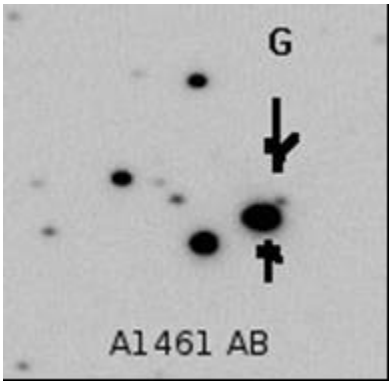

Figure 3: A1461AB appears elongated. Image shows new companion "G"

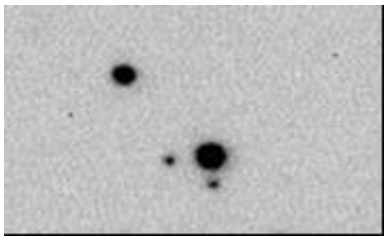

Figure 4: STI 2786 with new measured companions "C" and "D".

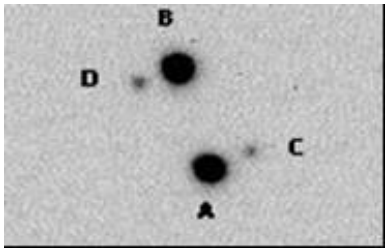

Figure 5: SMA 176 with new companions "C" and "D"

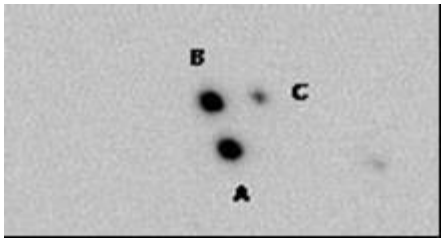

Figure 6: STI 2865 with new companion "C"

Neglected Double Star Observations Conducted at Kitt Peak Advanced Observer Program

Table 2: Summary data for new doubles discovered are reported. Data marked with asterisks (*) is the arithmetic mean of the measures supplied by Canopus' plate solution and photometry routines. The magnitudes are the raw instrumental measures taken with a clear filter. The data reported should NOT be considered precision astrometry or photometry. PAsd and SEPsd refer the the standard deviations of the results based on the number (No.) of images measured. USNO 2.0 catalog numbers are given for the primary.

Name	RA (P)*	DEC (P)*	USNO-2.0	Ins. Mag S, P *	PA	SEP	Epoch	No.	PAsd	SEPsd
7	22:22:17.50	56:53:14.60	1425-13286071	12.4, 12.2	76.0	5.12	2008.75	7	0.25	0.04
1	22:23:59.69	57:40:48.30	1425-13336933	12.3, 10.7	306.2	4.99	2008.75	7	0.31	0.04
2	22:24:51.97	57:38:10.50	1425-13368133	13.4, 12.0	188.6	2.70	2008.75	7	1.09	0.18
4	22:27:01.77	56:05:08.30	1425-13438519	13.2, 11.0	116.8	7.61	2008.75	7	0.08	0.02
3	22:40:11.76	52:34:11.60	1425-13846340	12.6, 11.2	306.6	9.37	2008.75	7	0.24	0.06
5	22:46:49.50	56:33:42.00	1425-14048943	11.5, 10.6	198.4	2.72	2008.75	5	1.10	0.13
8	22:50:11.97	56:25:06.20	1425-14149016	11.4, 11.2	126.8	2.86	2008.75	6	1.12	0.13
6AB	22:51:54.39	54:56:46.50	1425-14198161	13.6, 11.0	351.0	11.74	2008.75	7	0.30	0.06
6AC	22:52:16.70	54:59:34.70		13.6, 9.6	260.5	9.12	2008.75	7	0.67	0.06

(Continued from page 136)

Kitt Peak National Optical Observatory Visitors Center Advanced Observer Program. (http://www.noao.edu/outreach/aop/)

Mason, B.D. 2006. Requested double star data from the U.S. Naval observatory, JDSO. 2:21-35.

Monet, D. G., et al. 1998, USNO-A2.0 (Washington: US Nav. Obs.).

Romero, F.R. "Determination of the Nature of Visual Double Stars Using Probability Theory", JDSO, 3:21-26.

Schwekendiek,P. and A. Wicenec, 2000, "The Tycho-2 Catalog of the 2.5 Million brightest Stars", Astron. Astrophys, 355, L27-L30.

The author is a retired Federal Civil Service employee who enjoys learning about double stars, hiking, snow shoeing and target shooting. He resides in southern New Hampshire with his wonderful wife Luann, who tolerates him being lost in space most of the time.