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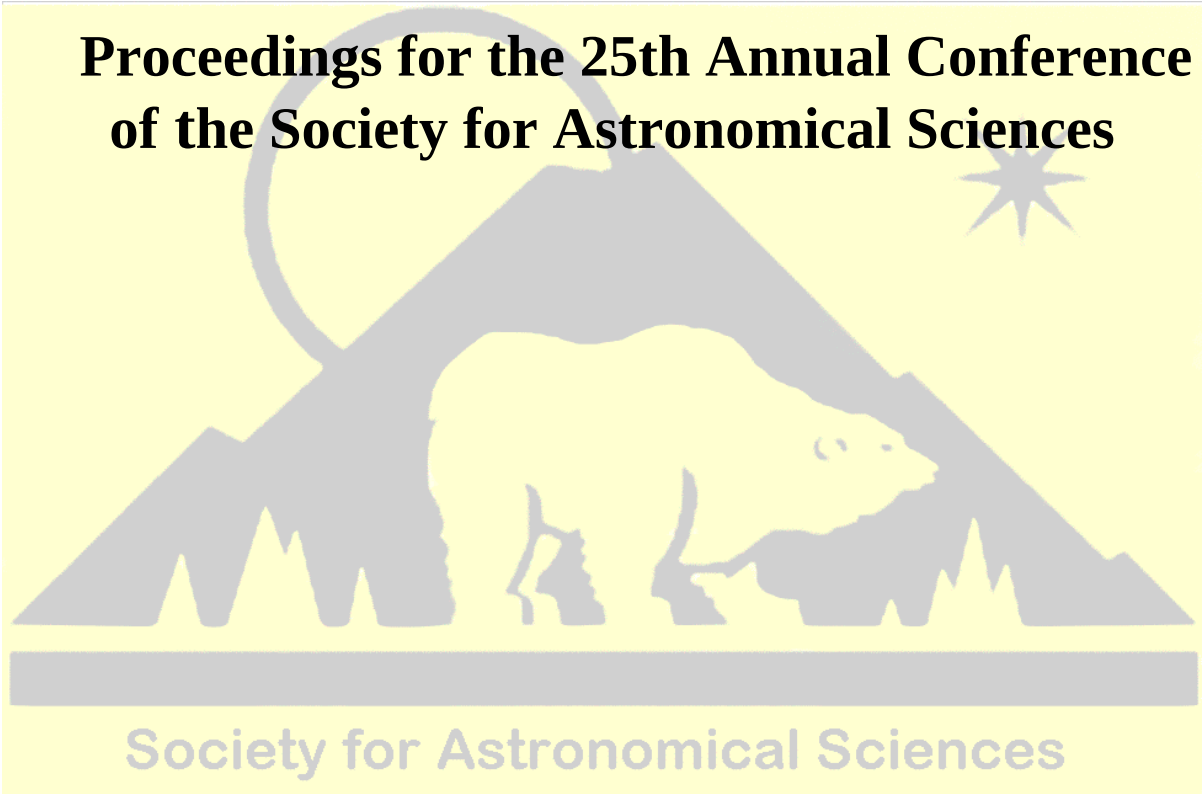

Symposium on Telescope Science

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Observing Visual Double Stars with a CCD Camera at the Palmer Divide Observatory

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Abstract

One of the more frustrating times for observing is when the moon is near full, when the rising chorus of our natural satellite drowns out the diminutive voices of faint asteroids. This doesn't mean that telescopes and cameras must sit idle during this time, allowing valuable photons to hit the ground. There are many other targets available even during full moon. Among these are visual double stars, which – with the aid of an automated telescope/camera – can be quickly measured and so add valuable observations that can be used to compute binary star orbits.

1. Introduction

Observing visual double stars with a CCD camera is a relatively easy way to get involved in scientific research. While many doubles are not true binary stars, many are. By measuring the distance and position angle of the secondary star with reference to the primary, it is possible to determine the orbit of the binary star. Once the orbit is known, then the masses of the two stars can be determined. Combined with spectroscopy or multi-color photometry, the data can be combined to determine a wealth of important astrophysical information.

2. Equipment and Software Requirements

Relatively simple and inexpensive equipment is required to observe double stars with a CCD camera.

2. 1. Telescope

Almost any telescope will do. Since the majority of stars being observed can be captured in 2-60 seconds, a high precision mount is not required but, obviously, is preferred.

2. 2. CCD Camera

Almost any camera that, combined with the telescope, gives a good pixel scale will do. Double stars have separations from <1 arcsecond to >200 arcseconds, so the pixel scale will determine which pairs you can work with sufficient precision and accuracy.

2. 3. Software

Any software that can perform accurate astrometry will do. It's better to work with derived astrometric positions than attempt to convert X/Y coordinates. Use the UCAC2 catalog exclusively when possible to get the most accurate astrometric positions. Some software packages, e.g., MPO Canopus, have special features specifically designed to store and generate reports of double star observations. Many observers record the derived positions in a spreadsheet and let the spreadsheet perform the calculations and generate a page that can be easily exported for publication.

3. Getting Started

The best place to start is with the Washington Double Star Catalog (WDS). The latest version is available on-line at

http://ad.usno.navy.mil/wds/wds.html

This web site includes not only the full catalog but also a selected list of "neglected" double stars, those that have not been measured for many years.

There is also an excellent Yahoo News Group for double star observers at

http://groups.yahoo.com/group/
binary-stars-uncensored/

This group is monitored by Brian Mason, one of the principals at USNO in charge of the WDS.

4. Taking Images

The exposure time you'll use depends on the brightness of the stars in the pair and whether or not you're using filters. Take at least three or four images of the pair (per filter if using filters). Measure each image once and find the mean and standard deviation for the combined data set.

4. 1. Short versus Long Exposures

To avoid apparent overlapping of stars, some observers use very short exposures of <1s. While this can appear to avoid overlapping, it also reduces the signal-to-noise (SNR) of the stars and the number of pixels involved for each star. This can lead to less precise astrometric solutions.

"Long" exposures, 2-20s depending on whether or not filters are used and the desired limiting magnitude, give a higher SNR. However, for very bright and close stars, the two images will overlap, making accurate astrometry difficult if not impossible without sophisticated techniques.

You'll need to experiment to see what works best for your system and observing goals.

4. 2. Filters

If at all possible you should use at least two filters and reduce the raw instrumental magnitudes to standard magnitudes. The additional information of standard magnitudes and one or more color indices is very valuable and takes only a little extra time and effort to determine.

5. The Measure of Double Stars

Double stars are measured in terms of the distance and position angle of the secondary from the primary. The primary is usually the brighter star. The position angle is measured from North (0°), to East (90°), and so on. The distance is measured in arcseconds.

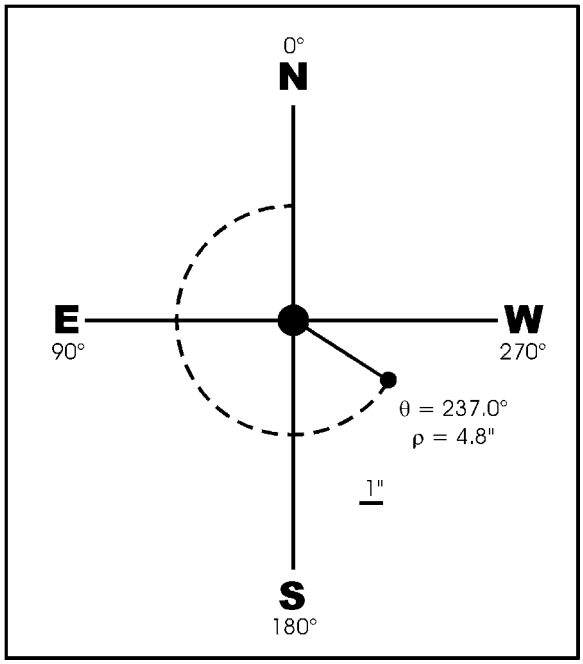


Figure 1. Measuring the distance and position angle of a double star.

To avoid problems with field rotation and pole precession, measurements are best determined by measuring the Right Ascension and Declination of the two stars in a standard epoch, e.g., J2000, with the UCAC2 catalog and then computing the distance and position angle from

$$\rho = \sqrt{(\alpha_b - \alpha_a)^2 \cos(\delta_a) + (\delta_b - \delta_a)^2}$$

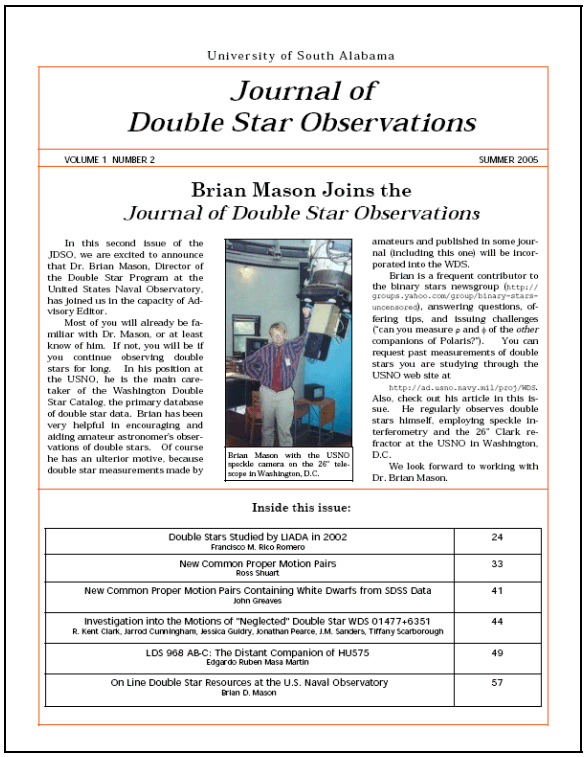
$$\theta = \tan^{-1}\left(\frac{\delta_b - \delta_a}{(\alpha_b - \alpha_a)\cos(\delta_a)}\right)$$

Where α_a / δ_a RA / Dec of the primary
α_b / δ_b RA / Dec of the secondary

6. Publishing Your Observations

You need to publish your observations if they are to be of any use. There are several possibilities. Two of the most prominent are:

6. 1. Journal of Double Star Observations



University of South Alabama

Journal of Double Star Observations

VOLUME 1 NUMBER 2 SUMMER 2005

Brian Mason Joins the *Journal of Double Star Observations*

In this second issue of the JDSO, we are excited to announce that Dr. Brian Mason, Director of the Double Star Program at the United States Naval Observatory, has joined us in the capacity of Advisory Editor.

Most of you will already be familiar with Dr. Mason, or at least know of him. If not, you will be if you continue observing double stars for long. In his position at the USNO, he is the main caretaker of the Washington Double Star Catalog, the primary database of double star data. Brian has been very helpful in encouraging and aiding amateur astronomer's observations of double stars. Of course he has an ulterior motive, because double star measurements made by amateurs and published in some journal (including this one) will be incorporated into the WDS.

Brian Mason with the USNO speckle camera on the 26" telescope in Washington, D.C.

Brian is a frequent contributor to the binary stars newsgroup (http://groups.yahoo.com/group/binary-stars-uncensored), answering questions, offering tips, and issuing challenges ("can you measure ρ and ϕ of the *other* companions of Polaris?"). You can request past measurements of double stars you are studying through the USNO web site at http://ad.usno.navy.mil/proj/WDS. Also, check out his article in this issue. He regularly observes double stars himself, employing speckle interferometry and the 26" Clark refractor at the USNO in Washington, D.C.

We look forward to working with Dr. Brian Mason.

Inside this issue:

This journal can be downloaded free off the Internet by visiting http://www.jdso.org/

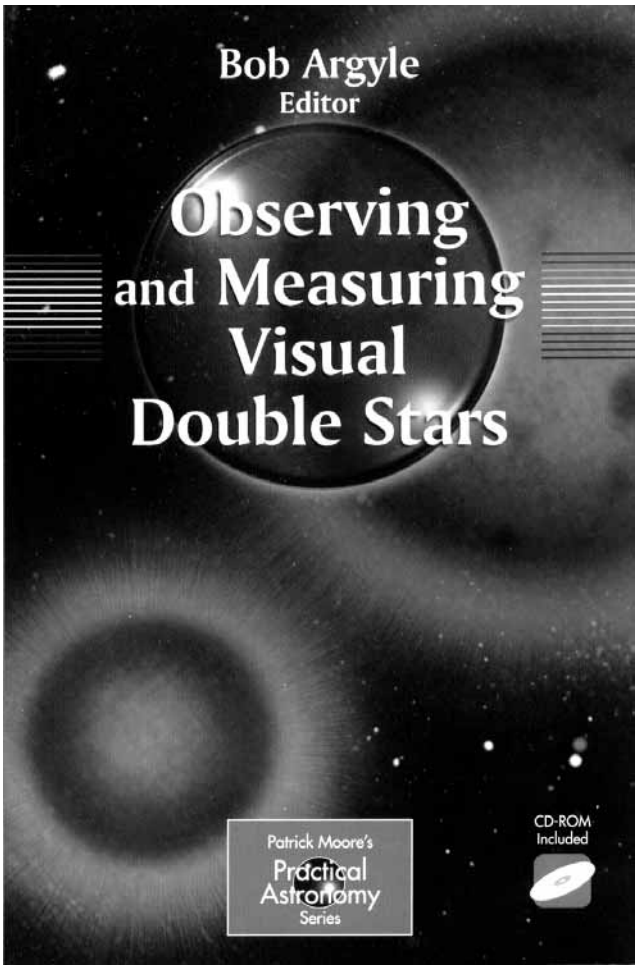
6. 2. The Webb Society Double Star Circulars

This is one of the journals published by the Webb Society. Visit:

http://www.webbsociety.freeserve.co.uk/notes/doublest01.html

Contact the editors for these journals to get information on submission requirements.

7. Additional Reading



Bob Argyle's "Observing and Measuring Visual Double Stars" is a must read. Argyle is the head of the Double Stars Section of the Webb Society.

Sample Data for Publication

Table 1. Clear Filter Observations

Name	Comp	RA	Dec	Mags	PA	Dist	Epoch	N	Obs	Psd	Dsd	Mpsd	Mssd
SCA 26		0400.0	+2122	9.1,11.5	59.2	31.19	2006.115	3	BW	0.06	0.030	0.01	0.01
SCA 27		0400.2	+2127	10.9,11.4	118.2	17.32	2006.115	3	BW	0.07	0.028	0.01	0.00
PLQ 47		0400.8	+0838	8.2,8.8	150.3	39.52	2006.115	3	BW	0.03	0.014	0.00	0.01
STF 487	AB	0400.9	–1027	8.8,9.1	9.4	11.55	2006.115	3	BW	0.14	0.074	0.01	0.01
STF 487	AC	0400.9	–1027	8.8,9.7	229.2	20.21	2006.115	3	BW	0.25	0.092	0.01	0.00
STF 487	BC	0400.9	–1027	9.1,9.7	215.0	30.04	2006.115	3	BW	0.13	0.017	0.02	0.00
SCA 28		0401.8	+2140	7.7,11.4	155.7	28.04	2006.115	3	BW	0.30	0.077	0.01	0.01
POU 355		0402.5	+2353	12.1,12.9	92.8	18.26	2006.115	3	BW	0.13	0.075	0.02	0.02
POU 357		0402.9	+2405	10.7,11.9	101.6	12.20	2006.115	3	BW	0.21	0.018	0.00	0.01
POU 364		0403.8	+2402	12.3,12.9	217.6	17.71	2006.115	3	BW	0.11	0.103	0.01	0.01
POU 366		0403.8	+2509	11.8,13.6	111.7	15.25	2006.115	3	BW	0.23	0.181	0.00	0.01
GRV 201		0403.9	+2447	10.5,10.9	29.2	37.50	2006.115	3	BW	0.04	0.045	0.00	0.01
HJ 2223		0407.9	+0119	10.4,11.2	199.9	18.50	2006.115	3	BW	0.15	0.047	0.01	0.01
ST 499	AC	0410.1	+2407	8.8,10.4	280.6	30.18	2006.115	3	BW	0.08	0.058	0.00	0.01
AG 78		0410.4	+3618	9.4,10.0	198.1	18.01	2006.115	6	BW	0.09	0.024	0.01	0.01
STF 502	AB	0411.2	+2630	8.0,9.6	246.2	16.60	2006.115	3	BW	0.50	0.108	0.01	0.01
STF 502	BC	0411.2	+2630	9.6,9.6	303.7	10.75	2006.115	3	BW	0.73	0.212	0.01	0.00
CHE 76		0412.8	+1614	11.4,12.0	272.5	28.75	2006.115	3	BW	0.06	0.072	0.01	0.01
SEI 37		0413.5	+3201	10.8,12.0	120.3	25.67	2006.115	3	BW	0.15	0.021	0.00	0.02
GRV 208		0414.5	+2852	10.4,11.0	196.2	22.84	2006.115	3	BW	0.05	0.035	0.00	0.01

Table 2. V and R Observations

Name	Comp	RA	Dec	Mags	PA	Dist	Epoch 2000+	N	n	Obs	V-Rp	V-Rs	PAsd	Dsd	Mpsd	Mssd
HLD 14	AC	1300.8	+0252	9.5,11.6	100.6	49.86	6.138	8	4	BW	0.337	0.329	0.06	0.089	0.01	0.01
HLD 14	AC	1300.8	+0252	9.2,11.2	100.6	49.86	6.138	8	4	BW	0.337	0.329	0.06	0.089	0.01	0.03
STF 1705		1300.8	+1423	8.9,9.9	187.8	26.77	6.138	8	4	BW	0.360	0.458	0.05	0.047	0.01	0.00
STF 1705		1300.8	+1423	8.5,9.5	187.8	26.77	6.138	8	4	BW	0.360	0.458	0.05	0.047	0.00	0.01
GRV 860		1300.9	+2135	12.5,12.6	231.7	30.40	6.138	8	4	BW	0.480	0.417	0.19	0.085	0.03	0.01
GRV 860		1300.9	+2135	12.0,12.2	231.7	30.40	6.138	8	4	BW	0.480	0.417	0.19	0.085	0.02	0.02
STF 1708		1302.1	+0717	9.0,10.1	294.1	10.53	6.138	6	2	BW	0.351	0.321	0.27	0.320	0.02	0.05
STF 1708		1302.1	+0717	8.6,9.8	294.1	10.53	6.138	6	4	BW	0.351	0.321	0.27	0.320	0.05	0.03
HJ 2632		1302.9	+4643	9.7,13.5	336.4	44.59	6.138	8	4	BW	0.275	0.772	0.09	0.077	0.01	0.05
HJ 2632		1302.9	+4643	9.4,12.7	336.4	44.59	6.138	8	4	BW	0.275	0.772	0.09	0.077	0.01	0.03
POU 3132		1303.1	+2412	13.6,14.1	291.5	10.88	6.138	8	4	BW	0.468	0.484	0.69	0.196	0.03	0.03
POU 3132		1303.1	+2412	13.1,13.6	291.5	10.88	6.138	8	4	BW	0.468	0.484	0.69	0.196	0.03	0.04

It's important to include error estimates whenever possible. This allows those computing orbits to give proper weight to your data.