Data Mining the MOTESS-GNAT Surveys as a Source of Double Star Observations

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Abstract: New measurements of eleven double stars selected from the Washington Double Star Catalog are presented. The measurements were made using archival images that formed the basis of the MOTESS-GNAT variable star catalog. In addition to these new observations, this work demonstrates that the MOTESS images are a viable source for double star measurement.

Introduction

The Moving Object and Transient Event Search System (MOTESS) is a three telescope, scan-mode, CCD imaging survey of the region around the celestial equator [1]. The MOTESS surveys provided time series imaging over durations of around two-three years at fixed declinations. The Global Network of Astronomical Telescopes (GNAT) has processed MOTESS images to create the MOTESS-GNAT (MG) variable star catalogs [2].

We selected and analyzed data from eleven double stars with the goal of determining whether the MOTESS images could be productively utilized to measure position angles and separations in order to better define the orbits of these systems. In this process we established constraints on such use of the MOTESS images.

The process was initiated when we accumulated Washington Double Star Catalog (WDS) data for double star candidates located in the MOTESS images. For each given star, a series of measurements that included the position angle, separation, magnitude of the primary and secondary star, Right Ascension, and the Declination coordinates were obtained from the WDS catalog.

Observations/ Source Data

Historical observations of the double stars were taken from the WDS: the first and most recent observation dates. For our purposes, we preferred the gap between the first and last observation date to be at least 40 years in hopes of easily detecting relative motions between the double stars.

More recent observational data were derived from raw MOTESS images, as obtained from a set of 14-inch aperture telescopes. The MOTESS images used for the MG surveys were unfiltered. The images from the CCD camera measure 1024 x 1128 pixels with a field of view of 48 arc minutes at a fixed declination of +03 18’. This produces an image scale of about 2.8 arc seconds per pixel.

The images of each double star selected from the MOTESS/GNAT System had to meet a range of requirements in order to be measurable. The software we used to help sort the images was the Vizier tool in the Simbad catalog. We set the range of magnitude for each of our candidates to be between 12th and 18th magnitude. We adopted a bright limit of 12th magnitude because we believed any star with a brighter magnitude would be saturated in the images. Likewise, we adopted a faint limit of 18th magnitude because we found that any star with a fainter magnitude would be difficult to locate against background stars.

After experimenting with a number of possible candidates, we also set limits on the separation of the double stars. We concluded that stars with separations less than 25 arc seconds were too close to measure, causing the images to easily merge, especially if both were bright. We set the upper limit of separation at 100 arc seconds, because locating the secondary star at a great distance, especially in crowded fields, was very difficult.

After setting these requirements, we narrowed down the list of possible candidates to 20 double stars. We then used the program Aladin to produce finding charts for each double star. After using these criteria, we were able to narrow the list down to 13 candidate double stars.

Data Reduction

The first step in the process was to plate solve each image file using the PinPoint astrometric software (DC-3 Dreams, Mesa, Arizona). After plate solving each image for the desired night, World Coordinate System parameters were written to the FITS image header. This allowed us to examine the images in PinPoint, while simultaneously returning a display of the equatorial coordinates of the cursor. This made location of the double star of interest relatively easy. Upon viewing each image, the usability of the image was determined by whether or not the stars were on edges of the frames or disrupted by light from a nearby bright source, such as a bright star or scattered moonlight. This resulted in deleting two stars from our candidate list, leaving 11 stars in our project.

MPO Canopus (Palmer Divide Observatory, Colorado Springs, CO) was then used to measure position angle and separation for both the primary and secondary stars of the double star pair. Measurements were made using six images obtained on three successive nights. For each star, the measurements were averaged and the standard deviation around the mean was calculated.

Results

Results of our measurements are shown in Table 1. A comparison of these observations with the historical data for each star is shown in Table 2.

Table 1. Observed Separation and Position Angles for the Target Stars.

WDS Name / Disc. Code	RA+DEC	MAGS (P,S)	PA (°)	SEP (")	DATE	N	NOTES
04463+0329 / LDS3617	044621+0329	15.9, 16.4	281.3	72.1	2002.862	6	1,2
05164+0321 / GWP 664	051625+0321	14.3, 14.6	115.8	89.9	2002.848	6	1,3
05297+0338 / GWP 683	052943+0337	14, 15.8	178.2	94.9	2002.848	6	1,4
08024+0320 / LDS5160	080223+0320	13.5, 18.3	223.1	49.3	2002.862	6	1,5
11275+0340 / SLE 601	112728+0440	12.18, 13.2	10.0	31.49	2003.01	6	1,6
13468+0255 / LDS5794	134644+0254	12.3, 17.4	157.64	42.4	2002.342	6	1,7
15259+0340 / UC 3002	152551+0339	12.7, 16.2	35.9	23.7	2002.346	6	1,8
16216+0255 / FMR 125	162128+0254	13.7, 16.7	134.0	34.0	2002.39	6	1,9
18270+0258 / LDS5864	182707+0258	14.6, 16	43.5	67.8	2003.42	6	1,10
22284+0305 / LDS4970	222820+0304	15.4, 16.1	244.9	26.1	2002.71	6	1,11
23258+0305 / LDS6032	232551+0304	16.98, 16.92	177.1	71.4	2002.86	6	1,12

Table 1 Notes:

1. All magnitudes in this table are extracted from the WDS Catalog.
2. Std Dev (PA)= 0.29; Std Dev (Sep)= 0.72
3. Std Dev (PA)= 0.14; Std Dev (Sep)= 0.22
4. Std Dev (PA)= 0.18; Std Dev (Sep)= 0.48
5. Std Dev (PA)= 0.22; Std Dev (Sep)= 0.16
6. Std Dev (PA)= 0.49; Std Dev (Sep)= 0.33
7. Std Dev (PA)= 0.66; Std Dev (Sep)= 0.49
8. Std Dev (PA)= 0.75; Std Dev (Sep)= 0.38
9. Std Dev (PA)= 0.25; Std Dev (Sep)= 0.70
10. Std Dev (PA)= 0.43; Std Dev (Sep)= 0.62
11. Std Dev (PA)= 0.41; Std Dev (Sep)= 0.13
12. Std Dev (PA)= 0.10; Std Dev (Sep)= 0.31

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Table 2. Trends of position angle and separation.

RA+Dec	Year 1	PA	Sep	Year 2	PA 2	Sep 2	Year 3	PA 3	Sep 3
044621+0329	1960	283	77	2000	281	72.5	2002[1]	281.29	72.12
051625+0321	1954	116	89.9	2002[1]	115.8	89.94	2010	115	89.7
052943+0337	1954	178	94.2	2002[1]	178.18	95.39	2010	178	94.3
080223+0320	1949	223	49	1960	223	49	2002[1]	223.08	49.33
112728+0440	1955	9	30.5	2002	13	31.3	2003[1]	10.04	31.49
134644+0254	1960	176	72	2000	177	71.9	2002[1]	177.71	71.42
152551+0339	1955	36	24.7	2002[1]	36.11	23.92	2010	36	24.9
162128+0254	1951	246	25.6	2000	245	26	2002[1]	244.91	26.11
182707+0258	1960	153	42	2000	156	43.1	2003[1]	157.64	42.43
222820+0304	1960	49	73	2000	43	66.2	2002[1]	43.5	67.8
232551+0304	1999	136	32.1	2000	136	32.1	2002[1]	134.03	33.99

1. Original observation from Table 1.

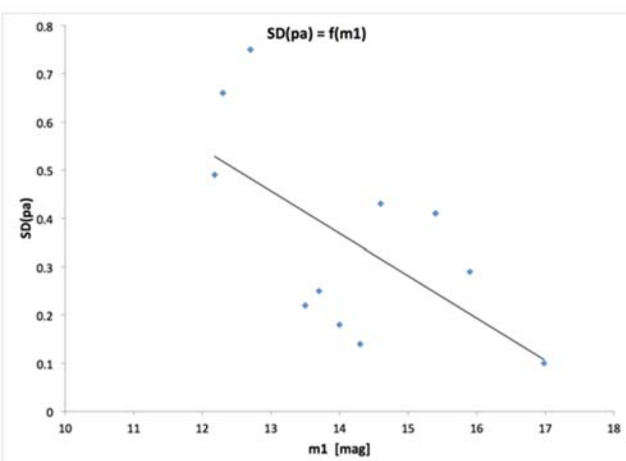

Figure 1. This is a plot of standard deviation about the mean position angle as a function of the brightness of the primary star. The straight line is a least squares linear regression fit.

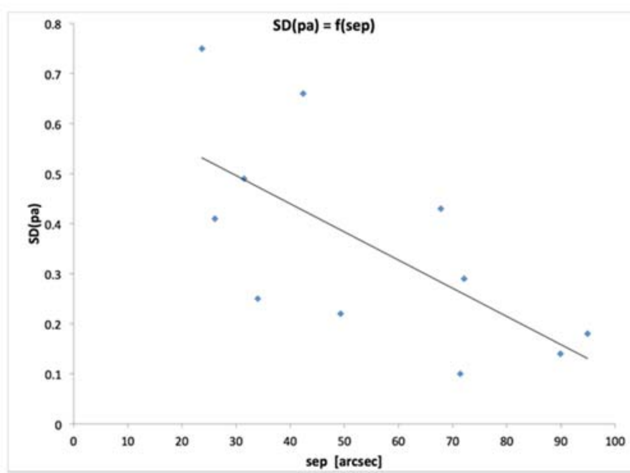

Figure 2. This is a plot of standard deviation about the mean position angle as a function of the separation of the components of the double stars. The straight line is a least squares linear regression fit.

Analysis

In order to gain empirical insight on the origins of the errors and position angles, we examined correlations of standard deviation versus observational parameters that include magnitude and separation. We display in Figure 1 a plot of standard deviation of position angle versus magnitude (of the primary star) along with a least squares regression line. Though there is considerable scatter present, there is nevertheless a trend of decreasing error with the fainter magnitude of the primary.

Likewise, we show in Figure 2 the correlation between standard deviation of position angle as a function of separation in the system. As in Figure 1, scatter is present, though as confirmed by the regression line there is a trend of decreasing standard deviation with increasing separation between the stars.

Similar analysis of the standard deviation about the mean separation does not show similar dependencies.

Conclusions

The primary goal of the project was fulfilled in that we measured all 11 double stars successfully, thus adding additional points to better define the orbits of these systems.

We found that the MOTESS images could be used within the defined constraints. The precision of the position angle measures was found to be a function of the brightness of the primary star and the separations. References to Figures 1 and 2 could provide a useful tool for future MOTESS image users.

Since the double stars were observed in the MOTESS images, the source for the MOTESS-GNAT variable star catalog, we are able to report that none of the components of our double star cohort were detected as a variable star.

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