Comparison of the Astrometric Measurements of SHJ355 and STF3022 Obtained with Different Techniques and Software

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Abstract: Astrometric measurements of Sh355 and STF3022 are reported along with standard deviations. Evaluation on the alignment of the images with IRIS 5.59 (by Christian Buil) and comparison between the average data obtained and the data obtained from the image are also discussed. Comparison of results obtained through the use of IRIS 5.59 and REDUC 3.88 (by Florent Losse) is presented.

Description of the Stellar Systems Studied and Methods

Sh355 (WDS 23300+5833 SHJ355: J2000 RA 23h30m01.92s; DEC 58°32'56.1") is a nice multiple system in Cassiopeia, whose main component has a blue tint (B3IV). The system has 8 components, where pairs AB and CD are difficult and very unbalanced. Therefore, in this study, we analyzed the system for only the six visual components. F and G, again form a double star (HJ 1887) while component I, belongs to a system attributed to Burnham in 1906 (BU 1149).

In the same field of the CCD another system is visible: STF3022 (WDS 23309+5825STF3022: J2000 AR 23h30m52.02s; DEC 58°24'56.5"). This is actually a triple star.

The telescope used was a Newtonian SkyWatcher 200/1000 on a EQ6 SkyScan German equatorial mount. Attached to the telescope was a MAGZERO MZ-5m CCD camera and MPCC Baader Planetarium coma corrector .

In Figure 1, you can see the CCD field with the systems SHJ355 and STF3022.

Image Capture and Data Analysis

Two software packages, IRIS 5.59 and REDUC 3.88, were used to analyze the images to determine the precision and accuracy of both.

IRIS 5.59 (by Christian Buil), will perform an astrometric reduction of a CCD field (using GSC-ACT as a reference) and the software implements a useful function to correct optic distortions.

The positions of the stars in the GSC-ACT catalog, have a stated accuracy of 0.2" and therefore the goal is to stay in this range.

We did an astrometric measurement of 9 stars on 10 images, plus other 9 measurements on the mean image for a total of 99 measurements of coordinates. Table 1 shows the mean of the 10 astrometric measurements. Table 2 shows the measurements taken from the mean image.

As can be seen in Figure 2 and from a comparison with Table 1 and Table 2, the mean measurements have minimal differences, compared with direct measurements on the mean image.

We have, therefore, an error less than one tenth

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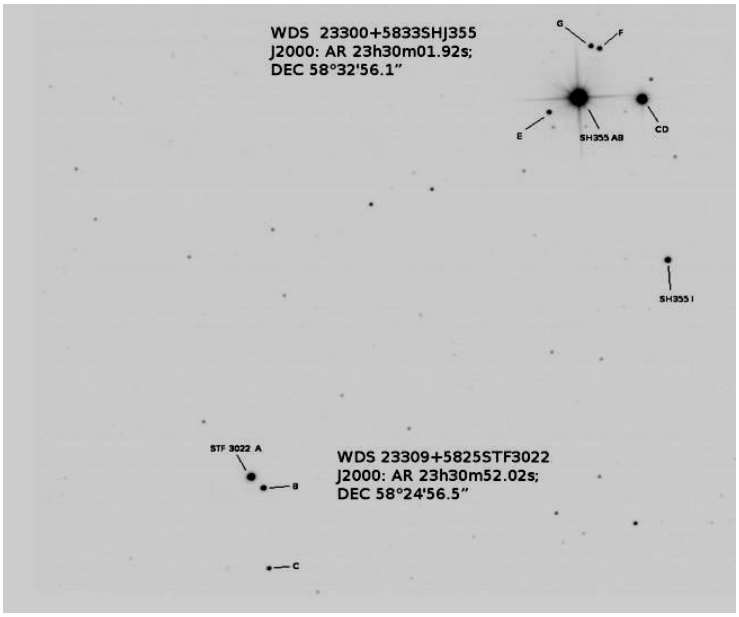

Figure 1: CCD field with the systems SHJ355 (upper right) and STF3022.

Table 1: Mean of 10 Astrometric Measurements Using IRIS 5.59

ID	RA	Dec
Sh355 Ab	23h 30m 02.073s	+58°32'56.67"
Sh355 Cd	23h 29m 52.354s	+58°32'54.72"
Sh355 E	23h 30m 06.601s	+58°32'38.37"
Sh355 F	23h 29m 58.849s	+58°33'58.84"
Sh355 G	23h 30m 00.167s	+58°34'01.92"
Sh355 I	23h 29m 48.461s	+58°29'31.27"
STF3022 A	23h 30m 52.134s	+58°24'57.01"
STF3022 B	23h 30m 50.243s	+58°24'42.96"
STF3022 C	23h 30m 49.371s	+58°23'01.41"

Table 2: Measurements on the mean image of the 10 images using IRIS 5.59

ID	RA	Dec
Sh355 Ab	23h 30m 02.073s	+58°32'56.64"
Sh355 Cd	23h 29m 52.359s	+58°32'54.75"
Sh355 E	23h 30m 06.598s	+58°32'38.33"
Sh355 F	23h 29m 58.854s	+58°33'58.84"
Sh355 G	23h 30m 00.169s	+58°34'01.86"
Sh355 I	23h 29m 48.478s	+58°29'31.29"
STF3022 A	23h 30m 52.136s	+58°24'56.99"
STF3022 B	23h 30m 50.245s	+58°24'42.94"
STF3022 C	23h 30m 49.376s	+58°23'01.35"

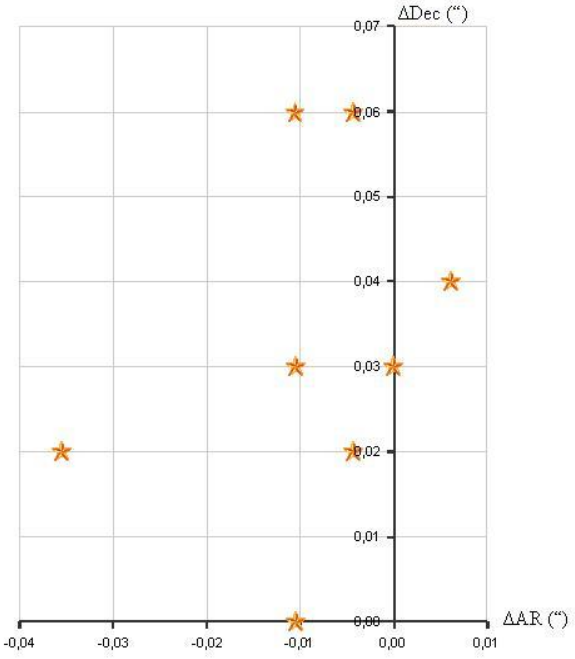

Figure 2: Difference Between the Data of Tables 1 and 2.

Table 3: Summary data on meaon of 10 measurements with the separation in arc seconds and the relative standard deviations.

Rho	SH355 CD	SH355 E	SH355 F	SH355 G	SH355 I
SH355 AB	76.088	39.881	67.091	66.937	231.422
SH355 CD		112.698	81.815	90.847	205.720
SH355 E			100.764	97.544	234.943
SH355 F				10.761	279.659
SH355 G					285.754
Rho	STF3022 B	STF3022 C			
STF3022 A	20.449	117.622			
STF3022 B		101.781			
Std. Dev. Rho	SH355 CD	SH355 E	SH355 F	SH355 G	SH355 I
SH355 AB	0.077	0.079	0.060	0.062	0.097
SH355 CD		0.082	0.089	0.080	0.091
SH355 E			0.047	0.041	0.070
SH355 F				0.034	0.045
SH355 G					0.060
Std. Dev. Rho	STF3022 B	STF3022 C			
STF3022 A	0.041	0.056			
STF3022 B		0.068			

Table 4: Summary data of the mean of 10 measurements of the postion angle and the relative standard deviations.

Theta	SH355 CD	SH355 E	SH355 F	SH355 G	SH355 I
SH355 AB	268.53	117.31	337.91	347.12	207.41
SH355 CD		98.34	38.41	42.30	188.52
SH355 E			322.98	328.92	217.19
SH355 F				73.33	196.89
SH355 G					198.69
Theta	STF3022 B	STF3022 C			
STF3022 A	226.60	190.64			
STF3022 B		183.86			
Std. Dev. Theta	SH355 CD	SH355 E	SH355 F	SH355 G	SH355 I
SH355 AB	0.04	0.12	0.07	0.09	0.02
SH355 CD		0.05	0.05	0.06	0.02
SH355 E			0.03	0.03	0.01
SH355 F				0.24	0.01
SH355 G					0.01
Std. Dev. Theta	STF3022 B	STF3022 C			
STF3022 A	0.09	0.06			
STF3022 B		0.05			

of an arc-second.

Table 3 shows the summary data of the mean of 10 measurements with the separation in arc-seconds and the relative standard deviations. In Table 4 is the summary data of the mean of 10 measurements of the position angle and the relative standard deviations. Analyzing the data, we found that the standard deviations of Theta, are more or less inversely proportional to Rho.

With IRIS, calibration and image orientation are obtained with trigonometry of two distant points of the mean image. The calibration data obtained are Sampling Σ=1.072572 a.s. / pixel and Orientation Δ=0.211°

With REDUC, instead, to make measurements you need to calibrate the image on a pair of stars with known measures to find the orientation and sampling.

Tables 5 and 6 show the data obtained with IRIS 5.59 and with REDUC 3.88.

In Figures 3 and 4, one can evaluate the performance of the two software packages. Figure 3 shows the values of position angle: theta values obtained with IRIS are shown in blue and theta values obtained with REDUC are shown in red.

Similarly, Figure 4 shows the values of separation in arc-seconds; yellow points are from IRIS and green points from REDUC.

From these two graphs, we note that the position angle values are similar. This is not the case for separation where the error increases with the absolute value of the measurement and the relative error, ΔRho / Rho, is around 1% for all data.

Comparison with the Official Data of Different Catalogs

The data obtained with IRIS and REDUC were compared with the most important catalogs. Table 7 shows the data from the Washington Double Star Catalog, UCAC3 (The third US Naval Observatory CCD Astrograph Catalog, 2009), and PPMXL (Catalog of Positions and Proper Motions on the ICRS, 2010).

Analyzing the data in Table 8, we can see that IRIS has a maximum relative error,

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Table 5: Data Obtained with IRIS 5.59

NAME	RA+DEC	MAGS	PA	ST. DEV. PA	SEP.	ST. DEV. SEP.	DATE	N	NOTES
SHJ 355AbCd	23300+5833	4.87 - 7.23	268.53	0.04	76.088	0.077	2010.772	1	1
SHJ 355AbE	23300+5833	4.87 - 11.28	117.31	0.12	39.881	0.079	2010.772	1	1
SHJ 355AbF	23300+5833	4.87 - 10.59	337.91	0.07	67.091	0.060	2010.772	1	1
SHJ 355AbG	23300+5833	4.87 - 11.11	347.12	0.09	66.937	0.062	2010.772	1	1
SHJ 355AbI	23300+5833	4.87 - 9.87	207.41	0.02	231.422	0.097	2010.772	1	1
SHJ 355FG	23300+5834	10.59 - 11.11	73.33	0.24	10.761	0.034	2010.772	1	1
STF3022AB	23309+5825	8.34 - 9.94	226.6	0.09	20.449	0.041	2010.772	1	1
STF3022AC	23309+5825	8.34 - 8.5	190.64	0.06	117.62	0.056	2010.772	1	1

Table 6: Data obtained with REDUC 3.88.

NAME	RA+DEC	MAGS	PA	DEV.ST.PA	SEP.	DEV.ST. SEP.	DATE	N	NOTES
SHJ 355AbCd	23300+5833	4.87 - 7.23	268.42	0.04	76.768	0.070	2010.772	1	1
SHJ 355AbE	23300+5833	4.87 - 11.28	117.15	0.26	40.308	0.158	2010.772	1	1
SHJ 355AbF	23300+5833	4.87 - 10.59	337.88	0.10	67.781	0.170	2010.772	1	1
SHJ 355AbG	23300+5833	4.87 - 11.11	347.08	0.06	67.666	0.082	2010.772	1	1
SHJ 355AbI	23300+5833	4.87 - 9.87	207.31	0.03	233.606	0.122	2010.772	1	1
SHJ 355FG	23300+5834	10.59 - 11.11	73.09	0.64	10.862	0.143	2010.772	1	1
STF3022AB	23309+5825	8.34 - 9.94	226.32	0.20	20.707	0.041	2010.772	1	1
STF3022AC	23309+5825	8.34 - 8.5	190.64	0.06	118.898	0.055	2010.772	1	1

Table 7: Data obtained with IRIS and REDUC compared with the most important catalogs.

	SHJ355 AC		SHJ 355 AE		SHJ355 FG		STF3022 AB		STF3022 AC	
	rho	theta	rho	theta	rho	theta	rho	theta	rho	theta
WDS	75.860	268.5	40.480	116.8	10.790	72.9	20.330	226.1	117.630	190.4
UCAC3 (2009)	75.615	268.76	40.582	116.6	10.718	73.24	20.410	226.26	117.705	190.48
PPMXL (2010)	75.655	268.74	40.580	116.7	10.787	72.91	20.451	226.33	117.807	190.49
mean IRIS	76.088	268.53	39.881	117.31	10.761	73.33	20.449	226.6	117.620	190.64
mean REDUC	76.768	268.42	40.308	117.15	10.862	73.09	20.707	226.32	118.898	190.64

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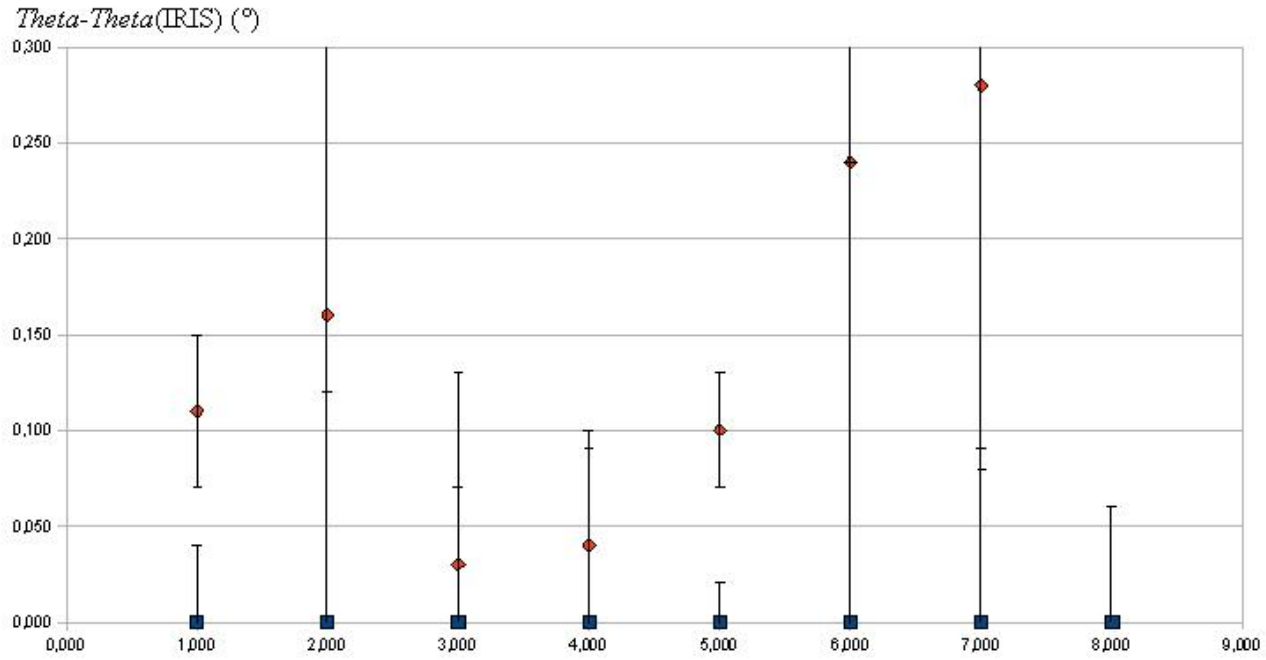

Figure 3: Comparison of the values of theta between IRIS and Reduc.

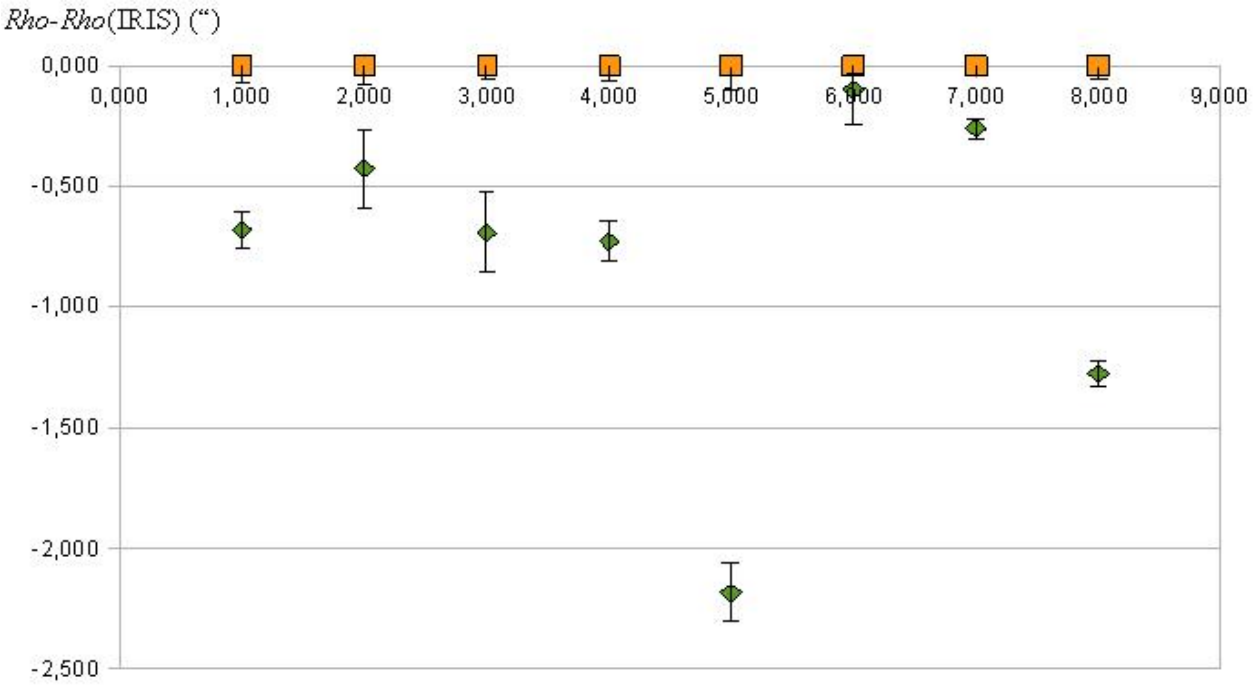

Figure 4: Comparison of the values of rho between IRIS and Reduc.

Table 8: margin of error expressed as % error.

	SHJ355 AC		SHJ 355 AE		SHJ355 FG		STF3022 AB		STF3022 AC			
	rho	theta	rho	theta	rho	theta	rho	theta	rho	theta		
Mean of UCAC3 & PPMXL data	75.635	268.750	40.581	116.650	10.753	73.075	20.431	226.295	117.756	190.485		
	e%	e%	e%	e%	e%	e%	e%	e%	e%	e%	mean e%	St. dev. e%
WDS	0.30	0.09	0.25	0.13	0.35	0.24	0.49	0.09	0.11	0.04	0.21	0.14
Mean IRIS	0.60	0.08	1.76	0.56	0.08	0.35	0.09	0.13	0.12	0.08	0.38	0.52
Mean REDUC	1.48	0.12	0.68	0.43	1.01	0.02	1.34	0.01	0.96	0.08	0.61	0.56

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while REDUC has the highest average error rate.

In both cases the data are certainly consistent with the Washington Double Star Catalog.

Conclusions

The two different methods software packages yielded values of Theta and Rho that were very similar. The separation (Rho) values had a relative error of 1%, while the position angle (Theta) values had a relative error around 0.2°.

IRIS and standard astrometric method should be more accurate when the double star is quite large, and a non-linear approximation of the entire star field is needed. For example, a coma corrector can cause distortion of the field, which IRIS can correct, as opposed to REDUC.

REDUC, for its simplicity, seems more appropriate for all other cases, when the component stars are close or very close. In these cases IRIS has some difficulty in managing the centroid and the error can be higher. REDUC should be a good choice when using small CCD too, when the field distortion can be ignored.

The performance of IRIS can be best with most recent star catalogs (UCAC3 or PPMXL).

References

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Aladin V.6.0: http://aladin.u-strasbg.fr/aladin.gml

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