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Speckle observations of double stars with PISCO at Pic du Midi: measurements in 1998.

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ABSTRACT

We present astrometric measurements of binary stars based on speckle observations of 164 independent sequences of observations ($\sim 10^4$ frames each) made with the PISCO speckle camera at Pic du Midi. They concern 147 objects whose duplicity was detected for 134 of them with a separation in the range 0.1-1.0". These objects were mainly selected among grade 3 orbits to improve the accuracy of their orbits and constrain their masses.

We discovered the binarity of 59 Aql with an angular separation of $0.09 \pm 0.01''$.

Subject headings: Methods: data analysis – Techniques: interferometric – Binaries: close

1. Introduction

The aim of our program is to observe all the short period orbital couples which are well suited to the telescope and the instrumentation we are using (magnitude, declination and angular separation) and which have an orbit of grade 3 (see Worley et al. (1983) for the definition of the *grade* of an orbit, which is an indication of the quality of this orbit) so that a limited number of observations may improve this orbit to grade 2. Using Hipparcos parallaxes, these orbits will then allow

a reasonably good determination of total system masses. This program has already provided a publication with measurements of 48 objects in 1995-97 and the revision of 8 orbits (Aristidi et al. 1999).

The observations were carried out in June and September 1998 with the PISCO¹ speckle camera (Prieur et al. 1994, 1998), developed by *Observatoire Midi-Pyrénées* and operated at

¹PISCO stands for "Pupil Interferometry Speckle camera and COronagraph".

the Cassegrain Focus of the 2-meter *Télescope Bernard Lyot* (TBL) of the Pic du Midi Observatory. It is a remotely controlled versatile instrument that can be configured in various observing modes during the observations (e.g., imaging and spectroscopic modes) which provides a powerful tool for investigating the field of close binary stars as already shown in previous publications (Carbillet et al. 1996; Aristidi et al. 1997b, 1999). An overall precision better than $0.01''$ can be reached under normal or good observing conditions with an observing sequence of ~ 5 minutes.

New orbits have been updated for some of the objects presented here (e.g., ADS 161, ADS 221, ADS 281, ADS 1097, ADS 1522, ADS 1762, ADS 2034, ADS 2236 and ADS 10140) and will be presented in a forthcoming paper (Scardia et al. 2000). We also plan to perform photometric measurements of these observational data and present them in another paper, with additional data concerning stars with composite spectrum (Prieur et al. 2000).

2. Observations

The measurements described in the following are related to two observing runs in 1998: on June 12th, August 27th, 30th, 31st, September 3rd and 5th. Seven more nights allocated to this program were completely spoiled because of bad weather. It was better than the previous runs: we could open the dome during 46% of the total allocated nights, whereas over the period 1993-1997 this rate was 33%, with more than one hundred allocated nights for PISCO (the average TBL rate is $\sim 50\%$).

The PISCO speckle camera was used in its full pupil imaging mode (Prieur et al. 1994, 1998). The atmospheric chromatic dispersion was corrected with real time computer-controlled Risley prisms, which provided a good correction with circular auto-correlation peaks (cf. section 3), except for a handful of objects due to a strong wind that caused an elongation of these peaks.

As a detector, we used the intensified CCD detector (Philips IP800T, hereafter called ICCD) of *Université de Nice* which is described in Aristidi et al. (1997b). It generates a video output at a rate of 50 frames/sec which is recorded on a SVHS video tape.

3. Data reduction

The procedure we used to extract the astrometry parameters of the double stars is based on the analysis of the mean auto-correlation function of short exposed frames.

The data recorded on video cassettes were digitized by an electronic "Full RIO" PCI board made by Ellips (Ellips/Rio 1999) at a rate of 50 frames/sec with a specially designed program controlling a video-cassette-recorder developed by JLP in C++. The digitized elementary frames were buffered into the memory of the PC (typically by sets of 200 frames) and processed to compute the mean auto-correlations and the mean cross-correlation between two elementary frames separated by about one second (i.e., larger than the coherence time).

Following Worden et al. (1977), we subtracted the mean cross-correlation to the mean auto-correlation, which removed the (possibly strong) background of the mean auto-correlation and allowed an easy display of the secondary peaks of the auto-correlation of the binary star.

The center of the auto-correlation peaks was accurately determined with a specially-designed interactive program written by JLP and described in Prieur et al. (2000). Alternatively, for the closest binaries, the astrometric measurements were done in the Fourier plane by fitting a cosine function with a program developed by EA and JLP.

The orientation of the frames was calibrated using the tracks of stars obtained by moving the telescope along the declination and right ascension axes. The estimated uncertainty was $\pm 0.35^\circ$, which has been taken into account for estimating the error of the position angle measurements displayed in Table 4.

The magnification scale was obtained by measuring a calibrating grid that can be placed at the entrance focal plane of the speckle camera. Using the value of 50.4 ± 0.1 m for the focal length of the TBL (determined by the Pic du Midi service of optics), we derived the values of respectively 0.0109 ± 0.0001 , 0.0258 ± 0.0001 and 0.1654 ± 0.0005 arc-sec/pixel for the three available magnifications obtained with a focal length of 10 mm, 20 mm and 50 mm for the imaging optics in our camera.

The validity of this calibration was checked

both internally by observing the same object with a different magnification (thus checking the ratio of the magnification scales) and externally with "astrometric standards" (cf. Prieur et al. (2000)).

4. Results and discussion

The astrometric measurements are displayed in Table 4. For each observing sequence, we give the name of the object (col. #1); the Focal Length (FL) in mm of the eyepiece used as imaging lens in the magnification wheel; the filter (col. #4) (as described in Table 2)²; the epoch (col. #5) in Besselian years; the FWHM seeing (col. #8) which was measured on the long integration obtained by adding all the elementary frames from that sequence; and the angular separation ρ in arc-seconds and the position angle θ in degrees.

The position angle of the companion θ (col. #6 of Table 4) was measured relative to the North and increasing in the direction of increasing right ascension on the auto-correlation function, which leaves a 180° ambiguity. In some cases, when the signal to noise ratio was good enough, the restricted triple-correlation technique described in Aristidi et al. (1997a) allowed us to remove this uncertainty and obtain absolute angle positions: this is noted with an asterisk in col. #8.

In the last column, we give some more information:

- (F) indicates that the measurement was done in the Fourier space by fitting a model to the fringes instead of measuring the position of the secondary peaks of the auto-correlation function. This was preferentially done for the closest binaries when the angular separation was less than $0.15''$ because it gives a better accuracy in this case.
- (F=) means that the two methods (Fourier and auto-correlation) gave exactly the same result.
- "Fuzzy", "faint contrast" are related to the secondary peaks of the auto-correlation function.
- "Artifacts close to the X axis": to mention the presence of some artifacts on the auto-correlation caused by the response of the ICCD to individual photons. In some cases the corresponding pattern was close to the secondary peaks of the binary and increased the measurement errors. When the artifacts were superimposed on these peaks (i.e. for $\theta \sim 100^\circ$ or $\theta \sim 280^\circ$), we used the Fourier fitting method.
- "Possible 180° ambiguity": the quadrant determination (cf. previous paragraph) was noisy and the result is uncertain.

For WDS 16563+6502, the two components were so widely separated that it was also possible to do a direct measurement on the long integration.

²For WDS 18145+0011, the filter value (V) is uncertain because of a problem with the filter wheel during this observation

TABLE 1

RELATIVE ASTROMETRIC DATA (EPOCH, ρ , θ , RESP. IN COL. #5, #7 AND #8) OF THE BINARY STARS (SEE SECTION 4). THE POSITION ANGLES θ HAVE A 180° AMBIGUITY EXCEPT WHEN ASTERISKED (FOR WHICH A TRIPLE CORRELATION METHOD REMOVED THIS AMBIGUITY).

WDS	Name	FL (mm)	Filt.	Epoch	Seeing arcsec	ρ arcsec	θ degrees	Comments
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
00121+5337	BU 1026 - ADS 148	10	R	1998.679	1.9	0.274±0.002	296.9±0.5*	
00134+2659	STT 2 - ADS 161	20	V	1998.663	1.7	0.364±0.007	171.0±0.6*	(F=)
00167+3629	STT 4 - ADS 221	10	R	1998.679	2.4	0.342±0.003	138.8±0.5	
00173+0852	A 1803 - ADS 238 AB	20	V	1998.663	2.8	0.168±0.02	123.2±1.5	Fuzzy (F).
"	STF 22 - ADS 238 AB-C	20	V	1998.663	2.8	-	-	Not resolved.
00182+7256	A 803 - ADS 243	10	R	1998.665	3.0	0.233±0.003	117.3±0.5	Very faint contrast.
"	"	20	V	1998.665	3.7	0.232±0.006	119.0±2.0	Artifacts close to X axis (F).
00206+1219	BU 1015 - ADS 281	10	R	1998.679	2.8	0.423±0.003	94.7±0.5	
00214+6700	STT 6 - ADS 293	20	V	1998.665	3.6	0.618±0.003	154.6±0.5*	
00308+4732	BU 394 - ADS 416	10	V	1998.666	2.8	0.180±0.002	88.5±0.6	Artifacts close to X axis.
"	"	20	V	1998.666	3.8	0.175±0.009	82.0±1.0	
00318+5432	STT 12 - ADS 434	20	R	1998.665	3.8	0.400±0.003	15.6±0.6	
00488+1842	BU 495 - ADS 673	20	V	1998.663	1.9	0.158±0.008	140.8±1.5	Fuzzy (F)
00516+2238	A 1808 - ADS 701	20	V	1998.663	1.8	0.159±0.005	12.4±2.0	Fuzzy (F)
"	"	10	V	1998.663	2.4	0.159±0.002	11.9±0.8	
00532+0406	A 2307 - ADS 732	10	R	1998.679	2.4	0.181±0.002	59.4±0.6*	Possible 180° ambiguity.
00546+1912	STT 20 - ADS 746	20	V	1998.663	2.5	0.518±0.003	14.6±0.5	
00550+2338	STF 73 - ADS 755	20	V	1998.663	1.8	0.871±0.003	305.7±0.5*	
00583+2124	BU 302 - ADS 805	10	R	1998.679	2.2	0.362±0.002	184.8±0.5*	
01011+6022	A 926 - ADS 832	20	V	1998.666	4.4	0.382±0.003	154.8±0.6	
01093+4715	STT 515 - ADS 940	20	RL	1998.666	3.6	0.505±0.004	127.1±0.5*	
01137+0733	STF 100 - ADS 996 AB	20	V	1998.655	3.1	-	-	Not resolved.
"	BU 1029 - ADS 996 BC	20	V	1998.655	3.1	-	-	Not resolved.
01213+1132	BU 4 - ADS 1097	10	R	1998.679	2.4	0.544±0.003	111.7±0.5*	
01297+2250	A 1910 - ADS 1183	10	R	1998.679	2.2	0.123±0.002	35.7±1.2	
01443+5732	BU 870 - ADS 1359	20	V	1998.655	3.4	0.747±0.003	348.2±0.5*	
"	"	20	RL	1998.666	3.6	0.744±0.003	348.6±0.5*	
01512+2439	HO 311 - ADS 1473	10	R	1998.679	2.7	0.247±0.003	164.8±0.5	
01551+2847	STF 183 - ADS 1522	10	R	1998.679	2.7	0.329±0.002	156.6±0.5	
01558+0151	STF 186 - ADS 1538	20	R	1998.679	2.2	1.046±0.005	61.5±0.5	
01570+3101	A 819 - ADS 1548	10	R	1998.679	2.5	0.198±0.002	73.3±0.5	
02020+0246	STF 202 - ADS 1615	20	R	1998.679	2.5	1.863±0.005	274.3±0.5*	
02037+2556	STF 208 - ADS 1631	20	R	1998.679	2.5	1.159±0.005	334.1±0.5*	
02157+2503	COU 79	20	V	1998.663	2.5	-	-	Not resolved.
"	"	20	W	1998.663	2.5	-	-	Not resolved.
02158+0638	A 2013 - ADS 1729	10	R	1998.679	3.4	-	-	Not resolved.
02182+3920	A 207 - ADS 1762	10	R	1998.679	1.7	0.317±0.002	354.8±0.5*	
02257+6133	STF 257 - ADS 1833	20	V	1998.655	4.1	0.391±0.003	63.7±0.5*	
02290+6724	CHR 6 Aa - ADS 1860	20	V	1998.655	3.2	-	-	Not resolved.
"	"	10	V	1998.666	2.2	0.299±0.002	91.9±0.7	Artifacts close to X axis.
"	"	20	RL	1998.666	3.9	0.30±0.05	93.0±3.0*	Very faint contrast.
02333+5218	STT 42 - ADS 1938	20	RL	1998.666	3.6	-	-	Cloudy, not resolved.
02407+2637	STT 43 - ADS 2034	20	R	1998.679	3.6	0.754±0.003	354.9±0.5*	
02572+0153	A 2413 - ADS 2236	10	R	1998.680	2.4	0.418±0.003	140.5±0.5	
03048+5330	LAB - ADS 2324	10	V	1998.666	1.6	0.251±0.002	244.8±0.5*	
"	"	20	V	1998.666	3.1	0.253±0.008	245.1±1.5*	(F)
03127+7133	STT 50 - ADS 2377	20	V	1998.655	3.4	1.102±0.005	158.2±0.5	Slightly elongated.
03175+6540	STT 52 - ADS 2436	20	V	1998.655	3.5	0.481±0.003	63.5±0.5*	
"	"	20	V	1998.666	3.2	0.480±0.003	64.0±0.5	
03284+6015	A 980 - ADS 2538	10	V	1998.666	2.5	0.336±0.003	171.6±0.5	
"	"	20	V	1998.666	3.2	0.331±0.003	171.4±0.5	
03350+6002	STF 400 - ADS 2612	20	V	1998.666	3.0	1.453±0.005	265.7±0.5*	
03344+2428	STF 412 - ADS 2616	20	R	1998.679	1.2	0.684±0.004	357.8±0.5*	
03496+6318	MOAI 1 - SAO 12917	20	V	1998.654	3.4	0.082±0.004	158.3±1.5	Faint
05167+4600	ANJ 1 - ADS 3841	10	B	1998.666	1.9	0.052±0.002	241.3±1.5	(F) Capella
"	"	10	V	1998.666	2.0	0.050±0.002	242.3±1.5	(F)
13202+1747	A 2166 - ADS 8863	20	R	1998.446	2.4	-	-	Not resolved.
13519+1008	B 2543	20	R	1998.446	2.2	-	-	Not resolved.
14153+0308	STF 1819 - ADS 9182	20	R	1998.446	2.9	0.896±0.005	23.0±0.5	
14268+1625	A 2069 - ADS 9264	20	R	1998.446	2.3	0.268±0.008	40.2±0.5	(F)
15161-0454	STF 3091 - ADS 9557	20	R	1998.446	2.8	0.584±0.004	49.4±0.5	
15273+1738	A 2074 - ADS 9645	20	R	1998.446	3.3	-	-	Video gain too low.

TABLE 1—Continued

WDS	Name	FL	Filt.	Epoch	Seeing	ρ	θ	Comments
(1)	(2)	(mm)	(4)	(5)	arcsec	arcsec	degrees	(9)
		(3)			(6)	(7)	(8)	
"	"	20	R	1998.446	2.4	0.241±0.008	253.4±1.0*	Artifacts close to X axis (F).
15282+0251	A 2175 - ADS 9654	20	R	1998.446	2.4	0.258±0.007	22.4±0.7	(F=)
15328+1945	HU 577 - ADS 9692	20	R	1998.446	2.4	0.274±0.006	185.0±0.5	(F=)
15542+1659	A 2080 - ADS 9831	20	R	1998.446	2.4	0.350±0.008	97.0±0.9	Artifacts close to X axis (F).
16367+6948	BU 953 - ADS 10140	10	R	1998.678	1.6	0.280±0.002	87.2±1.7*	Elongated.
16458-0046	A 1141 - ADS 10196	20	R	1998.446	2.5	0.195±0.008	24.3±2.0	Fuzzy (F)
16511+0925	STF 2106 - ADS 10229	20	R	1998.446	2.4	0.683±0.005	176.7±0.5*	
16515+0113	STT 315 - ADS 10230	20	R	1998.446	2.5	0.496±0.003	321.9±0.5*	
16563+6502	STF 2118 - ADS 10279	20	R	1998.678	1.8	1.116±0.006	68.1±0.6*	(auto-correlation)
"	"					1.07±0.02	69.6±1.0*	(long integration)
17003+3056	HR 6324	20	V	1998.654	3.0	-	-	Not resolved.
17082-0105	A 1145 - ADS 10355	20	R	1998.446	2.3	0.590±0.005	357.2±0.5*	
17088+6543	STA 1 - HR 6396	10	OIII	1998.679	1.6	-	-	Not resolved.
17303-0103	STF 2173 - ADS 10598	20	R	1998.446	2.4	0.686±0.005	322.8±0.5*	
17366+0722	A 1156 - ADS 10659	20	R	1998.446	2.2	0.193±0.008	174.0±1.0	Fuzzy (F=)
17399-0039	BU 631 - ADS 10696	20	R	1998.446	2.5	0.213±0.015	279.6±1.0*	Artifacts close to X axis (F).
17505+0715	STT 337 - ADS 10828	20	R	1998.446	2.1	0.484±0.004	171.6±0.5	
17564+1820	STF 2245 - ADS 10905 Aa-B	20	V	1998.654	2.0	2.638±0.005	112.5±0.5*	
17564+1820	MCA 49 - ADS 10905 Aa	20	V	1998.654	2.0	-	-	Not resolved.
17564+1820	- ADS 10905 B	20	V	1998.654	2.0	-	-	Not resolved.
17571+0004	STF 2244 - ADS 10912	20	R	1998.673	2.2	0.532±0.004	277.2±0.5*	Possible 180° ambiguity.
17572+2400	MCA 50	10	V	1998.673	2.3	-	-	Not resolved.
18063+3824	HU 1186 - ADS 11071	10	R	1998.673	2.9	-	-	Not resolved.
"	"	20	R	1998.673	3.0	0.362±0.009	110.1±0.5	
18078+2606	CHR 67 Aa	20	V	1998.654	3.3	0.245±0.006	335.3±1.5*	Very faint
18102+1628	STF 2289 - ADS 11123	20	R	1998.673	2.4	1.221±0.008	220.8±0.5*	
18117+3327	B 2545 - ADS 11149 AB	20	V	1998.654	3.0	-	-	Not resolved.
18117+3327	HO 82 - ADS 11149 AB-C	20	V	1998.654	3.0	0.711±0.005	219.4±0.5*	
18145+0011	STF 2294 - ADS 11186	20	V?	1998.673	3.1	1.279±0.005	273.9±0.5*	Possible 180° ambiguity.
18197+1016	HU 197 - ADS 11260	20	R	1998.673	2.8	0.445±0.004	86.7±0.5	
18207+7120	STT 353 - ADS 11311	10	R	1998.679	1.5	0.429±0.003	271.4±0.5*	Slightly elongated.
18250-0135	AC 11 - ADS 11324	20	R	1998.673	3.1	0.884±0.005	175.6±0.5	
18250+2723	STF 2315 - ADS 11334	20	R	1998.673	3.3	0.656±0.005	124.3±0.5	
18338+1744	HU 322 - ADS 11454 AB	20	V	1998.654	3.0	0.115±0.006	71.6±1.5	Artifacts close to X axis.
18338+1744	WAK 21 - ADS 11454 CD	20	V	1998.654	3.0	0.409±0.003	261.7±0.5*	
18338+1744	STF 2339 - ADS 11454 AB-CD	20	V	1998.654	3.0	1.675±0.007	277.0±0.5*	
18340+5221	A 1377 - ADS 11468	10	V	1998.679	1.5	0.258 ±0.002	113.4±0.5	
18355+2336	STT 359 - ADS 11479	20	R	1998.673	2.2	0.711±0.005	7.5±0.5*	
18410+2450	A 2988 - ADS 11574	10	R	1998.673	3.1	-	-	Not resolved.
18413+3018	STF 2367 - ADS 11579	10	R	1998.673	1.9	0.305±0.002	79.9±0.5*	
18462+6412	HU 937 - ADS 11692	20	R	1998.679	2.0	0.937±0.005	329.5±0.5*	Slightly elongated.
18466+3821	HU 1191 - ADS 11680	10	R	1998.673	1.9	0.156±0.002	40.5±0.6	
18477+4904	HEI 72	10	V	1998.679	1.5	0.580±0.004	227.7±0.5*	
18575+5814	STF 2438 - ADS 11897	20	R	1998.679	1.8	0.862±0.005	0.7±0.5*	Slightly elongated.
19022+5216	HU 757 - ADS 11979	10	W	1998.679	1.7	0.139±0.005	17.5±1.2	
19106+5429	A 1391 - ADS 12144	10	W	1998.679	1.5	0.139±0.007	153.6±1.5	Very fuzzy. (F)
19180+2012	COU 321	10	V	1998.679	1.8	0.087±0.005	132.8±3.0	(F=)
"	"	10	W	1998.679	3.3	-	-	Very fuzzy, doubtful.
19216+5223	BU 1129 - ADS 12366	10	V	1998.679	1.7	0.234±0.007	169.2±0.5	
19296+1224	A 1653 - ADS 12515	10	R	1998.673	2.3	0.213±0.009	170.0±1.5	Faint autoc. peaks (F)
19411+1349	KUI 93	20	V	1998.654	2.9	0.193±0.009	133.3±1.5	Artifacts close to X axis.
19542+0828	HR 7595 - 59 Aql	20	R	1998.657	2.9	0.09±0.01	60±5	New double
19573+0513	A 604 - ADS 13156	10	R	1998.679	2.1	0.133±0.003	50.6±1.2	
19580+0456	A 606 - ADS 13169	10	R	1998.679	2.4	0.548±0.004	147.9±0.5	
20158+2749	MCA 60 Aa	20	V	1998.654	3.0	0.239±0.006	143.9±1.2*	
20232+2052	A 288 - ADS 13777	10	V	1998.679	2.3	0.160±0.005	86.8±0.8	
20290+0710	A 610 - ADS 13894	10	R	1998.679	2.9	0.377±0.004	49.5±0.5	Very faint autoc. peaks.
20311+3332	COU 1962	10	R	1998.679	2.1	-	-	Not resolved.
20311+1548	A 1675 - ADS 13944	20	R	1998.662	2.6	-	-	Not resolved.
"	"	10	V	1998.662	3.2	-	-	Not resolved.
20375+1436	BU 151 - ADS 14073	20	V	1998.662	2.4	0.453±0.004	334.0±0.5*	
20396+0458	KUI 99	20	V	1998.662	3.1	0.381±0.005	124.4±1.2	Artifacts close to X axis.

Name	Central wavelength (nm)	Bandwidth (nm)
B	447	47
OIII	501	11
V	530	57
R	644	70
RL	743	69
W	650	418

Table 2: Characteristics of the filters used (cf. col #4 of Table 4). “W” means “White” since no filter has been used. In that case, the bandwidth selection was done with the ICCD response only.

The smallest errors for the angular separation were estimated at $\sim 0.002''$ for the best cases on the basis of the uncertainties coming from the determination of the center of the auto-correlation peak and those affecting the scale determination. Similarly we found $\sim 0.5^\circ$ for the angle position.

To investigate the possibility of systematic errors (e.g. a possible bad value for the focal length of the telescope), we plotted the residuals relative to the ephemerides computed with the known orbits for these objects (Fig. 1). The residuals are mostly concentrated near the point ($\Delta\theta=0$; $\Delta\rho=0$) with no clear offset, which is a good indication that our measurements have not systematic errors. This test was also successful for the last two sets of observations with PISCO published in Aristidi et al. (1997b) and Aristidi et al. (1999).

When we examine the case of the largest residuals, we see that they correspond to old orbits: Chara 6Aa (Heintz 1962), Fox 102 (Popovic, 1972), A 1391 (Baize, 1987), STT 483 (Valbousquet, 1981), Hei 72 (Baize, 1983) and STF 2244 (Baize, 1984).

For the same objects, more recent orbits, when available, lead to a better agreement:

- STT 483: $\Delta\theta=-3.7^\circ$, $\rho=0.03''$ with (Heintz, 1996),
- STF 2244: $\Delta\theta=0.1^\circ$, $\rho=0.04''$ with (Heintz, 1997).

The case of Cou 321 is more complex: it is difficult to observe (separation less than $0.1''$) and since the first measurements in 1969 it has not yet covered half of its orbit, with a big gap of observations between 1972 and 1985 (cf. Fig. 4 of Aristidi

et al. (1999)). Hence even the most recent orbits (Docobo, 1998, Aristidi, 1999) should be considered as preliminary. The residuals of table 4 are larger than the errors of our observations ($\sigma_\theta = 3.$ and $\sigma_\rho = 0.005$) although the orbits are recent:

- $\Delta\theta=8.7^\circ$, $\rho=+0.02''$ with (Docobo, 1998).
- $\Delta\theta=-0.5^\circ$, $\rho=-0.07''$ with our revised orbit (Aristidi, 1999).

This example clearly shows that (i) it is essential to have a continuous program of measurements and (ii) more speckle observations of good quality are needed to determine this orbit.

TABLE 1—*Continued*

WDS	Name	FL (mm)	Filt.	Epoch	Seeing arcsec	ρ arcsec	θ degrees	Comments
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
20397+1556	WCK 2 - ADS 14121	20	V	1998.662	2.5	0.144±0.015	125.8±2.0*	Faint (F)
20449+1219	STF 2723 - ADS 14233	20	V	1998.654	3.4	1.072±0.005	131.8±0.5*	
20451+1244	BU 64 - ADS 14238	20	V	1998.662	3.0	0.680±0.005	168.4±0.5	
20572+4110	ν Cyg	20	V	1998.654	3.3	-	-	Not resolved.
"	"	10	V	1998.679	1.6	-	-	Not resolved.
21002+0731	KUI 102	20	V	1998.662	2.6	0.360±0.003	13.8±0.5	
21080+0509	STT 527 - ADS 14666	20	V	1998.663	2.6	0.307±0.005	120.0±2.0	Faint autoc. peaks, Artifacts close to X axis. (F)
21125+2821	HO 152 - ADS 14748	10	R	1998.679	2.5	0.211±0.002	114.5±0.6	
21135+0713	BU 270 - ADS 14759	20	W	1998.679	2.0	0.611±0.005	349.9±0.5*	
21135+1559	HU 767 - ADS 14761	20	V	1998.663	2.4	0.214±0.003	140.9±2.3	Fuzzy (F=)
21423+0554	HU 280 - ADS 15236	20	V	1998.663	2.2	0.204±0.008	158.3±1.1	(F=)
21459+1153	A 1223 - ADS 15300	10	R	1998.679	2.9	0.151±0.008	21.0±0.9	Faint autoc. peaks.
21555+1053	BU 75 - ADS 15447	20	R	1998.679	2.4	0.767±0.005	15.6±0.5*	
22077+2622	COU 537	20	V	1998.663	2.4	-	-	Not resolved.
22139+3944	MCA 70 Ab - ADS 15758	20	V	1998.654	3.0	0.390±0.003	15.9±0.7	
22241-0451	BU 172 - ADS 15902	10	V	1998.679	2.1	0.269±0.002	67.3±0.5*	
"	"	20	V	1998.679	2.0	0.273±0.004	66.5±0.8*	
22288-0002	STF 2909 - ADS 15971	20	V	1998.679	2.1	1.935±0.005	10.1±0.5*	
22299+0425	STF 2912 - ADS 15988	20	V	1998.663	1.8	0.413±0.003	116.7±0.6*	
22307+1758	COU 234	20	V	1998.663	2.4	-	-	Not resolved.
22359+3938	CHR 112 - ADS 16095 Aa	20	V	1998.654	3.9	-	-	Not resolved.
22359+3938	STF 2922 - ADS 16095 Aa-B	20	V	1998.654	3.9	-	-	Not resolved.
22385+0218	HO 479 - ADS 16131	20	V	1998.663	2.5	0.465±0.04	90.0±1.5*	Artifacts close to X axis. (F)
22402+3731	HO 188 - ADS 16164	10	R	1998.679	2.2	0.373±0.003	35.5±0.5	
22405+0631	HU 494 - ADS 16165	10	R	1998.679	3.3	-	-	Not resolved.
22408-0333	KUI 114	20	V	1998.663	2.2	0.300±0.003	130.9±0.5	(F=)
22485+3106	BU 1146 - ADS 16278	10	R	1998.679	2.1	0.222±0.002	89.2±0.5*	Possible 180° ambiguity.
22514+2624	HO 482 - ADS 16314	20	V	1998.663	2.2	0.443±0.003	24.8±0.5	
22570+2441	COU 542	10	R	1998.679	2.4	0.237±0.002	168.8±0.5	
22585+0922	STT 536 - ADS 16417	20	V	1998.663	2.9	0.280±0.006	167.0±0.7	
22592+1144	STT 483 - ADS 16428	20	V	1998.663	1.7	0.503±0.005	333.1±0.5*	
23088+1057	A 1238 - ADS 16539	10	R	1998.679	2.1	0.299±0.002	147.8±0.5	
23176+1819	HU 400 - ADS 16650	20	V	1998.663	2.2	0.358±0.003	100.4±1.0	Artifacts close to X axis. (F=)
23189+0525	BU 80 - ADS 16665	10	R	1998.679	2.4	0.272±0.002	19.4±0.5	
23340+3120	BU 720 - ADS 16836	20	V	1998.663	1.6	0.546±0.004	93.0±0.5*	
23374+0737	FOX 102 - ADS 16873	10	R	1998.679	2.4	0.191±0.002	355.5±0.5	
23431+1150	A 1242 - ADS 16951	20	R	1998.679	2.8	0.981±0.006	152.8±0.5	
23440+2922	AGC 14 - ADS 16957	20	V	1998.663	1.6	0.835±0.005	266.9±0.5*	
23498+2740	A 424 - ADS 17030	20	V	1998.663	1.9	0.164±0.006	137.6±0.5*	(F)
23529-0309	FIN 359	10	R	1998.679	2.1	-	-	Not resolved.
23568+0443	A 2100 - ADS 17111	10	R	1998.679	2.0	0.213±0.002	288.2±0.5*	

TABLE 3

RESIDUALS OF THE EXPECTED POSITIONS COMPUTED WITH KNOWN ORBITS (OBSERVED - COMPUTED)
(CF. SECTION 4).

WDS	Name	Orbit	Residuals O-C		Comments
			ρ (arcsec)	θ (degrees)	
00121+5337	BU 1026 - ADS 148	Hartkopf (1996)	0.00	-0.1	
00134+2659	STT 2 - ADS 161	Heintz (1979)	0.04	5.4	
00167+3629	STT 4 - ADS 221	Scardia (1982)	-0.08	-13.1	
00173+0852	A 1803 - ADS 238	Baize (1987)	0.02	-1.8	
00182+7256	A 803 - ADS 243	Zulevic (1996)	0.01	-6.1	R 10mm
	" "	Zulevic (1996)	0.01	-4.4	V 20mm
00206+1219	BU 1015 - ADS 281	Scardia (1980)	-0.00	-3.2	
00214+6700	STT 6 - ADS 293	Muller (1954)	-0.10	5.0	
00308+4732	BU 394 - ADS 416	Zulevic (1997)	-0.05	-3.8	
00318+5432	STT 12 - ADS 434	Heintz (1995)	-0.06	0.7	
00488+1842	BU 495 - ADS 673	Couteau (1989)	-0.03	-8.3	
00516+2238	A 1808 - ADS 701	Docobo (1988)	-0.01	-2.0	V 20mm
		Docobo (1988)	-0.01	-2.5	V 10mm
		Baize (1989)	0.01	3.9	V 20mm
		Baize (1989)	0.01	3.4	V 10mm
00532+0406	A 2307 - ADS 732	Walker (1975)	-0.01	-2.6	
		Heintz (1975)	-0.08	2.1	
00546+1912	STT 20 - ADS 746	Couteau (1984)	0.03	2.2	
00550+2338	STF 73 - ADS 755	Docobo (1989)	-0.00	-0.3	
00583+2124	BU 302 - ADS 805	Popovic (1997)	-0.03	3.7	
		Zulevic (1997)	-0.07	5.0	
01011+6022	A 926 - ADS 832	Popovic (1997)	-0.03	2.0	
01093+4715	STT 515 - ADS 940	Baize (1958)	0.04	-0.4	
01213+1132	BU 4 - ADS 1097	Muller (1953)	0.08	7.4	
01297+2250	A 1910 - ADS 1183	Hartkopf (1996)	0.00	1.0	
01443+5732	BU 870 - ADS 1359	Popovic (1995)	0.08	2.7	V 20mm
		Popovic (1995)	0.08	3.1	RL 20mm
01512+2439	HO 311 - ADS 1473	Hartkopf (1989)	0.01	0.3	
01551+2847	STF 183 - ADS 1522	Couteau (1973)	-0.02	3.4	
01558+0151	STF 186 - ADS 1538	Mourao (1977)	0.03	-1.4	
01570+3101	A 819 - ADS 1548	Heintz (1997)	0.01	-4.6	
02020+0246	STF 202 - ADS 1615	Scardia (1983)	0.03	1.8	
02037+2556	STF 208 - ADS 1631	Kranjc (1960)	-0.08	-2.9	
		Heintz (1996)	-0.08	-2.9	
02182+3920	A 207 - ADS 1762	Heintz (1975)	-0.02	-6.1	
		Scardia (1982)	-0.05	3.4	
02257+6133	STF 257 - ADS 1833	Zaera de Toledo (1985)	-0.01	2.5	
02290+6724	CHARA 6 Aa	Heintz (1962)	0.21	49.7	V 10mm
		Heintz (1962)	0.21	50.8	RL 20mm
02407+2637	STT 43 - ADS 2034	Heintz (1962)	-0.21	-3.1	
02572+0153	A 2413 - ADS 2236	Scardia (1980)	-0.01	5.8	
		Heintz (1991)	0.01	-2.7	
03048+5330	LAB - ADS 2324	McAlister (1982)	-0.02	2.4	V 10mm
		McAlister (1982)	-0.02	2.7	V 20mm
03127+7133	STT 50 - ADS 2377	Popovic (1972)	0.18	4.1	
03175+6540	STT 52 - ADS 2436	Heintz unpub.	0.05	2.2	V 20mm 1998.655
		Heintz unpub.	0.05	2.7	V 20mm 1998.666
03284+6015	A 980 - ADS 2538	Zulevic (1992)	0.02	2.0	V 10mm
		Zulevic (1992)	0.02	1.8	V 20mm
		Baize (1993)	0.01	-0.8	V 10mm
		Baize (1993)	0.01	-1.0	V 20mm

TABLE 3—*Continued*

WDS	Name	Orbit	Residuals O-C		Comments
			ρ (arcsec)	θ (degrees)	
03350+6002	STF 400 - ADS 2612	Baize (1952)	-0.12	2.9	
		Scardia (1981)	0.01	-0.4	
03344+2428	STF 412 - ADS 2616	Luyten (1934)	-0.06	-2.5	
		Scardia (1985)	0.03	2.5	
05167+4600	ANJ 1 - ADS 3841	McAlister (1981)	0.01	-0.4	
		McAlister (1981)	0.01	0.6	
14153+0308	STF 1819 - ADS 9182	Houser (1987)	0.01	-0.5	
		Baize (1987)	0.08	7.3	
14268+1625	A 2069 - ADS 9264	Eggen (1965)	0.03	4.7	
		Couteau (1986)	-0.01	4.3	
15161-0454	STF 3091 - ADS 9557	Laques (1971)	0.10	5.5	
		Mason (1999)	0.00	2.1	
15273+1738	A 2074 - ADS 9645	Baize (1976)	0.03	2.9	
15282+0251	A 2175 - ADS 9654	Heintz (1996)	0.02	-0.9	
15328+1945	HU 577 - ADS 9692	Couteau (1984)	0.01	1.8	
15542+1659	A 2080 - ADS 9831	Zulevic (1973)	0.05	-20.4	
		Baize (1986)	0.13	-13.1	
16367+6948	BU 953 - ADS 10140	Scardia (1984)	0.07	6.6	
16458-0046	A 1141 - ADS 10196	Baize (1976)	0.01	2.3	
		Heintz (1982)	0.00	5.6	
16511+0925	STF 2106 - ADS 10229	Heintz (1963)	0.00	4.0	
16515+0113	STT 315 - ADS 10230	Docobo (1991)	0.00	1.7	
16563+6502	STF 2118 - ADS 10279	Scardia (1981)	-0.14	-0.1	(auto-correlation)
		Scardia (1981)	-0.19	1.4	(long integration)
17082-0105	A 1145 - ADS 10355	Heintz (1995)	0.11	3.2	
17303-0103	STF 2173 - ADS 10598	Heintz (1994)	0.00	0.2	
17366+0722	A 1156 - ADS 10659	Docobo (1991)	-0.01	3.8	
17399-0039	BU 631 - ADS 10696	Baize (1991)	-0.02	6.5	
		Heintz (1996)	-0.01	3.2	
17505+0715	STT 337 - ADS 10828	Docobo (1990)	0.02	1.3	
17571+0004	STF 2244 - ADS 10912	Baize (1984)	0.34	-13.6	
		Heintz (1997)	0.04	0.1	
18063+3824	HU 1186 - ADS 11071	Baize (1992)	0.04	1.0	
		Heintz (1995)	0.05	0.2	
18102+1628	STF 2289 - ADS 11123	Hopmann (1964)	-0.02	2.8	
18145+0011	STF 2294 - ADS 11186	Luyten (1934)	0.11	0.3	
18197+1016	HU 197 - ADS 11260	Baize (1972)	0.05	11.9	
		Heintz (1995)	0.03	1.7	
18207+7120	STT 353 - ADS 11311	Olevic (1990)	0.03	2.3	
18250-0135	AC 11 - ADS 11324	Heintz (1995)	0.02	0.4	
18250+2723	STF 2315 - ADS 11334	Heintz (1960)	-0.13	0.5	
18340+5221	A 1377 - ADS 11468	Scardia (1984)	0.00	-1.6	
18355+2336	STT 359 - ADS 11479	Symms (1964)	0.02	1.3	
18413+3018	STF 2367 - ADS 11579	Cester (1991)	-0.02	0.0	
18462+6412	HU 937 - ADS 11692	Baize (1989)	0.16	-2.9	
18466+3821	HU 1191 - ADS 11680	Morel (1969)	-0.01	-0.3	
18477+4904	HEI 72	Baize (1983)	0.29	-23.3	
18575+5814	STF 2438 - ADS 11897	Jastrzebski (1959)	-0.07	0.7	
19022+5216	HU 757 - ADS 11979	Heintz (1978)	0.03	-19.4	
19106+5429	A 1391 - ADS 12144	Baize (1987)	-0.03	22.3	
19180+2012	COU 321	Docobo (1998)	0.02	8.7	
		Aristidi (1999)	-0.07	-0.5	

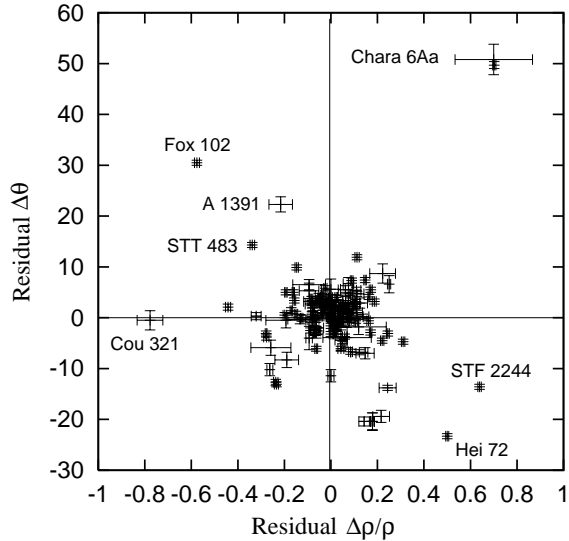


Fig. 1.— Residuals of the expected positions computed with known orbits (observed - computed) (cf. section 4).

5. The new binary 59 Aql

When reducing these data, it appeared that HR 7595, one of our reference stars, was actually double. Its power spectrum with the R filter exhibit clear fringes (cf. Fig. 2). The fringes are not so clear in V, whereas nothing can be seen in B. The cosine fit in the Fourier space lead to: $\rho = 0.09 \pm 0.01''$ and $\theta = 60. \pm 5.^\circ$. The errors are rather large because the seeing conditions were rather poor (FWHM=2.9''). We encourage other observers to confirm this binarity.

HR 7595 (HD 188310, or 59 Aql) is not known as double in any of the data bases that we consulted. It is a bright ($V=4.71$), G9III-type nearby star with a parallax of 16.0 mas.

6. Conclusion

The PISCO speckle camera of *Observatoire Midi-Pyrénées* with the ICCD of *Université de Nice* has proven to be well adapted to efficiently observe binary and multiple stars. Due to better weather conditions than in 1995-1997 (cf. Aristidi et al. (1999)), we have been able to provide a substantial number of measurements: 134 objects

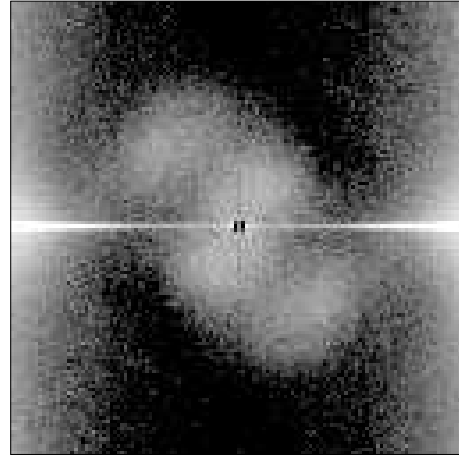


Fig. 2.— Modulus of the Fourier Transform of the new binary 59 Aql which exhibit clear fringes (R filter).

compared to 48 in our previous paper, with an accuracy generally better than 0.01'' for the angular separation and less than 1° for the position angle.

We have discovered the binarity of 59 Aql when examining the stars which were used as reference star for de-convolution, but the atmospheric conditions were rather poor with a FWHM of 2.9'' and we encourage other observers to confirm this binarity.

The example of Cou 321 shows that such extensive observing programs with speckle cameras with medium-size telescopes are essential for a good orbit determination. Unfortunately the new policy of telescope time allocation is going to another direction. No other observing run has been allocated since 1998 and the observations reported in this paper will be probably the last of this programme.

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TABLE 3—*Continued*

WDS	Name	Orbit	Residuals O-C		Comments
			ρ (arcsec)	θ (degrees)	
19216+5223	BU 1129 - ADS 12366	Baize (1984)	-0.01	2.5	
19296+1224	A 1653 - ADS 12515	Heintz (1963)	-0.02	5.3	
19573+0513	A 604 - ADS 13156	Heintz (1991)	0.01	6.7	
19580+0456	A 606 - ADS 13169	Baize (1984)	0.17	-4.7	
20232+2052	A 288 - ADS 13777	Docobo (1992)	0.01	1.5	
		Baize (1992)	0.01	5.5	
20290+0710	A 610 - ADS 13894	Heintz (1979)	0.02	2.5	
20375+1436	BU 151 - ADS 14073	Hartkopf (1989)	0.02	-0.4	
20396+0458	KUI 99	Baize (1981)	0.00	-11.4	
		Heintz (1984)	-0.10	-10.2	
20397+1556	WCK 2 - ADS 14121	Hartkopf (1989)	0.01	-3.9	
20451+1244	BU 64 - ADS 14238	Baize (1957)	0.15	-4.5	
		Heintz (1995)	0.11	-0.6	
21002+0731	KUI 102	Heintz (1996)	0.03	4.4	
21080+0509	STT 527 - ADS 14666	Popovic (1995)	0.01	1.5	
21125+2821	HO 152 - ADS 14748	Baize (1981)	-0.05	-12.7	
21135+0713	BU 270 - ADS 14759	Heintz (1979)	-0.00	0.0	
21135+1559	HU 767 - ADS 14761	Hartkopf (1989)	-0.02	-4.0	
21423+0554	HU 280 - ADS 15236	Baize (1987)	0.03	-7.0	
21459+1153	A 1223 - ADS 15300	Couteau (1963)	-0.02	-0.3	
21555+1053	BU 75 - ADS 15447	Baize (1974)	-0.01	2.6	
		Heintz (1996)	-0.00	0.4	
22241-0451	BU 172 - ADS 15902	Heintz (1996)	-0.01	4.1	V 10mm
		Heintz (1996)	-0.01	3.3	V 20mm
22288-0002	STF 2909 - ADS 15971	Heintz (1984)	0.03	2.5	
22299+0425	STF 2912 - ADS 15988	Zulevic (1988)	-0.03	-0.9	
22385+0218	HO 479 - ADS 16131	Zulevic (1979)	-0.09	-0.5	
		Heintz (1997)	-0.12	-5.9	
22402+3731	HO 188 - ADS 16164	Docobo (1986)	0.04	-0.6	
22408-0333	KUI 114	Baize (1976)	-0.01	1.5	
		Griffin (1987)	-0.02	0.5	
22485+3106	BU 1146 - ADS 16278	Couteau (1989)	-0.02	-0.4	
22514+2624	HO 482 - ADS 16314	Morel (1970)	-0.00	3.1	
		Starikova (1982)	-0.00	2.3	
22570+2441	COU 542	Couteau (1993)	0.02	-6.7	
22585+0922	STT 536 - ADS 16417	Cester (1991)	-0.09	0.3	
22592+1144	STT 483 - ADS 16428	Valbousquet (1981)	-0.17	14.3	
		Heintz (1996)	0.03	-3.7	
23088+1057	A 1238 - ADS 16539	Muller (1955)	-0.01	1.5	
23176+1819	HU 400 - ADS 16650	Heintz (1962)	0.02	-0.8	
23189+0525	BU 80 - ADS 16665	Heintz (1996)	-0.04	9.9	
23340+3120	BU 720 - ADS 16836	Baize (1976)	0.01	-3.2	
		Starikova (1982)	0.01	-2.0	
23374+0737	FOX 102 - ADS 16873	Popovic (1972)	-0.11	30.5	
23431+1150	A 1242 - ADS 16951	Zulevic (1977)	0.24	-3.1	
23440+2922	AGC 14 - ADS 16957	Popovic (1997)	-0.03	0.3	
23498+2740	A 424 - ADS 17030	Heintz (1984)	0.04	-13.8	
		Baize (1984)	0.02	-6.8	
23568+0443	A 2100 - ADS 17111	Heintz (1996)	0.00	0.4	

REFERENCES

- Aristidi, E., Carbillet, M., Lyon, J.-F., Aime, C., 1997a, *Astron. & Astrophys Suppl.*, **125**, 139.
- Aristidi, E., Carbillet, M., Prieur, J.-L., Lopez, B., Bresson, Y., Koechlin, L., 1997b, *Astron. & Astrophys Suppl.*, **126**, 555–561.
- Aristidi, E., Prieur, J.-L., Scardia, M., Koechlin, L., Avila, R., Lopez, B., Rabbia, Y., Carbillet, M., Nisenson, P., Gezari, D., 1999, *Astron. & Astrophys Suppl.*, **134**, 545-552.
- Carbillet, M., Lopez, B., Aristidi, E., Bresson, Y., Aime, C., Ricort, G., Prieur, J.-L., Koechlin, L., Helmer, G., Lefèvre, J., Cruzalebes, P., 1996, *Astron. & Astrophys.*, **314**, 112.
- Ellips/Rio 1999: see the web page: "<http://www.ellips.nl/rio.html>".
- Prieur, J.-L., Oblak, E., Lampens, P., Aristidi, E., Ruymaekers, G., Kurpiska-Winiarska, M., Koechlin, L., 2000, preprint.
- Prieur, J.-L., Festou, M.C, Koechlin, L., André, C., *Coll. National de Planétologie de l'INSU*, Toulouse, 13–16 Juin 1994, p S16-22.
- Prieur, J.-L, Koechlin, L., André, C., Gallou, G., Lucuix, C., 1998, *Experimental Astronomy*, **vol 8**, Issue 4, p 297-315.
- Prieur, J.-L, Carquillat, J.-M., Ginestet, N., Koechlin, L., Scardia, M., Aristidi, E., 2000, in preparation.
- Scardia, M., Prieur, J.-L, Aristidi, E., 2000, preprint.
- Worden S.P., Murray K.S., Schmidt G.D., Angel J.R.P., 1977, *Icarus* 32, 450.
- Worley, C.E., Heintz, W.D., 1983, *U.S. Naval Obs. Publ.* vol. XXIV, 7.