THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 142:95–104, 2002 September

SPECKLE OBSERVATIONS OF COMPOSITE SPECTRUM STARS WITH PISCO IN 1993–1998[1]

J.-L. PRIEUR, L. KOECHLIN, N. GINESTET, AND J.-M. CARQUILLAT
UMR 5572, Observatoire Midi-Pyrénées—CNRS, 14 Avenue E. Belin, 31400 Toulouse, France

E. ARISTIDI
UMR 6525, Université de Nice Sophia-Antipolis—CNRS, Parc Valrose, 06108 Nice Cedex 2, France

M. SCARDIA
Osservatorio Astronomico di Brera, Via E. Bianchi 46, 22055 Merate, Italy

L. ARNOLD
Observatoire de Haute-Provence, 04870 St. Michel l'Observatoire, France

R. AVILA
Instituto de Astronomia UNAM, Campus Morelia, A.P. 72-3 (Xangari), 58089 Morelia Michoacan, Mexico

M. C. FESTOU
UMR 5572, Observatoire Midi-Pyrénées—CNRS, 14 Avenue E. Belin, 31400 Toulouse, France

S. MOREL
ESO, Karl Schwarzschild Strasse 2, 85748 Garching bei München, Germany

AND

J.-P. PÉREZ
UMR 5572, Observatoire Midi-Pyrénées—CNRS, 14 Avenue E. Belin, 31400 Toulouse, France

Received 2002 January 11; accepted 2002 April 8

ABSTRACT

We present speckle interferometry observations of 47 composite spectrum stars obtained between 1993 and 1998 at the Pic du Midi Observatory with the PISCO speckle camera. 76% of over 150 independent 10 minute sequences of observations led to a companion detection. Binary component angular separations ranged from 0.″05 to 1.″2. We also obtained a series of 23 measurements of an additional nine close binaries. PISCO observations confirm, for the first time since their discovery, the duplicity of HD 29104 (L4), HD 83808 (WGT 1Aa), HD 183912 Aa′ (BON Ap), and HD 156729 (HR 6436). Discovered as double by *Hipparcos*, the particularly difficult to resolve HD 156729 was observed despite the large magnitude difference, $\Delta m = 4.2$, between its two components.

Subject headings: astrometry — binaries: visual — stars: fundamental parameters — techniques: high angular resolution — techniques: interferometric

On-line material: machine-readable tables

1. INTRODUCTION

Composite spectrum stars are binary stars (often spectroscopic binary stars) comprising in most cases a dwarf hot star (B or A type) and a cool evolved star (G, K, or M) (Ginestet et al. 1992). The study of these systems is of great astrophysical interest (i) to improve estimates of the mass of red giant stars and (ii) to constraint stellar evolution models (Schröder, Pols, & Eggleton 1997). A major problem arises when it comes to identifying the spectral types of the two components. As speckle interferometry can resolve some of these objects, we have undertaken an observational program with PISCO[2] at the Pic du Midi Observatory, and we report here on the astrometry done on some of them. The photometry and the spectra of the individual components will be presented elsewhere (Prieur et al. 2002, in preparation).

In 1993, we established the list of our targets from the following sources:

1. Hynek's catalog of composite spectrum stars (Hynek 1938);
2. McAlister's catalog of interferometric binaries (McAlister & Hartkopf 1988);
3. Griffin's list of spectroscopic binaries where he suggests that most of them are likely to be resolved with speckle interferometry (Griffin 1990);
4. A list of stars with composite spectra from Markowitz (1969).

Additional objects suspected to be composite stars—e.g., stars with abnormal color indices in the Bright Star Catalog (Hoffleit & Jaschek 1982)—have also been incorporated to our list.

When starting this project, most of the objects had already been resolved by speckle interferometry but their orbits were undetermined. To obtain a good determination of the spectral types of the two components, two of us (N. G. and J.-M. C.) have carried out a spectroscopic survey of these binaries with the Carélec and Aurélie spectrographs at the Haute-Provence Observatory. The results concerning

---

[1] Based on observations made with the Télescope Bernard Lyot at Pic du Midi Observatory, France.

[2] PISCO stands for "Pupil Interferometry Speckle camera and Coronagraph."

TABLE 1

OBSERVATIONS

DATES	DETECTOR	NIGHTS Attributed	NIGHTS Used	PROGRAM
1993 Aug.......	CAR	...	$\sim$1	Backup
1994 Sep........	CAR	...	<1	Backup
1995 Jul.........	CAR	8	4	Main
1997 Jan........	CAR	5	2	Main
1997 Jan........	ICCD		1	Main
1997 Jun........	PAPA	...	<1	Backup
1998 Aug.......	ICCD	7	5	Main

the cool components were presented in Ginestet et al. (1997; Ginestet, Carquillat, & Jaschek 1999). The classification of the hot components is in progress (Ginestet & Carquillat 2002).

During the 1993–1998 exploitation phase of PISCO, we applied a "flexible" scheduling to maximize the scientific return. Depending on the weather conditions, we selected the astrophysical program best suited for these conditions. Since part of our observations could be done when the FWHM seeing was larger than 1″.2, our program was often used as a backup for observations requiring good atmospheric conditions (e.g., high-resolution imaging of complex or faint objects). As a consequence, multiple observations of our targets were performed during the 1993–1998 period, which permitted a follow-up of the astrometry over 6 years for some of them.

2. OBSERVATIONS

The observations (Table 1) were carried out with the PISCO speckle camera (Prieur et al. 1998) developed at the Midi-Pyrénées Observatory and operated at the Cassegrain Focus of the 2 m Bernard Lyot Telescope (TBL) at Pic du Midi, with the filters presented in Table 2. PISCO is a remotely controlled versatile instrument whose observing modes (e.g., imaging or spectroscopy) can be configured in real time. It constitutes a powerful tool for investigating the field of close binary stars, as demonstrated in previous works (Aristidi et al. 1999; Scardia et al. 2000a; Prieur et al. 2001).

In this program, the PISCO speckle camera was used in its full pupil imaging mode. The atmospheric chromatic dispersion was corrected in real time with computer-controlled Risley prisms. Except when the wind was strong and caused an elongation of the autocorrelation peaks (e.g., for HD 33883), these peaks were circular, which is a good indication of the quality of the dispersion correction.

TABLE 2

FILTER CHARACTERISTICS

Name	Central Wavelength (nm)	Bandwidth (nm)
B............	447	47
OIII	501	11
V............	530	57
R............	644	70
RL	743	69
I.............	855	74

PISCO can make use of various detectors, as described in Prieur et al. (1998). The observations presented here were performed with three detectors: the CAR (Caméra à Anode Résistive or Ranicon detector), the ICCD (Intensified CCD with a microchannel plate), and the PAPA (photon-counting detector, derived from the version described in Papaliolios, Nisenson, & Ebstein 1985).

In Table 1, the nights are qualified as "used" when we could open the dome; however, the FWHM seeing was generally much poorer than the yearly average TBL value of $\sim$1″.2. During the period 1993–1998, over one hundred nights were allocated to the projects studied with PISCO, with a usability rate of 33% that is significantly less than the average rate of $\sim$50% for this site.

3. DATA REDUCTION

The data reduction of a given observing sequence started with a detector-dependent preprocessing phase that generated an autocorrelation according to the method described in Worden et al. (1977). The mean intercorrelation of two frames separated by a delay larger than the coherence time was subtracted from the mean autocorrelation of the elementary frames. This removed the background of the mean autocorrelation and nicely increased the contrast of the secondary peaks of binary stars. Astrometry parameters were then derived from this autocorrelation following the procedure described in Prieur et al. (2001).

3.1. *Calibration*

The orientation of the frames was calibrated by combining two methods: (i) by using the star tracks obtained by moving the telescope along the declination and right ascension axes, and (ii) by using wide pairs with slow orbital motion as "astrometric standards": HIP 1447 and HIP 4065 (Cuypers & Seggewiss 1999; Prieur et al. 2001). The resulting angular uncertainty was found to be ±0°.4 and was included in the error on the position angle measurements displayed in Tables 3 and 4.

Likewise, the magnification scale was obtained both by the "astrometric standards" and by measuring a calibration grid placed at the entrance focal plane of PISCO. A value of 50.4 ± 0.1 m was used for the focal length of the TBL, as determined by the Pic du Midi optics group. This grid was also used to measure and correct the geometric distortion.

3.2. *Preprocessing Data Collected with the CAR Detector*

The CAR detector produces no frames, but a continuous flow of photon coordinates in chronological order. With this camera, the mean autocorrelation was computed by correlating each photon coordinate with the N others collected during a given time interval. For each photon, this time interval, dubbed "the sliding window," starts after the photon is detected and ends after a chosen "frame time" has elapsed. This "frame time" can be chosen and adjusted during off-line data processing. If the frame time is significantly larger than the coherence time τ_c of the atmospheric turbulence, noise is added to high-resolution structures, and this prevents any detection of the companion. If the frame

TABLE 3

Relative Astrometric Data

HD Name (1)	WDS Name (2)	Epoch (3)	Filt. (4)	Detector (5)	θ (deg) (6)	ρ (arcsec) (7)	$\theta_{(O-C)}$ (deg) (8)	$\rho_{(O-C)}$ (arcsec) (9)	Orbit (10)	Comments (11)
HD 4775	00507+6415	1998.665	*R*	ICCD	. . .	. . .				SB, *P* = 2090 days
HD 8036	01198−0031	1998.657	*B*	ICCD	196.4 ± 0.5*	1.598 ± 0.005				Inversion of brightest comp.
		1998.657	*V*	ICCD	16.3 ± 0.5*	1.603 ± 0.005				
		1998.657	*R*	ICCD	16.5 ± 0.5*	1.599 ± 0.004				
HD 9352	01334+5820	1994.720	*R*	CAR	. . .	. . .				SB?
		1997.071	*B*	ICCD	. . .	. . .				
		1997.071	*V*	ICCD	115. ± 2.	0.085 ± 0.006				
		1997.071	*R*	ICCD	125. ± 10.	0.092 ± 0.01				Marginal detection
		1997.071	*RL*	ICCD	. . .	. . .				
		1997.071	*I*	ICCD	. . .	. . .				
		1997.079	*V*	CAR	. . .	. . .				
		1998.665	*R*	ICCD	. . .	. . .				
HD 12447	02020+0246	1998.657	*B*	ICCD	274.4 ± 0.5*	1.867 ± 0.007	1.9	0.035	SC 83	
		1998.657	*V*	ICCD	274.7 ± 0.5*	1.861 ± 0.007	2.2	0.029	SC 83	
		1998.657	*R*	ICCD	274.4 ± 0.5*	1.864 ± 0.016	1.9	0.032	SC 83	
		1998.660	*V*	ICCD	274.6 ± 0.5*	1.867 ± 0.007	2.1	0.035	SC 83	
HD 13474	02145+6631	1998.665	*R*	ICCD	. . .	. . .				SB *P* = 32 yr
HD 17245	02475+4416	1997.082	*R*	CAR	. . .	. . .				SB *P* = 349 days
		1997.082	*I*	CAR	. . .	. . .				
		1998.657	*V*	ICCD	. . .	. . .				
		1998.657	*V*	ICCD	. . .	. . .				
HD 17378	02945+5705	1994.720	*R*	CAR	. . .	. . .				
		1998.657	*V*	ICCD	. . .	. . .				Marginal detection
		1998.665	*R*	ICCD	. . .	. . .				
HD 18925	03048+5330	1998.657	*B*	ICCD	244.0 ± 1.1*	0.255 ± 0.003	−0.3	0.001	PB 00	SB *P* = 5350 days
		1998.657	*V*	ICCD	244.9 ± 0.5*	0.253 ± 0.003	0.6	−0.001	PB 00	
		1998.657	*R*	ICCD	245.2 ± 1.2*	0.252 ± 0.003	1.1	−0.002	PB 00	
HD 23089	03460+6321	1998.665	*V*	ICCD	. . .	. . .				SB *P* = 6150 days
HD 29104	04357+1953	1994.720	*R*	CAR	134. ± 3.5	0.065 ± 0.002				Marginal det., SB *P* = 488 days
HD 29140	04357+1010	1997.071	*B*	ICCD	125.9 ± 0.5*	0.175 ± 0.002	−0.7	0.002	BG 99	A is SB (*P* = 3.6 days)
		1997.071	*V*	ICCD	125.9 ± 0.5*	0.173 ± 0.006	−0.7	0.000	BG 99	
		1997.071	*R*	ICCD	126.9 ± 1.5*	0.164 ± 0.01	0.3	−0.009	BG 99	Fuzzy autocorr. peaks
HD 33883	05135+0158	1994.720	*R*	CAR	234 ± 6	0.60 ± 0.04	−3.1	0.015	MS 99	Elongated autocorr. peaks
HD 49618	06531+5927	1997.079	*B*	CAR	. . .	. . .				
		1997.079	*V*	CAR	(277 ± 10)	0.239 ± 0.017	(−16.5)	0.025	DC 84	Very bad seeing
							(−9.7)	−0.041	HZ 86	
		1997.079	*R*	CAR	(312 ± 10)	0.268 ± 0.051	(18.5)	0.054	DC 84	Very bad seeing
							(25.3)	−0.012	HZ 86	
		1997.079	*RL*	CAR	292 ± 3	0.219 ± 0.034	−1.5	0.005	DC 84	
							5.3	−0.061	HZ 86	
		1997.079	*I*	CAR	293 ± 2	0.240 ± 0.027	−0.5	0.214	DC 84	
							6.3	−0.040	HZ 86	
HD 82072	09296−0307	1997.079	*B*	CAR	. . .	. . .				
		1997.079	*RL*	CAR	30.3 ± 0.9	0.895 ± 0.010				
		1997.082	*B*	CAR	30.4 ± 0.5	0.868 ± 0.024				
		1997.082	*V*	CAR	. . .	. . .				
		1997.082	*R*	CAR	. . .	. . .				Marginal detection
HD 83808	09412+0954	1997.071	*V*	ICCD	267.9 ± 0.5	0.59 ± 0.1				(Aristidi et al. 1999)
		1997.076	*R*	CAR	. . .	. . .				A is SB, *P* = 14 days
		1997.079	*RL*	CAR	. . .	. . .				
		1997.079	*I*	CAR	. . .	. . .				
HD 85558	09525−0806	1997.082	*B*	CAR	64.7 ± 2.	0.594 ± 0.038	1.0	−0.012	HZ 82	
		1997.082	*V*	CAR	. . .	. . .				Marginal detection
		1997.082	*R*	CAR	63.4 ± 0.5	0.615 ± 0.013	−0.3	0.009	HZ 82	
HD 109358...	12337+4121	1997.079	*V*	CAR	. . .	. . .				
		1997.079	*R*	CAR	. . .	. . .				
HD 159870...	17335+5734	1995.556	*B*	CAR	307.8 ± 0.6	0.099 ± 0.005				
		1995.556	*R*	CAR	308.1 ± 0.7	0.102 ± 0.002				
		1995.561	*V*	CAR	309.2 ± 1.2	0.094 ± 0.004				
HD 166479...	18101+1629	1995.553	*B*	CAR	220.1 ± 0.5	1.218 ± 0.008	1.7	−0.023	HP 64	

TABLE 3—*Continued*

HD Name (1)	WDS Name (2)	Epoch (3)	Filt. (4)	Detector (5)	θ (deg) (6)	ρ (arcsec) (7)	$\theta_{(O-C)}$ (deg) (8)	$\rho_{(O-C)}$ (arcsec) (9)	Orbit (10)	Comments (11)
		1995.553	*V*	CAR	221.3 ± 0.5*	1.221 ± 0.019	2.9	−0.020	HP 64	
		1995.553	*R*	CAR	220.4 ± 0.5*	1.210 ± 0.002	2.0	−0.031	HP 64	
		1998.657	*B*	ICCD	220.6 ± 0.5*	1.228 ± 0.002	2.6	−0.013	HP 64	
		1998.657	*V*	ICCD	220.7 ± 0.5*	1.225 ± 0.002	2.7	−0.016	HP 64	
		1998.657	*R*	ICCD	220.7 ± 0.5*	1.229 ± 0.002	2.7	−0.012	HP 64	
HD 169985...	18272+0012	1998.657	*V*	ICCD	. . .	. . .				SB $P = 386$ days, triple system
HD 178452...	19082+1215	1995.561	*B*	CAR	181.9 ± 1.5	0.158 ± 0.002				
		1995.561	*V*	CAR	183.7 ± 0.8	0.156 ± 0.004				
		1998.657	*V*	ICCD	180.9 ± 0.5	0.169 ± 0.01				Weak autoc. peaks
HD 183912...	19307+2758 AB	1995.559	*B*	CAR	234.3 ± 1.0*	34.4 ± 0.2				Albireo
		1995.559	*V*	CAR	234.9 ± 1.0*	34.0 ± 0.2				
		1995.559	*R*	CAR	233.2 ± 1.0*	34.3 ± 0.2				
HD 183912...	19307+2758 Aa	1995.556	*B*	CAR	139.0 ± 0.8	0.398 ± 0.009	−1.9	0.008	HK 99	
		1995.556	*R*	CAR	140.9 ± 1.0	0.397 ± 0.009	−0.0	0.007	HK 99	
		1995.559	*V*	CAR	139.3 ± 1.0	0.397 ± 0.007	−1.6	0.007	HK 99	
		1998.657	*B*	ICCD	132.7 ± 0.5*	0.388 ± 0.005	0.5	0.018	HK 99	
		1998.657	*V*	ICCD	132.7 ± 0.5*	0.384 ± 0.006	0.5	0.007	HK 99	
		1998.657	*R*	ICCD	132.3 ± 0.9*	0.385 ± 0.007	0.9	0.008	HK 99	
		1998.660	*V*	ICCD	. . .	. . .				
HD 183912...	19307+2758 Aa′	1995.556	*B*	CAR	. . .	. . .				Marginal detection
		1995.556	*R*	CAR	. . .	. . .				Marginal detection
		1995.559	*V*	CAR	160.0 ± 4.0	0.045 ± 0.003				
HD 184759...	19348+2928	1998.657	*V*	ICCD	. . .	. . .				SB $P = 1572$ days
HD 186203...	19426+1150	1993.605	*V*	CAR	73. ± 1.	0.39 ± 0.01				
		1995.553	*R*	CAR	76.4 ± 1.0	0.421 ± 0.006				
		1995.559	*B*	CAR	76.9 ± 0.5	0.430 ± 0.005				
		1995.559	*V*	CAR	76.7 ± 0.5	0.431 ± 0.004				
		1998.657	*B*	ICCD	77.9 ± 0.5*	0.417 ± 0.002				
		1998.657	*V*	ICCD	77.4 ± 0.5*	0.417 ± 0.002				
		1998.657	*R*	ICCD	77.0 ± 0.5*	0.420 ± 0.002				
HD 186518...	19439+2708	1998.657	*B*	ICCD	282. ± 2.	0.348 ± 0.02				
		1998.657	*V*	ICCD	283.2 ± 0.6	0.360 ± 0.003				
		1998.657	*R*	ICCD	283.6 ± 0.5*	0.349 ± 0.004				(Prieur et al. 2001)
HD 187259...	19487+1149	1995.561	*B*	CAR	106.6 ± 0.7	1.499 ± 0.020				
		1995.561	*V*	CAR	106.8 ± 0.8	1.451 ± 0.008				
		1995.561	*R*	CAR	107.6 ± 0.8	1.467 ± 0.010				
		1998.657	*B*	ICCD	107.3 ± 0.5*	1.449 ± 0.003				
		1998.657	*V*	ICCD	107.4 ± 0.5*	1.450 ± 0.003				
		1998.657	*R*	ICCD	107.1 ± 0.5*	1.447 ± 0.004				
		1998.660	*V*	ICCD	107.0 ± 0.5*	1.447 ± 0.010				
HD 187321...	19487+1852	1998.657	*B*	ICCD	100. ± 2.*	0.400 ± 0.02				Artifact in central line
		1998.657	*V*	ICCD	99.5 ± 0.5*	0.412 ± 0.002				
		1998.657	*R*	ICCD	99.6 ± 0.5*	0.411 ± 0.002				
HD 192577...	20136+4644	1998.665	*V*	ICCD	. . .	. . .				SB $P = 3784$ days
		1998.665	*R*	ICCD	. . .	. . .				
HD 192909...	20155+4743	1998.665	*R*	ICCD	. . .	. . .				SB $P = 1148$ days
HD 194359...	20244+2417	1994.706	OIII	CAR	111.5 ± 1.7	0.363 ± 0.004				Noisy
		1998.657	*B*	ICCD	116.4 ± 0.6*	0.353 ± 0.004				
		1998.657	*V*	ICCD	117.0 ± 0.5*	0.357 ± 0.004				
		1998.657	*R*	ICCD	116.4 ± 0.5*	0.352 ± 0.002				
HD 195692...	20320+2548	1995.550	*V*	CAR	. . .	. . .				A is SB ($P = 11$ days)
		1995.550	*R*	CAR	240.1 ± 1.1	0.161 ± 0.005				
		1998.657	*B*	ICCD	244.3 ± 0.5	0.223 ± 0.002				
		1998.657	*V*	ICCD	243.7 ± 0.7	0.226 ± 0.006				
		1998.657	*R*	ICCD	242.6 ± 0.8*	0.227 ± 0.006				
		1998.660	*V*	ICCD	244.0 ± 1.2*	0.225 ± 0.008				
HD 196088...	20330+4950	1998.665	*R*	ICCD	220.0 ± 0.7	0.082 ± 0.003	7.9	0.065	OJ 00	SB
HD 196093...	20339+3515	1994.706	*V*	CAR	. . .	. . .				
		1995.550	*R*	CAR	. . .	. . .				
		1998.657	*B*	ICCD	280. ± 2.	0.317 ± 0.04				Artifact in central line
		1998.657	*V*	ICCD	. . .	. . .				Marginal detection
		1998.657	*R*	ICCD	278.4 ± 1.5*	0.282 ± 0.01				
HD 197177...	20410+3218	1998.657	*V*	ICCD	. . .	. . .				

TABLE 3—*Continued*

HD Name (1)	WDS Name (2)	Epoch (3)	Filt. (4)	Detector (5)	θ (deg) (6)	ρ (arcsec) (7)	$\theta_{(O-C)}$ (deg) (8)	$\rho_{(O-C)}$ (arcsec) (9)	Orbit (10)	Comments (11)
HD 199306...	20537+5918	1998.665	*R*	ICCD	97.4 ± 0.5	0.166 ± 0.002	−0.1	−0.001	HK 89	
HD 203338...	21193+5837	1998.665	*R*	ICCD	...	...				Very bad seeing
HD 208132...	21516+6545	1998.665	*R*	ICCD	147.7 ± 0.5*	1.450 ± 0.002				
HD 208816...	21567+6338	1998.665	*R*	ICCD	...	...				SB $P = 7430$ days
HD 209790...	22038+6438	1998.665	*R*	ICCD	...	...				SB $P = 811$ days
HD 213310...	22295+4742	1998.657	*V*	ICCD	...	...				SB $P = 42$ yr
HD 213973...	22330+6955	1998.665	*R*	ICCD	116.0 ± 1.0	0.198 ± 0.004	−3.8	0.012	SJ 99	
		1998.665	*R*	ICCD	121.2 ± 1.0	0.204 ± 0.008	1.4	0.018	SJ 99	
HD 214558...	22383+4511	1998.657	*V*	ICCD	...	...				Artifact in central line
HD 214606...	22373+6913	1998.665	*R*	ICCD	0.2 ± 0.5	0.535 ± 0.007				A is Am, perhaps SB
HD 215242...	22431+4710									Triple system
	... AB	1993.605	*V*	CAR	300.0 ± 1.0	0.462 ± 0.01				
	... AC	1993.605	*V*	CAR	309.0 ± 1.0	0.450 ± 0.01				
	... BC	1993.605	*V*	CAR	$42. \pm 6.$	0.069 ± 0.02				
	... AB	1993.605	*R*	CAR	300.7 ± 1.0	0.453 ± 0.01				
	... AC	1993.605	*R*	CAR	308.5 ± 1.0	0.453 ± 0.01				
	... BC	1993.605	*R*	CAR	$34. \pm 6.$	0.054 ± 0.01				
	... AB	1993.608	*B*	CAR	...	...				Marginal detection
	... AB	1993.611	*B*	CAR	...	...				
	... AB	1995.553	*R*	CAR	...	...				Marginal detection
	... AB	1995.556	*B*	CAR	306.0 ± 1.0	0.517 ± 0.01				
	... AB	1995.556	*V*	CAR	305.2 ± 1.0	0.508 ± 0.01				
	... AB	1995.556	*R*	CAR	305.7 ± 1.0	0.499 ± 0.01				
	... AB	1997.476	*R*	PAPA	302.8 ± 1.0	0.509 ± 0.01				
	... AC	1997.476	*R*	PAPA	308.2 ± 1.0	0.507 ± 0.01				
	... BC	1997.476	*R*	PAPA	$44.0 \pm 5.$	0.056 ± 0.01				
	... AB	1998.657	*B*	ICCD	302.6 ± 1.5	0.496 ± 0.005				Fuzzy autocorr. peaks
	... AB	1998.657	*V*	ICCD	304.6 ± 0.5	0.501 ± 0.002				
	... AB	1998.657	*R*	ICCD	304.4 ± 0.5*	0.499 ± 0.002				
	... AB	1998.660	*V*	ICCD	304.5 ± 0.5*	0.499 ± 0.002				
HD 223047...	23460+4625	1995.550	*R*	CAR	...	...				ψ And; Marginal detection
		1995.556	*B*	CAR	282.0 ± 1.7	0.327 ± 0.009				
		1995.559	*B*	CAR	282.3 ± 0.7	0.325 ± 0.006				
		1995.559	*V*	CAR	281.6 ± 1.0	0.317 ± 0.004				
		1998.657	*B*	ICCD	280.1 ± 0.5	0.351 ± 0.008				Artifact in central line
		1998.657	*V*	ICCD	280.3 ± 0.5	0.332 ± 0.009				
		1998.657	*R*	ICCD	280.2 ± 0.5*	0.342 ± 0.005				
HD 224646...	23595+5441	1998.665	*R*	ICCD	86.9 ± 0.5	0.386 ± 0.003				

Notes.—Relative astrometric data (epoch, ρ, θ, respectively, in cols. [3], [6], and [7]) of the composite spectrum stars. The position angles θ have a 180° ambiguity except those marked with an asterisk (*), for which triple correlation methods removed this ambiguity. Table 3 is also available in machine-readable form in the electronic edition of the *Astrophysical Journal Supplement*.

time is too small, the signal-to-noise ratio is degraded by photon noise, which may also impede companion detection.

To determine the optimum frame time, which maximizes the contrast of the secondary peaks in the autocorrelation function of the binary star, we computed from the same data a series of autocorrelations with frame times spanning the range 2–20 ms. Optimal values were 5–8 ms, which implies that the turbulence was fast ($\tau_c = 3$–5 ms).

Another important parameter of the reduction procedure was the spatial sampling factor (rebinning) of the autocorrelations. For each data set, a compromise had to be found since a large spatial sampling increases the signal-to-noise ratio (by reducing the photon noise), while decreasing the angular resolution. Hence, by providing a list of photo-events coordinates, the CAR detector offers a high flexibility and the possibility to determine during the data processing phase the optimum values for the frame time and the sampling factor.

Unfortunately, this detector presents two defects which had to be calibrated and corrected:

1. *A small geometric distortion:* the detector axes (i.e., those of the resistive anode) were not strictly perpendicular relative to each other (difference up to $2\overset{\circ}{.}5$), and at a different scale (up to 2%). To correct this geometric distortion, two-dimensional polynoms were fitted each night to images of the scaling grid available in PISCO and applied to the CAR data.
2. *A hole in the center of the autocorrelation function* commonly appears when using detectors coupled to a microchannel plate. This hole is due to the electronic depletion of a channel that appears after the detection of a photo-event in that channel. This depletion can last a few milliseconds and is a limitation to working at high illuminations. We thus limited the illumination to 10^4 photons s^{-1} by inserting neutral densities for bright objects ($V < 7$). We also modified

TABLE 4

Relative Astrometry of Our Complementary List (Same Structure as Table 3)

HD Name (1)	WDS Name (2)	Epoch (3)	Filt. (4)	Detector (5)	θ (deg) (6)	ρ (arcsec) (7)	$\theta_{(O-C)}$ (deg) (8)	$\rho_{(O-C)}$ (arcsec) (9)	Orbit (10)	Comments (11)
ADS 9701	15348+1032	1995.556	*B*	CAR	174.8 ± 0.5*	4.00 ± 0.01	−1.8	−0.254	HP 73	
		1995.556	*V*	CAR	174.7 ± 0.5*	4.00 ± 0.01	−1.9	−0.254	HP 73	
		1995.556	*R*	CAR	174.7 ± 0.5*	4.00 ± 0.01	−1.9	−0.254	HP 73	
ADS 11046.......	18055+0230	1995.559	*B*	CAR	165.7 ± 0.5*	2.63 ± 0.02	−0.4	0.071	PB 00	
		1995.559	*V*	CAR	165.6 ± 0.6*	2.62 ± 0.02	−0.5	0.061	PB 00	
		1995.559	*R*	CAR	165.6 ± 0.6*	2.61 ± 0.02	−0.5	0.051	PB 00	
HD 895	00134+2659	1993.602	*V*	CAR	172.5 ± 1.	0.347 ± 0.01	−3.8	0.005	SC 00	
		1993.608	*V*	CAR	172.1 ± 1.	0.342 ± 0.01	−4.2	0.000	SC 00	
		1993.608	*R*	CAR	172.5 ± 1.	0.335 ± 0.01	−3.8	−0.007	SC 00	
HD 2913	00324+0657	1993.614	*B*	CAR	...	0.180 ± 0.01				
		1993.611	*V*	CAR	286.7 ± 3.	0.198 ± 0.015	−5.4	0.007	MS 97	
		1993.611	*V*	CAR	290.0 ± 3.	0.183 ± 0.015	−2.1	−0.008	MS 97	
HD 156729.......	17177+3717	1994.720	*R*	CAR	139.1 ± 0.8	0.906 ± 0.007				
HD 196178.......	20339+4642	1993.602	*V*	CAR	60.9 ± 3.	0.260 ± 0.02				
		1993.605	*V*	CAR	63.0 ± 2.	0.270 ± 0.02				
		1993.614	*R*	CAR	62.3 ± 2.	0.305 ± 0.03				
HD 197018.......	20396+4035	1993.602	*V*	CAR	1.6 ± 1.	0.871 ± 0.02				
HD 206644.......	21424+4105	1993.602	*V*	CAR	335.5 ± 2.	0.167 ± 0.01	−2.6	0.003	HK 00	
HD 214810.......	22408−0333	1993.614	*B*	CAR	126.2 ± 2.	0.349 ± 0.01	−3.3	−0.021	SJ 99	
		1993.605	*V*	CAR	126.2 ± 1.	0.348 ± 0.01	−3.3	−0.022	SJ 99	
		1993.605	*R*	CAR	125.5 ± 1.	0.350 ± 0.01	−4.0	−0.020	SJ 99	
		1995.550	*V*	CAR	...	...				Marginal detection
		1995.550	*R*	CAR	129.0 ± 0.9	0.384 ± 0.004	−1.1	0.017	SJ 99	
V Cyg..............	...	1993.605	*R*	CAR	...	...				Asymmetric core

Note.—Table 4 is also available in machine-readable form in the electronic edition of the *Astrophysical Journal Supplement*.

the sliding window, shifting it by one or several milliseconds toward the future. In such a situation, each photon is not correlated with those immediately following, but correlated only with other photons detected at a time when the microchannels have partially recovered from depletion. The "photon counting hole" effect mainly affects the photometric measurements. Although it can reduce the detectability of very close binaries, it does not introduce artifacts on the astrometric measurements.

3.3. *Preprocessing Data Collected with the ICCD Detector*

The data from the ICCD were stored as frames in SVHS tapes with a rate of 50 frames s^{-1}. For the ICCD, the exposure time of elementary frames could take any value between 64 μs and 16 ms, but the time interval between two successive frames was fixed (20 ms). This detector could not work in genuine photon counting mode and thus did not provide the coordinates of individual photo-events. A specially designed program (by J. L. P.) controlled a videotape recorder and a digitizing board, allowing a fully automatic processing of these tapes (Prieur et al. 2001).

3.4. *Preprocessing Data Collected with the PAPA Detector*

The preprocessing phase of the data obtained with the PAPA detector is described in Aristidi et al. (1999) and concerns here only a few measurements.

3.5. *Astrometric Measurements*

The treatment of the mean autocorrelations was identical for all detectors. It consisted of accurately measuring the position of the secondary peaks of the binary stars, from which the position angles and angular separations of the components were derived. This was interactively done by a set of procedures described in Prieur et al. (2001).

4. RESULTS

The astrometric measurements are displayed in Tables 3 and 4. The HD name is in column (1), and the corresponding WDS name[3] is given in column (2). For each observing sequence, we give the epoch of observation (col. [3]) in Besselian years, the filter (col. [4]) (whose characteristics are listed in Table 2), the detector used (col. [5]), the position angle θ in degrees (col. [6]), relative to north increasing in the direction of increasing right ascension, and the angular separation ρ in arcseconds (col. [7]).

In columns (8) and (9) are indicated the residuals $O-C$ (observed minus computed) for the objects with a known orbit, whose origin is given in column (10): HP 64 (Hopmann 1964), HP 73 (Hopmann 1973), HZ 82 (Heintz 1982), SC 83 (Scardia 1983), DC 84 (Docobo & Costa 1984), HZ 86 (Heintz 1986), HK 89 (Hartkopf, McAlister, & Franz 1989), MS 97 (Mason 1997), BG 99 (Balega et al. 1999), HK 99 (Hartkopf 1999), MS 99 (Mason, Douglass, & Hartkopf 1999a), SJ 99 (Soderhjelm 1999), HK 00 (Hartkopf & Mason 2000) OJ 00 (Olevic & Jovanovic 2000), PB 00 (Pourbaix 2000), and SC 00 (Scardia et al. 2000b).

In some cases (noted as "Marginal detection" in col. [11]), although the companion could be detected, the meas-

---

[3] Washington Double Star Catalog, http://ad.usno.navy.mil/wds/wds.html.

urements are not given as they would be too uncertain to be of any use. Note that the *V* and *R* measurements of the position angle of HD 49618 have large errors; they are given between brackets. In column (11), we also indicate if the object is known to be a spectroscopic binary (SB) and, when applicable, give its orbital period.

The position angle θ of the companion was measured from the autocorrelation function, which leaves a 180° ambiguity. When the signal-to-noise ratio was good enough, the restricted triple-correlation technique described in Aristidi et al. (1997a), or the image restoration with bispectral techniques (Prieur, Lannes, & Cullum 1991), allowed us to remove this ambiguity. This is noted with an asterisk (*) in column (6). We note that for HD 8036, the brightest component in the *B* image is at 180° relative to that found in the *V* and *R* images.

To have a more comprehensive view of our program on composite spectrum stars, we have included in Table 3 two previously published measurements of HD 83808 and HD 186518 made with PISCO (references given in col. [11]).

The smallest (1 σ) errors for the angular separation (col. [6]) were estimated at $0\farcs002$ for close pairs (i.e., $\rho < 1''$) and 0.2% for wide pairs (i.e., $\rho > 1''$) on the basis of the uncertainties coming from the determination of the center of the autocorrelation peak and those affecting scale calibration. Similarly, the smallest (1 σ) error found for the angle position (col. [7]) was $0\fdg5$.

To evaluate systematic errors (e.g., a wrong value of the focal length), we plotted in Figure 1 the residuals relative to the ephemerides for objects with known orbits (cols. [8] and [9] of Tables 3 and 4). In this plot, we excluded the case of HD 196088 whose latest orbit led to particularly large residuals (discussed in § 5.1). Although some residuals are rather large—due to the poor knowledge of the orbits for these objects—they are globally centered at ($\Delta\theta = 0$; $\Delta\rho = 0$), which indicates the absence of systematic errors.

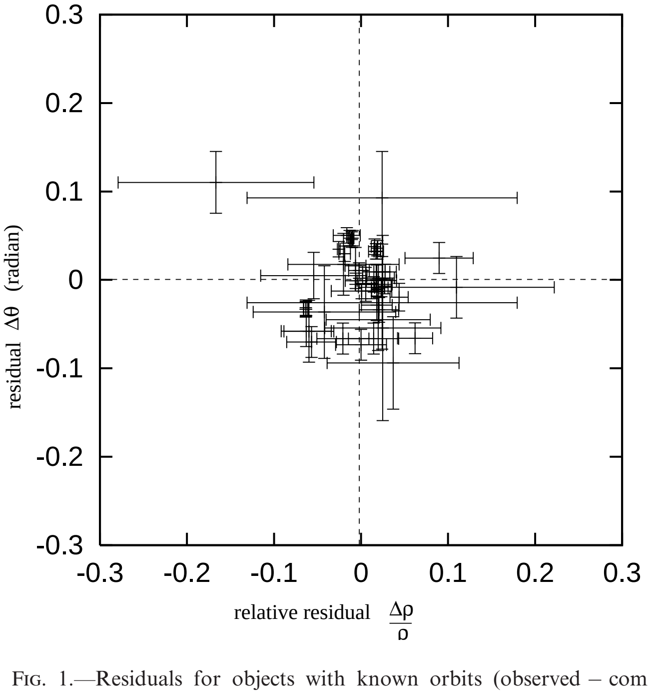

Fig. 1.—Residuals for objects with known orbits (observed − comcomputed).

5. DISCUSSION

We compared our measurements with those from other observers, making an extensive use of the CHARA Third Catalog[4] (hereafter CHARA3), which includes all published measures of binary stars obtained with interferometric techniques.

5.1. *Composite Spectrum Stars: Particular Cases*

In this section, we successively examine the binaries (L4, WGT 1Aa and BON Ap), whose duplicity is confirmed for the first time since their discovery, and the objects HD 49618 and HD 196088 which exhibit the largest residuals in Table 3 (cols. [8] and [9]).

The companion of HD 29104 (L4, ADS 3316) was discovered by Thomas Lewis in 1902 with the 28 inch refractor of the Greenwich Observatory, with $\theta = 192°$ and $\rho = 0\farcs34$ (Dyson 1921), and was never detected again, despite numerous attempts, especially in the period 1910–1922. Aitken (1932) concluded in his famous "New General Catalog of Double Stars" by the comment: "It is very doubtful whether the star is double." Only one observation (negative detection) is reported in CHARA3 (Bonneau, Carquillat, & Vidal 1984). Our measurement in 1994.720 with $\theta = 134\fdg0$ and $\rho = 0\farcs065$ is then the first confirmation of the duplicity of HD 29104, more than 90 years after its discovery.

Likewise, our observations of HD 83808 (WGT 1Aa, ADS 7480) and HD 183912 Aa′ (BON Ap) are the first successful detections since the discovery of the companions for both objects, respectively, with $\theta = 17\fdg0$, $\rho = 0\farcs463$ in 1980 (Weigelt & Wirnitzer 1983) and $\theta = 163°$, $\rho = 0\farcs125$ in 1978 (Bonneau & Foy 1980).

For HD 49618 (STF 963 AB, ADS 5514), the orbit computed by Docobo & Costa (1984) fits better our measurements than Heintz's (1986) orbit, although the residuals are large in both cases. This was unexpected since Heintz's orbit is more recent and should be more accurate.

The $O - C$ residuals of HD 196088 (MCA 61, BD +49 3310, HD 196089) are the largest seen in Figure 1. This is surprising since the orbit was computed in 2000 (Olevic & Jovanovic 2000) and should be compatible with our observation, made in 1998.665. We are quite confident about the quality of our measurement since it is in good agreement with the previous speckle observations reported in CHARA3. The angular separation has been increasing rather regularly from $0\farcs047$ to $0\farcs074$ during the period 1989–1996. Our measurement shows that the periastron passage predicted in 1998.49 by Olevic & Jovanovic did not occur.

As a general remark, our measurements will be very useful for future orbit determinations, because the number of speckle measurements of composite stars, and of binaries in general, has been decreasing in the 1990's. For example, since the *Hipparcos* measurement of 1991.25 (ESA 1987), only one measurement is given in CHARA3 for the objects HD 195692 (STF 2695, ADS 13971) and HD 214606 (CHR 113, BD +68 1319), obtained by Hartkopf et al. (2000) in 1996 and 1994, respectively. This decrease of the occurrence rate of speckle observations is of particular importance for

---

[4] See http://ad.usno.navy.mil/dsl/Speckle/intro.html.

the small angular separations, due to a lack of observations with large telescopes.

5.2. *Complementary List: Particular Cases*

For ADS 9701 (WDS 15348+1032), the orbit computed by Hopmann (1973) leads to large residuals ($\rho_{(O-C)} = -0''.254$) and clearly needs revision. The orbit of this double star is still undetermined because the companion has moved along an orbital arc of only 26° between 1822 and 1990. The relative motion of the two components is very slow, and the period is thus expected to be very large. In the hypothetical case (quite unlikely) of a circular orbit, the orbital period would be about 2300 years. Our measurement is in agreement with the *Hipparcos* data: $\theta = 174^\circ.8$, $\rho = 4''.012$.

During the data reduction, the objects HD 156729 and HD 196178 that we intended to use as reference stars were subsequently found to be double stars (Table 4).

HD 196178 (HIP 101475, WDS 20339+4642) was discovered as a double system by *Hipparcos* with $\rho = 0''.311$ and $\theta = 56^\circ$. In CHARA3, only one ground-based observation is reported in 1996.699, with $\rho = 0''.302$ and $\theta = 60^\circ.2$ (Mason et al. 1999b).

HD 156729 (HR 6436, HIP 84606) was also found double by *Hipparcos*: $\rho = 0''.844$, $\theta = 141^\circ$, with $\Delta m \sim 4.2$. This large magnitude difference between the two components explains why all speckle detection attempts of the companion have failed in 1988.169 ($\rho < 0''.038$; McAlister et al. 1993), in 1997.269 ($\rho < 0''.054$; Mason et al. 1999b) and in 1997.460 ($\rho < 0''.054$; Mason et al. 1999b). Our measurement in 1994.720 ($\rho = 0''.906$, $\theta = 139^\circ$) agrees well with the *Hipparcos* data. We also found a large magnitude difference, the companion brightness being close to our detection limit.

5.3. *Composite Spectrum Stars not Resolved by PISCO*

We now examine the possible reasons which may account for the nondetection of the companion of some targets. Let us recall that we could not resolve all the binary stars with angular separations less than the TBL diffraction limit ρ_d ($\rho_d = 0''.05$ in V).

The objects that were never resolved during our observations are listed in Table 5. If we take into account the last measurements by other observers (cols. [2]–[5]), the objects of this table belong to three groups (cf. col. [6]):

1. Binaries with a very small angular separation $\rho < \rho_d$;
2. Binaries with $\rho_d \leq \rho \leq 2\rho_d$, that can be resolved when atmospheric conditions are good;
3. Objects whose duplicity poses problem because it was never confirmed since their discovery.

5.3.1. *Objects with Small Angular Separations*

Among our sample of composite spectrum stars, there are binaries whose components are closer than the TBL diffraction limit over part of their orbit. Hence, the absence of a companion detection by PISCO is not surprising. An extreme case is HD 192577 (WRH 33Aa), which was always observed with angular separations smaller than $0''.03$.

With angular separations larger than ρ_d, the objects of the second group should have been resolved by PISCO. Let us remark that all of these objects were only observed once by PISCO and this absence of detection is not meaningful. It must be due to bad seeing. Actually, the performances of speckle interferometry are tightly related to the coherence time τ_c and radius r_0 of the atmospheric turbulence (cf., e.g., Roddier 1981). As the tur-

TABLE 5

Composite Spectrum Stars not Resolved by PISCO

Name (1)	Last Companion Detection Epoch (2)	θ (deg) (3)	ρ (arcsec) (4)	Reference (5)	Group (6)	
HD 4775 = MCA 2 = HR 233	1994.719	212.5	0.022	1	(1)	$\rho < 0''.05$
HD 192577 = WRH 33Aa = ADS 13554	1985.843	111.4	0.027	2	(1)	$\rho < 0''.05$
HD 184759 = WRH 32 = HR 7441	1994.721	17.8	0.032	1	(1)	$\rho < 0''.05$
HD 209790 = MCA 69Aa = ADS 15600	1994.716	206.4	0.039	1	(1)	$\rho < 0''.05$
HD 13474 = MCA 6 = HR 640	1994.709	217.8	0.07	3	(2)	$0''.05 \leq \rho \leq 0''.1$
HD 23089 = MCA 12 = HR 1129	1993.205	359.2	0.054	4	(2)	$0''.05 \leq \rho \leq 0''.1$
HD 203338 = BAG 9Aa = ADS 14864	1996.538	121.8	0.112	3	(2)	$0''.05 \leq \rho \leq 0''.1$
HD 213310 = MCA 71 = HR 8572	1994.716	43.1	0.082	5	(2)	$0''.05 \leq \rho \leq 0''.1$
HD 214558 = CHR 114 = HR 8617	1996.553	205.5	0.114	3	(2)	$0''.05 \leq \rho \leq 0''.1$
HD 17245 = CHR 7 = BD +43 576	1984.058	104.4	0.161	2	(3)	Dubious or difficult case
HD 17378 = MCA 9 = HR 825	1980.893	98.7	0.186	6	(3)	Dubious or difficult case
HD 109358 = BNU 4Aa = HR 4785	1978.397	43	0.110	7	(3)	Dubious or difficult case
HD 169985 = STF 2316Aa = ADS 11353	1976.613	156.9	0.250	8	(3)	Dubious or difficult case
HD 192909 = V1488 Cyg = HR 7751	. . .	. . .	. . .	9	(3)	Dubious or difficult case
HD 197177 = BNU 7Aa = ADS 14158	1979.463	19.0	0.244	7	(3)	Dubious or difficult case
HD 208816 = WRH 36 = HR 8383	1950.560	174.5	0.05	10	(3)	Dubious or difficult case

References.—(1) Schoeller et al. 1998; (2) McAlister et al. 1987; (3) Hartkopf et al. 2000; (4) Hartkopf et al. 1994; (5) Hartkopf et al. 1997; (6) McAlister & Hartkopf 1984; (7) Bonneau et al. 1980; (8) McAlister & Hendry 1982; (9) Never resolved; (10) Wilson 1951.

bulence can vary quickly, τ_c and r_0 can quickly reach values small enough to impede the resolution of close binaries. This explains why in Table 3, there are many negative detection reports associated with positive detections for the same object (e.g., HD 9352, HD 82072, and HD 183912 Aa), sometimes on the same night.

5.3.2. *Dubious or Difficult Cases*

There are objects that were never resolved with PISCO at the TBL, despite multiple attempts made during the 1993–1998 period, and whose duplicity has never been confirmed either by other observers since they were discovered:

HD 17245 (*CHR 7*).—Three observations were made in 1980–1984, with only one positive detection, by the discoverer (McAlister et al. 1987). We observed HD 17245 four times in 1997–1998 without success.

HD 17378 (*MCA 9*).—Only two observations are reported in CHARA3. The companion was found in 1980 by McAlister & Hartkopf (1984) and was not detected in 1984 with a 6 m telescope (Balega & Balega 1987). Our three observations in 1994–1998 led to a negative result.

HD 109358 (*BNU 4Aa*).—It was discovered as double with $\rho = 0''.110$ by Bonneau et al. (1980) but was never detected in any of the 17 other observations performed from 1921 to 1989. Our two observations in 1997 also led to a negative result.

HD 169985 (*STF 2316 Aa*).—The companion was observed twice in 1951, with $\rho = 0''.06$ (Wilson 1952), and 1976, with $\rho = 0''.250$ (McAlister & Hendry 1982). All eight subsequent observations in 1976–1992 have failed.

HD 192909 (*V1488 Cyg*).—The 20 observations made during the period 1921–1992 have failed to detect the companion.

HD 197177 (*BNU 7Aa*).—The companion was only observed once by the discoverers with $\rho = 0''.244$ (Bonneau et al. 1980). Nine other detection attempts made in 1949–1986 led to negative results.

HD 208816 (*WRH 36*).—The companion was only seen by Wilson (1951), with a very small separation: $\rho = 0''.05$, and never confirmed despite 17 other attempts in 1949–1992.

Hence, in the last 20 years or so, all the efforts made to resolve these objects with speckle interferometry have failed. One can then wonder whether the companions are detectable by speckle interferometry. As the spectra of all these objects are composite, their binary nature is certain and the magnitude difference between their two components is not very large (≤ 3). Hence, the nondetection of the companion by speckle interferometry likely means that the two components are closer than the diffraction limit of the telescopes used.

6. CONCLUSION

The PISCO speckle camera of the Midi-Pyrénées Observatory has proven to be an efficient tool to study binary and multiple stars. Despite bad weather conditions, campaigns led with PISCO have produced a large number of astrometric measurements of binary systems, many of which could be followed during six years.

Three very different detectors were used (CAR, ICCD, PAPA), with different processing procedures. However, the results are homogeneous. The very good agreement both internally (measurements obtained with those three detectors agree) (and externally—agreement with speckle interferometry observations by other authors) shows the absence of systematic errors when operating PISCO.

We confirm the duplicity of HD 156729 (HR 6436) discovered by *Hipparcos* as having a large magnitude difference between the two components ($\Delta m = 4.2$). PISCO is the first ground-based instrument that has been able to resolve this difficult object. Indeed, in most books, it is said that the speckle technique is limited to $\Delta m \leq 3$. The CAR detector that was used for this detection appears then particularly sensitive and exhibits a high dynamical range. We also confirm the duplicity of HD 29104 (L4), HD 83808 (WGT 1Aa), and HD 183912 Aa$'$ (BON Ap). For these objects, the measurements with PISCO are the first successfully performed since the discovery of their duplicity, in 1902, 1980, and 1978, respectively.

Some objects were not resolved during our observations. A close analysis of the results obtained by previous observers yields a logical explanation. For most objects, the angular separation was very close to, or smaller than, the diffraction limit of the TBL whose diameter is too small to perform continuous measurements during an orbital revolution. For others, the companion was observed only once, by their discoverers. As the presence of these companions has never been confirmed in the last 20 years or so, even with large telescopes, the two components responsible for the composite spectrum of these objects must be too close to be detected by 2–6 m class telescopes. To resolve them, interferometric arrays are required. Since these objects are very close binaries whose components are rather bright and have a small magnitude difference, they should be useful for testing the capabilities of these arrays.

Due to a change in policy of the TBL time committee, PISCO was decommissioned in 1998, and this paper is the last of a series that has produced numerous results (Carbillet et al. 1996; Aristidi et al. 1997b, 1999; Scardia et al. 2000a; Prieur et al. 2001). PISCO has contributed measurements of binary stars during the particularly critical period of the 1990's during which the frequency of speckle measurements with 2 m class, or larger, telescopes significantly decreased. Continuous observations are essential for establishing reliable orbits. In particular, measurements obtained during the periastron passage are crucial for accurate orbit determinations. The case of HD 196088 is illustrative of this problem. Our observations obtained close to the predicted periastron invalidate a very recently published orbit. This erroneous orbit was computed after the epoch of our observations, using too scarcely distributed data. We hope the situation will soon improve with new generation speckle cameras being installed on large-size telescopes and adaptive optics systems becoming available on most of medium-size telescopes.

We would like to thank the technical staff of the Télescope Bernard Lyot for providing assistance during the observations.

We are grateful to the people who lent us some of the detectors used: Peter Nisenson (Center for Astrophysics, USA) for the PAPA detector and Denis Mourard (Côte d'Azur Observatory, France) for the CAR detector. We also thank Jean-Pierre Barriot (Midi-Pyrénées Observatory), Yves Bresson (Côte d'Azur Observatory), Christine André, Boris Dintrans, and Pierre-Antoine Hermange (all students at Midi-Pyrénées Observatory), and Bruno Lopez (Côte d'Azur Observatory) who participated to some of the observations.

This work has made use of the "Third Catalog of Interferometric Measurements of Binary Stars" (see footnote 4) and of the "Besançon database of binary stars."[5] This research has also made use of the Washington Double Star Catalog maintained at the US Naval Observatory.

---

[5] See http://bdb.obs-besancon.fr.

REFERENCES

Aitken, R. G. 1932, New General Catalog of Double Stars (Washington: Carnegie Inst. Washington)
Aristidi, E., Carbillet, M., Lyon, J.-F., & Aime, C. 1997a, A&AS, 125, 13
Aristidi, E., Carbillet, M., Prieur, J.-L., Lopez, B., Bresson, Y., & Koechlin, L. 1997b, A&AS, 126, 555
Aristidi, E., et al. 1999, A&AS, 134, 545
Balega, I. I., & Balega, Y. Y. 1987, Soviet Astron. Lett., 13, 208
Balega, I. I., Balega, Y. Y., Maksimov, A. F., Pluzhnik, E. A., Shkhagosheva, Z. U., & Vasyuk, V. A. 1999, A&AS, 140, 287
Bonneau, D., Blazit, A., Foy, R., & Labeyrie, A. 1980, A&AS, 42, 185
Bonneau, D., Carquillat, J. M., & Vidal, J. L. 1984, A&AS, 58, 729
Bonneau, D., & Foy, R. 1980, A&A, 86, 295
Carbillet, M., et al. 1996, A&A, 314, 112
Cuypers, J., & Seggewiss, W. 1999, A&AS, 139, 425
Docobo, J. A., & Costa, J. M. 1984, IAU Circ. 93
Dyson, F. W. 1921, Catalog of Double Stars from Observations Made at the Royal Observatory, Greenwich, with the 28 Inch Refractor during the Years 1893–1919 (London: H. M. Stationery Office)
ESA. 1987, *Hipparcos* Catalog (ESA SP-1200) (Noordwijk: ESA)
Ginestet, N., & Carquillat, J.-M. 2002, ApJS, submitted
Ginestet, N., Carquillat, J.-M., & Jaschek, C. 1999, A&AS, 134, 473
Ginestet, N., Carquillat, J.-M., Jaschek, C., & Jaschek, M. 1997, A&AS, 123, 135
Ginestet, N., Carquillat, J.-M., Jaschek, M., Jaschek, C., Pédoussaut, A., & Rochette, J. 1992, Atlas de Spectres Stellaires (Toulouse: Obs. Midi-Pyrénées)
Griffin, R. F. 1990, J. Astrophys. Astron., 11, 491
Hartkopf, W. I. 1999, IAU Circ. 139
Hartkopf, W. I., & Mason, B. D. 2000, IAU Circ. 142
Hartkopf, W. I., et al. 2000, AJ, 119, 3084
Hartkopf, W. I., McAlister, H. A., & Franz, O. G. 1989, AJ, 98, 1014
Hartkopf, W. I., McAlister, H. A., Mason, B. D., Barry, D. J., Turner, N. H., & Fu, H.-H. 1994, AJ, 108, 2299
Hartkopf, W. I., McAlister, H. A., Mason, B. D., ten Brummelaar, T. A., Roberts, J. C., Jr., Turner, N. H., & Wilson, J. W. 1997, AJ, 114, 1639
Heintz, W. D. 1982, A&AS, 47, 569
———. 1986, A&AS, 64, 1
Hoffleit, D., & Jaschek, C. 1982, The Bright Star Catalog (New Haven: Yale Univ. Obs.)
Hopmann, J. 1964, Ann. Sternw. Wien, 26, 28
Hopmann, J. 1973, Mitt. Wien 13
Hynek, J. A. 1938, Contrib. Perkins Obs. 10
Markowitz, A. H. 1969, Ph.D. thesis, Ohio State Univ.
Mason, B. D. 1997, AJ, 114, 808
Mason, B. D., Douglass, G. G., & Hartkopf, W. I. 1999a, AJ, 117, 1023
Mason, B. D., et al. 1999b, AJ, 117, 1890
McAlister, H. A., & Hartkopf, W. I. 1984, Catalog of Interferometric Measurements of Binary Stars, CHARA Contrib. No. 1 (Atlanta: Georgia State Univ.)
———. 1988, Second Catalog of Interferometric Measurements of Binary Stars, CHARA Contrib. No 2 (Atlanta: Georgia State Univ.)
McAlister, H. A., Hartkopf, W. I., Hutter, D. J., & Franz, O. G. 1987, AJ, 93, 688
McAlister, H. A., & Hendry, E. M. 1982, ApJS, 48, 273
McAlister, H. A., Mason, B. D., Hartkopf, W. I., & Shara, M. M. 1993, AJ, 106, 1639
Olevic, D. J., & Jovanovic, P. 2000, IAU Circ. 141
Papaliolios, C., Nisenson, P., & Ebstein, S. 1985, Appl. Opt., 24, 287
Pourbaix, D. 2000, A&AS, 145, 215
Prieur, J.-L., Koechlin, L., André, C., Gallou, G., & Lucuix, C. 1998, Exp. Astron., 8, 297
Prieur, J.-L., Lannes, A., & Cullum, M. 1991, Proc. ESO Conf. on High Resolution Imaging by interferometry II, ed. J. M. Beckers & F. Merckle (Garching: ESO), 353
Prieur, J.-L., Oblak, E., Lampens, P., Aristidi, E., Kurpinska-Winiarska, M., Koechlin, L., & Ruymaekers, G. 2001, A&A, 367, 865
Roddier, F. 1981, The Effects of Atmospheric Turbulence in Optical Astronomy, ed. E. Wolf (Vol. 2; Elsevier: North-Holland), 283
Scardia, M. 1983, Astron. Nachr., 304, 257
Scardia, M., Prieur, J.-L., Aristidi, E., & Koechlin, L. 2000a, ApJS, 131, 561
———. 2000b, Astron. Nachr., 321, 255
Schoeller, M., Balega, I. I., Balega, Y. Y., Hofmann, K.-H., Reinheimer, T., & Weigelt, G. 1998, Astron. Lett., 24, 283
Schröder, K.-P., Pols, O. R., & Eggleton, P. P. 1997, MNRAS, 285, 696
Soderhjelm, S. 1999, A&A, 341, 121
Weigelt, G., & Wirnitzer, B. 1983, Opt. Lett., 8, 389
Wilson, R. H. 1951, AJ, 56, 69
———. 1952, AJ, 57, 248
Worden, S. P., Murray, K. S., Schmidt, G. D., & Angel, J. R. P. 1977, Icarus, 32, 450