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TELEVISION SPECKLE INTERFEROMETRY OF BINARY STARS AT THE ZEISS-1000 TELESCOPE

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ABSTRACT. *Observations of 69 binary stars have been carried out with the 1 m Zeiss-1000 telescope of the Special Astrophysical Observatory by the television speckle interferometry. The angular separation between the components of binaries ranges from 0.094" to 1.190". The accuracy of relative positions in the pairs is 1.4° for the position angle, and 0.011" for the separation. The observations have shown that a 1 m class telescope, equipped with the digital instrumentation for speckle interferometry, can effectively be used for measurements of binary stars within the framework of a special program.*

На 1 м телескопе Zeiss-1000 Специальной астрофизической обсерватории с применением телевизионного спекл-интерферометра выполнены наблюдения 69 двойных звезд. Угловые расстояния между компонентами пар заключены в диапазоне от 0.094" до 1.190". Точность определения взаимных положений составляет 1.4° по позиционному углу и 0.011" по расстоянию. Наблюдения показали, что телескоп метрового класса, оснащенный цифровым оборудованием для спекл-интерферометрии, может эффективно использоваться для массовых измерений двойных и кратных звездных систем в рамках специальной программы.

1. INTRODUCTION

At present high angular resolution measurements of binary stars with speckle interferometry are widely used at most large telescopes. Merits of speckle interferometry are not so evident for smaller instruments. Indeed, the diffraction limit of resolution for a 1 m mirror is close to 0.1″ in the blue region. This is only a little better than the resolution of classical photographic observations. The precision of high angular resolution measurements is also lower for smaller telescopes. Despite that, speckle interferometry with such instruments can open new prospects of research in astronomy.

First of all, a small number of speckles in the image, equal to $(D/r_0)^2 \simeq 100$, where D is the diameter of the mirror, and r_0 is the Fried-parameter, allows to use two-dimensional detectors with a small number of pixels per image: 128^2 or 256^2. Second, there are some observational problems, that can be effectively solved with the help of small telescopes. The example of such a problem is the ground-based observational support of the mission of astrometric satellite HIPPARCOS.

As it is known, despite the problems of launching into orbit, HIPPARCOS began the program of measurements of stellar parallaxes and proper motions with a nominal precision of about 0.002″. During preparation of the mission a question arose about the possible influence of binary sources on the reduction of observational data. Out of 14000 binaries included into Input Catalog of HIPPARCOS 827 have no information about relative positions of their components. For a few thousands of other binaries only old positions are known. This is enough for pointing the telescope on stars, but can cause large errors during tne data reduction. It is also expected that high number of new binaries will be discovered during the mission. Therefore it is evident that new measurements of component relative positions in multiple systems are of great importance for the program. Mostly these multiples are accessible for the resolution with a 1 m class telescope using speckle technique. Coordinators of the HIPPARCOS mission and the IAU Commission 26 (Binary Stars) call for support of the HIPPARCOS project with ground-based high-precision observations of binary stars (Dommanget, 1990). They count on relatively small telescopes, equipped with the necessary instrumentation and available for the long term observations.

2. OBSERVATIONS

The digital speckle interferometer (Balega & Ryadchenko, 1984) was installed in the Cassegrain focus (f:13) of the Zeiss-1000 1 m telescope of the Special Astrophysical Observatory. Speckled snapshots were obtained with a photon counting camera at the frequency rate 50 images per second through the 600/20 nm interference filter. The 20x, 0.50 numerical aperture microscope objective was used to match the speckle size to the TV pixel size giving thus the required image scale of 0.0222″ per pixel. Geometry of binary stars was found from the position of the secondary peak in the two-dimensional autocorrelation function of speckle images. Between October 1990 and January 1991. 88 measurements for 69 stars were made with the mean seeing of about 2″. 8 binaries were not resolved. Stellar magnitudes of the objects from the list were distributed in the range from 2.9 to 7.4.

3. RESULTS OF MEASUREMENTS

Autocorrelations of binary stars were processed with the software developed for the processing of speckle interferometric data of the 6 m telescope. The results are collected in Table 1. It includes the names of stars and their catalogue numbers, coordinates for the epoch 2000, dates of observations, position angles θ for the companions, given in degrees (180° uncertainty), and angular distances ρ, given in arcseconds. Unresolved pairs are indicated by letters UR.

The precision of θ and ρ values was estimated from the repeated measures of the same pairs. A comparison of the measurements with ephemerides of the well-studied binaries was made also. The error of our results was found to be about ±1.4° for the position angles, and ±0.011″ for the distances. Therefore, we conclude that the precision of our measurements of binaries with the 1 m telescope is roughly 3 times lower than the one for the 6 m telescope.

Table 1. Measurements of binary stars

Catalogue number	Object name	Coordinates for 2000	Date 1990.0+	θ°	ρ″
ADS 102	STF 2	00091+7943	.7747	21	0.694
ADS 207	STF 13	00163+7657	.7747	55	0.936
ADS 434	STT 12	00138+5432	.7747	191	0.444
ADS 784	Bu 1099 AB	00568+6022	1.0293	334	0.268
ADS 940	STT 515	01093+4715	.7718	131	0.477
			1.0292	132	0.487
ADS 1123	Bu 1163	01243-0655	1.0292	224	0.220
ADS 1538	STF 186	01558+0151	1.0292	58	1.190
ADS 1598	Bu 513 AB	02019+7054	.7719	232	0.828
			1.0293	233	0.844
ADS 1630	STT 38 BC	02039+4220	.7719	108	0.568
HR 657	Cou 79	02157+2503	.7719	40	0.188
ADS 1938	STT 42 AB	02333+5218	1.0292	UR	
ADS 2200	Bu 524 AB	02537+3820	.7720	250	0.200
HR 915	γ Per	03048+5330	1.0294	UR	
ADS 2336	STF 346 AB	03055+2515	.7720	69	0.295
ADS 2436	STT 52 AB	03175+6539	1.0294	65	0.468
ADS 2799	STT 65	03504+2536	.7721	213	0.295
			1.0296	211	0.289
HR 1199	Kui 15	03519+0633	.7721	208	0.711
			1.0296	207	0.715
ADS 3064	A 1938	04136+0743	.7721	UR	
			1.0351	UR	
HR 1411	McA 15	04286+1557	.7723	UR	
			1.0351	UR	
ADS 3317	CHARA 18 Aa	04357+1010	.7722	154	0.173
HR 1497	McA 16	04422+2257	.7722	357	0.197
HR 1569	McA 17	04548+1125	1.0269	UR	
ADS 3711	STT 98	05074+0830	.7723	348	0.665
			1.0270	346	0.684
ADS 3799	STT 517 AB	05134+0158	.7723	237	0.581
			1.0270	236	0.579
ADS 4020	A 848	05255-0033	.7723	166	0.238
ADS 4134	Hei 42 Aa	05320-0018	.7723	138	0.271
			1.0270	137	0.267
ADS 4229	Bu 1240 AB	05386+3030	1.0271	6	0.178
ADS 4241	Bu 1032 AB	05387-0235	1.0271	132	0.243
			1.0324	134	0.251

Table 1 (continued)

Catalog number	Object name	Coordinates for 2000	Date 1990.0+	θ°	ρ″
ADS 4265	Bu 1007	05411+1632	.7723	241	0.330
			1.0244	240	0.328
			1.0325	237	0.314
ADS 4324	A 496	05449+2620	1.0352	8	0.300
ADS 4617	A 2715 AB	06024+0939	1.0326	21	0.408
HR 2134	Kui 23 AB	06041+2316	.7724	200	0.201
			1.0271	199	0.190
			1.0326	202	0.229
+37 1645	McA 29	07043+3734	1.0272	179	0.200
ADS 6185	STT 175 AB	07352+3058	1.0272	*147*	0.209
			1.0353	*148*	0.219
ADS 6313	A 2534 AB,C	07431+0012	1.0273	229	0.836
ADS 6378	WRH 15 AB	07486+2309	1.0273	45	0.290
ADS 6993	SP AB	08468+0625	1.0355	UR	
HR 3794	Fin 349	09326+0151	1.0274	193	0.183
HR 3889	Kui 44	09498+2111	1.0274	202	0.185
ADS 7545	STT 208	09521+5404	1.0274	199	0.190
HR 4291	CHARA 33	11006+0337	1.0276	UR	
ADS 8231	STF 1555 AB	11363+2747	1.0276	146	0.650
HR 4544	McA 36	11510-0520	1.0276	UR	
HR 4789	WRH	12348+2238	1.0277	359	0.222
			1.0330	359	0.222
ADS 8801	McA 38 Aa	13100-0532	1.0277	334	0.440
ADS 8804	STF 1728 AB	13100+1731	1.0277	194	0.436
ADS 8987	Bu 612 AB	13396+1044	1.0277	236	0.225
			1.0330	234	0.234
HR 7486	Kui 93	19412+1349	.7712	313	0.179
ADS 12808	STT 380 AB	19426+1149	.7739	76	0.427
ADS 12973	AGC 11 AB	19489+1908	.7739	170	0.229
ADS 13277	STT 395	20018+2456	.7740	122	0.842
HR 7744	McA 60 Aa,B	20158+2749	.7740	142	0.296
ADS 14073	Bu 151 AB	20375+1436	.7714	178	0.245
ADS 14126	STT 410 AB	20396+4036	.7741	6	0.851
ADS 14121	WCK Aa	20397+1556	.7714	220	0.198
ADS 14499	STF 2737 AB	20591+0418	.7741	283	0.932
HR 8038	Kui 102	21002+0731	.7744	37	0.338
ADS 14787	AGC 13 AB	21147+3802	.7742	12	0.633
ADS 15115	Hu 371	21354+2427	.7742	303	0.295
HR 8300	Kui 108	21425+4106	.7715	2	0.216
			.7742	3	0.181
ADS 15281	Bu 989 AB	21446+2539	.7742	328	0.094
ADS 16345	Bu 382 AB	22537+4445	.7744	215	0.956
ADS 16428	STT 483	22592+1144	.7715	318	0.542
			.7744	317	0.560
HR 8762	McA 77 AB	23019+4219	.7745	352	0.179
ADS 16467	Bu 1147 AB	23026+4245	.7745	350	0.338
ADS 16497	A 417 AB	23052-0742	.7745	69	0.215
ADS 16530	Hu 994	23078+6338	.7717	310	0.224
ADS 16836	Bu 720	23340+3120	.7745	268	0.541
ADS 16877	STT 500 AB	23375+4426	.7746	3	0.463

CONCLUSION

Speckle observations with the digital equipment at the Zeiss-1000 telescope confirm the idea that the moderate size instrument can effectively be used for precise observations of binary stars. Having available a well prepared observational program one can measure up to 200 pairs per night with a practical object brightness limit of about 9^m.

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