Serb. Astron. J. № 157 (1998), 13 – 17 **UDC 521.328/524.382**
Original scientific paper

INCLINATION OF THE ORBITAL PLANES OF VISUAL BINARIES

G. M. Popović

Astronomical Observatory, Volgina 7, 11160 Belgrade 74, Yugoslavia

(Received: March 2, 1998)

SUMMARY: The inclination of the orbital planes of 78 visual binaries with known orbits with respect to the galactic was examined. No double star groupings were found having approximately equal orientation of their orbital planes. Viewed the orbital plane north poles there are more binary systems with counterclockwise motion than those moving clockwise.

1. INTRODUCTION

The question of the orientation of the double star orbital planes has been considered by many authors. It was studied already as far back as closing years of the 19th century, Yet, we start here with Chang (1929), who investigated a sample of 16 binary systems. That orientation was examined also by Finsen (1933) on a sample of 23 systems and Arend (1950). All of these analyses showed a random orientation distribution. Huang and Wade Jnr. (1966), analysed the angular momentum origins in 1263 eclipsing binaries, bringing out in the framework of this study also a random orientation distribution. Orbital planes and space velocities of visual binaries were investigated by Lippincott (1967), whose inference was that there existed only a tendency of the space velocities to some parallelity with their orbital planes, abstaining, however, from taking sides as to the question of complanarity of their orbital planes. Lavus (1979) studied the inclination of orbital planes of 888 spectroscopic binaries, spacially close to each other, the purpose being to establish possible complanarity of these planes. He found 120 groups, containing 313 binaries, in which a complanarity within the groups was acceptable.

2. STATING THE TASK

The knowledge of the ascending node position of a binary orbit allows us to solve simply the question of the orbit plane inclination. This inclination is defined by the celestial coordinates of that plane's pole. If α and δ are the equator coordinates of a double star Σ, whose orbital plane inclination is required, Ω the position angle of the orbit ascending node and i the inclination of the orbital plane with respect to the observer's tangential plane, then the following relations for the equator coordinates α_0 and δ_0 of the orbit pole may be derived:

$$\alpha_0 = \alpha - \arctan \frac{\omega}{\sqrt{(1-\omega^2)}}$$

$$\delta_0 = \arctan \frac{v}{\sqrt{(1-v^2)}}$$

where

$$v = \sin\delta \sin i \sin\Omega$$

$$\omega = \frac{\sin i \cos\Omega}{\cos\delta_0}$$

The equator coordinates α_0 and δ_0 of the pole, after they are transformed into galactic ones l_0, b_0, can be made to run from 0° to 360° for l_0 and b_0 to be always north between 0° and +90°.

The coordinates of the orbital plane pole once adopted, one is able to consider the question of the sense of motion in the orbital plane as observed from the orbit's north pole.

3. OBSERVATIONAL MATERIAL

The present work is based on 78 visual binary systems with known orbital elements. The binaries concerned were taken from the following four sources: Worley (1983), Dommanget (1967), Dommanget (1968) and IC IAU Comm. 26. The data on these doubles are given in Table 1.

Column 1: WDS number i.e. α and δ coordinates for the epoch 2000
" 2: Star name
" 3: ADS number
" 4: Orbital plane inclination i with respect to the observer's tangential plane
" 5: Binary's ascending node
" 6: Orbit's author and the year of publication
" 7: Galactic longitude l_0 of the orbital plane pole
" 8: Galactic latitude b_0 of the orbital plane pole
" 9: Sense of binary's motion as viewed from the orbital plane north pole.

In Fig. 1. are plotted the positions of all the 78 binaries in galactic coordinates.

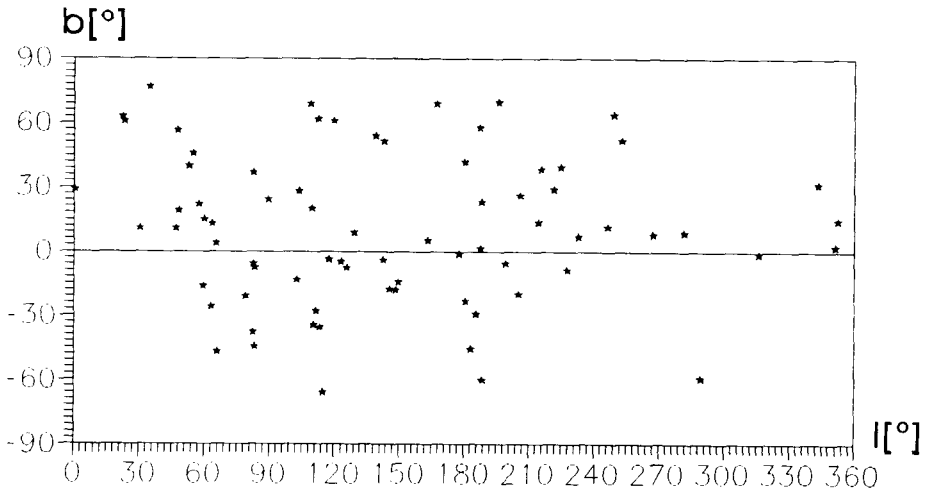

Fig. 1. *Positions of 78 treated systems in the galactic coordinate system.*

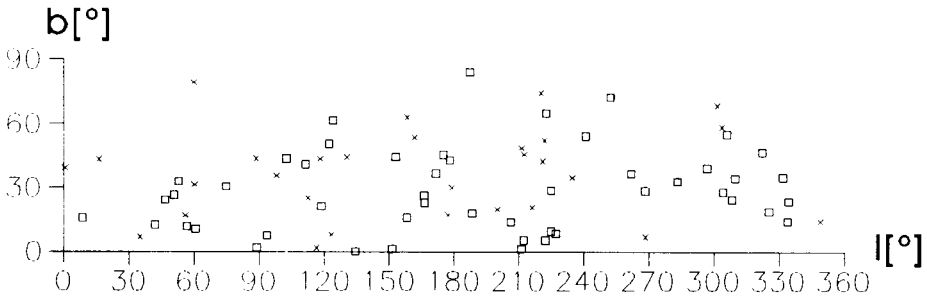

Fig. 2. *Positions of the orbital plane poles of 78 double stars.*

Table 1. Input Data for Orbits of 78 Double Stars with known Ascending node and Galactic Coodinates of Orbit Poles

WDS (1)	Name (2)			ADS (3)	i (4)	Ω (5)	Author (6)	l_0 (7)	b_0 (8)	Dir. (9)
00062 + 5786	STF	3062		61	44.40	219.10	P.Baize,57	331.7	34.7	−1
00134 + 2626	STT	2	AB	161	127.5	15.7	W.D.Heintz,79	.6	39.1	1
00352 − 0336	HO	212	AB	490	45.6	345.8	Gatewood,Behall,75	220.9	42.3	1
00488 + 5750	STF	60	AB	671	34.76	278.42	K.A.Strand,69	296.8	39.1	−1
01076 + 5459	BUP	-	Aa-P	-	109.5	47.4	S.L.Lippincott,81	15.9	43.1	1
01397 − 5642	DUN	5		-	142.82	13.12	G.B.van Albada	74.6	30.4	−1
01619 + 7025	BU	513	AB	1598	22.8	64.2	W.D.Heintz,69	112.4	25.0	1
02396 − 1178	FIN	312		-	31.9	30.0	W.S.Finsen,70	303.6	58.2	1
02422 + 4012	McA	8		-	123.0	227.9	H.A.McAlister,78	93.5	7.6	−1
02537 + 3780	BU	524	AB	2200	114.3	28.3	W.D.Heintz,81	34.9	6.8	1
02649 + 5330	HJ	2170	Aa	2324	88.0	242.6	H.A.McAlister,82	52.6	32.8	−1
03082 + 4057	BU	526	Aa-P	2362	61.1	106	Bachmann,Hershey,75	130.3	44.1	1
03183 − 0056	AC	2		2459	62.44	82.66	A.Valbousquet, 81	134.5	.2	−1
04136 + 0743	A	1938		3064	66.8	322.7	W.D.Heintz,82	187.1	83.8	−1
04228 + 1449	STT	82		3169	138.0	12.0	W.D.Heintz,69	212.2	5.4	−1
05167 + 4561	ANJ	-	AP	3841	136.64	40.2	H.A.McAlister,81	206.0	13.9	−1
05244 − 0224	DA	5	Aab-c	4002	90	312.1	H.A.McAlister,76	158.1	62.8	1
05322 + 3030	BU	1240	AB	4229	136.2	327.5	P.Baize,56	178.0	42.8	−1
05624 + 0939	A	2715	AB-P	4617	91.8	27.6	V.Osvalds,64	283.1	32.9	−1
05641 + 2316	KUI	23	AB	-	58.2	174.9	W.D.Heintz,85	221.8	51.8	1
06452 − 1641	AGC	1	AB	5423	136.53	44.57	W.H.van den Bos,60	268.3	6.8	1
07346 + 3153	STF	1110	AB	6175	115.94	40.47	W.Rabe,58	261.7	36.4	−1
07394 + 0516	SHB	-	AB	6251	35.7	284.3	K.A.Strand,51	60.6	10.5	−1
07518 − 1352	BU	101		6420	77.8	103.3	R.Wooley, L.Symms	152.8	44.3	−1
08122 + 1740	STF	1196	AB-Cc	6650	144.6	256.7	G.Gasteyer,54	166.1	26.2	−1
08122 + 1740	STF	1196	Cc-C	6650	144	251	G.Gasteyer,54	166.2	22.8	−1
08391 − 2240	BU	208	AB	6914	83.6	210.7	J.L.Newburg,67	334.4	23.5	−1
08468 + 0625	SP	-	AB	6993	49.3	109.3	W.D.Heintz,63	161.5	53.4	1
08468 + 0625	STF	1273	AB-Cc	6993	42.0	55.5	W.D.Heintz,63	177.2	17.0	1
08608 + 4148	KUI	37	AB	-	134.8	22.8	W.D.Heintz,67	252.2	72.0	−1
09123 + 1459	FIN	347	AP	-	121.4	133.4	W.D.Heintz,83	55.9	16.9	1
09288 + 0904	STF	1356		7390	66.05	325.69	E.van Dessel,76	50.6	26.3	−1
09307 − 4028	COP	-		-	58.5	287.2	O.J.Eggen,67	118.0	43.4	1
10221 + 3643	HU	879		7780	77.0	39.0	W.D.Heintz,81	333.8	14.3	−1
10373 − 4774	SEE	119		-	129.4	38.3	W.S.Finsen,68	151.3	1.3	−1
10557 + 0044	BU	1076		7982	119.6	214.2	P.J.Morel,70	188.2	17.8	−1
10637 + 6145	BU	1077		8035	152.0	320.3	W.D.Heintz,63	102.4	43.4	−1
11182 + 3133	STF	1523		8119	122.65	101.59	W.D.Heintz,67	268.3	28.6	−1
11182 + 3133	Xi	UMa	Aa-P	8119	86.3	326.0	W.D.Heintz,67	56.6	11.7	−1
11238 + 1032	STF	1536		8148	127.7	234.7	W.D.Heintz,85	171.5	36.6	−1
11324 + 6105	STT	235		8197	47.7	81.0	W.D.Heintz,72	123.4	7.8	1
11308 + 4117	STT	234		8189	56.7	337.1	P.Couteau,65	216.0	20.5	1
12606 + 5622	BU	1082		8739	51.0	274.5	W.D.Heintz,81	301.4	68.0	1
13239 + 5456	STF	1744	Aa	8891	60	102	H.N.Russell,27	116.3	1.8	1
13197 + 4747	HU	644		8862	94.1	91.2	W.D.Heintz,76	308.3	24.2	−1
13492 + 2659	STF	1785		9031	46.8	155.1	K.A.Strand,55	60.0	31.3	1
14396 − 6050	-	-	AB	-	79.24	204.87	W.D.Heintz,60	211.0	48.3	1
14426 + 1930	HU	575		9352	120.57	177.10	G.A.Starikova,76	240.7	53.9	−1
14514 + 1907	STF	1888	AB	9413	140.04	348.10	R.Wielen,62,Orb3	46.4	24.1	−1
15123 − 1947	H	44	AB	9532	162.0	34.6	W.D.Heintz,82	348.8	14.2	1
15232 + 3018	STF	1937	AB	9617	59.02	203.72	E.Silbernagel,29	211.2	1.3	−1
15644 − 1122	STF	1998	AB	9909	52.0	196.6	R.S.Harrington,87	200.0	19.6	1
16147 + 3352	STF	2032	AB	9979	33.33	7.74	W.Rabe,58	59.4	79.0	1
16294 − 2626	GRA	-		10074	86.3	273.0	W.D.Heintz,60	97.8	35.6	1
16414 + 3136	STF	2084		10157	132.9	229.2	P.Baize,76	123.9	61.4	−1
17054 + 5427	STF	2130	AB	10345	144.7	282.8	W.D.Heintz,81	118.7	21.1	−1
17100 − 3459	MLO	4	AB	-	128.4	314.8	P.Baize,46	222.2	5.3	−1
18054 + 0232	STF	2272	AB	11046	121.15	301.7	W.D.Heintz,73	88.9	2.0	−1
18059 + 2126	STT	341		11060	77.0	270.8	W.D.Heintz,82	158.1	15.9	−1
18070 + 3033	AC	15	AB	11077	32.0	218.7	W.D.Heintz,72	227.1	8.5	−1

WDS (1)	Name (2)			ADS (3)	i (4)	Ω (5)	Author (6)	l_0 (7)	b_0 (8)	Dir. (9)
18208 + 7245	BUP	XiDr		-	79.9	231.8	H.A.McAlister,80	224.7	28.6	−1
18359 + 1659	STT	358	AB	11483	134.23	16.63	W.D.Heintz,54	234.6	34.6	1
18413 + 3018	STF	2367	AB	11579	119	243.5	B.Cester,91	122.1	50.4	−1
18433 + 5933	STF	2398	AB	11632	69.3	136.55	W.D.Heintz,68	325.2	18.7	−1
18571 + 3253	BU	648	AB	11871	115.16	48.13	G.von Schrutka,39	212.3	45.5	1
19394 + 3009	McA	57		-	79.0	252.2	H.A.McAlister,82	174.9	45.3	−1
20375 + 1436	BU	151	AB	14073	63.6	178.6	P.Couteau,62	306.0	54.9	−1
20389 + 7535	HEI	7		-	29.2	0.9	J.L.Hershey,75	88.5	43.5	1
21063 + 3839	STF	2758	AB	14636	51.85	172.30	F.J.Josties,81	309.6	34.4	−1
21147 + 3762	AGC	13	AB	14787	134.2	159.7	W.D.Heintz,70	41.9	12.6	−1
21187 + 1134	BU	163	AB	14839	99.8	253.2	W.D.Heintz,69	111.2	40.8	−1
21446 + 2539	BU	989	AB	15281	108.4	111.1	Morel,Couteau,72	178.8	29.8	1
22288 − 0032	STF	2909		15971	131.25	310.22	R.S.Harrington,68	304.0	28.0	−1
22408 + 1432	HO	296	AB	16173	138.5	69.6	W.D.Heintz,85	219.9	74.1	1
22537 + 4445	BU	382	AB	16345	47.1	207.1	W.Rabe,61	322.1	46.6	−1
22585 + 0882	STT	536	AB	16417	90	166.7	B.Cester,91	8.5	15.8	−1
23595 + 3343	STF	3050	AB	17149	65.0	349.8	W.D.Heintz,74	224.7	9.5	−1
23620 + 2666	BU	733	AB	17175	50.0	288.6	R.G.Hall,49	222.4	64.6	−1

4. RESULTS, ANALYSIS, CONCLUSION

The results of this study are summerized in columns (7) and (8) of Table 1. and illustrated in Fig. 2.

As evident from Fig. 2. one wouldn't be right in saying that there were groupings of binaries with equal or similar orientation of their orbital planes. The orbital poles positions show a distribution of an eminently accidental character. Nevertheless, the conclusion of the absence of binaries with equal or similar orientation of their orbital planes is to be taken with reservation as the 78 samples treated here are still unsuficient for any firm stand.

Viewed from the orbit plane north poles, indicated in Fig. 2. by squares, the motion of the binaries appears counterclockwise in 49 pairs and clockwise in 29 pairs, their total, as above related, being 78 pairs.

Acknowledgments – This work is a part of the project "Astrometrical, Astrodynamical and Astrophysical Researches" supported by the Ministry of Science and Technology of Serbia. I thank R. Pavlović, V. Živkov and M.G. Popović for their help in the technical preparation of Table and figures.

REFERENCES

Arend, S.: 1950, Communication de l'Obs. Royal de Belgique, **20**.
Batten, A.H.: 1967,Contribution from the Dominion Astroph. Obs. **104**.
Chang, Y.C.: 1929, Astron. J.**40**, 11.
Dommanget, J.: 1967, Obs. Royal de Belgique, Communications, Série B, **15**, 1.
Dommanget, J.: 1968, Obs. Royal de Belgique, Bull. Astronomique, **VI**, 246.
Finsen, W.S.: 1933, Union Obs.Circ, **3**, 397.
Huang Su–Shu and Wade, C. Jnr.: 1966, Astroph. J., **143**, 146.
Lippincott, S.: 1967, Obs. Royal de Belgique, Communications, Série B, **17**, 68.
Worley, C.E., Heintz, W.D.: 1983, Pub. U.S.Naval Obs. **XXIV**, P.VII.
Yavuz, I.: 1979, Astron. Astrophys. Supp. Ser. **36**, 25.

НАГИБИ ОРБИТАЛНИХ РАВНИ ВИЗУАЛНО ДВОЈНИХ ЗВЕЗДА

Г. М. Поповић

Астрономска опсерваторија, Волгина 7, 11160 Београд 74, Југославија

УДК 521.328/524.382
Оригинални научни рад

За 78 визуелно двојних система познатих орбиталних елемената и дефинисаних узлазних чворова орбите испитани су нагиби орбиталних равни у односу на галактичку раван. Нема група двојних звезда са приближно једнаком оријентацијом орбиталних равни. Гледано из полова орбиталних равни више је система са смером кретања у равни орбите супротним казаљци на часовнику.