Determination of declinations and latitude from azimuths and zenith distances

Herk, G. van

TABLE 2 (*continued*).

Number Grw.	Number Boss	φ	O—Boss Leiden	O—Boss Berl.-Bab. 25	Number Boss	O—Boss (+ 28°) Leiden	O—Boss (+ 28°) Berl.-Bab. 25	Number Boss	O—Boss (equator) Leiden	O—Boss (equator) Berl.-Bab. 25
		52°9′								
2086	721	20″38	+ ″06					3895	+ ″1·25	+ ·84
					751	+ ″1·30		3939	+ 1·47	
1201	914	19·96	— ·17		865	+ 1·23		4026	+ 1·02	
4791		20·07			4176	+ 1·37	+ ″·71	1024	— ·31	+ ·08
4339	4672	19·86	— ·10	+ ″·36	4742	+ ·68		1599	+ ·11	
2881		19·65			1693	+ ·04		4719	+ ·07	
					1722	— ·24				
3058	4838	20·00	+ ·16		4867	+ 1·33	+ 1·00	1848	— ·49	— ·30
								1873	+ ·44	
4853		20·33			4872	+ 1·58		1999	+ 1·28	
2521	2174	19·65	+ ·11	+ ·10	2232	+ ·19		5090	— ·27	
4394	5280	19·91	+ ·56	+ ·74	5235	+ ·12		2227	+ ·30	
					5319	+ ·70	+ ·89			
3710		19·79			2338	+ ·55	+ 1·04	5242	+ ·01	
1656	4603	20·08	+ ·77	+ ·40	4629	+ ·20	+ ·68	1514	+ ·81	+ 1·27
4661		20·03			2364	— ·04		5406	+ ·75	+ ·30
4665		20·35			2409	+ 1·20		5503	+ ·95	+ ·40
1394		20·08			5522	+ ·98		2589	+ 1·01	+ ·87
2353		19·84			5673	+ ·33		2623	+ ·54	
2924	2668	20·08	— ·01		2727	+ ·69		5595	+ ·94	
1836		19·51			1780	+ ·06		4953	— ·21	+ ·31
4913		19·59			5806	+ ·54		2760	— ·07	+ 1·15
4915	5716	19·51	+ ·85	+ ·54	5806	+ ·84	+ ·49	2760	— ·02	
2560		19·95						5908	+ ·47	
					2839	+ ·03		5924	+ ·73	
2202		20·38			2852	+ ·72		5959	+ 1·21	+ ·63
4457		19·91			6023	— ·04	+ ·78	2982	— ·06	+ ·70
3541	6129	19·62	+ ·10		6094	— ·32		3058	— ·09	+ ·92
		φ = 19·97								
14 Boss stars mean			+ ″·26	(+ ″·07)	mean	+ ″·52	(+ ″·62)	mean	+ ″·56	(+ ″·57)
9 » » Berl.-Bab. 25 and Leiden			+ ·40	+ ·33						

Determination of declinations and latitude from azimuths and zenith distances, by *G. van Herk.*

In 1917 Mr. C. SANDERS has proposed [1]) a method by which latitude and declination are determined from azimuth observations of greatest elongation combined with the meridian zenith distances of the same stars.

At the moment of greatest elongation the relation exists:

$$\sin a = \frac{\cos \delta}{\cos \varphi}.$$

One of the unknowns, either δ or φ can be eliminated by the formula:

$$z = \delta - \varphi, \text{ valid in the meridian.}$$

[1]) *The Observatory* 40, 271.

Then the star's declination follows from:

$$\tan \delta = \frac{1 - \sin a \cos z}{\sin a \sin z}$$

and the latitude from:

$$\tan \varphi = \frac{\cos z - \sin a}{\sin z}.$$

This method having never been tried, Mr. SANDERS suggested to me to try it. I wish to thank Mr. SANDERS for all his advice during the work and the preparation of this paper and Messrs. DE ROOY and SCHEPPER for their help with the computations.

The stars observed have been chosen from the Greenwich second nine year catalogue, most of them occur in Boss' P. G. C.

For 30 stars measurements in both coordinates are available. The declinations range from + 72° to + 86°.

The mean numbers of observations of the zenith distances and of the greatest elongations are 3·5 and 4 respectively. Only 12 stars could be observed in east and west elongation. No stars could be observed in both culminations.

The instrument used is a broken altazimuth theodolite by Sartorius. It is described in *M. N. R. A. S.* **80**. 455 and *B. A. N.* 164. It was mounted in the west tower on the southern pillar.

First, the collimation was determined on a conical mark at a distance of about a 800 m not visible at night. During the observations a collimator has been placed on the northern pillar at a distance of 1·5 m. This enabled me to determine the collimation at every moment and more precisely.

The inclination of the horizontal axis has been determined with a level the value of one division of which is 7″·50; for the inclination of the microscopes reading the vertical circle a reversible level (one division 2″·22) has been used. For one revolution of the screw of the micrometer the value 63″·065 has been adopted. These three values are the same as formerly used by Mr. SANDERS, the redetermination of them gave values satisfactorily close to the old ones.

The micrometer has been turned 90° to measure the other coordinate.

The barometer used was a holosteric of Giltay thoroughly compared with a mercury one by Fuess. A scale, temperature and barometer correction have been determined from 71 equations of condition.

The thermometer used was hung at the middle of the slit.

The zenith distances have been determined by circummeridian observations made about 4 minutes before and after the meridian passage of the star. In the mean four pointings symmetrical to the middle thread have been made with the movable wire. The circle has been read twice in each microscope on two divisions.

The zeropoint of the horizontal circle has been determined mainly on Polaris, a few times on λ Ursae Minoris. In both positions of the instrument the fixed wire has been pointed on Polaris followed by some pointings of the movable wire using the same circle reading.

The azimuth observations of the stars were made about 4 minutes before and after the time of greatest elongation, the instrument being revolved in the mean time. The order of succession of the positions of the instrument for the same star has been altered each night. In the mean 4 pointings have been made with the movable wire. The inclination of the horizontal axis has been determined in each position of the instrument. The first reading of the level and its reversal preceded the circle reading and the star pointings.

From the adopted R. A. the circummeridian observations have been reduced to meridian zenith distances with the tables and formulae of ALBRECHT [1]). The several pointings with the movable wire have been reduced to the fixed one. An appreciable inclination of the wire could not be found. The mean has been applied to the circle readings, corrected for inclination of the microscopes. The mean of both positions of the instrument has been corrected for refraction with the tables of ALBRECHT [1]) and for flexure of the tube. The flexure derived by Mr. SANDERS at Matuba from observations north and south of the zenith is given by the formula: + 0″·59 sin z. This is rather uncertain but no better value was available.

The comparison of the results of the different evenings showed the remarkable fact that one evening the zenithdistances of all stars (12 in number) were systematically 0″·60 less than the mean of their observations on other nights. As the sky was foggy this evening, it will be best to reject these observations.

The mean error of one of the remaining observations is ± 0″·37.

The zeropoint of the horizontal circle has been obtained by subtracting from the circle reading, after it had been corrected in the usual way for inclination, collimation, daily aberration etc., the computed azimuth from the position of Polaris (of the Berl. Jahrbuch) by the formula:

$$\tan a = -\frac{\cot \delta \sec \varphi \sin t}{1 - \cot \delta \tan \varphi \cos t}$$

From the differences in the zeropoint of the horizontal circle derived by the pointings of Polaris on the fixed wire and the movable one on one evening, a systematic correction of the point of coincidence of the movable and fixed middle thread has been calculated. The corrected value has been applied to all stars observed. A new value for the inequality of the pivots has been determined from the differences of both positions of the instrument, the collimation being equal before and after observation. The correction to the old value (− 2″·19) is + ″·57 ± ″·12 (m. e.) and has been applied.

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[1]) See: *Formeln und Hilfstafeln für Geographische Ortsbestimmungen.*

The mean error of one determination of the zeropoint ± 0″·91 has been calculated from the comparison of the several values of one evening; the average number of determinations being 3·7.

From the differences in time of the moments of greatest elongation and the observation of the star the reduction in azimuth to the circle reading has been computed rigorously. An error in the latitude or declination used has practically no influence.

The mean of the corrected values from both positions diminished by the mean zeropoint of the evening has been called the azimuth of greatest elongation.

From the differences in east and west elongations of the 12 stars observed on several nights a correction of the zeropoint for these nights has been calculated. For the remaining 6 nights, which had no stars observed both east and west, so called night corrections have been calculated.

The mean error of one azimuth determination is ± ″·87.

All measurements have been reduced to 1930·0 taking into account the influence of the variation of latitude.

The table gives the number of the stars, the calculated δ and φ, the number of observations, the mean errors calculated from those of a and z, the differences with Boss' P. G. C. or Grw. catalogue.

The mean of the 30 values of the latitude, taking into account the different mean errors, is:

52°9′ 20″·43 ± 0″·14

Then the latitude of the meridian circle is:

52°9′ 19″·69 (adopted value: 52°9′ 19″·80)

There is no explanation for the deviations of the stars 5784, 5787 and 5899.

In the most unfavourable case an error in the z entered into the δ and φ multiplied by 0·55 and 1·55 respectively and for an error in the a these factors were 0·89 and 0·88.

Star	number east	obs. (a) west	n (z)	$\delta_{1930\cdot0}$	ε_δ	φ_0	ε_φ	O—Boss (G)
B 1916	4		2	+81° 2′ 35″·48	± 0″·22	52° 9′ 20″·34	± 0″·31	+ 0″·28
2034	2	3	2	80 26 41·47	·20	20·55	·29	+ ·55
2103	4	3	1	84 15 56·25	·18	20·34	·37	+ ·66
2186		3	2	72 37 36·88	·21	20·42	·27	+ ·41
G 2175	4	2	2	77 21 53·23	·15	19·97	·25	+ ·80
B 2536	1	3	3	81 38 17·72	·22	20·06	·28	+ ·70
2598	2	2	2	79 27 34·31	·21	20·24	·30	— ·42
2656	4	1	3	73 12 49·17	·17	20·41	·22	+ ·56
3204	3		1	86 49 28·98	·31	21·45	·45	— ·57
4724	3	2	3	77 29 36·71	·33	21·63	·44	— ·40
4788	4		4	75 21 8·37	·39	21·82	·47	— ·19
4863		5	4	76 57 7·08	·34	20·86	·42	— ·02
4911	4		4	76 26 41·25	·38	21·05	·45	+ ·30
4990		5	5	79 27 50·04	·30	20·54	·37	— ·15
5154	3		5	76 17 12·40	·43	20·96	·49	— ·07
5199	3		4	77 30 5·04	·42	21·54	·49	+ ·05
5293	2	4	2	81 11 51·27	·27	19·61	·42	+ ·05
5290	4	4	4	74 42 53·68	·29	21·16	·39	— ·29
5308	2	3	2	81 11 3·69	·29	19·97	·44	— ·22
5377	3		4	82 16 24·34	·37	20·01	·43	— ·49
5388	4		2	80 17 26·05	·35	20·27	·47	— ·58
5450	2	1	4	77 50 34·00	·41	20·63	·48	— ·41
5533	1		4	80 13 12·15	·67	20·61	·71	— ·56
G 1711		3	4	79 58 32·26	·38	21·06	·46	— ·62
B 5784		3	5	85 45 22·70	·30	18·64	·39	— 1·38
5787	1		2	85 52 12·52	·56	17·55	·65	— 2·06
5818	1	3	3	78 27 54·03	·36	21·34	·45	— ·12
5827		4	4	75 51 56·05	·38	22·11	·46	— ·10
5899		3	3	82 46 55·70	·36	18·71	·44	— 1·42
6078		3	2	77 14 29·76	·43	20·72	·55	— ·30