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4.

Mean Declinations and Proper Motions of 58 Stars; and the Latitude of the Sayre Observatory.

In the summer of 1875 I began the work of a careful reduction of the Declinations and Proper Motions of a list of stars to be used in the determination of the Latitude of this Observatory. I believed further that the Places of the Stars, so determined, would be of value to others besides myself.

The instrument used for determining the Latitude was the Zenith Telescope having an objective of 3 inches diameter and a magnifying power of 75, and the List of Stars used was selected, as far as possible, from the Catalogue, compiled by Professor Boss, for the use of the United States Northern Boundary Commission.

It was generally possible to find one star of a pair in this list, the other being taken from the British Association Catalogue, (B. A. C.). In this manner over 100 preliminary pairs were selected.

The catalogues, contained in the Library of the Washington Observatory, were then consulted for material for an accurate reduction of these B. A. C. Stars.

Where a sufficient number of authorities was not found the pair was rejected. Sixty pairs were finally retained.

Of the stars composing these sixty pairs, fifty-eight were reduced by myself, the process being precisely the

$$\delta_t = \delta_{1875} - \frac{d\delta}{dt}(1875-t) + \frac{1}{2}\frac{d^2\delta}{dt^2}(1875-t)^2 - \frac{1}{6}\frac{d^3\delta}{dt^3}(1875-t)^3$$

giving the assumed value of δ for the epoch t .

In computing the values of the differential coefficients Peters' Constants were used.

Boss' systematic corrections were applied to the catalogue values of the declinations.

Each catalogue place then gave an equation of condition of the form $\sqrt{p}(\Delta\delta - t, \Delta\mu' = \delta - \delta_1)$ p being the weight.

The computations were all carefully checked by duplication and by comparison with the Greenwich Catalogue and others.

The following list comprises the stars in question.

same as that used by Boss in the list referred to. For the details, reference may be had to the report of the U. S. Northern Boundary Commission which, it is expected, will soon appear.

The reduction is based on all the material to be found in the Library of the Washington Observatory.

The method was, briefly, as follows. An approximate value of the declination for 1875.0, was first obtained by bringing the catalogue places up to that date. For this purpose the precession and secular variation of the Greenwich Catalogue were used whenever the star was found in one of them. A series of conditional equations was then formed having as unknown quantities the correction to an assumed declination, and the proper motion. The resulting values of the declination and proper motion, which were in all cases very near the final values, were then used as the basis of the more accurate reduction, as follows.

The place of the star was carried back to the epoch of each catalogue by means of a very carefully computed value of the annual motion as far as terms of the third order:

The familiar formula

The mean places are given for 1875.0. The numbers in column 2 are those of the British Association Catalogue. The magnitudes are taken from that catalogue; $\frac{d\alpha}{dt}$ includes proper motion; $\frac{d^2\alpha}{dt^2}$ is given in units of the 5th decimal place; $\frac{d\delta}{dt}$ includes the value of the proper motion given in column 12; $\frac{d^2\delta}{dt^2}$ is in units of the 6th decimal place; $\frac{d^3\delta}{dt^3}$ is in units of the 8th decimal place.

The constants a' , b' , c' , d' are computed for 1877.0.

B.A.C. No.	Mag.	AR	$\frac{da}{dt}$	$\frac{d^2a}{dt^2}$	δ	Probable error of δ	$\frac{d\delta}{dt}$	$\frac{d^2\delta}{dt^2}$	$\frac{d^3\delta}{dt^3}$	n	Probable error of n	a	b	c	d	Nr. of Authority.
12786	6	8 ^h 12 ^m 28 ^s 2	+3.658	—	17 27° 37' 14" 69	14	—	11.3383	—4421	+102	—	3815	461.0400 _n 9.9229 _n 7.5704 _n 9.4040 _n 15			
22792	5	8.14.20.0	+4.586	—	50 53.37.11.44	35	—	11.2178	—5526	+189	—	1248	981.0455 _n 9.9205 _n 9.6159 _n 9.6491 _n 10			
32880	6½	8.28.8.2	+3.457	—	13 20.1.6.16	28	—	12.0837	—3969	+95	—	0053	721.0823 _n 9.9020 _n 9.1289 _p 9.3145 _n 10			
42984	6½	8.42.46.1	+3.745	—	24 33.45.02.11	23	—	13.1553	—4079	+127	—	0801	801.1167 _n 9.8796 _n 8.7795 _n 9.5592 _n 9			
52982	5½	8.43.3.5	+5.009	—	90 62.25.39.77	16	—	13.0673	—5475	+278	+	0271	461.1174 _n 9.8791 _n 9.6721 _n 9.7629 _n 13			
63218	5½	9.20.27.9	+3.963	—	43 46.8.52.18	31	—	15.5296	—3638	+171	—	1410	741.1874 _n 9.8067 _n 9.2079 _n 9.7432 _n 15			
73303	5	9.33.28.4	+3.067	—	4—0.34.35.07	11	—	16.1658	—2602	+86	—	0725	321.2068 _n 9.7755 _n 9.6434 _p 7.9140 _p 8			
83425	6	9.56.17.1	+4.030	—	63 54.29.41.88	49	—	17.2471	—2943	+197	—	0444	1261.2357 _n 9.7105 _n 9.2200 _n 9.8442 _n 10			
93534	6	10.15.6.8	+3.233	—	12 15.36.17.76	18	—	18.0257	—2003	+109	—	0352	621.2551 _n 9.6449 _n 9.4760 _p 9.3824 _n 15			
103652	5	10.34.5.7	+4.405	—	144 69.43.44.52	15	—	18.6931	—2276	+271	—	0312	481.2711 _n 9.5629 _n 9.2844 _n 9.9411 _n 13			
113748	7½	10.49.16.3	+3.205	—	12 18.49.6.08	21	—	19.1144	—1335	+110	—	0076	731.2813 _n 9.4819 _n 9.4955 _p 9.4874 _n 9			
123864	6	11.15.24.8	+3.628	—	86 65.0.51.14	14	—	19.6451	—938	+162	+	0308	611.2940 _n 9.2851 _n 7.9346 _p 9.9491 _n 13			
133877	4	11.17.24.4	+3.131	—	7 11.13.3.04	20	—	19.8036	—761	+105	—	0947	621.2947 _n 9.2656 _n 9.5908 _p 9.2811 _n 24			
143973	6	11.36.59.9	+3.200	—	29 42.24.58.26	19	—	19.9645	—372	+113	—	0112	671.3000 _n 8.9988 _n 9.4033 _p 9.8267 _n 7			
154010	6½	11.45.46.2	+3.485	—	31 38.36.54.73	25	—	25.8147	—324	+145	—	5.7991	1041.3014 _n 8.7892 _n 9.4779 _p 9.7943 _n 20			
164141	6	12.13.0.3	+3.038	—	10 23.43.45.07	43	—	20.0505	+337	+97	—	0285	981.3015 _n 8.7571 _p 9.6235 _p 9.6038 _n 9			
174267	6	12.35.15.9	+3.022	—	2 11.6.44.13	22	—	19.8425	+759	+94	—	0252	571.2970 _n 9.1867 _p 9.6584 _p 9.2793 _n 12			
184271	5	12.35.33.5	+3.037	—	2 10.55.29.19	21	—	19.9201	+771	+96	—	1067	891.2969 _n 9.1903 _p 9.6584 _p 9.2719 _n 12			
194300	6	12.41.58.2	+2.586	—	36 63.27.49.89	18	—	19.7215	+772	+60	—	0026	501.2948 _n 9.2612 _p 9.5529 _p 9.9443 _n 8			
204318	7	12.45.59.3	+2.986	—	4 17.45.15.64	35	—	19.6697	+952	+91	—	0178	881.2934 _n 9.3005 _p 9.6759 _p 9.4751 _n 7			

Σ	B.A.C. Mag. Nr.	AR	$\frac{da}{dt}$	$\frac{d^2a}{dt^2}$	δ	Probable error of δ	$\frac{d\delta}{dt}$	$\frac{d^2\delta}{dt^2}$	$\frac{d^3\delta}{dt^3}$	μ	Probable error of μ	a'	b'	c'	d'	Nr. of Authority.
214477	6	13.16m50.3	+3 101	+ 8	-4°16' 11" 19	29	- 18.9623	+1568	+ 99	.0246	971	2775m9	5178p9	6108p9	8.8480p11	11
224498	6	13.19.43.8	-2.738	+ 977	85.24.30.59	26	- 18.7909	-1349	+ 578	.0620	1051	2754m9	5322p9	5332p9	9.9718m11	11
234713	6	14.5.56.2	+3.030	+ 6	2.59.54.97	37	- 17.1499	+2377	+ 86	.0480	1451	2329m9	7182p9	6633p9	8.6479m	7
244733	var.	14.9.22.2	- 334	+ 155	78.8.5.48	23	- 16.9092	- 190	+ 122	.0340	591	2290m9	7283	9.7873	9.9174m14	14
254826	7	14.29.24.5	+1.959	- 1	53.26.58.17	48	- 15.7143	+1785	+ 30	.2273	1241	2024m9	7831	9.8727	9.8051m	9
264942	6	14.54.38.4	+2.299	0	40.8.31.86	32	- 14.4613	+2382	+ 38	.0469	2121	1615m9	8392	9.8904	9.6686m	7
275187	5	15.35.58.7	+2.672	+ 4	20.4.27.17	24	- 11.8323	+3196	+ 46	.0431	661	0712m9	9081	9.8358	9.3045m	10
285194	6	15.37.44.7	+3.011	+ 7	2.55.2.52	43	- 11.8153	+3616	+ 62	.1516	1171	0666m9	9105	9.6764	8.4701m	9
295295	5½	15.51.14.7	+2.182	+ 3	38.18.32.59	18	- 10.6020	+2744	+ 28	.0811	551	0285m9	9276	9.9371	9.5185m	13
305466	3½	16.16.24.4	+2.645	+ 4	19.26.53.16	11	- 8.7129	+3503	+ 34	.0463	341	9421m9	9541	9.8504	9.1622m	18
315693	5	16.48.13.7	+2.272	+ 3	31.54.35.64	21	- 6.1866	+3168	+ 19	.0085	701	7904m9	9784	9.9401	9.2113m	14
325714	6½	16.52.23.2	+2.462	+ 3	25.32.50.15	15	- 5.8149	+3463	+ 20	.0161	621	7652m9	9809	9.9053	9.0977m	10
335944	6	17.29.9.4	+1.902	+ 3	41.19.58.63	31	- 2.7469	+2754	+ 8	.0562	141	4290m9	9961	9.9913	8.9466m	8
346005	5½	17.38.13.8	+2.461	+ 2	24.23.0.81	24	- 1.8353	+3570	+ 7	.0665	621	2776m9	9981	9.9064	8.5912m	10
356089	5	17.54.4.3	+2.967	+ 2	4.22.40.31	58	- .5338	+4324	+ 2	.0151	1539	7076m9	9999	9.7067	7.2881m	9
366101	5½	17.55.24.6	+3.041	+ 2	1.18.36.19	44	- .4056	+4435	+ 1	.0041	1119	5940m9	9999	9.6596	9.6509m	7
376231	5½	18.15.0.6	+2.537	+ 2	21.54.35.00	22	+ 1.2381	+3688	- 5	.0744	561	1205p9	9991	9.8892	8.3902	9
386497	6	18.55.18.0	+2.268	+ 1	31.58.18.36	29	+ 4.7832	+3199	- 14	.0089	721	6811	9.9872	9.9456	9.1028	10
396625	5½	19.13.44.0	-2.144	- 90	76.21.4.03	27	+ 6.2146	-2985	- 135	.1266	621	8018	9.9772	.0105	9.4871	10
406740	4	19.34.26.3	+2.367	+ 1	29.51.59.08	9	+ 8.0666	+3125	- 25	.0348	321	9052	9.9620	9.9204	9.3002	9

B.A.C. No.	Mag.	AR	$\frac{d\alpha}{dt}$	$\frac{d^2\alpha}{dt^2}$	δ	Probable error of δ	$\frac{d\delta}{dt}$	$\frac{d^2\delta}{dt^2}$	$\frac{d^3\delta}{dt^3}$	μ'	Probable error of μ'	a'	b'	c'	d'	Nr. of Authority.
416784	5	19.41m40s9	+2.274	+2	33.26' 16".44	13	+8.1496	+2958	-23	-.4588	42	9352	9.9557	9.9344	9.3742	14
426789	6	19.42 48.6	+2.826	-1	11.30.21.92	21	+8.6727	+3674	-41	-.0248	60	9398	9.9547	9.7817	8.9376	13
436901	6	19.59.36.8	+2.660	0	19.38. 2.59	22	+10.0759	+3322	-40	+.0781	52	1.0002	9.9379	9.8451	9.2245	10
447084	6	20.26.14.5	+2.278	+2	36.30.56.17	21	+11.9377	+2618	-32	-.0080	49	1.0774	9.9047	9.9173	9.5498	8
457161	7	20.35.10.1	+2.020	+2	45.13.32.64	21	+12.5553	+2240	-27	-.0087	68	1.0993	9.8917	9.9339	9.6483	8
467311	6	20.56.11.1	-0.621	-116	75.26.29.92	10	+13.9882	-704	-124	+.0457	35	1.1443	9.8566	9.9057	9.8279	10
477356	8	21. 4.54.2	+2.698	+2	21.56.47.30	31	+14.4616	+2659	-56	-.0190	93	1.1610	9.8398	9.8202	9.4315	7
487438	6	21.17. 2.0	-.544	-131	76.29. 8.12	55	+15.2021	-570	-126	+.0078	114	1.1817	9.8147	9.8669	9.8673	9
497501	7	21.28.37.0	+2.242	+7	44.18. 0.16	26	+15.8336	+1937	-38	-.0025	140	1.1998	9.7877	9.8693	9.7494	8
507597	5	21.41.32.1	+2.757	-41	71.44.50.14	20	+16.4601	+546	-39	-.0432	56	1.2176	9.7543	9.8295	9.8930	15
517643	5½	21.50.41.2	+2.010	+8	56. 1.11.95	40	+16.9490	+1494	-31	+.0032	113	1.2291	9.7280	9.8362	9.8456	10
527778	4½	22.10.26.1	+2.202	+14	56.25.14.53	10	+17.8383	+1437	-39	+.0324	39	1.2506	9.6626	9.7945	9.8692	22
537882	6	22.30.41.5	+2.470	+17	49.25.26.33	77	+18.5531	+1283	-51	+.0023	176	1.2684	9.5793	9.7563	9.8468	5
548052	4½	23. 1. 1.5	+2.914	+11	24.47.38.02	19	+19.3519	+998	-84	-.0421	72	1.2877	9.4050	9.6994	9.6083	12
558077	6	23. 4.59.8	+2.348	+35	66.33.49.38	23	+19.4968	+733	-46	+.0174	84	1.2896	9.3754	9.5914	9.9500	9
568195	6	23.25. 8.8	+2.933	+21	38.32.59.24	18	+19.7377	+568	-87	-.0851	44	1.2972	9.1792	9.6369	9.7897	14
578272	7	23.41.49.2	+3.057	+5	7.33. 6.94	20	+19.9621	+267	-98	-.0290	113	1.3069	8.8965	9.6439	9.1180	8
588310	5½	23.48. 8.8	+2.966	+14	56.48.14.25	13	+20.0253	+137	-90	-.0021	29	1.3016	8.7098	9.4478	9.9221	11

It may not be without interest as illustrating the process to give in full the details of computation of one star. I select for this purpose, B. A. C. 4010 = Groombridge 1830, on account of the interesting character of the star itself, although the residuals in this case are unusually large.

The assumed values of the declination and proper motion were as follows;

$$\delta = 38^{\circ}36'54''.97$$

$$\mu' = -5''.7868$$

For $(1875-t)$, δ_1 then becomes

$$\delta_1 = +38^{\circ}36'54''.97 + 25''.8147 (1875-t) - .000324 \frac{(1875-t)^2}{2} - .00000145 \frac{(1875-t)^3}{6}$$

The comparison of the places computed from this formula with the catalogue places is then as follows.

Nr.	Authority	Nr. of obs.	Weight	1875-t	$\phi-c$	v
1	Gould's D'Agelet	4	.05	91	+ 3.44	+ 2.56
2	Groombridge	5	.2	64	- 1.28	- 1.82
3	W. Bessel	1	.1	46	+ 2.07	+ 1.74
4	Rümker	9	.3	39	- .86	- 1.10
5	Armagh	20	.4	25	- 1.34	- 1.41
6	Poulkova	48	5.0	32	+ .49	+ .33
7	Radcliffe	32	.7	24	+ .05	- .01
8	Facot's Madras	4	.3	25	+ .13	+ .07
9	Greenwich, 12 year	16	2.0	29	+ .31	+ .19
10	" 50 "	19	1.5	24	+ .02	- .03
11	Brussels	25	2.5	15	- 1.61	- 1.55
12	Edinburgh	5	.5	16	- 1.20	- 1.16
13	Greenwich, 7 year	18	2.5	12	+ .51	+ .60
14	" New 7 year	8	2.0	9	+ .16	+ .28
15	" Annual	16	2.0	5	+ .58	+ .75
16	2 nd Radcliffe	12	.6	19	- .67	- .66
17	Radcliffe Annual	3	.2	6	- .66	- .49
18	Washington prime vertical 1847	2	.5	28	+ .30	+ .19
19	Washington, p. v. 1848	1	.5	27	+ .57	+ .47
20	Washington Mural Circle	3	.5	7	- .10	+ .05

$$\begin{aligned} \text{Normal equations.} \quad 22.35 \Delta\delta - 4.693 \Delta\mu' &= +.481 \\ - 4.693 \Delta\delta + 1.266 \Delta\mu' &= -.445 \end{aligned}$$

The solution of these equations gives

$$\Delta\delta = -.236 \pm .249$$

$$1.0 \Delta\mu' = -1.226 \pm 1.043$$

and for the final values

$$\delta = 38^{\circ}36'54''.73 \pm .25$$

$$\mu' = -5''.7991 \pm .0104.$$

The column above, marked $\phi-c$, gives the absolute terms of the equations of condition.

The quantities in the column, marked v , are the final residuals.

The latitude was deduced from 459 observations of 60 pairs of stars. The value from each pair with the number of observations and weight in each case are given below, the seconds of latitude only being given in the table.

Nr.	B.A.C.	Nr. of Observ.	Latitude	p .	v .
1	2786	8	23° 24'	3.04	65
	2792				
2	2819	9	23 85	3.89	4
	2880				

Nr.	B.A.C.	Nr. of Observ.	Latitude.	p .	v .
3	2953	8	23° 76'	4.43	13
	2982				
4	2984	7	23.58	3.39	31
	3075				

Nr.	B.A.C.	Nr. of Observ.	Latitude	p.	v.
5	3178 3218	6	24° 29	2.82	40
6	3199 3303	8	24.14	4.72	25
7	3371 3425	8	23.27	2.31	62
8	3496 3534	7	23.43	3.77	46
9	3652 3708	8	23.25	4.65	64
10	3748 3777	7	23.57	3.83	32
11	3838 3864	7	23.60	3.77	29
12	3877 3914	6	23.38	3.38	51
13	3973 4010	7	24.28	3.18	39
14	4123 4141	8	23.77	2.61	12
15	4222 4267	7	23.76	3.56	13
16	4239 4271	7	23.68	3.75	21
17	4300 4318	8	24.32	2.93	43
18	4477 4498	8	24.64	2.96	75
19	4713 4733	8	23.57	2.66	32
20	4804 4808	7	24.01	3.58	12
21	4826 4876	6	23.80	2.07	9
22	4942 4958	8	23.87	3.40	2
23	5084 5157	6	23.64	3.22	25
24	5115 5187	5	23.98	2.21	9
25	5194 5285	8	23.29	2.66	60
26	5271 5295	6	23.40	2.87	49
27	5466 5512	7	23.44	4.35	45
28	5523 5617	8	24.03	3.72	14
29	5596 5693	8	24.44	3.76	55

Nr.	B.A.C.	Nr. of Observ.	Latitude	p.	v.
30	5714 5801	9	25° 06	2.39	117
31	5874 5944	9	23.56	3.04	33
32	5941 6006	9	24.29	5.53	40
33	6005 6079	9	24.26	4.02	37
34	6089 6114	7	24.06	1.72	17
35	6101 6206	7	24.02	2.22	13
36	6231 6318	11	23.97	4.41	8
37	6421 6497	9	24.53	2.95	64
38	6476 6491	7	24.13	1.86	24
39	6528 6612	9	23.63	5.68	26
40	6585 6625	7	24.30	2.20	41
41	6697 6740	10	24.19	5.85	30
42	6784 6830	7	24.37	3.47	48
43	6789 6836	5	23.01	2.81	88
44	6901 6970	10	23.40	3.77	49
45	7073 7161	7	24.04	3.41	15
46	7084 7171	7	24.02	3.83	13
47	7206 7311	9	23.69	3.52	20
48	7356 7377	6	23.82	2.34	7
49	7380 7438	7	24.09	1.87	20
50	7453 7501	9	23.75	3.39	14
51	7561 7597	7	24.29	3.88	40
52	7571 7643	8	24.62	3.55	73
53	7679 7765	7	24.70	1.35	81
54	7706 7778	7	24.03	4.17	14

Nr.	B.A.C.	Nr. of Observ.	Latitude	p.	v.	Nr.	B.A.C.	Nr. of Observ.	Latitude	p.	v.
55	7843	10	23° 86	1.30	3	58	8195	10	24.42	5.05	53
	7882						8229				
56	8034	7	23.99	3.70	10	59	8272	7	23.79	3.70	10
	8077						8314				
57	8052	7	23.27	3.37	62	60	8310	8	23.38	4.42	51
	8083						8324				

Taking the mean according to the weights we have

$$\text{Latitude} = 40^{\circ} 36' 23'' 887 \pm '' 036.$$

Lehigh University, South Bethlehem, Pennsylvania December 14, 1878.

C. L. Doolittle.

Planeten-Beobachtungen am Meridiankreis der Wiener Sternwarte.

		Mittlere Wiener Zt.	Scheinb. AR.	Faden	Scheinb. Decl.	Parall- axe	B. — R. <i>d</i> α <i>d</i> δ		Grösse
U r a n u s.									
1878	März	27	9h33m 7s	9h53m38s47	11	+13°37' 54" 0	+ 0'3	— 0'04	— 0'9
		30	9.21. 0	9.53.18.59	11	+13.39.32.8	+ 0.3	+ 0.05	— 1.9
	April	2	9. 8.53	9.53. 0.11	11	+13.41. 5.9	+ 0.3	+ 0.09	— 0.5
		3	9. 4.52	9.52.54.20	11	+13.41.35.2	+ 0.3	+ 0.02	+ 0.1
1879	März	14	10.45.52	10.14.22.74	11	+11.46.35.1	+ 0.3	+ 0.15	— 2.5
		18	10.29.33	10.13.47.56	11	+11.49.48.7	+ 0.3	+ 0.30	— 2.3
		19	10.25.28	10.13.38.90	11	+11.50.36.2	+ 0.3	+ 0.22	— 1.5
	April	1	9.32.41	10.11.58.46	11	+11.59.35.3	+ 0.3	+ 0.02	— 2.3
		3	9.24.37	10.11.45.36	11	+12. 0.46.2	+ 0.3	+ 0.23	— 1.7

N e p t u n.

1878 Jan.	10	6.51.56	2.12.23.03	11	+11.25.45.6	+0.2	—0.14	+5.5		
	11	6.48.0	2.12.22.42	11	+11.25.48.3	+0.2	—0.17	+7.3		
Nvbr.	30	9.45.6	2.23.25.66	9	+12.19.20.7	+0.2	+0.18	—6.2		

Die Genauigkeit dieser drei Beobachtungen wurde durch Federgewölke etwas beeinträchtigt.

① Ceres.

1878 Nvbr.	30	9.26.23	2.4.39.02	11	+2.39.22.4	+3.2	+6.68	+59.4	8	
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② Pallas.

1878 Octbr.	2	10.5.54	22.51.40.15	10	—5.11		—1.88		9	
	8	9.39.19	22.48.29.79	4	—6.23.48.1	+3.2	—1.75	+22.1	9	

Beide Beobachtungen sind unsicher. Die zweite wurde besonders durch das Mondlicht gestört.

③ Juno.

1878 Octbr.	2	9.15.33	22.1.14.73	8	—10.3.9.4	+5.2	+5.58	+17.3	8.9	
	8	8.51.14	22.0.27.22	7	—10.50.43.3	+5.1	+5.40	+15.6	8.9	