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The Position and Proper Motion of Polaris. By *Milton Updegraff*.

An ephemeris of Polaris computed from the position and proper motion of the star for 1875.0 contained in *Newcomb's Fundamental Catalogue* (Vol. VIII, Part 2, Astr. Papers of the Am. Eph.) has been used as the basis of this investigation. The notation used in that work has been followed, and nearly all the old data, given on Page 144 of Vol. VIII Part 2, have been deduced anew, as far as possible from the original sources.

The proper motion, especially in right ascension, has been greatly strengthened by the use of observations which have become available during the past fifteen years. This new material, consisting of re-reductions of old observations and of new observations, has been derived from the following sources.

1. New reduction of *Groombridge's* Circumpolar Catalogue for 1810, by *Dyson* and *Thackeray*, (RA. only).
2. *Auwers'* re-reduction of *Pond's* observations 1811-1819, for 1815.0.
3. *F. Cohn* and *H. Struve*, re-reduction of *Bessel's* observations with the Dollond Transit and the Cary Circle 1813-1819, Königsberger Beob. Abt. 39 and Abt. 40.
4. *Bessel's* observations in declination at Königsberg with the Reichenbach Meridian Circle 1836-1840, A. N. Nr. 422, and with the Repsold Meridian Circle, 1842-44, reduced by *E. Luther*, A. N. 1076.
5. *E. W. Preuss'* observations at Dorpat, 1826-1838, Dorpat Obs. Vols. I to VIII.
6. *Pond's* Catalogue of 1112 stars for 1830.0.
7. Pulcowa transit observations for 1885 by *A. Wagner* and others, Pulcowa Obs. Vol. III Series II.
8. Pulcowa vertical circle observations 1893, by *M. Nyren* and *A. Ivanof*, Pulcowa Obs. Vol. VIII Series II.
10. Observations in declination 1898, made at the Lick Observatory by *R. H. Tucker*, Publ. Lick Obs. Vol. VI.
11. Greenwich 2nd 9-Year Catalogue, for 1900.
12. Radcliffe Catalogue of 1772 Stars for 1900 (decl. only).
13. Observations with the 6-inch Transit Circle, U. S. Naval Obs., 1900-1902. [The observed right ascensions of Polaris are omitted from the individual results given in Washington Obs. Vol. III (New Series) p. D 81-102, and have been omitted in part from the individual results in Vol. IV, p. C 101. The missing results have been deduced from the observations printed in these volumes.]

After careful consideration it was decided to use *Bradley's* right ascension as reduced by *Auwers*, but to reject his declination. All the material used is based on observations believed to be essentially of a fundamental character. Attention is called to the fact that the number of observations in right ascension of this kind available in recent years is small.

No corrections for systematic errors have been made, since their applicability is doubtful in this case. It is believed that errors in declination due to variation of latitudes and to errors of refraction tables have, with one or two exceptions, been nearly eliminated from the mean result of each series of observations used.

The weights in both right ascension and declination were derived from the sums of separate weights assigned to various elements affecting or supposed to affect the accuracy of the results. This method was derived and used with a view to escape the uncertainties inherent in the assignment of weight by a single act of judgement. Since the personal equation in right ascension is a large source of error in observations of circumpolar stars, the number of observers has been regarded as an important element in the determination of weights.

Excepting the observations made at Greenwich since Dec. 31, 1888, and those made at Pulcowa after February 1863, all the observations in right ascension used here have been made by the eye and ear method. Since the time when chronographic observations came regularly into use at Pulcowa it has been the practice there to observe Polaris at each transit by both methods, and to use the mean of the two observed times in deducing the observed right ascension.

Strictly speaking, all the observations made by the chronographic method should be reduced to the eye and ear standard in order particularly to avoid the effect on the proper motion due to the fact that all the chronographic observations used here have been made since 1863, while the earliest observations used — those of *Bradley*, by eye and ear — are for the epoch 1755. Yet, after consideration of the data available for this purpose, it was decided not to apply such corrections to the chronographic observations made at either Greenwich or Pulcowa, although in case of Pulcowa 1885 it would have been practicable to do so with entire safety. It is believed that the error from this source is very small.

Observed Corrections to *Newcomb's* Place, Fund. Cat. Astr. Papers Am. Eph. Vol. VIII Part 2, Page 256.

Place	Observer or Authority	Epoch	Observed RA.	Tab. RA.	Residual	Wt.	Observed Decl.	Tab. Decl.	Residual	Wt.
Greenwich	<i>Bradley (Auwers)</i>	1755	0 ^h 43 ^m 42 ^s 83	42 ^s 29	+0 ^s 54	4	+87° 59' 41".1	41".15	[-0".05]	
Greenwich	<i>Maskelyne</i>	1785	0 49 17.66	17.68	-0.02	4				

Place	Observer or Authority	Epoch	Observed RA.	Tab. RA.	Residual	Wt.	Observed Decl.	Tab. Decl.	Residual	Wt.
Blackheath	<i>Groombridge (Dyson and Thackeray)</i>	1810	0 ^h 54 ^m 39 ^s .08	39 ^s .50	-0 ^s .42	3	+88° 17' [39 ^s .6]	39 ^s .57	[+0 ^s .03]	
Königsberg	<i>Bessel (Cohn)</i>	1815	0 55 49.61	49.35	+0.26	5				
Königsberg	<i>Bessel (H. Struve)</i>	1815					+88 19 16.8	16.96	-0.16	4
Greenwich	<i>Pond (Auwers)</i>	1815	0 55 49.75	49.35	+0.40	3	+88 19 17.24	16.96	+0.28	6
Dorpat	<i>W. Struve</i>	1824					+88 22 12.04	11.99	+0.05	7
Dorpat	<i>W. Struve</i>	1825	0 58 15.22	15.27	-0.05	5				
Königsberg	<i>Bessel</i>	1825	0 58 16.04	15.27	+0.77	5	+88 22 31.32	31.42	-0.10	8
Dorpat	<i>Preuss</i>	1830	0 59 32.39	31.53	+0.86	4	+88 24 8.34	8.43	-0.09	5
Cambridge, E.	<i>Airy</i>	1830	0 59 30.88	31.53	-0.65	4	+88 24 8.78	8.43	[+0.35]	
Greenwich	<i>Pond</i>	1830	0 59 31.16	31.53	-0.37	4	+88 24 8.4	8.43	-0.03	8
Königsberg	<i>Bessel</i>	1840					+88 27 21.84	22.01	-0.17	7
Greenwich	<i>Airy</i>	1840	1 2 11.06	11.24	-0.18	4	+88 27 22.20	22.01	+0.19	5
Königsberg	<i>Bessel</i>	1843					+88 28 19.83	19.95	-0.12	8
Greenwich	<i>Airy</i>	1845					+88 28 58.81	58.54	+0.27	5
Pulcowa	<i>F., L. and W.</i>	1845	1 3 35.22	34.91	+0.31	11				
Pulcowa	<i>Peters</i>	1845					+88 28 58.49	58.54	-0.05	10
Greenwich	<i>Airy</i>	1850	1 5 1.23	1.33	-0.10	6	+88 30 35.09	34.91	+0.18	7
Red Hill	<i>Carrington</i>	1855	1 6 31.27	30.61	[+0.66]		+88 32 11.2	11.10	[+0.10]	
Greenwich	<i>Airy</i>	1860	1 8 3.00	2.94	+0.06	8	+88 33 47.10	47.10	0.00	10
Greenwich	<i>Airy</i>	1864					+88 35 3.71	3.77	-0.06	9
Pulcowa	<i>Wagner</i>	1865	1 9 38.90	38.46	+0.44	11				
Pulcowa	<i>Nyrén</i>	1865					+88 35 22.79	22.90	-0.11	13
Washington	<i>Newcomb</i>	1865	1 9 38.46	38.46	0.00	7				
Greenwich	<i>Airy</i>	1870	1 11 16.88	17.34	-0.46	8				
Washington	<i>Newcomb</i>	1870					+88 36 58.64	58.46	+0.18	8
Leiden	<i>Kaiser</i>	1870					+88 36 58.42	58.46	-0.04	13
Greenwich	<i>Airy</i>	1872					+88 37 36.67	36.63	+0.04	11
Washington	<i>Eastman</i>	1875	1 12 59.82	59.80	+0.02	6	+88 38 33.81	33.81	0.00	7
Greenwich	<i>Airy</i>	1880	1 14 45.37	46.02	-0.65	8	+88 40 8.96	8.92	+0.04	11
Washington	<i>Eastman</i>	1884					+88 41 24.83	24.82	+0.01	8
Pulcowa	<i>Wagner</i>	1885	1 16 36.30	36.22	+0.08	13				
Pulcowa	<i>Nyrén</i>	1885					+88 41 43.70	43.76	-0.06	14
Greenwich	<i>Christie</i>	1890	1 18 30.74	30.64	+0.10	8	+88 43 18.38	18.35	+0.03	12
Oxford	<i>Stone</i>	1890					+88 43 18.33	18.35	-0.02	5
Madison	<i>Brown</i>	1890					+88 43 18.36	18.35	+0.01	6
Pulcowa	<i>Nyrén</i>	1893					+88 44 14.84	14.95	-0.11	11
Mt. Hamilton	<i>Tucker</i>	1895					+88 44 52.46	52.63	-0.17	5
Mt. Hamilton	<i>Tucker</i>	1898					+88 45 48.94	49.06	-0.12	5
Washington	<i>Updegraff</i>	1900	1 22 33.16	33.19	-0.03	4	+88 46 26.40	26.61	-0.21	6
Greenwich	<i>Christie</i>	1900	1 22 33.33	33.19	+0.14	8	+88 46 26.44	26.61	-0.17	9
Oxford	<i>Rambaut</i>	1900					+88 46 26.7	26.61	+0.09	5
Washington	<i>Updegraff</i>	1902	1 23 23.62	24.04	-0.42	4	+88 47 3.91	4.11	-0.20	6
Greenwich	<i>Christie</i>	1907					+88 48 37.47	37.63	-0.16	7

Equations of Condition.

Right Ascension.						
Epoch	$\Delta\alpha_0$	$\Delta\delta_0$	$\Delta\mu_0$	$\Delta\mu'_0$	n	Weight
1755	+0.67	-0.19	-0.80	+0.23	= +0.54	1
1785	+0.74	-0.17	-0.67	+0.15	= -0.02	1
1815	+0.81	-0.15	-0.49	+0.09	= +0.11	3
1825	+0.84	-0.13	-0.42	+0.07	= +0.13	6
1845	+0.90	-0.08	-0.27	+0.02	= +0.11	5
1865	+0.97	-0.03	-0.10	0.00	= +0.05	9
1885	+1.04	+0.04	+0.10	0.00	= -0.09	9
1900	+1.11	+0.11	+0.28	+0.03	= -0.04	4

Declination.

Epoch	$\Delta\alpha_0$	$\Delta\delta_0$	$\Delta\mu_0$	$\Delta\mu'_0$	n	Weight
1815	+0.02	+1.00	-0.01	-0.60	= +0.10	3
1825	+0.02	+1.00	-0.01	-0.50	= -0.04	9
1845	+0.02	+1.00	0.00	-0.30	= +0.02	14
1865	0.00	+1.00	0.00	-0.10	= -0.06	11
1875	0.00	+1.00	0.00	0.00	= +0.04	17
1885	0.00	+1.00	0.00	+0.10	= -0.01	15
1900	-0.01	+1.00	0.00	+0.25	= -0.14	18

In forming the weights assigned to the equations of condition in right ascension, the weights given in the table

of observed corrections to the tabular place of Polaris have been divided by 4, while in declination, the number 3 was used as a divisor in the same manner. The scale of weights in each coordinate should in theory be so adjusted that the numerical mean error corresponding to the unit of weight will be the same in right ascension that it is in declination. The difference between these mean errors as deduced below is not great enough to practically affect the results of the solution of the normal equations.

Normal equations.

$\Delta\alpha_0$	$\Delta\delta_0$	$\Delta\mu_0$	$\Delta\mu'_0$	n
+34.39	-0.69	-4.25	+0.80	= +1.21
-0.69	+87.34	+0.99	-5.76	= -2.79
-4.25	+0.99	+3.73	-0.52	= -1.23
+0.80	-5.76	-0.52	+6.11	= -0.45

Results of solution of Normal Equations.

For 1875.0	Weight	Mean err.
$\Delta\alpha_0 = -0^s.005$	$\alpha_0 = 1^h 12^m 59^s.795$	29.6 $\pm 0^s.040$
$\Delta\mu_0 = -0^s.346$	$\mu_0 = +11^s.944$	3.2 $\pm 0^s.123$
$\Delta\delta_0 = -0^s.037$	$\delta_0 = +88^\circ 38' 33''.773$	81.9 $\pm 0^s.035$
$\Delta\mu'_0 = -0^s.138$	$\mu'_0 = +0^s.372$	5.7 $\pm 0^s.132$

The mean errors for unit weight are:

in RA. $\pm 0^s.220$, in Decl. $\pm 0^s.314$.

The mean epoch of the observations is:

in RA. 1855, in Decl. 1869.

The positions and proper motions of the star for 1875.0 and 1900.0 are as follows:

	RA.	Prop. Mot.	Decl.	Prop. Mot.
1875.0	$1^h 12^m 59^s.80$	$+11^s.94$	$+88^\circ 38' 33''.77$	$+0^s.37$
1900.0	$1^h 22^m 33.07$	$+13.26$	$+88^\circ 46' 26.53$	$+0.22$

The following comparative ephemerides are given.

Epoch	Right Ascension			
	N.	A.-P.	B.	U.
1755	$0^h 43^m 42^s.29$	$42^s.65$		$42^s.55$
1775	$0^h 47^m 20.33$	20.66		20.56
1800	$0^h 52^m 25.55$	25.82	$25^s.49$	25.72
1810	$0^h 54^m 39.50$	39.77	39.47	39.67
1820	$0^h 57^m 1.24$	1.50	1.23	1.39
1830	$0^h 59^m 31.53$	31.78	31.53	31.66
1840	$1^h 2^m 11.24$	11.47	11.25	11.34
1850	$1^h 5^m 1.33$	1.53	1.36	1.40
1860	$1^h 8^m 2.94$	3.12	2.99	2.99
1870	$1^h 11^m 17.34$	17.51	17.41	17.36
1880	$1^h 14^m 46.02$	46.15	46.09	46.01
1890	$1^h 18^m 30.64$	30.74	30.73	30.58
1900	$1^h 22^m 33.19$	33.25	33.27	33.07
1910	$1^h 26^m 55.88$	55.90	55.97	55.72
1920	$1^h 31^m 41.36$	41.33	41.47	41.14
1930	$1^h 36^m 52.70$	52.64		52.42
1940	$1^h 42^m 33.45$	33.34		33.10
1950	$1^h 48^m 47.85$	47.69		47.42
1960	$1^h 55^m 40.79$	40.59		40.28

Washington D. C., September 1911.¹⁾

¹⁾ Bei der Redaktion eingetroffen 1912 April 20. Red.

An Ephemeris of Polaris 1755 to 1960.

Year	RA.	Prob. Err.	Decl.	Prob. Err.
1755	$0^h 43^m 42^s.55$	$\pm 0^s.09$	$+87^\circ 59' 41''.26$	$\pm 0^s.10$
1775	$0^h 47^m 20.56$	± 0.07	$+88^\circ 6' 14.70$	± 0.09
1800	$0^h 52^m 25.72$	± 0.05	$+88^\circ 14' 24.47$	± 0.07
1810	$0^h 54^m 39.67$	± 0.04	$+88^\circ 17' 39.64$	± 0.06
1820	$0^h 57^m 1.39$	± 0.04	$+88^\circ 20' 54.32$	± 0.05
1830	$0^h 59^m 31.66$	± 0.03	$+88^\circ 24' 8.46$	± 0.04
1840	$1^h 2^m 11.34$	± 0.03	$+88^\circ 27' 22.02$	± 0.04
1850	$1^h 5^m 1.40$	± 0.02	$+88^\circ 30' 34.91$	± 0.03
1860	$1^h 8^m 2.99$	± 0.02	$+88^\circ 33' 47.08$	± 0.03
1870	$1^h 11^m 17.36$	± 0.03	$+88^\circ 36' 58.43$	± 0.02
1880	$1^h 14^m 46.01$	± 0.03	$+88^\circ 40' 8.87$	± 0.03
1890	$1^h 18^m 30.58$	± 0.04	$+88^\circ 43' 18.28$	± 0.03
1900	$1^h 22^m 33.07$	± 0.04	$+88^\circ 46' 26.54$	± 0.04
1910	$1^h 26^m 55.72$	± 0.05	$+88^\circ 49' 33.48$	± 0.04
1920	$1^h 31^m 41.14$	± 0.06	$+88^\circ 52' 38.92$	± 0.05
1930	$1^h 36^m 52.42$	± 0.06	$+88^\circ 55' 42.66$	± 0.06
1940	$1^h 42^m 33.10$	± 0.07	$+88^\circ 58' 44.43$	± 0.07
1950	$1^h 48^m 47.42$	± 0.08	$+89^\circ 1' 43.93$	± 0.08
1960	$1^h 55^m 40.28$	± 0.09	$+89^\circ 4' 40.79$	± 0.08

The results for 1875.0, of *Newcomb*, *Auwers-Peters*, *Boss* and those deduced above are given for comparison.

	RA.	μ	Decl.	μ'
<i>Newcomb</i>	$1^h 12^m 59^s.80$	$+12^s.29$	$+88^\circ 38' 33''.81$	$+0^s.51$
<i>Auwers-Peters</i>	$1^h 12^m 59.95$	$+11.99$	$+88^\circ 38' 33.73$	$+0.46$
<i>Boss</i>	$1^h 12^m 59.87$	$+12.4$	$+88^\circ 38' 33.76$	$+0.3$
<i>Updegraff</i>	$1^h 12^m 59.80$	$+11.94$	$+88^\circ 38' 33.77$	$+0.37$

The relatively large value in right ascension given by the *Auwers-Peters* Catalogue is probably due to greater weight given to the Pulcowa observations. The proper motion in right ascension given by *Boss* seems to be inconsistent with the observed data tabulated above.

Declination				
N.	A.-P.	B.	U.	
$+87^\circ 59' 41''.15$	$41''.11$		$41''.26$	
$+88^\circ 6' 14.60$	14.57		14.70	
$+88^\circ 14' 24.41$	24.37	$24''.53$	24.47	
$+88^\circ 17' 39.57$	39.54	39.69	39.64	
$+88^\circ 20' 54.26$	54.23	54.36	54.32	
$+88^\circ 24' 8.43$	8.38	8.50	8.46	
$+88^\circ 27' 22.01$	21.95	22.05	22.02	
$+88^\circ 30' 34.91$	34.84	34.92	34.91	
$+88^\circ 33' 47.10$	47.02	47.08	47.08	
$+88^\circ 36' 58.46$	58.38	58.42	58.43	
$+88^\circ 40' 8.92$	8.84	8.85	8.87	
$+88^\circ 43' 18.35$	18.26	18.25	18.28	
$+88^\circ 46' 26.61$	26.51	26.49	26.54	
$+88^\circ 49' 33.56$	33.46	33.42	33.48	
$+88^\circ 52' 39.02$	38.91	38.85	38.92	
$+88^\circ 55' 42.78$	42.66		42.66	
$+88^\circ 58' 44.55$	44.43		44.43	
$+89^\circ 1' 44.06$	43.94		43.93	
$+89^\circ 4' 40.95$	40.83		40.79	

Milton Updegraff.