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ELEMENTS AND EPHEMERIS OF THE LOWELL OBSERVATORY OBJECT
(PLUTO)—SECOND PAPER¹

BY

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The numerous observations of the Lowell Observatory Object, recently named Pluto, which have been published since its discovery, now permit the determination of the orbit with a fair degree of accuracy. Of prime importance in this connection is the identification of the object on prediscovery plates: in order of announcement, at Uccle by Delporte January 1927, at Mount Wilson by Nicholson on four plates taken by Humason December 1919, and at Williams Bay by Ross on plates taken by him January 1927 and by Barnard January 1921. On the other hand slight in-

accuracies of the 1930 observations complicated the problem. Preliminary elements were released on April 5.²

The following observations are now available. Corrections for parallax, sufficiently accurate for the other observatories, were taken from a table formed from the Lick Observatory tables,³ with sidereal time as argument and a mean value of ρ , α and δ . The residuals in the last columns correspond to the final orbit derived in this paper, designated as Elements XVIII.

	1919 U.T.	$\alpha(1930.0)$	$\delta(1930.0)$	Observer	Place	Inst.*	Authority	$\Delta\alpha$	$\Delta\delta$
(1) ^a	Dec. 28. 1861	6 ^h 29 ^m 08 ^s .53	+19°21'47".0	Humason	Mt. Wilson	P10 ^{1a} .	Letter	+0".8	- 2".7
(2) ^a	Dec. 28. 2861	6 29 07.68	+19 21 49.0	Humason	Mt. Wilson	P10	Letter		
(3) ^a	Dec. 29. 4285	6 29 02.13	+19 21 56.8	Humason	Mt. Wilson	P10	Letter		
(4) ^a	Dec. 30. 3660	6 28 57.14	+19 22 01.5	Humason	Mt. Wilson	P10	Letter		
1921 U.T.									
(5) ^b	Jan. 29. 0896	6 31 22.14	+19 43 13.8	Barnard	Williams Bay	.....	Letter	+13.6	- 3.3
1927 U.T.									
(6) ^c	Jan. 6. 25	7 04 03.17	+21 13 03.1	Ross	Williams Bay	P 3	Letter	- 0.2	- 2.0
(7) ^d	Jan. 27. 8942	7 01 59.7	+21 17 59.5	Delporte	Uccle	P	B.C.A.C. 280	- 0.4	+17.7
1930 U.T.									
(8) ^e	Jan. 23. 2274	7 18 56.37	+21 57 40.1	.....	Flagstaff	P13	Lowell Obs. Circ.	- 2.3	- 2.9
(9) ^e	Feb. 23. 1944	7 16 36.39	+22 04 06.8	.....	Flagstaff	P13	Lowell Obs. Circ.	- 1.8	- 0.9
(10)	Mar. 16. 0554	7 15 42.55	+22 07 10.6	Van Biesbroeck	Williams Bay	P24	H.A.C. 112	- 0.5	- 0.2
(11)	Mar. 17. 0793	7 15 40.92	+22 07 18.0	Van Biesbroeck	Williams Bay	P24	H.A.C. 112	- 1.2	+ 0.2
(12)	Mar. 18. 1667	7 15 39.46	+22 07 26.7	Neubauer	Mt. Hamilton	P36	L.O.B. 14, 192	+ 0.3	+ 1.6
(13)	Mar. 19. 0917	7 15 38.15	+22 07 31.3	Van Biesbroeck	Williams Bay	P24	Letter	- 0.8	+ 0.2
(14)	Mar. 19. 1542	7 15 38.00	+22 07 31.4	Neubauer	Mt. Hamilton	P36	L.O.B. 14, 192	- 1.9	- 0.1
(15)	Mar. 19. 1979	7 15 38.14	+22 07 31.8	Meyer	Mt. Hamilton	P36	L.O.B. 14, 192	+ 1.1	0.0
(16)	Mar. 19. 8694	7 15 37.27	+22 07 36	Madwar	Helwan	P	B.C.A.C. 269, 270	+ 0.7	0.0
(17)	Mar. 20. 0668	7 15 36.99	+22 07 38.1	Van Biesbroeck	Williams Bay	P24	Letter	- 0.1	+ 0.9

* Instrument: P=photographic, V=visual.

* Large images 4" from center in δ . Measured and reduced by Nicholson.^b Diffuse images 3"2 from center. Measured and reduced by Ross and Van Biesbroeck. Mean of P10^{1a} and P6^{1a}.^c Sharp images 6" from center. * Measured and reduced by Lampland.^d Equinox 1927.0. Revised position received 1930 July 19, $\alpha=7^h 1^m 59^s.96$, $\delta=+21^\circ 17' 44".0$ (B. C. A. C. 292). $\Delta\alpha=+3".6$ $\Delta\delta=+2".2$.¹ Continued from *L. O. B.* 14, 189.² *H. A. C.* 118.³ *Publ. Lick Obs.* 1, 259.

	1930 U.T.	$\alpha(1930.0)$	$\delta(1930.0)$	Observer	Place	Inst.	Authority	$\Delta\alpha$	$\Delta\delta$
(18)	Mar. 20. 1562	7 ^h 15 ^m 36 ^s .98	+22°07'38".6	Neubauer	Mt. Hamilton	P36 ⁱⁿ .	L.O.B. 14, 192	+ 1.3	+ 0.8
(19)	Mar. 20. 2292	7 15 36.84	+22 07 38.3	Meyer	Mt. Hamilton	P36	L.O.B. 14, 192	+ 0.6	+ 0.1
(20)	Mar. 20. 8160	7 15 36.11	+22 07 38.8	Schneller	Babelsberg	P40 ^{cm}	A.N. 238, 211	- 0.4	- 3.0
(21) [/]	Mar. 21. 2153	7 15 35.74	+22 07 44.3	Meyer	Mt. Hamilton	P36 ⁱⁿ	L.O.B. 14, 192	+ 0.6	+ 0.1
(22) [/]	Mar. 21. 881	7 15 34.98	+22 07 48.4	Robinson	Oxford	P24	M.N. 90, 611	- 0.3	+ 0.3
(23)	Mar. 21. 8845	7 15 34.97	+22 07 48.3	Baade	Bergedorf	.....	B.C.A.C. 265	- 0.4	+ 0.1
(24)	Mar. 21. 9333	7 15 34.98	+22 07 47.5	G. Struve	Babelsberg	V	A.N. 238, 211	+ 0.5	- 1.0
(25)	Mar. 21. 9542	7 15 35.03	+22 07 47.5	Schneller	Babelsberg	P40 ^{cm}	A.N. 238, 211	+ 1.6	- 1.1
(26)	Mar. 22. 1282	7 15 34.96	+22 07 49.7	.....	Washington	.....	H.A.C. 123	+ 3.0	+ 0.1
(27)	Mar. 22. 8749	7 15 34.04	+22 07 54.6	Baade	Bergedorf	.....	B.C.A.C. 265	- 0.3	+ 0.7
(28)	Mar. 22. 9457	7 15 33.99	+22 07 54.6	G. Struve	Babelsberg	V	A.N. 238, 211	- 0.1	+ 0.3
(29)	Mar. 23. 1075	7 15 34.06	+22 07 55.1	.....	Washington	.....	H.A.C. 123	+ 3.1	- 0.1
(30) ^o	Mar. 23. 1413	7 15 33.85	+22 07 55.6	.....	Flagstaff	P42 ⁱⁿ .	Lowell Obs. Circ.	+ 0.3	+ 0.2
(31)	Mar. 23. 1733	7 15 33.83	+22 07 55.4	Mayall	Mt. Wilson	P60	Letter	+ 0.4	- 0.2
(32)	Mar. 24. 1458	7 15 33.02	+22 08 00.7	Mayall	Mt. Wilson	P60	Letter	+ 0.2	- 0.3
(33)	Mar. 24. 8552	7 15 32.53	+22 08 05	Madwar	Helwan	.....	B.C.A.C. 269	+ 0.7	+ 0.2
(34) [/]	Mar. 24. 864	7 15 32.46	+22 08 05.4	Robinson	Oxford	P24	M.N. 90, 611	- 0.4	+ 0.6
(35) [/]	Mar. 26. 2118	7 15 31.60	+22 08 12.2	Meyer	Mt. Hamilton	P36	L.O.B. 14, 192	- 0.6	+ 0.3
(36)	Mar. 26. 7986	7 15 31.21	+22 08 17.4	Taffara	Catania	P33 ^{cm}	A.N. 238, 252	- 1.9	+ 2.6
(37)	Mar. 26. 8619	7 15 31.25	+22 08 14.1	G. Struve	Babelsberg	V	A.N. 238, 211	- 0.8	- 1.0
(38) ^o	Mar. 26. 8976	7 15 31.23	+22 08 14.0	.....	Paris	P	B.C.A.C. 276	- 0.8	- 1.2
(39) [/]	Mar. 27. 2250	7 15 31.09	+22 08 16.6	Meyer	Mt. Hamilton	P36 ⁱⁿ .	L.O.B. 14, 192	- 0.6	- 0.2
(40)	Mar. 27. 8507	7 15 30.84	+22 08 21.3	Taffara	Catania	P33 ^{cm}	A.N. 238, 252	- 0.5	+ 1.5
(41) ^o	Mar. 27. 8993	7 15 31.08	+22 08 21.1	.....	Paris	P	B.C.A.C. 276	+ 3.4	+ 1.0
(42)	Mar. 28. 1122	7 15 30.80	+22 08 21.4	Van Biesbroeck	Williams Bay	P24 ⁱⁿ .	Letter	+ 0.3	+ 0.3
(43)	Mar. 28. 1497	7 15 30.80	+22 08 20.7	Mayall	Mt. Wilson	P60	Letter	+ 0.4	- 0.6
(44) [/]	Mar. 28. 2424	7 15 30.72	+22 08 21.4	Meyer	Mt. Hamilton	P36	L.O.B. 14, 192	- 0.2	- 0.3
(45) ^o	Mar. 28. 9056	7 15 30.51	+22 08 25.7	.....	Paris	P	B.C.A.C. 276	- 0.3	+ 1.0
(46)	Mar. 29. 8000	7 15 30.22	+22 08 30.3	Taffara	Catania	P	A.N. 238, 252	- 1.8	+ 1.6
(47)	Mar. 29. 8376	7 15 30.33	+22 08 29	Madwar	Helwan	P	B.C.A.C. 269	0.0	+ 0.1
(48)	Mar. 29. 853	7 15 30.34	+22 08 29.5	Barrett	Oxford	P24	M.N. 90, 611	+ 0.2	+ 0.6
(49) ^h	Mar. 29. 8812	7 15 30.26	+22 08 28.3	Gonnissiat	Alger	P	A.N. 238, 252	- 0.9	- 0.8
(50)	Mar. 30. 1348	7 15 30.31	+22 08 29.1	Van Biesbroeck	Williams Bay	P24	Letter	+ 0.4	- 1.1
(51) ^o	Mar. 30. 1382	7 15 30.29	+22 08 30.2	.....	Flagstaff	P42	Lowell Obs. Circ.	+ 0.1	0.0
(52)	Mar. 30. 1694	7 15 30.53	+22 08 30.2	.....	Washington	.....	H.A.C. 123	+ 3.8	- 0.1
(53)	Mar. 30. 1924	7 15 30.42	+22 08 30.0	Neubauer	Mt. Hamilton	P36	L.O.B. 14, 192	+ 2.1	- 0.5
(54)	Mar. 30. 8244	7 15 30.23	+22 08 33.6	Baade	Bergedorf	.....	B.C.A.C. 268	+ 0.2	+ 0.5
(55)	Mar. 30. 8606	7 15 30.20	+22 08 36.0	Mündler	Königstuhl	V	A.N. 238, 300	- 0.2	+ 2.8
(56)	Mar. 31. 0927	7 15 30.20	+22 08 34.1	Van Biesbroeck	Williams Bay	P24	Letter	0.0	- 0.1
(57)	Mar. 31. 8042	7 15 30.14	+22 08 38.5	Taffara	Catania	P	A.N. 238, 252	- 0.9	+ 1.4
(58)	Mar. 31. 8179	7 15 30.15	+22 08 37.5	Madwar	Helwan	P	B.C.A.C. 280	- 0.7	+ 0.4
(59)	Mar. 31. 8328	7 15 30.17	+22 08 37.5	G. Struve	Babelsberg	V	A.N. 238, 211	- 0.5	+ 0.3
(60) ^o	Mar. 31. 8799	7 15 30.25	+22 08 37.7	.....	Paris	P	B.C.A.C. 276	+ 0.7	+ 0.3
(61)	Apr. 1. 0706	7 15 30.23	+22 08 39.0	Raynsford	Washington	V26	H.A.C. 133	+ 0.2	+ 0.9
(62)	Apr. 1. 8255	7 15 30.30	+22 08 42.0	G. Struve	Babelsberg	V	B.C.A.C. 267	+ 0.1	+ 1.0
(63)	Apr. 1. 8382	7 15 30.14	+22 08 42.4	Taffara	Catania	P	A.N. 238, 252	- 2.3	+ 1.3
(64)	Apr. 2. 0775	7 15 30.37	+22 08 41.7	Van Biesbroeck	Williams Bay	P24	Letter	+ 0.5	- 0.3
(65) [/]	Apr. 2. 2451	7 15 30.36	+22 08 42.3	Meyer	Mt. Hamilton	P36	L.O.B. 14, 192	0.0	- 0.3
(66)	Apr. 2. 8444	7 15 30.45	+22 08 46.6	Taffara	Catania	P	A.N. 238, 252	- 0.7	+ 1.8
(67)	Apr. 2. 870	7 15 30.51	+22 08 45.5	Robinson	Oxford	P24	M.N. 90, 611	+ 0.1	+ 0.6
(68)	Apr. 3. 0656	7 15 30.60	+22 08 46.5	Van Biesbroeck	Williams Bay	P24	Letter	+ 0.6	+ 0.9
(69) ^o	Apr. 3. 8382	7 15 30.80	+22 08 47.2	.....	Paris	P	B.C.A.C. 276	0.0	- 1.0
(70)	Apr. 3. 9627	7 15 30.84	+22 08 48.8	Baade	Bergedorf	P	B.C.A.C. 268	0.0	+ 0.2
(71)	Apr. 4. 1842	7 15 30.94	+22 08 49.5	Van Biesbroeck	Williams Bay	P24	Letter	+ 0.2	+ 0.1
(72) [/]	Apr. 4. 1969	7 15 30.95	+22 08 49.2	Meyer	Mt. Hamilton	P36	L.O.B. 14, 192	+ 0.2	- 0.2

^o Observed and reduced by Mineur, Canavaggia, Barbier, and De Grandchamp.

[/] Mean of two plates.

^h Reduced by Filippoff.

^o Measured and reduced by Lampland.

	1930 U.T.	$\alpha(1930.0)$	$\delta(1930.0)$	Observer	Place	Inst.	Authority	$\Delta\alpha$	$\Delta\delta$
(73) ^o	Apr. 4.8715	7 ^h 15 ^m 31 ^s .15	+22°08'50".8	.....	Paris	P	B.C.A.C. 276	- 1.1	- 0.8
(74)	Apr. 5.1459	7 15 31.39	+22 08 52.2	Van Biesbroeck	Williams Bay	P24 ⁱⁿ .	Letter	+ 0.5	- 0.3
(75) ⁱ	Apr. 10.8167	7 15 35.54	+22 09 08.1	Favaro	Catania	P	A.N. 238 , 300	- 4.8	+ 1.0
(76) ⁱ	Apr. 12.8139	7 15 38.13	+22 09 13.4	Favaro	Catania	P	A.N. 238 , 300	- 1.7	+ 2.6
(77) ^o	Apr. 15.8528	7 15 42.77	+22 09 14.0	.....	Paris	P	B.C.A.C. 276	+ 1.7	- 1.0
(78) ^j	Apr. 16.1910	7 15 43.23	+22 09 15.5	Meyer	Mt. Hamilton	P36	Letter	+ 0.3	+ 0.1
(79)	Apr. 16.8257	7 15 44.22	+22 09 18.5	Favaro	Catania	P	A.N. 238 , 300	- 0.7	+ 2.5
(80)	Apr. 17.8278	7 15 46.07	+22 09 18.4	Favaro	Catania	P	A.N. 238 , 300	+ 0.6	+ 1.6
(81) ^o	Apr. 17.8799	7 15 46.15	+22 09 15.7	.....	Paris	P	B.C.A.C. 276	+ 0.4	- 1.1
(82)	Apr. 19.0786	7 15 48.40	+22 09 17.4	Van Biesbroeck	Williams Bay	P24	Letter	+ 0.4	- 0.1
(83)	Apr. 19.7915	7 15 49.77	+22 09 17.5	Madwar	Helwan	P	B.C.A.C. 280	- 0.1	- 0.3
(84) ^o	Apr. 19.8701	7 15 49.98	+22 09 17.3	.....	Paris	P	B.C.A.C. 276	+ 0.7	- 0.5
(85)	Apr. 20.7922	7 15 51.80	+22 09 18.2	Madwar	Helwan	P	B.C.A.C. 280	- 0.5	+ 0.2
(86)	Apr. 20.8328	7 15 51.90	+22 09 18.1	Sternberk	Stara Dala	P60 ^{cm}	B.C.A.C. 275	- 0.2	+ 0.1
(87) ^o	Apr. 20.8785	7 15 52.03	+22 09 17.4	.....	Paris	P	B.C.A.C. 276	+ 0.2	- 0.6
(88)	Apr. 21.8209	7 15 54.03	+22 09 18.9	Madwar	Helwan	P	B.C.A.C. 280	- 0.3	+ 0.8
(89)	Apr. 22.0851	7 15 54.75	+22 09 18.4	Van Biesbroeck	Williams Bay	P24 ⁱⁿ .	Letter	+ 1.6	+ 0.3
(90)	Apr. 22.1602	7 15 54.82	+22 09 18.2	Mayall	Mt. Wilson	P60	Letter	+ 0.2	+ 0.1
(91)	Apr. 22.8551	7 15 56.34	+22 09 19.1	Warzee	Uccle	.....	B.C.A.C. 283	- 0.7	+ 1.1
(92)	Apr. 22.8554	7 15 56.48	+22 09 18.8	Baade	Bergedorf	P	A.N. 238 , 299	+ 1.4	+ 0.8
(93) ⁱ	Apr. 22.8757	7 15 56.22	+22 09 18.9	G. Struve	Babelsberg	V	B.C.A.C. 275	- 3.2	+ 0.9
(94)	Apr. 23.7972	7 15 58.58	+22 09 18.3	Favaro	Catania	P	A.N. 238 , 300	- 0.5	+ 0.6
(95)	Apr. 23.8551	7 15 58.76	+22 09 17.2	Baade	Bergedorf	P	A.N. 238 , 299	+ 0.2	- 0.5
(96) ⁱ	Apr. 23.9045	7 15 58.72	+22 09 18.5	G. Struve	Babelsberg	V	B.C.A.C. 275	- 2.2	+ 0.9
(97)	Apr. 24.1151	7 15 59.36	+22 09 17.0	Van Biesbroeck	Williams Bay	P24	Letter	- 0.3	- 0.6
(98) ^o	Apr. 24.9062	7 16 01.43	+22 09 16.2	.....	Paris	P	B.C.A.C. 276	+ 1.4	- 0.9
(99)	Apr. 25.7814	7 16 03.54	+22 09 16.8	Madwar	Helwan	P	B.C.A.C. 280	- 0.5	+ 0.3
(100) ⁱ	Apr. 25.8396	7 16 03.73	+22 09 18.1	Favaro	Catania	P	A.N. 238 , 300	0.0	+ 1.6
(101)	Apr. 25.9098	7 16 03.96	+22 09 17.4	G. Struve	Babelsberg	V	B.C.A.C. 275	+ 0.8	+ 1.0
(102)	Apr. 26.1361	7 16 04.57	+22 09 16.0	Van Biesbroeck	Williams Bay	P24	Letter	+ 1.0	- 0.2
(103)	Apr. 26.7724	7 16 06.18	+22 09 16.6	Madwar	Helwan	P	B.C.A.C. 280	- 0.3	+ 0.9
(104)	Apr. 26.8312	7 16 06.25	+22 09 17.0	Favaro	Catania	P	A.N. 238 , 300	- 1.6	+ 1.4
(105)	Apr. 27.7621	7 16 08.95	+22 09 15.1	Madwar	Helwan	P	B.C.A.C. 280	+ 0.5	+ 0.5
(106)	Apr. 27.8635	7 16 09.22	+22 09 15.8	G. Struve	Babelsberg	V	B.C.A.C. 275	+ 0.4	+ 1.3
(107)	Apr. 28.7714	7 16 11.80	+22 09 14.5	Madwar	Helwan	P	B.C.A.C. 280	+ 0.3	+ 1.1
(108)	Apr. 29.7606	7 16 14.66	+22 09 13.0	Madwar	Helwan	P	B.C.A.C. 280	- 0.3	+ 1.0
(109)	Apr. 29.8271	7 16 14.80	+22 09 16.3	Taffara	Catania	P	A.N. 238 , 314	- 1.2	+ 4.4
(110)	Apr. 29.8616	7 16 14.87	+22 09 12.5	G. Struve	Babelsberg	V	B.C.A.C. 279	- 1.7	+ 0.6
(111)	Apr. 30.8192	7 16 17.88	+22 09 10.7	Madwar	Helwan	P	B.C.A.C. 280	- 0.2	+ 0.4
(112)	Apr. 30.8271	7 16 17.79	+22 09 12.6	Favaro	Catania	P	A.N. 238 , 314	- 1.9	- 2.3
(113)	May 1.1163	7 16 18.82	+22 09 09.1	Van Biesbroeck	Williams Bay	P24	Letter	+ 0.1	- 0.7
(114) ⁱ	May 1.8814	7 16 21.19	+22 09 08.9	G. Struve	Babelsberg	V	B.C.A.C. 279	- 0.4	+ 0.5
(115)	May 2.1806	7 16 22.16	+22 09 07.7	Meyer	Mt. Hamilton	P36	Letter	- 0.2	- 0.2
(116) ⁱ	May 2.8615	7 16 24.48	+22 09 06.0	G. Struve	Babelsberg	V	B.C.A.C. 279	+ 1.6	- 0.5
(117) ^h	May 9.8446	7 16 49.40	+22 08 47.1	Renaux	Alger	P	B.C.A.C. 281	+ 0.1	- 1.0
(118) ^{j/l}	May 10.2000	7 16 50.79	+22 08 47.3	Meyer	Mt. Hamilton	P36	.....	+ 0.2	+ 0.4
(119)	May 15.7551	7 17 13.78	+22 08 26.6	Madwar	Helwan	P	B.C.A.C. 285	- 0.4	+ 0.5
(120)	May 16.7569	7 17 18.28	+22 08 21.3	Madwar	Helwan	P	B.C.A.C. 285	+ 0.8	- 0.5
(121)	May 17.1218	7 17 19.83	+22 08 22.2	Van Biesbroeck	Williams Bay	P24	Letter	- 0.3	+ 2.0
(122) ^k	May 17.7566	7 17 22.82	+22 08 17.6	Madwar	Helwan	P	B.C.A.C. 285	+ 1.6	+ 0.2
(123)	May 20.7610	7 17 36.70	+22 08 03.3	Madwar	Helwan	P	B.C.A.C. 285	+ 0.7	+ 0.1
(124) ^m	May 22.1719	7 17 43.42	+22 07 56.2	Mayall	Mt. Wilson	P60	Letter	- 0.3	+ 0.2
(125) ^{j/l}	May 22.2031	7 17 43.65	+22 07 56.4	Meyer	Mt. Hamilton	P36	.....	+ 0.9	+ 0.5
(126) ^{j/l}	May 23.2010	7 17 48.52	+22 07 50.7	Meyer	Mt. Hamilton	P36	.....	+ 0.7	+ 0.1
(127) ^m	May 24.1173	7 17 53.01	+22 07 46.0	Van Biesbroeck	Williams Bay	P24	H.A.C. 129	- 0.2	+ 0.3

^o Observed and reduced by Mineur, Canavaggia, Barbier, and De Grandchamp.

^h Haze or moonlight.

ⁱ Mean of two plates.

^k Reduced by Filippoff.

^j Reduced by Bower by Wilson's method.

^j Very difficult.

^k Image superposed on star.

^m Diffuse images.

	1930 U.T.	$\alpha(1930.0)$	$\delta(1930.0)$	Observer	Place	Inst.	Authority	$\Delta\alpha$	$\Delta\delta$
(128)	May 24.7642	7 ^h 17 ^m 56 ^s .24	+22°07'42".0	Madwar	Helwan	P	B.C.A.C. 287	- 0".5	- 1".0
(129) ^m	May 25.1209	7 17 58.05	+22 07 40.5	Van Biesbroeck	Williams Bay	P24 ^h	H.A.C. 129	- 0.3	- 0.4
(130)	May 25.7645	7 18 01.36	+22 07 37.0	Madwar	Helwan	P	B.C.A.C. 287	+ 0.2	+ 0.5
(131) ^m	May 26.1202	7 18 03.15	+22 07 34.4	Van Biesbroeck	Williams Bay	P24	H.A.C. 129	- 0.3	- 0.1
(132)	May 26.7636	7 18 06.54	+22 07 31.4	Madwar	Helwan	P	B.C.A.C. 287	+ 0.8	+ 0.7
(133) ^{m/n}	May 27.1927	7 18 08.72	+22 07 27.8	Pease	Mt. Wilson	P100	Letter	+ 0.1	- 0.4
(134) ^o	May 27.7626	7 18 11.74	+22 07 25.6	Madwar	Helwan	P	B.C.A.C. 287	+ 0.7	+ 0.8
(135)	May 28.7649	7 18 17.07	+22 07 20.2	Madwar	Helwan	P	B.C.A.C. 287	+ 1.3	+ 1.4
(136) ^{m/n}	June 1.1809	7 18 35.51	+22 06 58.1	Van Maanen	Mt. Wilson	P100	Letter	+ 0.3	+ 0.9

^m Diffuse images.

ⁿ Measured and reduced by Mayall.

^o On reseau.

When the 1930 Flagstaff, Mount Hamilton, Mount Wilson, and Williams Bay observations as far as (113) May 1 became available, a smooth curve was drawn through a plot of the residuals from our previous Orbit III.⁴ By the aid of this graph the following positions, which are comparable to normal places, were adopted:

	1930 U.T.	α	δ
Mar. 16.0554	108° 55' 38".23	+22° 07' 10".67	
Apr. 2.2451	108 52 35.84	+22 08 42.38	
May 1.1163	109 04 42.46	+22 09 09.70	

The Flagstaff observation, (8) Jan. 23, received in the meantime, was represented by Orbits I-VI:⁴

Orbit		$\Delta\alpha$	$\Delta\delta$
I General direct solution	($r' = +$)	- 1".6	- 3".0
II General corrected	($r' = -$)	- 4.6	- 3.8
III Conditioned ellipse A	($r' = +$)	-14.0	-1.2
IV Conditioned ellipse B	($r' = -$)	- 7.3	- 3.1
V Parabola A	($r' = +$)	-21.2	+0.3
VI Parabola B	($r' = -$)	+ 0.2	-4.8

Orbit	VII General $r' = +$		VIII Conditioned ellipse A $r' = +$		IX Conditioned ellipse B $r' = -$		X $\frac{1}{2}(\text{VIII} + \text{IX})$ $r' = +$		XI Parabola A $r' = +$		XII Parabola B $r' = -$	
	$\Delta\alpha$	$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$
(8) Jan. 23	0".0	0".0	0".0	-2".1	0".0	-3".0	0".0	-2".6	0".0	-1".1	0".0	-4".0
(9) Feb. 23	+3.6	-0.5	+0.4	-0.7	-0.9	-0.8	-0.2	-0.7	+1.9	-0.6	-2.4	-0.8
Mar. 16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Apr. 2	-3.3	+0.1	-0.7	0.0	+0.4	0.0	-0.1	0.0	-3.4	+0.3	+1.6	-0.1
May 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

At Professor Crawford's suggestion an orbit X was formed from VIII and IX by taking the mean of ρ , x' , y' , z' , and this represented rather better than either of the orbits from which it was formed.

Since Orbit VII was hyperbolic and the residual in α of Apr. 2 exceeded the probable accumulation of errors from the three normal places, (8) Jan. 23 was believed to be in error. A similar treatment with Apr. 2 as middle date indicated that (9) Feb. 23 was also in error. These conclusions are substantiated by the residuals tabulated above with the observations.

On account of the small motion of the object in its orbit during the three months of observation, the relatively small inaccuracy of (8) Jan. 23 produced a range in the eccentricity from 0.11 in Orbit X, through 0.3 in VIII and IX, and 1.0 in XI and XII, to 1.8 in VII, and is responsible for the high eccentricities

⁴ L. O. B. 14, 190.

Since Orbit I, the original direct solution from (10) Mar. 16, (35) Mar. 26, and (65) Apr. 2 gave the smallest residuals, it was selected for correction to represent the arc available at this point.

With the foregoing normal of Mar. 16 as middle place, the residuals to be removed were

	$\Delta\alpha$	$\Delta\delta$
(8) Jan. 23	-2".7	-2".7
(9) Feb. 23	-0.6	-0.9
Mar. 16	0.0	0.0
May 1	-3.6	+0.9

A position here and in following tables not preceded by a serial number represents a normal place. In addition to a differential correction for a general solution, conditioned differential corrections were made as before. The new set of orbits gave the residuals:

obtained by other investigators.^{5, 6} The range in r , however, was only from 41.2 to 41.5 astronomic units.

With further observations, extending the arc about ten days, attempts along the same general lines still gave unsatisfactory results. This was due largely to an error (corrected later) of 3" in δ of a late observation. An ephemeris from an ellipse formed like Orbit X was furnished to Mount Wilson for 1920 and 1921. The object was subsequently found by Nicholson on the 1919 Dec. plates about 50' from this predicted place.

On resuming the work after (8) 1927 Jan. 27 and most of the 1930 observations had been received, the residuals were found from an ephemeris based on Orbit X. Weights were assigned to selected observations, and normal places formed:

⁵ H. A. C. 121, Van Biesbroeck.

⁶ H. A. C. 131, Miller.

1930 U.T.	α			δ	Nr. obs.
Mar. 26.2118	108° 52'	54"73		+22° 08' 11"88	43
Apr. 24.1151	108 59	51.17		+22 09 17.74	30
May 24.1173	108 28	15.54		+22 07 46.03	8

At this point the Gaussian constant was modified to $k\sqrt{1+\Sigma m}=0.017\ 213\ 628$, which assumes that all the major planets are concentrated at the center of the Sun. This is not theoretically correct, of course, but is a much better approximation than to assume that the Sun is the only attracting body.

With Mar. 26 as middle place, the residuals of Orbit X to be removed were

	$\Delta\alpha$	$\Delta\delta$
(8) Jan. 23	+0"1	-2"8
May 24	+2.3	0.0

The resulting general orbit was still hyperbolic, and the mean conditioned ellipse, an orbit XIII, gave

	$\Delta\alpha$	$\Delta\delta$
(8) Jan. 23	0"0	-2"5
(9) Feb. 23	0.0	-0.8
Mar. 26	0.0	0.0
Apr. 24	-0.9	+0.1
May 24	0.0	0.0

The normal places were believed to be better than the residual in α of Apr. 24 seemed to indicate, and pointed again to the fact that the orbit was very sensitive to errors in δ .

An orbit XIV, derived by differential correction of XIII to satisfy only the normal places, represented thus:

	$\Delta\alpha$	$\Delta\delta$
(7) 1927 Jan. 27	+209"1	+75"2
(8) 1930 Jan. 23	- 6.3	- 1.8
(9) Feb. 23	- 2.6	- 0.5
Mar. 26	0.0	0.0
Apr. 24	0.0	0.0
May 24	0.0	0.0

The residuals of (7) 1927 Jan. 27, were within the range of solution, indicating that this was an observation of the object under investigation. It is interesting to note that the f and g series hold over the three years, only the fourth power of the long interval being needed, thus permitting the use of the simple differential correction formulas.

With Mar. 26 again as middle date, an orbit XV was derived by differential correction of XIV, to represent (7) 1927 Jan. 27, 1930 Mar. 26 and May 24, yielding the following residuals:

	$\Delta\alpha$	$\Delta\delta$
(7) 1927 Jan. 27	- 0"5	-0"1
(8) 1930 Jan. 23	+10.6	-4.4
(9) Feb. 23	+ 3.0	-1.4
Mar. 26	0.0	0.0
Apr. 24	- 0.9	+0.2
May 24	0.0	0.0

A modification of Leuschner's differential correction was here introduced, namely, to satisfy four right ascensions and two declinations instead of the usual

three complete observations. From the manner of the formation of x, y, z , any $\Delta\rho$ satisfies the middle α, δ , and with P_x, Q_x, P_y, Q_y ,⁷ gives the x', y' which satisfy the first and third α . A fourth α may be represented with suitable values of $\Delta\rho$, from which the $\Delta\rho$ may be interpolated that gives zero residual. Or directly,

$$\Delta\rho = \frac{fy + g(y' + P_y) + Y - [fx + g(x' + P_x) + X] \tan \alpha}{(f\lambda - gQ_x) \tan \alpha - (f\mu - gQ_y)}$$

where the quantities λ and μ are direction cosines at the middle date. Four right ascensions and one declination are then satisfied. This $\Delta\rho$ together with the corresponding P_x, Q_x gives the z' which satisfies either the first or third δ . Or instead, any other δ may be satisfied by forming

$$z' = \frac{(\rho \cos \delta)_c \tan \delta_o - fz - Z}{g}$$

where subscripts c and o indicate computed and observed values. This and other similar modifications enable the computer to base the orbit almost as easily upon other data as upon those originally chosen, without recomputing the coefficients in the differential correction.

The differential correction which gave Orbit XV was thus modified to represent (7) 1927 Jan. 27 and 1930 Mar. 26, and the right ascensions of (8) Jan. 23 and May 24. This put a residual of 1".4 into δ of May 24, which was quite unsatisfactory.

This orbit with middle place changed to (8) Jan. 23 gave

	$\Delta\alpha$	$\Delta\delta$
(7) 1927 Jan. 27	-3"7	+3"2
May 24	-0.2	+4.9

The removal of these residuals produced an orbit XVI which represented thus:

	$\Delta\alpha$	$\Delta\delta$
(7) 1927 Jan. 27	- 0"2	0"0
(8) 1930 Jan. 23	0.0	0.0
(9) Feb. 23	+10.6	0.0
Mar. 26	+16.8	-0.4
Apr. 24	+13.1	-0.7
May 24	0.0	0.0

The sensitiveness of the orbit to errors in δ is again evident. An error of 18" in δ of (7) 1927 Jan. 27, first exhibited in the next step, together with the error of 3" in δ of (8) 1930 Jan. 23, account for the quite unacceptable residuals in α .

The differential correction which produced Orbit XV was modified to satisfy 1930 Mar. 26 and May 24, and the right ascensions of (7) 1927 Jan. 27 and (8) 1930 Jan. 23. The resulting Orbit XVII represented as follows, including the Mount Wilson 1919 normal⁸ received in the mean time:

⁷ *Publ. Lick Obs.* 7, 255.

⁸ *H. A. C.* 133.

		$\Delta\alpha$	$\Delta\delta$
1919	Dec. 29	-82".3	-20".1
(7)	1927 Jan. 27	- 0.4	+17.9
(8)	1930 Jan. 23	0.0	- 3.0
(9)	Feb. 23	- 1.0	- 0.9
	Mar. 26	0.0	0.0
	Apr. 24	+ 0.1	0.0
	May 24	0.0	0.0

A revision of the normal place of May 24 on the basis of Orbit XVII produced no material change in the adopted position.

On request, an approximate position from Orbits XIV and XVII was furnished to Yerkes Observatory for (5) 1921 Jan. 29 by the aid of which an image was found within 3' of the place from XIV and 2" from XVII.

In the meantime the differential correction which produced XV was again modified to satisfy 1919 Dec. 29 and 1930 Mar. 26, and the right ascensions of (7) 1927 Jan. 27 and 1930 May 24. The residuals from this finally adopted Orbit XVIII are tabulated above with the observations; they were derived by applying the correction, X-XVIII, read from graphs, to the residuals previously obtained with X. The residuals in 1919 Dec. 29 are due to a revision of the observations, received after conclusion of the computations. The error in δ of (7) 1927 Jan. 27 is confirmed by the δ of 1919 Dec. 29 and (5) 1921 Jan. 29.

The orbit may be improved by removing the $\Delta\delta$ of 1919 Dec. and distributing the residuals in α of 1919 Dec. and (5) 1921 Jan. 29; it may be possible to satisfy the right ascensions of 1919, 1921, 1927 and 1930 with moderate residuals in the declinations. However, such improvement is unnecessary at this time because the ephemerides from XVIII are entirely sufficient.

At no point in the work were difficulties experienced, most of the computation after Orbit XII being caused by errors of observation. A single differential correction always represented the adopted basic positions.

ELEMENTS XVIII⁹, 1930.0

T	1989 Feb. 27.473 U.T.	e	0.253741
ω	113° 08' 26".1	P	249.1661 years
Ω	109 21 36.9	a	39.59673
i	17 08 57.0	p	37.04732
q	29.54942	μ	0".003958276

$$\begin{aligned}x &= -27.66610 (\cos E - e) + 25.24472 \sin E \\y &= -28.32223 (\cos E - e) - 24.34350 \sin E \\z &= -0.58200 (\cos E - e) - 15.39646 \sin E\end{aligned}$$

The similarity of these to preliminary elements IV¹⁰ is due to the fact that the body is actually near one end of the minor axis, where the conditioned orbit places it. Elements XVIII closely resemble those of Nicholson and Mayall¹¹ which are based on 1919 and 1930 observations only.

⁹ H. A. C. 136, airmail letter of June 17, 1930.

¹⁰ L. O. B. 14, 190.

¹¹ H. A. C. 134.

The character of the orbit is exhibited in the accompanying diagram. It should be remembered that the inclination of the orbit is 17° to the plane of the paper and distances of the object from the planets are correspondingly greater than represented. The latest closest approaches of *Uranus* and *Neptune* to the object were about 30 units in 1853 and 18 units in 1892, respectively. *Neptune* is now ahead of it at a distance of about 28 units and will remain approximately so for many years, since the two bodies in this part of their orbits travel at about the same speed. If *Neptune* were now a few years' motion behind the object, these two bodies would remain within 12 units of each other for nearly 100 years, approaching within three units near the descending node. In such case considerable perturbations would result.

Diagram of orbit.

An approximate ephemeris for past oppositions was formed by computing the opposition positions for ten-year intervals, interpolating values for each year, and assuming these to be for the midnight nearest opposition. From a complete ephemeris for 1890-91, 1910-11, and 1930-31 the differences in position from opposition were formed, between which were interpolated differences for all other years. Adding these to the opposition positions gave the complete ephemeris. The magnitude in 1890 was 15.7, assuming the value 15.0 for 1930.

Grateful acknowledgment is made to the Lick, Mount Wilson, and Yerkes observatories for their prompt communication of observations; to Professors Leuschner and Crawford for their kindly cooperation; and to Director Aitken for the opportunity afforded to complete this investigation by extending the period of our residence at Berkeley under Lick Observatory Fellowships.

EPHEMERIS 1890-1930

U.T.	$\alpha(1900.0)$	$\delta(1900.0)$	U.T.	$\alpha(1900.0)$	$\delta(1900.0)$	U.T.	$\alpha(1900.0)$	$\delta(1900.0)$
1890-91			1898-99			1906-07		
Oct. 1	4 ^h 32 ^m 9	+10° 02'	Oct. 8	5 ^h 02 ^m 3	+12° 47'	Oct. 17	5 ^h 33 ^m 9	+15° 25'
21	32.0	9 57	28	01.4	43	Nov. 6	32.9	22
Nov. 10	30.8	53	Nov. 17	5 00.2	39	26	31.6	20
30	29.4	49	Dec. 7	4 58.6	37	Dec. 16	30.0	20
Dec. 20	27.9	47	27	57.1	36	Jan. 5	28.4	20
Jan. 9	26.6	48	Jan. 16	55.8	37	25	27.1	22
29	4 25.8	+ 9 50	Feb. 5	4 54.9	+12 40	Feb. 14	5 26.2	+15 25
1891-92			1899-1900			1907-08		
Oct. 2	4 36.5	+10 23	Oct. 9	5 06.1	+13 07	Oct. 18	5 38.0	+15 44
22	35.6	18	29	05.2	13 03	Nov. 7	37.0	42
Nov. 11	34.4	14	Nov. 18	03.9	13 00	27	35.7	40
Dec. 1	32.9	10	Dec. 8	02.4	12 58	Dec. 17	34.1	39
21	31.4	09	28	5 00.9	12 57	Jan. 6	32.5	40
Jan. 10	30.2	09	Jan. 17	4 59.6	12 58	26	31.2	42
30	4 29.3	+10 12	Feb. 6	4 58.7	+13 1	Feb. 15	5 30.3	+15 45
1892-93			1900-01			1908-09		
Oct. 2	4 40.1	+10 44	Oct. 11	5 10.0	+13 27	Oct. 19	5 42.2	+16 03
22	39.2	39	31	09.1	23	Nov. 8	41.2	16 01
Nov. 11	38.0	35	Nov. 20	07.8	20	28	39.9	16 00
Dec. 1	36.5	32	Dec. 10	06.2	18	Dec. 18	38.3	15 59
21	35.0	30	30	04.7	18	Jan. 7	36.7	16 00
Jan. 10	33.8	31	Jan. 19	03.4	19	27	35.3	16 02
30	4 32.9	+10 33	Feb. 8	5 02.5	+13 22	Feb. 16	5 34.4	+16 05
1893-94			1901-02			1909-10		
Oct. 3	4 43.7	+11 04	Oct. 12	5 13.9	+13 47	Oct. 20	5 46.4	+16 22
23	42.9	11 00	Nov. 1	13.0	43	Nov. 9	45.4	20
Nov. 12	41.6	10 56	21	11.7	40	29	44.1	19
Dec. 2	40.1	53	Dec. 11	10.1	39	Dec. 19	42.5	18
22	38.6	51	31	08.6	38	Jan. 8	40.9	19
Jan. 11	37.4	52	Jan. 20	07.3	39	28	39.5	21
31	4 36.5	+10 55	Feb. 9	5 06.4	+13 42	Feb. 17	5 38.6	+16 24
1894-95			1902-03			1910-11		
Oct. 4	4 47.4	+11 25	Oct. 13	5 17.8	+14 06	Oct. 21	5 50.6	+16 41
24	46.5	21	Nov. 2	16.9	14 03	Nov. 10	49.7	39
Nov. 13	45.3	17	22	15.6	14 00	30	48.3	38
Dec. 3	43.8	14	Dec. 12	14.0	13 59	Dec. 20	46.7	38
23	42.3	12	Jan. 1	12.5	13 59	Jan. 9	45.1	39
Jan. 12	41.0	13	21	11.2	14 00	29	43.7	41
Feb. 1	4 40.1	+11 16	Feb. 10	5 10.2	+14 03	Feb. 18	5 42.8	+16 44
1895-96			1903-04			1911-12		
Oct. 6	4 51.1	+11 46	Oct. 14	5 21.8	+14 26	Oct. 22	5 55.0	+16 59
26	50.2	41	Nov. 3	20.8	23	Nov. 11	54.0	58
Nov. 15	48.9	37	23	19.5	21	Dec. 1	52.6	57
Dec. 5	47.4	35	Dec. 13	18.0	19	21	51.0	57
25	45.9	34	Jan. 2	16.4	19	Jan. 10	49.4	16 58
Jan. 14	44.7	34	22	15.1	21	30	48.0	17 01
Feb. 3	4 43.8	+11 37	Feb. 11	5 14.2	+14 24	Feb. 19	5 47.1	+17 04
1896-97			1904-05			1912-13		
Oct. 6	4 54.8	+12 06	Oct. 15	5 25.8	+14 46	Oct. 23	5 59.3	+17 18
26	53.9	12 02	Nov. 4	24.8	43	Nov. 12	58.3	16
Nov. 15	52.6	11 58	24	23.5	41	Dec. 2	57.0	16
Dec. 5	51.1	55	Dec. 14	21.9	39	22	55.3	16
25	49.6	54	Jan. 3	20.4	39	Jan. 11	53.7	18
Jan. 14	48.4	55	23	19.0	41	31	52.3	20
Feb. 3	4 47.5	+11 58	Feb. 12	5 18.1	+14 44	Feb. 20	5 51.4	+17 23
1897-98			1905-06			1913-14		
Oct. 7	4 58.5	+12 26	Oct. 16	5 29.8	+15 05	Oct. 24	6 03.7	+17 36
27	57.7	22	Nov. 5	28.9	03	Nov. 13	02.8	35
Nov. 16	56.4	19	25	27.5	01	Dec. 3	6 01.4	35
Dec. 6	54.9	16	Dec. 15	26.0	00	23	5 59.7	35
26	53.4	15	Jan. 4	24.4	00	Jan. 12	58.1	37
Jan. 15	52.1	16	24	23.0	01	Feb. 1	56.7	39
Feb. 4	4 51.2	+12 19	Feb. 13	5 22.1	+15 04	21	5 55.8	+17 42

EPHEMERIS 1890-1930 (cont.)

U.T.	$\alpha(1900.0)$	$\delta(1900.0)$	U.T.	$\alpha(1900.0)$	$\delta(1900.0)$
1914-15					
Oct. 25	6 ^h 08 ^m 2	+17° 54'	Nov. 3	6 ^h 46 ^m 0	+20° 08'
Nov. 14	07.2	53	23	45.0	10
Dec. 4	05.8	53	Dec. 13	43.6	12
24	04.2	54	Jan. 2	41.9	14
Jan. 13	02.5	56	22	40.2	18
Feb. 2	01.1	17 58	Feb. 11	38.7	21
22	6 00.2	+18 01	Mar. 3	6 37.7	+20 24
1915-16					
Oct. 26	6 12.7	+18 12	Nov. 4	6 51.0	+20 24
Nov. 15	11.7	11	24	50.0	25
Dec. 5	10.3	12	Dec. 14	48.6	28
25	08.7	12	Jan. 3	46.9	31
Jan. 14	07.0	14	23	45.1	34
Feb. 3	05.6	17	Feb. 12	43.7	37
23	6 04.7	+18 20	Mar. 3	6 42.7	+20 41
1916-17					
Oct. 27	6 17.3	+18 29	Nov. 4	6 56.1	+20 38
Nov. 16	16.3	29	24	55.1	40
Dec. 6	14.9	30	Dec. 14	53.7	43
26	13.2	31	Jan. 3	51.9	46
Jan. 15	11.6	33	23	50.2	50
Feb. 4	10.2	36	Feb. 12	48.7	53
24	6 09.2	+18 39	Mar. 4	6 47.8	+20 56
1917-18					
Oct. 28	6 21.9	+18 47	Nov. 6	7 01.3	+20 53
Nov. 17	20.9	46	26	7 00.3	55
Dec. 7	19.5	47	Dec. 16	6 58.8	20 58
27	17.8	49	Jan. 5	57.1	21 02
Jan. 16	16.2	51	25	55.3	05
Feb. 5	14.8	54	Feb. 14	53.9	09
25	6 13.8	+18 57	Mar. 6	6 52.9	+21 12
1918-19					
Oct. 29	6 26.6	+19 04	Nov. 7	7 06.5	+21 07
Nov. 18	25.6	04	27	05.5	09
Dec. 8	24.2	05	Dec. 17	04.0	13
28	22.5	06	Jan. 6	02.3	16
Jan. 17	20.8	09	26	7 00.5	20
Feb. 6	19.4	12	Feb. 15	6 59.1	24
26	6 18.5	+19 15	Mar. 7	6 58.1	+21 27
1919-20					
Oct. 31	6 31.4	+19 20	Nov. 9	7 11.8	+21 20
Nov. 20	30.4	21	29	10.8	23
Dec. 10	28.9	22	Dec. 19	09.3	27
30	27.3	24	Jan. 8	07.6	31
Jan. 19	25.6	26	28	05.8	35
Feb. 8	24.2	29	Feb. 17	04.3	39
28	6 23.2	+19 33	Mar. 8	7 03.3	+21 42
1920-21					
Oct. 31	6 36.2	+19 37	Nov. 9	7 17.2	+21 33
Nov. 20	35.2	37	29	16.2	36
Dec. 10	33.8	39	Dec. 19	14.7	40
30	32.1	41	Jan. 8	12.9	45
Jan. 19	30.4	44	28	11.2	49
Feb. 8	28.9	47	Feb. 17	09.7	53
28	6 28.0	+19 50	Mar. 9	7 08.7	+21 56
1921-22					
Nov. 1	6 41.0	+19 53	Nov. 10	7 22.7	+21 46
21	40.1	54	30	21.6	49
Dec. 11	38.6	55	Dec. 20	20.2	53
31	36.9	19 58	Jan. 9	18.4	21 58
Jan. 20	35.2	20 01	29	16.6	22 03
Feb. 9	33.8	04	Feb. 18	15.1	07
Mar. 1	6 32.8	+20 07	Mar. 10	7 14.1	+22 10

EPHEMERIS 1930-31*

1930 U.T.	$\alpha(1930.0)$	$\delta(1930.0)$	Light time
Aug. 0 7 ^h 25 ^m 03 ^s .07 +21° 58' 04".77 0 ^d .2432			
8	25 53.97	56 50.4	.2429
16	26 42.29	55 40.6	.2425
24	27 27.33	54 36.8	.2420
Sept. 1	28 08.37	53 40.7	.2414
9	7 28 44.76	+21 52 53.9	0.2407
17	29 15.99	52 17.8	.2400
25	29 41.51	51 53.6	.2393
Oct. 3	30 00.88	51 42.7	.2385
11	30 13.82	51 45.7	.2377
19	7 30 20.10	+21 52 03.1	0.2368
27	30 19.60	52 35.4	.2360
Nov. 4	30 12.37	53 22.3	.2352
12	29 58.61	54 23.4	.2345
20	29 38.62	55 37.8	.2338
28	7 29 12.82	+21 57 04.6	0.2332
Dec. 6	28 41.88	21 58 42.0	.2326
14	28 06.51	22 00 28.3	.2321
22	27 27.54	02 21.6	.2318
30	7 26 45.94	04 19.6	.2315
1931			
Jan. 7	7 26 02.75	+22 06 20.0	0.2313
1930 U.T. $\alpha(1931.0)$ $\delta(1931.0)$ Light time			
Dec. 30	7 ^h 26 ^m 49 ^s .51 +22° 04' 12".2	0 ^d .2315	
1931			
Jan. 7	7 26 06.33	+22 06 12.6	.2313
15	25 22.58	08 13.3	.2313
23	24 39.36	10 11.8	.2314
31	23 57.76	12 06.1	.2316
Feb. 8	23 18.79	13 54.2	.2319
16	7 22 43.37	+22 15 34.3	0.2323
24	22 12.38	17 04.8	.2328
Mar. 4	21 46.57	18 24.6	.2334
12	21 26.49	19 32.6	.2340
20	21 12.63	20 28.1	.2347
28	7 21 05.33	+22 21 10.6	0.2354
Apr. 5	21 04.76	21 39.8	.2362
13	21 10.92	21 55.8	.2369
21	21 23.77	21 58.7	.2377
29	21 43.10	21 48.8	.2384
May 7	7 22 08.55	+22 21 26.8	0.2391
15	22 39.73	20 53.3	.2397
23	23 16.17	20 09.1	.2403
31	23 57.26	19 15.2	.2409
June 8	24 42.37	18 12.8	.2413

* The annual aberration, including the "constant" term not given in the annual ephemerides, has been subtracted from the ephemeris place as usually given. That is, an astrophotographic place corrected for parallax is to be compared directly with the position interpolated with the reduced time.

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