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ELEMENTS OF COMET 1933 *f* (WHIPPLE)

BY

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Comet 1933 *f* was discovered 1933, Oct. 21, by F. L. Whipple, on a Harvard plate taken at Oak Ridge, Mass., 1933, Oct. 15. Its magnitude was 13, and it had a 3' tail.

The magnitude decreased to 16.5 at the time of the last observation, 1934, Mar. 5, before conjunction with the Sun.

The following observations have been received:

1933 U. T.	α (1933)	δ (1933)	Observer	Place	Authority
(1) Oct 15.27492	3 ^h 25 ^m 19 ^s .58	+10°02' 11".9	Whipple, Cunningham	Harvard	H.A.C. 284
(2) Oct 21.12265	3 22 55.02	+ 9 19 37.6	Whipple, Cunningham	Harvard	H.A.C. 284
(3) Oct 21.40807	3 22 46.52	+ 9 17 34.7	Whipple, Cunningham	Harvard	H.A.C. 284
(4) Oct 22.21423	3 22 23.40	+ 9 11 39.3	Van Biesbroeck	Williams Bay	H.A.C. 286
(5) Oct 22.33296	3 22 19.65	+ 9 10 46.0	Whipple, Cunningham	Harvard	H.A.C. 284
(6) Oct 22.42859	3 22 16.81	+ 9 10 03.5	Jeffers	Mt. Hamilton	L.O.B. 460
(7) Oct 22.97727	3 21 59.96	+ 9 06 01.7	Schwassmann, Wachmann	Bergedorf	B.C.A.C. 458
(8) Oct 23.06402	3 21 57.74	+ 9 05 20.8	Simonow	Neubabelsberg	B.C.A.C. 459
(9) Oct 23.28260	3 21 51.14	+ 9 03 47.4	Van Biesbroeck	Williams Bay	H.A.C. 286
(10) Oct 23.30200	3 21 50.77	+ 9 03 35.1	Wyse	Mt. Hamilton	Post Card
(11) Oct 23.93413	3 21 31.00	+ 8 58 56.2	Simonow	Neubabelsberg	B.C.A.C. 459
(12) Oct 24.02154	3 21 28.71	+ 8 58 23.9	Bourgeois	Uccle	B.C.A.C. 458
(13) Oct 24.04017	3 21 27.95	+ 8 58 13.5	Delporte	Uccle	B.C.A.C. 459
(14) Oct 24.05361	3 21 27.09	+ 8 58 02.9	Simonow	Neubabelsberg	B.C.A.C. 459
(15) Oct 25.22640	3 20 50.08	+ 8 49 33.0	Van Biesbroeck	Williams Bay	H.A.C. 286
(16) Oct 31.40225	3 17 13.71	+ 8 04 49.3	Whipple, Cunningham	Harvard	H.A.C. 287
(17) Nov 7.87698	3 12 23.82	+ 7 13 44.5	Simonow	Neubabelsberg	B.C.A.C. 460
(18) Nov 8.92132	3 11 41.5	+ 7 06 56.7	Terkán	Budapest	R.I. 915
(19) Nov 9.93696	3 11 01.00	+ 7 00 32.3	Arend	Uccle	B.Z. 47 (1933)
(20) Nov 9.98280	3 10 59.68	+ 7 00 10.5	Simonow	Neubabelsberg	B.C.A.C. 460
(21) Nov 11.20959	3 10 10.14	+ 6 52 38.3	Barnes, Barthelman	Harvard	H.A.C. 297
(22) Nov 12.91472	3 09 01.6	+ 6 42 18.9	Terkán	Budapest	R.I. 915
(23) Nov 13.11686	3 08 53.92	+ 6 41 11.4	Barnes, Barthelman	Harvard	H.A.C. 297
(24) Nov 15.28983	3 07 27.39	+ 6 28 42.6	Van Biesbroeck	Williams Bay	Letter
(25) Nov 16.23895	3 06 50.35	+ 6 23 27.0	Van Biesbroeck	Williams Bay	Letter
(26) Nov 17.93577	3 05 43.5	+ 6 14 20.1	Terkán	Budapest	R.I. 915
(27) Nov 18.15972	3 05 36.02	+ 6 13 17.9	Van Biesbroeck	Williams Bay	Letter
(28) Nov 19.96541	3 04 27.41	+ 6 04 16.3	Delporte	Uccle	B.C.A.C. 463
(29) Dec 10.85520	2 54 41.28	+ 5 02 55.6	Arend	Uccle	B.Z. 1 (1934)
(30) Dec 14.88538	2 53 46.95	+ 5 00 29.8	Arend	Uccle	B.Z. 1 (1934)

1933, 1934 U. T.	α (1933)	δ (1933)	Observer	Place	Authority
(31) Dec 16.92819	2 ^h 53 ^m 27 ^s .32	+ 5°00' 29".9	Schorr	Bergedorf	A.N. 251, 212 (1934)
(32) Dec 18.20755	2 53 18.10	+ 5 00 53.6	Van Biesbroeck	Williams Bay	Letter
(33) Jan 18.97759	3 01 35.02	+ 6 26 57.8	Barnes, Barthelman	Harvard	H.A.C. 297
(34) Jan 19.02509	3 01 36.93	+ 6 27 10.0	Barnes, Barthelman	Harvard	H.A.C. 297
(35) Mar 5.21395	3 44 37.97	+10 33 08.6	Jeffers	Mt. Hamilton	H.A.C. 297
(36) Mar 5.23409	3 44 39.39	+10 33 16.1	Jeffers	Mt. Hamilton	H.A.C. 297

A preliminary orbit was computed by J. W. Abrams under the direction of Professor Leuschner. A solution by Leuschner's method, based on observations numbered (1), (2), and (6), gave the following elements:

ELEMENTS, 1933.0

$T=1933$ July 29.58824 U.T.	$e=0.358355$
$\omega=189^\circ 01' 06''.2$	$a=3.847979$
$\Omega=188$ 10 52.9	$q=2.469038$
$i=10$ 05 34.3	$P=7.548298$ years

The residuals for the basic observations were:

Date	$\Delta \alpha \cos \delta$	$\Delta \delta$
1933 Oct 15.27	-0".3	-0".5
Oct 21.12	0.0	0.0
Oct 22.43	+0.1	-0.1

The following additional residuals were computed by Miss Dorothy Johnstone and P. S. Riggs:

Date	$\Delta \alpha \cos \delta$	$\Delta \delta$
(9) 1933 Oct 23.28	+ 0".2	+ 1".2
(10) Oct 23.30	+ 1.7	- 2.9
(15) Oct 25.23	+ 1.9	+ 3.0
(16) Oct 31.40	+ 0.7	- 4.0
(17) Nov 7.88	+12.3	-13.9
(19) Nov 9.94	+ 6.4	-19.8
(20) Nov 9.98	+15.6	-24.3
(28) Nov 19.97	+ 5.4	-49.6
(29) Dec 10.86	-52.9	-134.9
(30) Dec 14.89	-64.5	-158.5

The present orbit is a correction of Abrams' elements, based on the later observations which have become available. A differential correction was made, with observation (6) replaced by (28) as the third position. The following residuals resulted:

Date	$\Delta \alpha \cos \delta$	$\Delta \delta$
(1) 1933 Oct 15.27	- 0".3	+ 0".3
(2) Oct 21.12	0.0	0.0
(28) Nov 19.97	- 0.4	+ 0.8

This orbit represented other observations as follows:

Date	$\Delta \alpha \cos \delta$	$\Delta \delta$
(3) 1933 Oct 21.41	+ 0".7	+ 3".1
(4) Oct 22.21	- 0.2	+ 2.9
(5) Oct 22.33	+ 0.2	+ 1.9
(6) Oct 22.43	- 0.8	+ 1.1
(7) Oct 22.98	- 8.6	+ 2.5
(8) Oct 23.06	- 0.6	- 0.2
(9) Oct 23.28	- 1.0	+ 2.0
(10) Oct 23.30	+ 0.5	- 2.1
(11) Oct 23.93	- 2.2	- 1.1

Date	$\Delta \alpha \cos \delta$	$\Delta \delta$
(12) 1933 Oct 24.02	+ 5".6	+ 4".9
(13) Oct 24.04	+ 3.5	+ 2.7
(14) Oct 24.05	- 2.2	- 1.9
(15) Oct 25.23	- 0.6	+ 4.6
(21) Nov 11.21	+ 0.6	+ 2.3
(22) Nov 12.91	- 3.7	- 0.7
(23) Nov 13.12	+ 0.9	+ 3.0
(24) Nov 15.29	+ 0.2	+ 2.0
(25) Nov 16.24	+ 2.5	+ 0.1
(26) Nov 17.94	-13.0	- 5.8
(27) Nov 18.16	+ 1.8	+ 0.8

In order to secure a longer arc between the first and middle places, a change of middle date was made before representing the later observations. A first normal place was computed for Oct. 23.06 by using the means of the residuals for observations (2), (3), (4), (5), (6), (7), (8), (9), (10), (11), (12), (13), (14), and (15), and a second normal place was formed from the means of the residuals for observations (21), (22), (23), (24), (25), (27), and (28), applied to Nov. 15.29. The middle date was changed to the second normal place, and the following residuals resulted:

Date	$\Delta \alpha \cos \delta$	$\Delta \delta$
(I) 1933 Oct 23.06 (first normal)	- 0".4	+ 0".3
(II) Nov 15.29 (second normal)	0.0	0.0
(35) 1934 Mar 5.21	-28.5	-17.2
(36) Mar 5.23	-29.1	-16.5

The third normal place was formed from the mean of the residuals for observations (35) and (36), for March 5.23. On the basis of the three normal places:

(I) 1933 Oct 23.06402	$\alpha=50^\circ 29' 26''.3$	$\delta=+ 9^\circ 05' 22''.5$	(1933.0)
(II) 1933 Nov 15.28983	$\alpha=46^\circ 51' 50''.9$	$\delta=+ 6^\circ 28' 41''.8$	
(III) 1934 Mar 5.23409	$\alpha=56^\circ 09' 51''.1$	$\delta=+10^\circ 33' 15''.8$	

a differential correction by closed expressions was made, resulting in the following residuals for the normal places:

Date	$\Delta \alpha \cos \delta$	$\Delta \delta$
(I) 1933 Oct 23.06	- 0".1	- 0".1
(II) Nov 15.29	0.0	0.0
(III) 1934 Mar 5.23	- 0.1	+ 0.2

This orbit gave the following residuals for the observations:

Date	$\Delta \alpha \cos \delta$	$\Delta \delta$
(1) 1933 Oct 15.27	- 0".9	- 1".5
(2) Oct 21.12	+ 0.1	- 1.8
(3) Oct 21.41	+ 0.9	+ 1.5
(4) Oct 22.21	0.0	+ 1.2
(5) Oct 22.33	+ 0.4	+ 0.2
(6) Oct 22.43	- 0.5	- 0.6

	Date	$\Delta\alpha \cos \delta$	$\Delta\delta$
(7)	1933 Oct 22.98	- 8".3	+ 0".9
(8)	Oct 23.06	- 0.3	- 1.8
(9)	Oct 23.28	- 0.7	+ 0.4
(10)	Oct 23.30	+ 0.8	- 3.7
(11)	Oct 23.93	- 1.9	- 2.7
(12)	Oct 24.02	+ 5.9	+ 3.3
(13)	Oct 24.04	+ 3.8	+ 1.1
(14)	Oct 24.05	- 1.9	- 3.3
(15)	Oct 25.23	0.0	+ 3.2
(16)	Oct 31.40	- 5.3	+ 1.3
(17)	Nov 7.88	+ 2.4	+ 3.1
(18)	Nov 8.92	- 8	- 0.6
(19)	Nov 9.94	- 4.0	+ 1.5
(20)	Nov 9.98	+ 5.4	- 2.8
(21)	Nov 11.21	+ 1.0	+ 1.2
(22)	Nov 12.91	- 3.6	- 1.9
(23)	Nov 13.12	+ 0.8	+ 1.8
(24)	Nov 15.29	- 0.1	+ 0.8
(25)	Nov 16.24	+ 2.1	- 1.1
(26)	Nov 17.94	-13.6	- 6.9
(27)	Nov 18.16	+ 1.2	- 0.5
(28)	Nov 19.97	- 1.2	- 0.2
(29)	Dec 10.86	- 3.7	- 0.3
(30)	Dec 14.89	+ 1.4	- 5.7
(31)	Dec 16.93	- 3.6	- 3.2
(32)	1933 Dec 18.21	- 5.6	- 1.5
(33)	1934 Jan 18.98	- 8.7	- 5.7
(34)	Jan 19.03	- 4.8	- 6.3
(35)	Mar 5.21	+ 0.7	- 0.2
(36)	Mar 5.23	- 0.4	+ 0.5

In representing, series expressions were used for all 1933 observations, and closed expressions for 1934 ob-

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servations, for which the series did not converge sufficiently rapidly.

The elements and constants for the equator are given below:

ELEMENTS, 1933.0

$T=1933$ July 31.9630 U.T.	$e=0.348759$
$\omega=190^\circ 24' 02".8$	$a=3.832313$
$\Omega=188 \ 33 \ 57.5$	$\mu=0".131375$
$i=10 \ 12 \ 56.9$	$P=7.50225$ years

CONSTANTS FOR THE EQUATOR, 1933.0

$$\begin{aligned}x &= +3.625875 (\cos E - e) - 1.159024 \sin E \\y &= +1.181595 (\cos E - e) + 3.314697 \sin E \\z &= +0.378749 (\cos E - e) + 0.754759 \sin E\end{aligned}$$

The prediction of this orbit compares as follows with the first and last dates of the ephemeris given by Maxwell* for the next opposition of the comet:

1934 Sept 16.0	(Correction to Maxwell's ephemeris)	$\Delta\alpha$	$\Delta\delta$
		+0".2	00'
1935 Feb 23.0		+0.2	-01

The orbit predicts the same ρ 's for these dates as does Maxwell's.

The comet is receding from the Sun, and it will probably be of about the seventeenth magnitude or a little fainter at the next opposition, when the ρ will be about equal to that when it was last observed, while the r will have increased from 2.9 to 3.8.

* *Pub. Obs. U. of Mich.*, 5, 189 (1934).