Det Kgl. Danske Videnskabernes Selskab.
Mathematisk-fysiske Meddelelser. **XIII,** 15.

THE ORIGINAL ORBIT OF COMET 1904 I (BROOKS)

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LEVIN & MUNKSGAARD
EJNAR MUNKSGAARD
1935

Printed in Denmark.
Bianco Lunos Bogtrykkeri A/S.

In Publ. of the Copenhagen Observatory No. 98 the result of a determination of the original orbit of Comet 1907 I (GIACOBINI), according to the principles set out by Prof. E. STRÖMGREN, has been given. The result was similar to those obtained in all other cases treated according to the principles referred to (cfr. the references given at the end of this paper): the hyperbolicity of the orbit turned out to be illusory.

The result of an investigation of the original orbit of Comet 1904 I (BROOKS) is given hereafter.

A definitive orbit of this comet has been published by S. KASAKOV [Détermination de l'orbite définitive de la Comète 1904 I (Moscow Annals 8, 1)]. The determination of the orbit was based upon 1216 observations distributed over a period of $13^2/_3$ months, so that the orbit is among the most accurate yet determined, a fact that is also evident from the very small mean errors of the elements given on p. 55 of the paper quoted.

The elements as found by KASAKOV are given hereafter, together with their mean errors (l. c. p. 55—56):

Comet 1904 I (BROOKS).

Osculation 1904 May 3.0 mean time Berlin (day beginning at noon).

$T = 1904$ March 7.17596 mean time Berlin (day beginning at noon).

$$\left.\begin{aligned} \omega &= 53^\circ 32' 31''.05 \pm 1''.93 \\ \Omega &= 275\ 47\ 25.38 \pm 0.52 \\ i &= 125\ \ 7\ 42.52 \pm 0.42 \end{aligned}\right\} 1904.0 \qquad \left.\begin{aligned} q &= 2.707778 \pm 0.000014 \\ e &= 1.0013646 \pm 0.0000216 \\ \frac{1}{a} &= -0.0005040 \pm 0.0000079 \end{aligned}\right\} \quad (1)$$

Reducing to 1950.0 and expressing the perihelion time in Greenwich mean time, we find:

$T = 1904$ March 7.13875 mean time Greenwich (day beginning at noon).

$$\left.\begin{aligned} \omega &= 53^\circ.53476 \\ \Omega &= 276.42848 \\ i &= 125.12972 \end{aligned}\right\} 1950.0 \qquad q,\ e \text{ and } \frac{1}{a} \text{ as given above.} \quad (2)$$

The corresponding equatorial constants are as follows:

$$\left.\begin{aligned} P_x &= -0.3933174 & P_y &= -0.8510704 & P_z &= +0.3478228 \\ Q_x &= -0.4298901 & Q_y &= +0.5046490 & Q_z &= +0.7486815 \end{aligned}\right\} 1950.0. \quad (3)$$

The orbit was traced backwards through an interval of 14 years by direct numerical integration of rectangular co-ordinates. The attractions by the Sun, Jupiter and Saturn were taken into account. The planetary co-ordinates and the accelerations of the Sun were taken from Comrie: Planetary Co-ordinates. The calculation was carried out to 7 decimal places.

Perturbed equatorial Co-ordinates of Comet 1904 I.

			x	y	z
1904	July	18.5	−1.747443	−1.071532	+2.241205
	June	28.5	1.666452	1.280345	2.070957
	„	8.5	1.577793	1.483248	1.891180
	May	19.5	1.481292	1.678759	1.702004
	Apr.	29.5	1.376926	1.865338	1.503792
	„	9.5	1.264856	2.041464	1.297166
	Mar.	20.5	1.145443	2.205724	1.083009
	Feb.	29.5	1.019244	2.356904	0.862434
	„	9.5	0.886988	2.494078	0.636731
	Jan.	20.5	0.749538	2.616653	0.407295
1903	Dec.	31.5	0.607837	2.724399	+0.175541
	„	11.5	0.462846	2.817430	−0.057172
	Nov.	21.5	0.315499	2.896160	0.289609
	„	1.5	0.166656	2.961242	0.520695
	Oct.	12.5	−0.017083	3.013493	0.749540
	Sep.	22.5	+0.132567	3.053835	0.975435
	„	2.5	0.281749	3.083231	1.197847
	Aug.	13.5	0.430027	3.102647	1.416394
	July	24.5	0.577059	3.113016	1.630821
	„	4.5	0.722586	3.115219	1.840980
	June	14.5	0.866415	3.110074	2.046805
	May	25.5	1.008414	3.098329	2.248294
	„	5.5	1.148493	3.080664	2.445494
	Apr.	15.5	1.286601	3.057691	2.638485
	Mar.	26.5	1.422714	3.029956	2.827372
	„	6.5	1.556829	2.997950	3.012277
	Feb.	14.5	1.688961	2.962109	3.193331
	Jan.	25.5	1.819136	2.922822	3.370671
	„	5.5	+1.947391	−2.880436	−3.544436

			x	y	z
1902	Dec.	16.5	+ 2.073767	− 2.835258	− 3.714764
	Nov.	26.5	2.198310	2.787564	3.881792
	„	6.5	2.321068	2.737600	4.045653
	Oct.	17.5	2.442092	2.685583	4.206475
	Sep.	7.5	2.679141	2.576158	4.519494
	July	29.5	2.909857	2.460622	4.821780
	June	19.5	3.134631	2.340053	5.114182
	May	10.5	3.353833	2.215321	5.397470
	Mar.	31.5	3.567809	2.087136	5.672334
	Feb.	19.5	3.776884	1.956083	5.939397
	Jan.	10.5	3.981356	1.822644	6.199219
1901	Dec.	1.5	4.181501	1.687220	6.452302
	Oct.	22.5	4.377573	1.550147	6.699100
	Sep.	12.5	4.569805	1.411707	6.940022
	Aug.	3.5	4.758412	1.272139	7.175438
	June	24.5	4.943592	1.131643	7.405685
	May	15.5	5.125526	0.990394	7.631068
	Apr.	5.5	5.304384	0.848537	7.851864
	Feb.	24.5	5.480318	0.706200	8.068331
	Jan.	15.5	5.653474	0.563491	8.280700
1900	Dec.	6.5	5.823983	0.420505	8.489185
	Oct.	27.5	5.991970	0.277323	8.693985
	Sep.	17.5	6.157549	− 0.134016	8.895282
	Aug.	8.5	6.320826	+ 0.009356	9.093242
	June	29.5	6.481901	0.152738	9.288023
	May	20.5	6.640867	0.296084	9.479769
	Apr.	10.5	6.797810	0.439353	9.668614
	Mar.	1.5	6.952813	0.582509	9.854684
	Jan.	20.5	7.105951	0.725522	10.038095
1899	Dec.	11.5	+ 7.257296	+ 0.868362	− 10.218957

			x	y	z
1899	Sep.	22.5	+7.554874	+1.153436	−10.573435
	July	4.5	7.846038	1.437573	10.918864
	Apr.	15.5	8.131229	1.720649	11.255900
	Jan.	25.5	8.410840	2.002573	11.585130
1898	Nov.	6.5	8.685224	2.283273	11.907075
	Aug.	18.5	8.954699	2.562695	12.222204
	May	30.5	9.219553	2.840800	12.530939
	Mar.	11.5	9.480048	3.117560	12.833662
1897	Dec.	21.5	9.736420	3.392955	13.130720
	Oct.	2.5	9.988888	3.666973	13.422428
	Apr.	25.5	10.482885	4.210850	13.990925
1896	Nov.	16.5	10.963439	4.749186	14.541187
	June	9.5	11.431734	5.282023	15.074942
	Jan.	1.5	11.888775	5.809432	15.593668
1895	July	25.5	12.335424	6.331511	16.098642
	Feb.	15.5	12.772420	6.848373	16.590973
1894	Sep.	8.5	13.200398	7.360145	17.071628
	Apr.	1.5	13.619913	7.866968	17.541456
1893	Oct.	23.5	14.031444	8.368996	18.001203
	May	16.5	14.435421	8.866397	18.451527
1892	Dec.	7.5	14.832231	9.359350	18.893008
	June	30.5	15.222232	9.848042	19.326163
	Jan.	22.5	15.605762	10.332665	19.751451
1891	Aug.	15.5	15.983147	10.813409	20.169289
	Mar.	8.5	16.354706	11.290458	20.580050
1890	Sep.	29.5	16.720748	11.763980	20.984080
	Apr.	22.5	+17.081578	+12.234130	−21.381700

Perturbed equatorial co-ordinates and velocities x, y, z and $\frac{dx}{dt}$, $\frac{dy}{dt}$, $\frac{dz}{dt}$ for 1891 March 8.5 are given in the following.

The reductions ξ, η, ζ and $\frac{d\xi}{dt}$, $\frac{d\eta}{dt}$, $\frac{d\zeta}{dt}$ to the centre of gravity of the system Sun-Jupiter-Saturn are also given, together with co-ordinates and velocities $\bar{x}$, $\bar{y}$, $\bar{z}$, $\frac{d\bar{x}}{dt}$, $\frac{d\bar{y}}{dt}$, $\frac{d\bar{z}}{dt}$ referred to the said centre of gravity:

$$\left.\begin{array}{lll} x = +16.354706 & y = +11.290458 & z = -20.580050 \\ \xi = - \quad 1463 & \eta = + \quad 1715 & \zeta = + \quad 733 \\ \hline \bar{x} = +16.353243 & \bar{y} = +11.292173 & \bar{z} = -20.579317 \end{array}\right\} \quad (4)$$

$$\left.\begin{array}{lll} 160\frac{dx}{dt} = -0.3687499 & 160\frac{dy}{dt} = -0.4752584 & 160\frac{dz}{dt} = +0.4073408 \\ 160\frac{d\xi}{dt} = - \quad 5243 & 160\frac{d\eta}{dt} = - \quad 7211 & 160\frac{d\zeta}{dt} = - \quad 3016 \\ \hline 160\frac{d\bar{x}}{dt} = -0.3692742 & 160\frac{d\bar{y}}{dt} = -0.4759795 & 160\frac{d\bar{z}}{dt} = +0.4070392 \end{array}\right\} \quad (5)$$

The reciprocal semi-major-axis $\frac{1}{a}$ is calculated from these values by means of the following equation:

$$V^2 = w^2 k^2 (1 + \Sigma m)\left[\frac{2}{\bar{r}} - \frac{1}{a}\right]$$

or:

$$\frac{1}{a} = \frac{2}{\bar{r}} - \frac{V^2}{w^2 k^2 (1 + \Sigma m)}.$$

The result is as follows:

$$\frac{1}{a} = +0.0002165. \quad (6)$$

An upper limit to the perturbation in $\frac{1}{a}$ due to the action of Jupiter and Saturn before 1891 March 8.5 can be obtained by means of Publ. of the Copenhagen Observatory No. 19, equation (33). In this way it is easily shown, that

the character of the orbit can not have changed during the interval of time prior to 1891 March 8.5, which is not covered by the numerical integrations of the present investigation.

The final result then is: *While the osculating orbits of Comet 1904 I* (BROOKS) *for dates of osculation near the time of perihelion were decidedly hyperbolic, the original orbit as determined by integration backwards was decidedly elliptic.*

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Copenhagen 1935 Sept.

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Færdig fra Trykkeriet den 20. December 1935.