

Comet Halley in 1163 BC and the Fall of Troy

by

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§ 1. The elements of Halley's Comet

The elements of Halley's Comet deduced by the author on the ground of the previous researches of Cowell and Crommelin [1], Yamamoto [2] and of the author [3] were taken as the basis for the computation of the positions of this Comet on the sky for the period 240 BC—2400 BC. In this period, the value of the eccentricity e was assumed as constant

$$e = 0.9673 \quad \text{or} \quad \varphi = 75^{\circ} 18'.4.$$

The values of Ω , ω , i are given in Table 4 below. For the moments T of perihelion passages of the Comet as well as for the resulting values of its mean daily motion n , which corresponds to the given apparition of the Comet — we assumed the values given in Table 4 of our previous article [4]. This Table contains the moments T of perihelion passages of the Comet for the period 622 BC—2389 BC, computed by three quite independent methods. Their arithmetic means are given in Table 1 below. This Table was completed with moments T for the period 240 BC—622 BC computed by M. Viliew [5]

Table 1.

n	T	n	T	n	T
— 14	— 238.0	— 24	— 1008.9	— 34	— 1780.0
— 15	— 312.7	— 25	— 1084.3	— 35	— 1855.2
— 16	— 389.7	— 26	— 1161.3	— 36	— 1931.6
— 17	— 465.7	— 27	— 1237.2	— 37	— 2007.3
— 18	— 544.0	— 28	— 1315.4	— 38	— 2082.7
— 19	— 621.0	— 29	— 1392.3	— 39	— 2159.3
— 20	— 700.1	— 30	— 1471.3	— 40	— 2234.6
— 21	— 777.2	— 31	— 1548.6	— 41	— 2311.9
— 22	— 855.6	— 32	— 1626.8	— 42	— 2388.2
— 23	— 931.8	— 33	— 1703.1		

Considering the mutual agreement of triple values of T [4], one can assume that the values contained in Table 1 are exact within two years.

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When forming the direct differences of these T , we obtain the periods τ of the revolution of the Comet between its n and $n + 1$ apparition

$$\tau_{n+0.5} = T_{n+1} - T_n$$

We note that the periods τ computed in this way from Table 1 are close enough to those which were found and published in our previous Table 3 by a quite different method [4].

The mean daily motion n can be computed in dividing $1296000''$ by the period τ expressed in days. Table 2 contains these values as well as those of the semi-major axis a corresponding to the various periods τ of the revolution of the Comet.

Table 2.

τ	n	a	τ	n	a
$74^y 0$	$47'' 948$	17.626	$76^y 5$	$46'' 382$	18.021
74.5	47.628	17.705	77.0	46.080	18.099
75.0	47.311	17.784	77.5	45.783	18.178
75.5	46.998	17.862	78.0	45.490	18.255
76.0	46.688	17.942	78.5	45.202	18.333

At the close approach of Halley's Comet to the Earth, e. g. in the vicinity of its descending node \mathcal{V} , one should assume for n those values, which correspond to the actual apparition of the Comet. But for the most part one can adopt the average values of n_0 and a_0 , resulting from the average value of the period τ_0 of the revolution of the Comet round the Sun

$$\tau_0 = 76^y 900 \quad n_0 = 46'' 141 \quad a_0 = 18.083.$$

When computing the position of the Comet on the celestial sphere we meet two more arguments which play an important role. They are: the true anomaly f and the radius-vector r , as well as the difference $t - T$, i. e. the interval between the given moment t and the moment T of the perihelion passage, expressed in days. They are given in Table 3. In the computation, the following average values for e and n were adopted:

$$e = 0.9673 \quad n'' = 46'' 141$$

Table 3.

f	$t - T$	r	f	$t - T$	r
0	d		0	d	
0	0.00	0.5914	25	8.48	0.6199
5	1.61	0.5925	30	10.32	0.6331
10	3.27	0.5958	35	12.25	0.6491
15	4.98	0.6015	40	14.29	0.6683
20	6.71	0.6095	45	16.46	0.6909

Table 3 (continued)

f	$t-T$	r	f	$t-T$	r
50^0	$18^{\circ}78$	$0^{\circ}7174$	90^0	$49^{\circ}57$	$1^{\circ}1634$
55	$21^{\circ}29$	$0^{\circ}7483$	95	$56^{\circ}52$	$1^{\circ}2706$
60	$24^{\circ}06$	$0^{\circ}7842$	100	$64^{\circ}87$	$1^{\circ}3983$
65	$27^{\circ}11$	$0^{\circ}8258$	105	$75^{\circ}07$	$1^{\circ}5520$
70	$30^{\circ}52$	$0^{\circ}8742$	110	$87^{\circ}77$	$1^{\circ}7388$
75	$34^{\circ}32$	$0^{\circ}9305$	115	$103^{\circ}93$	$1^{\circ}9679$
80	$38^{\circ}68$	$0^{\circ}9961$	120	$124^{\circ}75$	$2^{\circ}2530$
85	$43^{\circ}70$	$1^{\circ}0728$	125	$152^{\circ}47$	$2^{\circ}6134$
			130	$190^{\circ}33$	$3^{\circ}0761$

As regards the elements Ω , ω , i they are to be found in Table 4 for the period 100 BC — 2300 BC. They are referred to the equinoxes of date.

Table 4.

Year	Ω	ω	i	Year	Ω	ω	i
— 100	$29^{\circ}3$	$109^{\circ}4$	$161^{\circ}8$	— 1200	$366^{\circ}2$	$107^{\circ}2$	$163^{\circ}1$
— 200	$27^{\circ}2$	$109^{\circ}2$	$161^{\circ}9$	— 1300	$364^{\circ}1$	$107^{\circ}0$	$163^{\circ}2$
— 300	$25^{\circ}1$	$109^{\circ}0$	$162^{\circ}0$	— 1400	$362^{\circ}0$	$106^{\circ}8$	$163^{\circ}3$
— 400	$23^{\circ}0$	$108^{\circ}8$	$162^{\circ}1$	— 1500	$359^{\circ}8$	$106^{\circ}6$	$163^{\circ}4$
— 500	$20^{\circ}9$	$108^{\circ}6$	$162^{\circ}2$	— 1600	$357^{\circ}7$	$106^{\circ}4$	$163^{\circ}6$
— 600	$18^{\circ}8$	$108^{\circ}4$	$162^{\circ}4$	— 1700	$355^{\circ}6$	$106^{\circ}2$	$163^{\circ}7$
— 700	$16^{\circ}7$	$108^{\circ}2$	$162^{\circ}5$	— 1800	$353^{\circ}5$	$106^{\circ}0$	$163^{\circ}8$
— 800	$14^{\circ}6$	$108^{\circ}0$	$162^{\circ}6$	— 1900	$351^{\circ}4$	$105^{\circ}8$	$163^{\circ}9$
— 900	$12^{\circ}5$	$107^{\circ}8$	$162^{\circ}7$	— 2000	$349^{\circ}3$	$105^{\circ}6$	$164^{\circ}0$
— 1000	$10^{\circ}4$	$107^{\circ}6$	$162^{\circ}8$	— 2100	$347^{\circ}2$	$105^{\circ}4$	$164^{\circ}2$
— 1100	$8^{\circ}3$	$107^{\circ}4$	$163^{\circ}0$	— 2200	$345^{\circ}1$	$105^{\circ}2$	$164^{\circ}3$
— 1200	$6^{\circ}2$	$107^{\circ}2$	$163^{\circ}1$	— 2300	$343^{\circ}0$	$105^{\circ}0$	$164^{\circ}4$

It should be pointed out that in the present state of the theory of Halley's Comet, element Ω cannot be computed accurately. The values given above are to some extent of an orientational character.

However some inexactness of these values has no greater influence on the position of the Comet on the celestial sphere, as can be seen from the path of Halley's Comet in 2320 BC [3].

§ 2. Formulae for the computation of positions of the Comet.

We take from Table 1 the proper values for T , and compute the positions of the Comet for the given moment t in the following manner:

With the argument $t-T$ one finds from Table 3 — by two approximations — the true anomaly f of the Comet and its radius vector r .

Then we find the argument of latitude u by the formula

$$u = \omega + f$$

where ω is taken from Table 4.

From P. Neugebauer's tables („Tafeln für Sonne, Planeten und Mond... für die Zeit 4000 vor Chr., bis 3000 nach Chr.“, Leipzig 1914) one computes the true longitude \odot of the Sun and its distance R from the Earth. The values of \odot are referred to the actual equinox of the date. The Tables in question are arranged according to the Old Style.

We then compute the geocentric longitude λ and the latitude β as well as the distance Δ of the Comet from the Earth according to the known formulae

$$\begin{aligned} \Delta \cos \beta \sin (\lambda - \Omega) &= r \sin u \cos i + R \sin (\odot - \Omega) \\ \Delta \cos \beta \cos (\lambda - \Omega) &= r \cos u + R \cos (\odot - \Omega) \\ \Delta \sin \beta &= r \sin u \sin i \end{aligned}$$

§ 3. The positions of Halley's Comet on the celestial sphere in 1163 BC

The 26th perihelion passage of the Comet T_{-26} recorded backwards from the main initial Epoch 837⁰⁰ AD is as follows (Table 1):

$$T_{-26} = -1161.3 = -1162 \text{ Sept. } 13.0 = 1163 \text{ BC Sept. } 13.0$$

The date of Sept. 13⁰ was adopted for definiteness. Let us compute the positions of the Comet e. g. for two dates of August: $t_1 = 1163 \text{ BC Aug. } 4.0$ and $t_2 = 1163 \text{ BC Aug. } 9.7$.

For both of them we assume (Table 4):

$$\Omega = 7^0 0' \quad \omega = 107^0 18' \quad i = 163^0 4'$$

For $t_1 = 1163 \text{ BC Aug. } 4.0$ we find

$$\begin{aligned} t_1 - T = -40.0, \text{ whence } f_1 &= -81^0 24' & \lg r_1 &= 0.0071 \\ \odot_1 &= 119 43 & \lg R_1 &= 0.0024 \end{aligned}$$

Computing further with the formulae of § 2, we find the position of the Comet to be as follows:

$$\lambda_1 = 50^0 42' \quad \beta_1 = +10^0 5' \quad \Delta_1 = 0.7391.$$

For the second moment $t_2 = 1163 \text{ BC Aug. } 9.7$ we find

$$\begin{aligned} t_2 - T = -34.32, \text{ whence } f_2 &= -75^0 0' & \lg r_2 &= 9.9687 \\ \odot_2 &= 125 16 & \lg R_2 &= 0.0018 \end{aligned}$$

Hence

$$\lambda_2 = 59^0 45' \quad \beta_2 = +15^0 45' \quad \Delta_2 = 0.5337$$

When fixing the approximate boundaries of the constellation Gemini for 1163 BC, we assumed the margin stars from the Tables of P. Neugebauer as follows:

No 137 η Gem (4^m)	$\alpha = 47^{\circ}49$	$\delta = +16^{\circ}69$	} - 1162 ^o
No 174 β Gem (1^m 5)	$\alpha = 67^{\circ}10$	$\delta = +28^{\circ}65$	

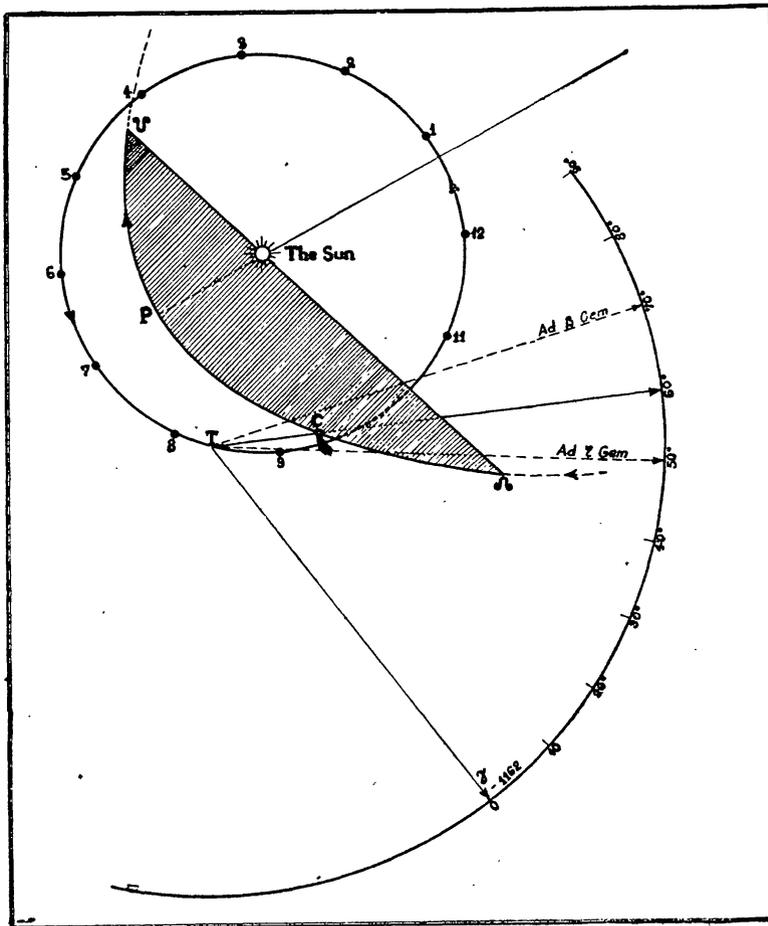
These coordinates correspond to the following ones:

η Gem (4^m)	$\lambda = 49^{\circ}6$	$\beta = -1^{\circ}3$	} - 1162 ^o
β Gem (1^m 5)	$\lambda = 69^{\circ}9$	$\beta = +6^{\circ}4$	

Hence follow the boundaries of Gemini in longitude:

$$49^{\circ}6 < \text{Gemini} < 69^{\circ}9$$

Consequently, both positions of the Comet for 1163 BC, Aug. 4^o and Aug. 9⁷, were situated inside the constellation of Gemini (v. the diagram).



We have already pointed out, that the moments T in Table 1 are probably exact within 2 years or so. On the other hand, the po-

sitions of the Earth on its orbit for the given data t are nearly the same for several consecutive years. Consequently, the configuration: Earth — Comet, described above, can happen again in

1165 BC — 1164 BC — 1163 BC — 1162 BC — 1161 BC.

The enclosed diagram shows the mutual positions of the Earth and of part of the Comet's orbit, or rather — the projection of the latter on the plane of the ecliptic, which is almost the same, since the inclination i of the Comet's orbit to the ecliptic is comparatively small. In this diagram the figures 1, 2, 3... 12 indicate the positions of the Earth for the first of every month. Consequently, 8 is its position for August 1st. We note that on August 10th 1163 BC the Comet C was seen from the Earth T in the direction TC and was situated in Gemini. As the Earth moved from 8 to 9, i. e. from August to September, the Comet mounted higher and higher on the sky, moving from Gemini to Leo and approaching its perihelion P .

§ 4. Records of annalists

On turning to the records of ancient annalists in order to find some references concerning the appearances of the comets of old, we find first of all the following note in the well known work of S. Lubieniecki^[6]:

VII. „Anno Mundi 2770. mense Augusto, terribilis Cometa in Geminis ab Assyriis visus est... Bellum diuturnum et miserabile propter Helenam, quam Paris filius Priami Regis, Menelao Regi Spartanorum rapuit, ortum est... Troia capta et devastata est Anno Mundi 2783“. Rockenbachius.

On the other hand, we read on p. 28 (*ibidem*):

XLI. „Anno Mundi 3947 quo Natus est Christus, conspectus est Cometa, de quo Sybilla Augusto consulenti respondit: Hic puer te major est, hunc adora. Eadem praedixit, Cometam istum significare Christianam religionem“. Alstedius.

Now, accepting in accordance with this second note that „Anno Mundi 3947 Christus natus est“ — we find that the Comet of 2770 AM appeared in

2770 — 3947 = — 1177 or in 1178 BC.

According to note VII it was visible in August on the background of Gemini. It was undoubtedly a bright Comet, since the faint ones were not mentioned by the annalists.

The agreement of our astronomical computations with the chronicle note is striking: in both cases the Comet appears just in August and just in Gemini. There exists, however, a difference in the years of the apparition provided it was Halley's Comet. This difference amounts to 15 or at least 13 years.

On the other hand, we read in VII that „Troia capta et devastata est Anno Mundi 2783“ — which corresponds, on the assumptions above, to the year 1165 BC. But this year coincides almost exactly with the appearance of Halley's Comet (v. § 3).

§ 5. The year of the birth of Christ, and the apparitions of Halley's Comet

It is to be noted that mediaeval scholars and ancient annalists assumed various data for the year of the birth of Christ. S. Lubieniecki (Vol. II, p. 1) quotes a long series of them from 3947 AM to 3984 AM. We cite here some because they are related to the ancient apparitions of Halley's Comet (v. Table 5). Thus,

Calvisius, Helvicus Alstedius et Mircaelius	3947 AM
Iosephus Scaliger, Illustrissimus temporum emandator	3948 AM
Eckstormius	3969 AM
Petavius	3984 AM

On converting the years of the apparitions of some comets quoted by S. Lubieniecki to our contemporary reckoning of time with the help of the above given various dates for the birth of Christ, we get Table 5.

Table 5.

No	Lub. II	Comet	Chron.	Comet Halley	Annalist
1	p. 3	1657 AM — 3969	— 2312	— 2312	Eckstormius et Helvicus
2	p. 28	1944 AM — 3947	— 2003	— 2007	Rockenbachius
3	p. 4, 29	2018 AM — 3947	— 1929	— 1932	Rockenb. et Eckstormius
4	p. 5	2128 AM — 3984	— 1856	— 1855	Eckstorm. ex Herlicio
5	p. 5	2237 AM — 3947	— 1710	— 1703	Eckst. ex Herlicio
6	p. 29	2770 AM — 3947	— 1177	— 1162	Rockenbachius
7	p. 30	2795 AM — 3969	— 1172	— 1162	Rockenbachius

Note: Comets 1, 2, 6, of the above list have already been investigated by the author.

Now, in considering the diversity of all these data even S. Lubieniecki expresses his doubts as to the year of the apparition of Comet VII (v. above) and the events ascribed to it (Vol. II p. 30).

Still more deviates from S. Lubieniecki's chronology the year of the outbreak of the Trojan War given by Pingre [7]. He quotes:

„Vers 1200, au mois d'Août, les Assyriens virent une Comète dans les Gemaux; l'impie Amenemos, roi d'Egypte, mourut peu après: la guerre de Troie suivit, et cette ville fut détruite treize ans après l'apparition de la Comète“ (Hév. Lub. Rock. Coesius. Zahn).

M. Pingré is very sceptical towards this note. He cites a series of other sources according to which the date of the fall of Troy is spread almost over the whole century [7].

And yet, on ending his reflections, he quotes the opinion of Eratosthenes (Vol. I, p. 251) „Eratosthènes, dont la chronologie parut peu après celle de Timée, et fut plus généralement adoptée, place la prise de Troie sur l'an 1184“.

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Now, the task of the author consists in the astronomical elaboration of the ancient apparitions of Halley's Comet. In the present article this problem was solved concerning the apparition of it about 1163 BC. But the elucidation of contradictions of the confused ancient chronology is quite a different task; it belongs rather to historians. However, some of them are very sceptical as to the scientific value of the annalists' notes. They even thought that such notes are nothing more than imaginations of mediaeval annalists...

The author considers that such extreme sceptical views are by no means justified. Indeed, in what reasonable way could one guess that about some chronological datum—say, about 2320 BC, 2008 BC, or 1163 BC—a certain comet, undoubtedly bright, appeared in the place described by the annalist, on the background of a definite constellation and was moreover seen for a number of days? From all the orbits of long-period comets it is only that of Halley's Comet which enables us to compute its positions on the celestial sphere even many centuries BC. But until the end of the 17th century nobody could suspect its regular returns to the Sun. It is therefore quite improbable that „phantastic visions of annalists“ could have been so close to astronomical reality. There is no doubt that this reality was often handed down by generations of annalists, and thus it could have been distorted. There is no doubt also that certain comets were observed and recorded. But in the present stage of science among all these comets it is only the circumstances of the apparitions of Halley's Comet that can be to some extent reconstructed.

§ 6. Conclusion

The year 1163 BC of the perihelion passage of Halley's Comet can hardly be erroneous for more than two years (v. § 1). In assuming that it was the year of the outbreak of the Trojan War, which lasted 13 years (acc. to tradition rounded off to 10 years), we come to the conclusion that the fall of Troy took place in 1150 BC, with possible inexactitude of a few years.

Now, Ancient History cannot fix the date of the destruction of Troy VII with the desirable exactness. One assumes that it happened in the period 1350 BC — 1250 BC — 1200 BC (Blegen).

It is interesting to note that the Polish novelist Dr. Zenon Kosidowski in his fascinating book „Gdy Słońce było bogiem“ — (When the Sun was God) quotes the year 1180 BC for the destruction of Troy [8]. According to oral information he gave to the author this datum is presumably adopted by American archaeologists. It differs from the author's datum only by 30 years.

However, the most convincing method of fixing the year of the fall of Troy is the application of the C_{14} method to date the remains of its ashes found *illo tempore* by Henry Schlieman, during excavations of Troy VII.

In conclusion we remark that Tables 1, 2, 3, 4, 5 can be of great use when investigating other apparitions of Halley's Comet in the period 240 BC — 2400 BC.

REFERENCES

- [1] A. C. D. Crommelin, *M. N.*, **68**, p. 112.
- [2] A. S. Yamamoto — Preliminary General Catalogue of Comets (*Publ. Kwasan Observatory*. Vol. 1, No 4, Kyoto 1936).
- [3] M. Kamiński — The Probable Apparition of Halley's Comet in 2320 BC. *Acta Astronomica*, Vol. 6, Cracow, 1956.
- [4] M. Kamiński — Researches on the Periodicity of Halley's Comet. Part III. Revised List of Ancient Perihelion Passages of the Comet. *Acta Astronomica*, Vol. 7, part 2. Cracow, 1957.
- [5] M. A. Viliew — Issledowania po teorii dwizenia Komety Galley'a. *Izvestia Russkago Obszczestwa Lubitielej Mirowiedenia*. Tom VI, No 4 (28). August 1917, p. 215-219.
- [6] S. Lubieniecki — Historia Cometarum A Diluvio usque ad praesentem annum vulgaris Epochae, a Christo Nato 1665 decurrentem... Amstelodami.
- [7] M. Pingré — Cométographie ou Traité Historique et Théorique des Comètes. Tome I. Paris 1783, p. 249.
- [8] Zenon Kosidowski — Gdy Słońce było bogiem. Warszawa, 1956, p. 218.

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