AN ACCOUNT OF THE COMET, WHICH APPEARED IN THE MONTHS OF SEPTEMBER, OCTOBER AND NOVEMBER 1807*

Captain John Warren
Acting Astronomer, Madras Observatory, Madras, India.

The Comet of which it is the object of this paper to describe the path, was noticed for the first time in Bengal, at Penang and at Sea (in latitude 10°S) about the 20th of September.

By some unaccountable over sight or accidental intervention of clouds, it was not noticed at Madras untill the 2d of October, when it appeared in the constellation of the Serpent, about 9½ degrees W of α of that asterism, of the size of a star of the first magnitude with a faint beard about 3° in length just discernible to the naked eye. Viewed thro' a Telescope, its nucleous was ill defined, with hardly any apparent diameter, and surrounded with a haze similar to that of its beard. Its size rapidly diminished and on the 8th of October it did not seem magnified when viewed through a Telescope with a power of about 80. It was seen distinctly as late as the 8th of December, but the weather having thickened previous to the memorable hurricane of the 10th and 11th of that month and kept clouded subsequently, it was but just perceived when the sky cleared up on the 13th of December.

There being no Instrument in the Madras Observatory wherewith to take at once angles of altitude and azimuth, I ascertained the position of this Comet relatively to the neighbouring fixed stars with an 8 Inch Radius Sextant made by Ramsden, I observed it from the 3d of October until it became too faint to admit of a tolerable observation by means of an instrument of so little power.

As the object of this paper is principally to investigate the orbit of the Comet, I shall only give here an abstract of such observations as I have used in working it.

On the 3d of October at 7h: 13′: 24″.7 P.M. mean time I observed the Comet 8°: 31′: 47″ E of α Serpentis and 13°: 9′: 5″ N of β Librae.

On the 14th of the same Month it was at 6h: 45″: 17″ P.M. 14°: 8′: 15″ of α Coronae Borealis and 7°: 50′: 25″ NE of α Serpentis.

On the 25th, at 6h: 42′: 15″ P.M., it was of ζ Herculis 9°: 26′: 15″ S, and 8°: 47′ :45″ SW of σ Herculis.

On the 18th of November the Comet was from α Lyrae 4°: 50′: 7″ SW and from Altair 35°: 1′: 15″ NW.

With these data and the sum or difference of the respective stars right ascensions and declinations we are enabled to compute by spherical trigonometry the situation of the Comet as seen from the Earth on each of these days; But as the detail of these computations afford nothing particularly interesting I shall only insert the results in the following General Table, which can easily be verified, and leave the operation recorded at the Madras Observatory.

Having thus obtained four longitudes and elongations of the Comet with corresponding latitudes, we are to look for a parabola which will represent its position in the heavens at these respective periods. As the details of this investigation are but little known to any but astronomers, I shall concisely state the different steps which have led me to the resolution, or rather approximation of this laborious problem.

Let SA (Fig I) be the distance of ⊙ and ⊕ at the moment of observation (A)SH, the curtate distance from ⊙ to Comet or distance reduced to the plane of the Ecliptic SHA(*c*).

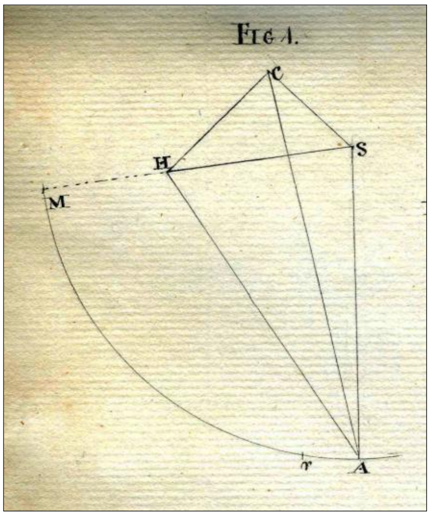
SAH the difference of ⊙ & Comet's longitude, seen from the Earth, called the angle of Elongation (*E*).

HSA the assumed difference of Comet and Earth! Heliocentric Longitude called the angle of Commutation (*n*).

SHA the angle at the Comet reduced to the plane of the Ecliptic (*m*).

Time of Observation at Madras	AR	Declin	Geocentric Longitude	Geocentric Latitude	⊙ long. Contempo.	Longitude of ⊙'s distance
D h ′ ″	° ′ ″	° ′ ″	s ° ′ ″	° ′ ″	s ° ′ ″	
Oct 3:7:13:24.7	225:35:47.0	4:32:50	7:11:42:46	20:52:17 N	6: 9:24:25.5	9.997990
14:6:45:17.5	237: 1:14.4	14:13:02	7:20:51:03	33:18: 7 N	6:20:16:02.3	9.9985320
25	247:29:42	22:34:00	8: 0:41:50	43:45:51 N	7: 1:12:32.6	9.9972190
Nov 18	272:24:58.0	36:11:44	9: 3:51:28	59:37:31 N	7:25:19:45.3	9.9946970

* Based on a MS dated 1 January 1808 now in the RAS Archives, London (RAS MSS Madras 6). We are grateful to the Royal Astronomical Society for permission to publish this manuscript and to Dr Sian Prosser (RAS Librarian and Archivist) for his help.

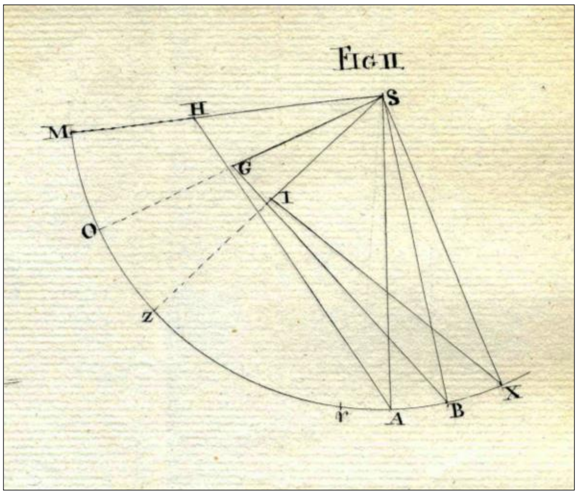


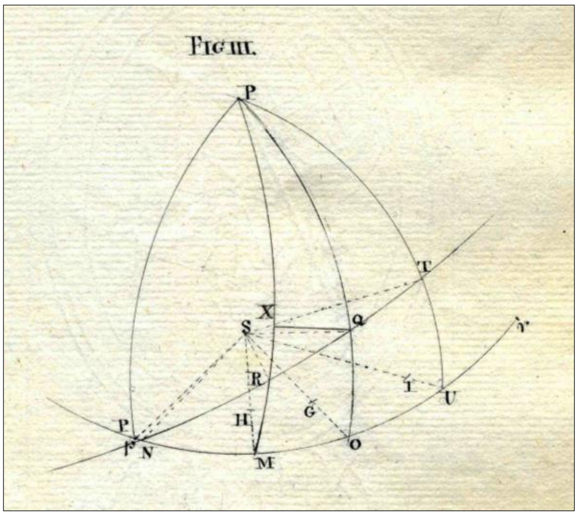
Draw CH perpendicular to the plane of the Ecliptic SHA, and let C be the place of the Comet in its orbit.

Then CAH is the Geocentric Latitude as observed (*l*) and

CSH is the Heliocentric Latitude which is to be determined (*L*)

of these different terms are only given SAH, the Elongation, and CAH the Geocentric Latitude





such further data as may be required to work the problem must be assumed; and this may be done either by assuming SH, the curtate distance, or (when the angle H at the Comet is very near 90°) to assume that angle.

As these cases belong to plane trigonometry, I shall merely state that preserving the above notation we have the angle at Comet.

$$m = (\text{Sin } E \times \text{A})/c$$

and the angle <u>of Comm</u>utation

$$n = m + E - 180$$

which when worked and assuming SH = 0.5868 will give m = 65°: 33′: 11″ and n = 82°: 8′: 28″

We resolve the Comet's Heliocentric Longitude by taking the angle of Commutation from the Earth's Longitude adding in this case 12 signs to it, because the Earth is in ♈ and the Comet is East of it/ and the remainder leaves the Comets Longitude of which HS♈ is the supplement to 360.

In this case ☉'s long. being	12ˢ: 9°: 24′: 25″
and n = - - - - - - - - - - - -	2: 22: 8: 28
we have Heliocentric long. Ist obsⁿ.	9: 17: 15: 57

(*l*)

The Heliocentric Latitude CSH is … [indistinct] and in this case, *L* = 35°: 15′: 1″.

C being the true place of Comet on orbit, SC will be true distance from the Sun; or the Radius Vector (*V*) which is to be determined by dividing the curtate distance SH by the cosine of the Heliocentric Latitude *L*, the log. of which in this case will be 9.8564601.

2ᵈ Observation

Proceeding in the same manner for the 2ᵈ observation and assuming SG (Fig II) = 53101 we shall have

∠ at Comet …………..	12°: 43″: 53″
∠ of Commutation…..	77: 0: 5
Heliocentric Long.	10ˢ:3°: 15′: 57″
Heliocentric Latiᵈᵉ	51: 31: 10
Rad. Vector log.	9.9311422

difference of Longitude Iˢᵗ and 2ᵈ observation HSG (Fig I) or MO (Fig III) 16°.

We are now to determine Iˢᵗ the Perihelion or focal distance Sp of the Parabola (Fig III) 2ᵈ. The two anomalies pR, pQ. 3ᵈ. The interval of time elapsed between the two observations which if SH, SG have been rightly assumed will be the same as the interval observed.

Let NMO (Fig III) be an arc of the Ecliptic, P its pole, Np RQ a part of the Parabola required p, the Perihelion N the Node, and ∠RNM the Inclination of the orbit with the Ecliptic.

Then RM, QO, are the two Heliocentric Latitudes, RQ is the motion of the Comet on orbit between the two observations, and MO, the difference of Heliocentric Longitudes corresponding to it.

By common spherical trigonometry we have for RQ

$$\text{tang}^t\ PX = \text{Cos MO} \times \text{co.tang}^t\ QO$$

and Co-sine RQ = (Cos RX × Sine QO)/Cos PX

which in this instance is = 19°: 51′: 12″.

For the whole anomalies pR, pQ, if we put *V* for Rad. Vector SR, and *v* for SQ; we shall have by spherical trigonometry

$$\text{tang}^t\ [(\tfrac{1}{2}V/v) - 45]/\text{tang}^t\ (\tfrac{1}{4}RQ) = \angle p'$$

and $\angle p \pm \tfrac{1}{4} RQ = \tfrac{1}{2}\{$ pQ greater anomaly / pR less anomaly

which being worked accordingly will in this case be

pQ =	62: 34: 10	Greater anomaly
pR =	42: 42: 50	less anomaly
diff.	19: 51: 12	as found before.

By referring to the General Table of anomalies for the comet of 109 days we will find the number of days corresponding with the greater anomaly to be 56.1038
and the lesser 33.7879
diff. 22.3159 which

difference being multiplied by the 3/2 power of the Perihelion Distance will give the number of days elapsed which belong to this Parabola.

Now we have (by conic sections) for the Perihelion Distance Sp

$Sp = (\cos\tfrac{1}{2}\ pQ)^2 \times SQ = .62325$ and
$(Sp)^{3/2} = .49203$ whence
$(62325)^{3/2}$ or 49203 × 22.3159 = $10^d.98$ which is exactly the interval observed.

A Parabola has therefore been found which answers to the position of the Comet at the times of the first and second observation.

Therefore if by applying it to the circumstances of the 3^d^ observation, it is also found to answer then it will be the real path, or orbit of the Comet.

Preparatory to this investigation we must determine the following Elements, to be deduced from the preceding results

I^st^ the Long. of Node
2^d^ the time of passage of Perihelion
3^d^ the Obliquity of Orbit or ∠N

For this we are to compute the different parts of the triangle RNM which by spherical trigonometry (Fig III) will be done as follows

$$\text{tang}^t\ \angle R = (\text{Sine PX} \times \text{tang}^t\ MO)/\text{Sine RX} = 30°: 17′: 9″$$

$$\text{tang}^t\ MN = \text{Sine MR}.\text{tang}^t\ \angle R = 18:37:38$$

$$\text{Cosine}\ \angle N = \text{Sine}\ \angle R \times \text{Cosine MR} = 65:40:19$$

$$\text{Sine NR} = (\text{Rad} \times \text{Sine MR})/\text{Sine}\ \angle N = 39°: 18′: 3″$$

For the Longitude of Node

distance from Node MN	18°: 37′: 38″
Heli. Long I^st^ obs^n^	9^s^.17°: 15′: 57″
Long. of Node	8^s^.28°: 38′: 19″

Reducing the days of the Tables corresponding with the smaller anomaly, to days of the Comet, by multiplying these into 3/2 power of Perihelion Distance, we have the time elapsed since passing = 16.624 days and this reduced to the preceding month by subtracting it from October 3^d^ 7^h^: 13^m^: 24.7^s^ gives the passage on September the 16^th^ 16^h^: 14′: 53″ or 16.67691 days.

For the Longitude of Perihelion

longitude of Node	8^s^.28°: 38′: 19″
argnt. of Latitude RN	1: 9: 18: 3
Sum	10: 7: 56: 22
Lesser anomaly pR	1: 12: 42: 58

Longitude of Perihelion 8: 25: 13: 24 on orbit

3^d^ Observation

We have now obtained the following Elements which will enable us to compute the Geocentric Latitudes and Longitudes resulting from the 3^d^ observation, and which (if a right hypothesis had been assumed), ought to be the same as have been observed.

Longitude of Perihelion	8^s^.25°: 13′: 24″
Longitude of Node	8 28 : 38 :19
Inclination of Orbit	65 : 40 : 19

time of passing Perihelion Sept^r^ 16^th^ 16^h^: 14^m^: 53^s^
time (observed) of 3^d^ observation Oct^r^ 25^th^ 6^h^: 42^m^: 45^s^ or October 25.2795 days
log. of Perihelion Distance 9.7946652

For time elapsed since passage of Perihelion

3^d^ observation & corres. anomaly
time of passage Sept^r^ 16.677
30
13.323

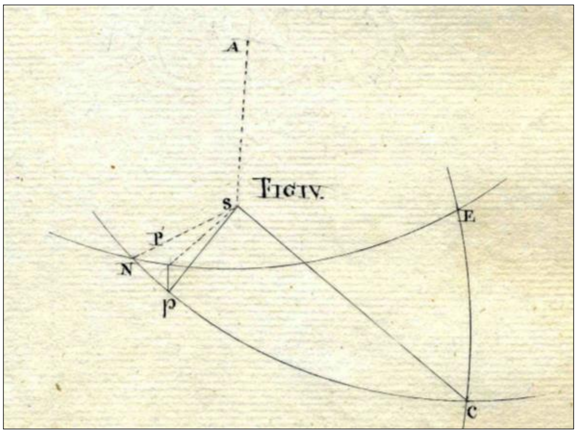
which divided by 3/2 power of Perihel^n^. Distance give us days of the Table 78.455 corresponding with 76°: 36′: 46″ of anomaly = pT (Fig III).

For the arg^t^. of Lat. NT

Anomaly pT	2^s^: 16°: 36′: 46″
Long. of Perihelion	8: 25: 13: 24
Heli. place of Comet on orbit	11: 11: 50: 10
Long. of Node	8: 28: 38: 19
NT arg^t^. of Latitude	2: 13: 11: 51

For distance of Comet from Node on Ecliptic NO

$$\text{tang}^t.\ NO = (\text{Rad} \times \text{Cos}\ \angle N)/\text{Cosine NT}$$



= 53°: 45′: 38″

For Heliocentric Longitude on Ecliptic

distance from Node	1^s. 23°: 45′: 32″
place of Node	8 28: 38: 19
⨀'s Longitude	10: 22: 23: 51
	13: 1: 12: 32
∠ISX of Commutation	2: 8: 38: 41

For the Heliocentric Latitude

$\text{tang}^t\ TU = (\text{Rad} \times \text{Sine } NU)/\text{Cotang}^t \angle N$
= 60°: 32′: 57″

For the Curtate Distance
By conic sections

curtate dist SI = (Cosine TU × per. dist.)/(Co-sine½ pT)^2 = .49765

For angle at Comet SIX, and of Elongation SXI (Fig II)

Let SX = x and SI = y, then by plane trigonometry and

∠p ± ½ Supp^t. ISX = ∠SIX at Comet 81° 38′ 56″
= ∠SXI of Elong. 29: 42: 4

For Geocentric Longitude

Elongation	29°: 42′: 20″
⨀'s longitude	7^s: 1°: 12′: 32″
Geo. Longitude	= 8: 0: 54: 52
But it was obs$^{d.}$	8: 0: 41: 50
error	13′: 2″

For Geocentric Latitude
By plane trigonometry

tangent Geocentric Lat. = (Sine IXS × tang^t. Hel. Lat.)/Sine ISX

hence computed Geo. Lat.	= 43°: 18′: 57″
But it was obs^d.	43 : 45: 51
error	26: 54

I shall not detain the attention of the reader by giving him an account of the various trials which I have made to obtain, that hypothesis which would produce the nearest coincidence, with the greatest number of positions.

I have selected for an example the three preceeding observations because they were the three first taken when the Comet was most distinct and consequently when it was to be presumed the arcs were most accurately, measureed but when I came to apply the hypothesis to remoter observations I found that it gave too small a motion to the Comet. It was not untill I had made a great number of trials of observations and taken three that I brought out at least an hypothesis which (though not absolutely perfect,) yet represented sufficiently well the position of the Comet as seen from the Earth to justify the adoption of the following Elements on which I shall ground my subsequent remarks.

In order to be more concise I shall annex to these the Elements of the Comet of 1684, which is the only one that bears the least resemblance with ours; observing at the same time before we can venture any final opinion on the subject, we must look to astronomers in Europe for that information which can only be obtained by adequate means both as to talents and Instruments.

Let us now examine what must have been the position of the Comet at any given period before its perihelion, for example at 90° anomaly descending.

Let S be the Sun (Fig IV) NṔE, a part of the Ecliptic, N the place of node, Ṕ the place of perihelion on Ecliptic, p the perihelion, pC an arc of 90° anomaly, CE the Heliocentric Latitude of Comet when at C and SA the direction of the Earth.

We have then

Place of the Node	8^s. 29°: 1′: 15″
Place of Perihelion on its orbit	8^s. 26: 13: 41
Np arg^t. Lat. Perihelion =	2: 47: 34
which added to pC =	90
gives NC arg^t. of Latitude	92: 47: 34

This with the Inclination of orbit gives by spherical trigonometry

NE the dist. to Node	96: 16: 44
which taken from Long of Node	^{s}8. 29°: 1′: 15″
leaves Heli. Long. of Comet	^{s}5. 22°: 44′: 31″
also the Heliocentric Lat.	63°: 32′: 41″

Elements	Comet of 1807	Comet of 1684
Perihelion distance	0.61305	0.96015
Inclination of orbit	63°: 40′: 51″	65°: 48′: 40″
Long. of ascending node	^{s}8: 29°: 1′: 15″	^{s}8: 28°: 15′: 0″
Place of perihelion	^{s}8: 26°: 13: 40	^{s}7: 28: 52: 0
Time of pass. Per. Greenwich time	Sep^t. 16^d: 21^h: 2′: 36″	June 8th:10^h: 15′: 40″
Motion	direct	direct

We are now to find the number of days which our Comet will take to move through 90º of anomaly.

For this we have in the Tables corresponding to 90° anomaly 109.67 days which divided by the 3/2 power of Perihelion Distance will give for this Comet 52.645 days or 52^{days}:15^{h}:29′ by which quantity it may (as usual) be denominated.

Now the time of passing the Perihelion being on September 17th 2^{h}:23′:50″, we have for the day on which the Comet had 90° anomaly descending, the 26th of July at 10^{h}:56 on which day the Suns Longitude + 6 signs was

	10^{s}. 2°: 43′: 16″
Heliocentric Long. of Comet	5^{s}. 22°: 42′: 31″
∠ of commutation	4^{s}: 9°: 58: 45

which being disposed of as usual will give for 90° anomaly descending

The Elongation	17°: 0′: 52″
Geocentric Longitude	4^{s}. 19°: 44′: 8″

and Radius Vector or dist from the Sun SC log 0.0885873.

For curtate distance of Perihelion and Radius Vector of Node, we have, Co-sine Heli. Latitude × Perihelion Dist. = curtate dist. SP of Perihelion = 60250 (log 9.7871104) and Perihelion Dist. × Co-sine (½ anomaly)^2 = Rad. Vector at Node = 6134(log 9.7877712).

Lastly for the distance from Earth to Comet on the 3$^{d.}$ of October and 23$^{d.}$ of November, we have by plane trigonometry (Fig I)

Distance AH = (Sine Comm$^{n.}$ HSA × Curt. SH)/ Sine Elongation = 1.0648

which divided by Co-sine Latitude 20°: 52′: 50″ gives the distance CA = 1,1386 from Earth to Comet on the 3$^{d.}$ of October, and by the same rule for the 23$^{d.}$ of November = 1.72250.

We may deduce from the preceeding results that had the Comet been in its Node on the 21st of June at Noon (when the Earth has ^{s}8: 29°: 1′: 15″ anomaly) the Comet would have eclipsed the Sun, and would have been nearer to us in the proportion of 10.16 to 4.026.

The same serves also to explain the reason why the Comet was not seen at the time of its approach to the Sun; for having computed its place when at 90° anomaly descending (which happened on the 26th of July at 10^{h}:54′) I found that its Elongation, or difference of Geocentric Longitude from the Sun was on that day only 17°: 0′: 52″ and had only increased to 32°: 20′: 14″ by the 3$^{d.}$ of October, from which it is evident that for a long while it was much too near that luminary, not to be lost in its rays, had not even the Comet’s distance from us, been then more than double that from the Sun, that is nearly in the proportion of 10 to 22. Which alone would have prevented our seeing it, since it was barely discernible on the 23$^{d.}$ of November, when its distance from the Earth was only as 10 to 11 and when it had 40° Elongation.(*)

I shall now take leave of this difficult subject, which would have been investigated with infinitely more ease and accuracy, had I been suplied with more appropriate instruments; and beg on that account to submit the preceding investigation to the notice of the public more as an essay than a successful description of the orbit of the Comet of 1807.

Having been prevented by illness to observe after the 2$^{d.}$ of December the Bramin assistant Senivassachairy, continued to notice it. On the 8th of December at 7^{h} P.M. he took roughly its distance from α Cygnii which was about 9°:47′ N.W. and from α Aquilae 35°:11′ NE.

The last sight he had of it was on the 13th after which the light of the Moon prevented his perceiving it any longer.

Madras Observatory
1st of January 1808

[Signed] John Warren
Act^{g} Astronomer

*The Comet might have been seen when at its Perihelion; for then its Elongation was 32°: 49′: 21″ and its distance as 11.26, which is a little more than what it was on the 23$^{d.}$ of Nov. when it was still discernible to the naked eye.

As it passed its Node on the 17th of Sept^{r}. at 20^{h}: 5′,when its Elongation was 34°: 42′: 56″ and its distance somewhat less than the above, it must have been distinctly visible: and so it seems was the case since it was noticed at several places about the 20th of that Month.

I shall here observe that the present hypothesis gives the Elong. of Node in the last degree of Libra, that is, its Geocentric Long.