ART. LVI.—*On the Southern Comet of February, 1880* ; by
B. A. GOULD.

ON the evening of February 2nd, before the twilight was fully past, my attention was drawn to a remarkable streak of light in the southwest, which extended through about 18° , at an angle not much inclined to the vertical. Its lower extremity was perhaps 20° above the horizon, and the brightness was in no part much, if indeed any, greater than that of a star of the $5\frac{1}{2}$ magnitude. It seemed to taper in both directions, fading away at each extremity, and to be between 1° and 2° wide in the middle. A moment's reflection assured me that what I saw must be part of the tail of a comet, the lower portion being obscured by haze and its nucleus being below the horizon, which was concealed by a bank of clouds. No time was lost in preparing for an accurate drawing of its position, but the mist and clouds obscured it completely within a very few minutes, before any delineation could be made. Messrs. W. G. Davis and C. W. Stevens did, however, plot from memory upon the index-map of the Uranometry a sketch of its position and form, which seemed correct to both.

Inquiries the next morning showed that the same phenomenon had been observed on the evening of February 1st, by several persons, and one assured me that he had noticed it on the evening of Saturday, January 31st. All had supposed it to be connected in some way with the burning of grass or bushes, an occurrence which is here so frequent as to attract little attention, but which caused me useless labor and inquiry on more than one occasion during the first year of my residence in this country.

In the evening the ray or streak was about 30° long, and a little brighter than on the previous night, and it had moved laterally northward. Still, a careful search, beginning immediately after sunset, failed to discover the head, or indeed any increase of brightness in the vicinity of the horizon, although the direction of the tail seemed toward the position of the sun. Careful drawings were independently made, on this and each subsequent evening during its visibility, by Mrs. Gould and Mr. C. W. Stevens: the maps Nos. 2 and 3 of the Uranometry affording an excellent means for very minute delineation.

On the 4th I saw the head for a few moments in the twilight. It scarcely seemed brighter than Encke's comet appeared under similar circumstances at its last perihelion; but it was much larger and had a coarse and undefined aspect. No nucleus was visible. There was no opportunity to discover any comparison-star, before it was lost in the mists of the horizon; but a rough position was obtained by means of the setting-circles of the equatorial. This gave, for $5^h 27^m 55^s$ of Cordoba sidereal time, R.A. $22^h 24^m 10^s$, Decl. $-31^\circ 29' 1''$. The altitude of the comet having been less than $2^\circ 42'$, no great reliance can be placed on this determination, which was moreover crude in other respects.

On February 5th, I obtained tolerably good comparisons with an undetermined star, the approximate position of which is $22^h 41^m 40^s$, $-32^\circ 27'$ for the mean equinox of 1880.0; and from that date to February 19th, there were but two evenings on which observations were not secured, the sky having been especially propitious during that period. The tail, which I think was brightest February 6th or 7th, although then not more brilliant than the Milky Way in Taurus, maintained its inordinate length of from 35° to 40° until it faded from view, which took place only five days before the head became invisible in the $11\frac{1}{4}$ inch equatorial. Indeed it was with the greatest difficulty that I was able to observe it on the 19th, when it was only to be recognized as a slight whiteness in the field, unnoticeable without special attention. No nucleus was visible at any time during the whole duration of its visibility, nor was there any definite form or even perceptible outline to

the head, excepting on one or two nights at the beginning of the series of observations. It then exhibited an elongated form, somewhat rounded at its anterior margin, and shading away to form the tail, which was but little inferior in brightness, and seemed lost from view in the telescope in consequence of its lateral expansion almost as much as by any defect of its total light. On the 20th, the comet could not be detected in the telescope, although my ephemeris was so accurate as to leave no doubt concerning its position in the field.

The positions of the comparison-stars employed on the 7th, 8th and 11th cannot be sharply determined for several months. The observations on other days give the following results which are uncorrected for parallax, or aberration.

	Cordoba M. T.			R. A.			Decl.		
	h	m	s	h	m	s	°	'	"
1880, Feb. 6,	8	37	56.3	22	58	32.9	—32	55	55.0
9,	8	47	37.8	23	50	51.4	33	45	41.7
12,	8	23	40.8	0	39	51.0	33	6	15.3
14,	8	24	49.3	1	9	21.8	32	2	48.0
15,	8	27	38.9	1	22	58.1	31	23	19.1
17,	8	37	51.8	1	47	43.9	29	54	32.5
18,	8	34	4.5	1	58	55.2	29	7	12.8
19,	9	0	26.8	2	9	34.4	—28	17	44.8

The excessive length of the narrow tail, its lack of gradation in brilliancy, and the relative faintness of the head, formed very notable characteristics. But, to my astonishment, on computing a parabola from the observations of February 6th, 9th and 12th, I found reproduced the orbit of the Great Comet of 1843. The almost incredibly small perihelion distance suggests in each case the origin of the huge tail; but the other elements were almost equally similar. A second orbit, from observations embracing the twelve days' interval from February 6th to 18th, proved equally similar to the orbit resulting from Hubbard's unsurpassed discussion of the Comet of 1843; and leaves no doubt whatever in my mind as to the identity of the two bodies, notwithstanding that an ellipse of 532 years was found to afford the best representation of the series of observations in 1843 as a whole. The elements now obtained are these: which are expressed in Washington mean time, and referred to the mean equinox of 1880.0.

T	1880, Jan. 27 ^d .40479
Ω	6° 10' 29".6
ω	86° 18' 19".0
i	144° 39' 38".8
log q	7.7393644

This result leads, however, to a yet more remarkable inference. At the time of apparition of the Comet of 1843, its identity with that of 1668 was very generally discussed and credited. Only the circumstance that Hubbard found the total

series of observations to be more satisfactorily represented by an ellipse of much longer period served to weaken this belief to any extent. Nevertheless Hubbard showed that the corresponding diminution of the major axis was compatible with a probable error of only $\pm 11''.32$ for a single observation, in place of $\pm 8''.44$ to which this value would be reduced by the adoption of his final elements. The similarity of the comet's appearance to that of 1702 also attracted attention. The orbit calculated for that comet by Struyck in Amsterdam bears no similarity to the well-determined one of the comet of 1668; but Cassini, who observed the former, believed the two to be identical. The same opinion was maintained by Cooper in 1843. The tail in 1702 was 40° long, and its path was chiefly in the southern hemisphere, both which facts favor the supposition of identity. Nevertheless, while a computation by Petersen, using for 1702 the orbit of the Comet of 1843, showed that the roughly given geocentric path might thus be somewhat roughly represented, Schumacher considered that the resultant places were compatible neither with the position of the tail March 2, 1702, as described by Maraldi, nor with the observation of the ship-captain Brouwer, cited by Struyck.

The interval between the perihelion-passages of 1668 and 1702 differs from 34 years by only a few days; that between those of 1843 and 1880 is but a month less than 37 years. If these three apparitions belong, as I am convinced, to one and the same comet, we have the singular phenomenon of a rapidly increasing period, for the interval from the perihelion of 1702 to that of 1843 is just 141 years, which gives $35\frac{1}{4}$ years for the average length of the four intermediate periods. The assumptions that the increase of the period has been systematic and that no other important perturbations have affected the times of perihelion-passage give for the successive returns to perihelion the following dates:—

1702 Feb. 23.	1771 June 6.	1843 Feb. 27.
1736 July 12.	1806 Dec. 12.	1880 Jan. 27.

The second Comet of 1806 appears to have passed its perihelion on December 28th of that year. The latest determination of its orbit is that by Hensel in 1862, the resulting inclination being essentially the same as that of the present comet. His other elements, however, are completely discordant, the form of the orbit being hyperbolic and the perihelion-distance large. It remains to be seen whether the observations could be represented by an orbit of different form and dimensions. There are other recorded apparitions which seem likely to have been returns of the same comet, such as those of the years 1533, 1468, and perhaps 1264; but I have not here the means of forming any careful opinion.

It might perhaps be supposed that no appearance of so impressive an object during the last two or three centuries could have failed to be recorded; but it does not seem so to me in the case of a comet whose orbit lies almost exclusively to the south of the ecliptic, so that it would in all probability be noticed in our northern hemisphere only in the northern winter.

The wonderfully small, and apparently diminishing perihelion-distance affords an explanation of the increasing period; for, according to the present elements, this distance is but 0·00549, while the sun's own radius is 0·00466. It seems impossible that one side of the coma should not suffer actual friction against the body of the sun, to say nothing of its traversing the densest portion of his atmosphere through a full semi-circumference. The mechanical resistance thus interposed must have acted to diminish the perihelion-distance; and we find this accordingly to have been 0·005538 after the passage of 1843, and 0·005487 after that of 1880. Yet, while this resistance and the lateral friction must during their continuance be causing a diminution of the radius-vector, it would appear that they have not diminished, but, on the contrary, increased, the major axis. This is a delicate and in some respects a difficult question; and since I have at present neither the requisite time nor books of reference at my disposal, I will not here enter into any of its details, but will confine myself to the statement that so far as I am able to form an opinion, the observed facts do not appear to conflict with theory.

A most interesting question arises regarding the densest portion of the tail. There is no reason to doubt that this pointed southward before the perihelion, as it did afterward. Now the comet's center of gravity passed from one side to the other of the sun, describing an arc of 180° in true anomaly in about $2^h 8^m$; and indeed described $141^\circ 42'$ in a single hour. If the tail in general consisted of the same particles before as after the hour of perihelion, it must have been actually severed by the body of the sun, surrendering of course a considerable amount of its material.

In conclusion, I append the dimensions and position of the tail for each night of its visibility, given by means of the declinations of the intersection of its axis with the principal meridians upon the chart, and the width at these points of intersection. They are derived from the drawings of Mr. Stevens, and confirmed by the absolutely independent and accordant ones of Mrs. Gould. The positions of the head are as measured from these drawings, made upon map 2 of the *Uranometria Argentina*, without any reference to the ephemeris; but the ephemeris from the elements already given accompanies them.

The observed length of the tail depended, to a considerable degree, upon the clearness of the night.

Ephemeris for Washington mean Noon and mean Equinox
1880.0.

1880.	R. A.	Decl. S.	log Δ.	log r.
	^h ^m ^s			
Feb. 2	21 47 33	28 57 27	9.868303	9.533186
4	22 19 9	31 10 55	9.847750	9.622916
6	22 52 59	32 45 2	9.835007	9.691392
8	23 27 52	33 36 1	9.829783	9.746770
10	0 2 18	33 43 58	9.831555	9.793264
12	0 35 0	33 13 55	9.839451	9.833330
14	1 4 59	32 14 12	9.852389	9.868533
16	1 31 48	30 54 13	9.869191	9.899922
18	1 55 27	29 22 31	9.888754	9.928246
20	2 16 6	27 45 47	9.910133	9.954049
22	2 34 8	26 8 41	9.932570	9.977744
24	2 49 53	24 34 13	9.955492	9.999648
26	3 3 42	23 4 7	9.978483	0.020014
28	3 15 56	21 39 14	0.001251	0.039043

Positions as measured from the drawings.

Date 1880.	Feb. 2.	Feb. 3.	Feb. 4.	Feb. 5.	Feb. 6.	Feb. 7.
Cordoba M. T.	8 ^h 20 ^m	8 ^h 20 ^m	8 ^h 35 ^m	8 ^h 30 ^m	8 ^h 35 ^m	8 ^h 35 ^m
Head R. A.			22 ^h 24 ^m	22 ^h 40 ^m	22 ^h 59 ^m	23 ^h 17 ^m
S. Decl.			31°20'	32° 0'	32°50'	33°25'
End R. A.	23 ^h 36 ^m	0 ^h 40 ^m	1 ^h 16 ^m	1 ^h 50 ^m	2 ^h 20 ^m	2 ^h 32 ^m
S. Decl.	57° 0'	60° 0'	57°40'	55°40'	52°40'	49°30'
Length seen	18°	30°	40½°	42½°	41½°	40½°
At 22 ^h 40 ^m	S. Decl.	43°45'	38°20'	35° 0'	32°45'	
	Width	1°40'	1° 0'	0°36'	0°15'	
At 23 ^h 0 ^m	S. Decl.	39°30'	42°40'	38°45'	35°43'	33°20'
	Width	1°45'	1°40'	1°20'	0°45'	0°15'
At 23 ^h 20 ^m	S. Decl.	54°10'	46°50'	41°48'	38°45'	36°40'
	Width	1°40'	1°40'	1°40'	1°38'	0°50'
At 23 ^h 40 ^m	S. Decl.		50°50'	45°50'	41°45'	39°17'
	Width		1°40'	2° 0'	1°42'	1°35'
At 0 ^h 0 ^m	S. Decl.		54°25'	49°10'	44°35'	41°15'
	Width		1°40'	2° 0'	1°50'	1°40'
At 0 ^h 20 ^m	S. Decl.		56°55'	51°55'	46°55'	43°35'
	Width		2° 0'	2° 0'	2° 0'	1°50'
At 0 ^h 40 ^m	S. Decl.		60° 0'	54°20'	49°30'	45° 3'
	Width		2° 0'	2° 0'	2° 0'	1°50'
At 1 ^h 0 ^m	S. Decl.			56°35'	51°35'	46°55'
	Width			2° 0'	2° 5'	2° 0'
At 1 ^h 20 ^m	S. Decl.				53°20'	48°45'
	Width				2°10'	2°10'
At 1 ^h 40 ^m	S. Decl.				55° 0'	50° 3'
	Width				2°10'	2° 0'
At 2 ^h 0 ^m	S. Decl.					51°50'
	Width					2°10'
At 2 ^h 20 ^m	S. Decl.					52°40'
	Width					2° 0'

Date 1880. Cordoba M. T.		Feb. 8. 8 ^h 40 ^m	Feb. 9. 8 ^h 50 ^m	Feb. 11. 8 ^h 25 ^m	Feb. 12. 8 ^h 35 ^m	Feb. 14. 8 ^h 50 ^m
Head R. A.		23 ^h 32 ^m	23 ^h 43 ^m	0 ^h 23 ^m	0 ^h 40 ^m	1 ^h 7 ^m
S. Decl.		33°41'	33°50'	33°45'	33° 5'	32° 6'
End R. A.		2 ^h 45 ^m	2 ^h 53 ^m	3 ^h 12 ^m	3 ^h 32 ^m	3 ^h 50 ^m
S. Decl.		47°25'	45° 0'	40°50'	38°35'	36° 0'
Length seen		39½°	39½°	35°	34½°	34°
At 23 ^h 40 ^m	S. Decl.	34°40'				
	Width	0°15'				
At 0 ^h 0 ^m	S. Decl.	36°50'	35° 2'			
	Width	0°40'	0°15'			
At 0 ^h 20 ^m	S. Decl.	38°45'	36°42'			
	Width	0°45'	0°25'			
At 0 ^h 40 ^m	S. Decl.	40° 3'	38° 0'	35° 2'	33° 5'	
	Width	0°50'	0°40'	0°12'	0° 0'	
At 1 ^h 0 ^m	S. Decl.	42° 0'	39°40'	36°55'	34°25'	
	Width	1° 5'	0°50'	0°10'	0°10'	
At 1 ^h 20 ^m	S. Decl.	43°20'	40°30'	37°40'	35°25'	32°35'
	Width	1°30'	1°10'	0°20'	0°15'	0° 5'
At 1 ^h 40 ^m	S. Decl.	44°35'	41°35'	38°35'	36°20'	33°20'
	Width	1°50'	1°20'	0°35'	0°13'	0° 5'
At 2 ^h 0 ^m	S. Decl.	45°25'	42°30'	39°15'	37°25'	34°10'
	Width	1°50'	1°40'	0°40'	0°20'	0°10'
At 2 ^h 20 ^m	S. Decl.	46°10'	43°50'	40°10'	37°50'	34°35'
	Width	1°40'	1°40'	0°50'	0°15'	0°15'
At 2 ^h 40 ^m	S. Decl.	47° 0'	44°15'	40°25'	38°10'	35° 0'
	Width	1°30'	1°25'	0°40'	0°15'	0°10'
At 3 ^h 0 ^m	S. Decl.			40°20'	38°25'	35°20'
	Width			0°30'	0°10'	0° 5'
At 3 ^h 20 ^m	S. Decl.				38°45'	35°40'
	Width				0°10'	—
At 3 ^h 40 ^m	S. Decl.					36°10'
	Width					—

Cordoba, March 3, 1880.