NOTES ON THE GREAT METEORIC STREAM OF 1913, FEBRUARY 9TH

SEEN IN CANADA AND THE UNITED STATES

By W. F. Denning

PROFESSOR CHANT, in the Journal of the Royal Astronomical Society of Canada, for May–June, 1913, has given us an extremely interesting and valuable paper on the extraordinary flight of meteors witnessed across Canada and the United States on February 9, 1913. That meteoric exhibition seems to have been unparalleled in two respects *viz.*:—(1) Its multiple nature, consisting as it did, of a long procession of meteors. (2) The great length of its observed luminous flight extending over more than one-tenth of the earth's circumference.

I have been in the habit of watching the heavens since 1865 and have never noticed anything similar. There are meteors occasionally seen with multiple, crumbling heads and broad spark trains, but the wonderful stream of successive meteors seen on February 9 seems, like Saturn's rings, without a parallel.

Professor Chant has made some useful deductions concerning the real course of the meteoric stream, and of its height as it passed between the eastern border of Lake Huron and Buffalo, but the data, upon which he necessarily had to rely, are rather contradictory, and absolutely accurate results cannot be obtained from them. I have partially gone over the work again, and the results obtained exhibit a good general agreement with those derived by Professor Chant. I am, however, disposed to give the objects a rather greater elevation than that assigned by him. Taking the whole of the estimates of the altitude, I should ascribe a height of about 38 miles as the meteors passed over the region near Toronto. There are a few significant observations indicating the lower elevation mentioned by Professor Chant,

but there are also a great number supporting the conclusion that the objects were decidedly more than 30 miles high. Several reasons support this, *viz.*: — (1) The great improbability that the stream could have prolonged its flight so far in a fairly dense region of air only 26 miles above the earth's surface. (2) The red or yellow, slow meteors, moving in horizontal flights, are usually more than 30 miles high, and generally between 56 and 40 miles. In cases of very slow fireballs, falling at a slight angle towards the earth, they frequently penetrate deeper, collapsing between 32 and 26 miles, and rarely go farther. I have computed the heights of a considerable number of meteors, moving in long horizontal paths and they have almost invariably been more than 40 miles above the earth's surface. The objects seen in February last may, however, have been abnormal in their elevation as well as in their distribution.

The data are of such a character that everyone studying them may derive a different result according to his interpretation of the records. The following remarks are, therefore, merely intended as independent views, and are in no sense offered in the light of criticism.

The mean height of the objects from many observations in the region between longitude 82° and 78° West was 38 miles. Some of the components seemed higher than others, and ranged, perhaps, up to 44 miles. But the observed differences in the apparent altitude of the meteors may have been possibly induced by considerable width in the stream rather than by actual differences in height of the particles.

The velocity was about 8 miles per second. The motion of the meteors was direct like that of the planets, and comets of short period.

If we adopt three minutes as the period occupied by the whole stream in passing a given spot, its length must have been 1440 miles. The earth was running away from the meteors at the rate of about 18 miles per second.

The observed path of the stream extended over 2,600 miles from N.W. of Mortlach, Saskatchewan, to E. of Bermuda.

The position of the "trace" or track over which the meteors passed is, no doubt, well placed by Professor Chant. The writer would be inclined to locate it two or three miles south of the line adopted, but there are uncertainties due to the conflicting evidence, and the positions shown in Professor Chant's maps, probably represent the best deduction that can be made.

The stream must have had a curved flight, fairly concentric with the earth's surface. Had it been travelling in a straight horizontal line without any curve or deflection, and 38 miles high near Toronto — it would have had a height of 250 miles at the beginning and end of its observed luminous flight owing to the earth's curvature. Of course it could not travel in any such straight line owing to air resistance and gravitation. There is no well attested case of a meteor ever having been seen at anything approaching the latter elevation and it is probably far outside even the rarer limits of our atmosphere.

The stream seems to have consisted of from ten to twenty groups, or meteors with fragments in the form of spark trails, including in all several hundreds of particles. The larger ones were probably traced over 180 miles by individual observers, and the duration was 23 seconds.

Had the stream met the earth in her orbit and moved east to west the velocity would have been about 44 miles per second, and the interval occupied in passing a given point 33 seconds. The motion at the end does not appear to have been very different to that remarked at the beginning. Judging from the aspect of the swarm as viewed from Bermuda it was not nearing exhaustion, but apparently quite capable of a further 1,000 miles or more flight across the North Atlantic Ocean.

It is probable that the stream may have developed from one mass originally, and that it was formed by one of the largest bodies of the kind we have ever encountered. The disintegration of meteors is a well attested fact of observation. The meteoric stones of L'Aigle, April 26, 1903, numbered two or three thousand, and their fall was distributed over an ellipse, of which the larger axis was 6·2 miles and the smaller 2·5 miles.

The meteorite of May 12, 1861, at Batnera, descended in fragments which were picked up several miles asunder, and they fitted precisely.

In any case the vanguard of the meteors of February 9 must have been of enormous size to have sailed with astonishing brilliancy, and retained their compact form, along a curved path of some 2,600 miles. Even after this extensive flight, Col. Winter, at Bermuda, where the last observation was made, says its diameter was equal to that of the moon. The testimony of various observers was that the chief bodies were subject to explosions scattering fiery sparks behind them in long trains. There was evidently a great expenditure of material going on along the whole line. The low velocity would certainly cause a vastly slower rate of combustion than that of meteors which dash into our atmosphere like the Leonids at 44 miles per second and acquire a white heat, destroying them instantly.

These meteors were red or yellowish-red and their color sufficiently showed the very moderate rate of combustion. It is generally the case that the apparently slow meteors overtaking the earth, and moving in nearly horizontal flights, last a long time, and travel over very lengthy paths. I found a path of 611 miles for the meteor of August 21, 1902, and a path of 590 miles for that of February 19, 1911, and they were probably much longer. The small area of England is not suitable for the determination of these long flights.

At Pense, the second station from whence the meteors of February 9 last were observed, the phenomena were described as a "procession of stars" lasting about two minutes.

At Bermuda, where the final view was obtained, Col. Winter estimated that the meteors occupied two minutes in passing a given spot, so that their enormously lengthy flight had certainly not extended the stream. This string of newly-made terrestrial satellites maintained the same relative distances from each other, without any lagging behind of the tail, even after encountering all the vicissitudes involved in a journey of one-tenth the distance around the earth. The times occupied in their passing

were not very exactly recorded, but no material lengthening out could have occurred. Probably the meteors existed in nearly the same distribution before their immersion, and combustion in our atmosphere. The resistance of the air, and terrestrial attraction, would seem to have counteracted the effects of the earth's curvature, and to have kept the stream well in tow, at a pretty equable height.

The tail end of the stream certainly did not consist of the same objects all along the flight, but was formed of burning fragments peeling off from the leading meteors. At Toronto, Mr. H. D. Ashley says that the last four meteors were extremely dim, and that two of them, observed to rise in the north-west, became invisible before passing over. Several of the larger meteors of the group doubtless existed all along the observed flight, while the smaller, scattered particles at the end were reinforced by luminous debris from the leaders in numbers sufficient to compensate for disappearances.

The reports from Fort William, Richard's Landing and Bermuda give evidence that the height was 60 to 80 miles when passing near these places. At Thamesville the swarm was seen below Cassiopeia and the polar star. The distance between these is about 28 degrees and taking 42½° as the altitude of Polaris, and that the meteors as shown in the sketch were as much as 12 degrees less, the resulting height must be 64 miles, the distance being 107 miles to the point on the earth underneath the meteors, and the altitude 30°. If we infer very considerable error in the proportions of the sketch and decrease the elevation to 25° we get a height of 51 miles, which seems probable.

As seen from Sudbury, about 190 miles north of the place under the southern point of the meteors' flight, they must have been quite 40 miles high, for there was a hill between the observers and the meteors which probably cut off fully 10° from the horizon.

At Winchester, some 5½° east and 1¼° south of Sudbury, the distance was 221 miles, and the altitude said to reach 15°. Taking the altitude as only 10° the height would be 45 miles.

There is decided evidence that the meteors were higher in the air, in the earlier and later part of their visible display, than in the middle section of their flight but not very considerably so.

In deriving the mean height near the middle part of the stream, (Toronto region), I deducted one-third of the estimated altitudes. In some cases this may not be sufficient, for there is a general propensity to overstate the elevation. But in other instances it is certainly taking off too much, for the given altitude is probably just about correct, and there are several descriptions where the estimate is obviously too high!

I believe that reducing altitudes by one-half the estimated values is too great. The difference between 45° and 23° is enormous, and few observers of ordinary intelligence, and exercising a little care, could make such an error. If a number of people are asked to give the altitude of an object 30° high, they will often say 45° — but 23° is so obviously nearer the horizon than the zenith, that very few estimate it as midway.

At Caledon East special weight has been given to the statement that "the meteors went over, or nearly over, the belt of Orion." They may, however, very likely have passed above it, and some of them certainly did, for they were at different altitudes.

There were two observers at Bolton, a little farther from the meteors than the Caledon one, and the independent estimates of altitude are: — "Some of them died out just as they passed over, though they were not directly over me, but a little to the south-west." "They appeared in the western sky about four-fifths of the way up from the horizon."

At Jackson, further west, but at nearly a similar distance from the meteors they were said to have passed nearly over head, but a little to the south-east. These statements indicate a path far above the belt of Orion even allowing for excessive estimates.

At Parry Sound Mr. W. L. Haight and a companion fixed the elevation as 35° to 38° after going back and determining its position from their point of view. Taking the altitude as really only 22° the resulting height will be 51 miles.

On page 157 of the article in the JOURNAL, Professor Chant gives nine values for the height, with a mean of 33·8 miles, after deducting half the estimated altitudes. I find that on computing from the same data, and correcting for earth's curvature, the mean comes out 35·8 miles, and I cannot explain the discrepancy. If one-third instead of one-half of the altitudes is deducted, the mean height is 51 miles, which certainly appears too great.

With regard to the thunder-like detonations, it is to be feared that endeavors to deduce the height from the time intervals elapsing between the appearance of the meteors and the reports, cannot lead to very certain or exact conclusions. The velocity of sound in ordinary air at 32° Fahr. is 1,088 feet per second or 12½ miles per minute, but we do not know accurately the velocity in the upper, colder and rarer regions of the atmosphere. We know that sound travels slower at low temperatures, and that loud explosions travel faster than faint ones. If computed on the basis of temperature at the earth's surface, the distance and heights of meteors determined from the noise of their bursting would be much too small.

At Mount Hamilton, California, a detonating fireball was very accurately observed in 1894, (July 27), and it was concluded that the sound was transmitted through an air medium with a mean temperature of — 193° Fahr. and sound velocity of 800 feet per second. The meteor exploded at height of 28 miles. The distance from Mount Hamilton was 59·25 miles and the noise occupied 390·7 seconds in reaching the observatory.

Mr. John Butterfield, at Toronto, heard the rumbling or thunder-like sound at $9^h\ 12^m$ on February 9, or seven minutes after the big leader of the meteor swarm had passed. If it was 38 miles high the observers distance from it was 47 miles. From the experiments made and knowledge gained, with regard to the decrease of temperature relatively to height it appears probable that the velocity of sound would not be more than 640 feet per second for a mean height of 19 miles which would give a distance of 51 miles — nearly agreeing with that observed by Mr. Butterfield. The data upon which these conclusions are based

cannot, however, be said to afford anything more than a rough approximation to the truth.

The radiant point of the meteors is uncertain. We know the direction of flight in azimuth, when the meteors were first seen from Mortlach and Pense, but do not know the inclination at which they were descending. If they were moving horizontally even at that probably very early period of their display, the point about 328°, + 9° — a few degrees east of ϵ Pegasi, was on the horizon in the direction 15° north of west indicated by the "trace" given by Professor Chant. If the meteors were in view before coming within range of the observer at Mortlach, it is certainly strange that there are no records from westerly towns in Alberta and British Columbia.

I draw the inference that the meteors first became visibly luminous in the region of Mortlach, Saskatchewan. As seen there, if they were falling a little towards the earth, the radiant must have been in the western region of the Square of Pegasus. I saw a meteor with extremely slow motion and a yellow train directed from this point on February 8 last, about 30 hours before the great display, and the fact has some interest as suggesting that there was certainly a meteoric shower in Pegasus at the time. But I can find no mention in former records of such a shower or of any fireballs from this quarter in the second week in February. The region sets soon after the sun.

Meteoric astronomy has, however, been sadly neglected in the past, and there are comparatively few accurate data available for reference. Of the myriads of fireballs which are annually displayed in the earth's atmosphere, not more than about a score are well observed and properly investigated.

There are probably more than a million meteors brighter than Venus appearing every year in the night skies of various parts of the world. If but twenty of these are subject to proper study we may form some conception as to the very few drops we gather of the great and continuous storm of meteoric fireballs.

February is becoming a notable month for abnormal meteors. Though August brings us its abundant Perseids, and November

its occasional brilliant showers of Leonids, February seems in recent years to have provided marvellous fireballs of a unique pattern, and quite unmatched in the history of meteoric astronomy. On February 8, 1894, there was a great daylight fireball, appearing in the sunshine soon after noon. On February 22, 1909, a fireball left a streak several hundreds of miles long which remained visible two hours, and drifted about 236 miles to the north-west over the English Channel and south-west of England.

Could photography have been applied and furnished a number of views of its path-position, the wonderful planetary swarm of February 9th last might have taught us some new and important facts. Its visit has certainly provided us with a great novelty among the transient phenomena of our skies. We must evidently be prepared to view the incursion of a strange object into the firmament at any time. The various forms of meteoric apparition are so extremely diversified that past researches have not nearly exhausted them. Observers are practically nonplussed by the surprise visits of remarkable meteors, and they ought to be better prepared and more alert, if they would improve upon the very defective observations made of past phenomena. The unique object of last February will direct a useful attention to the subject, and if it leads up to the making of but one new observer it will not have come in vain.

BRISTOL, ENGLAND,
September, 1913.

REMARKS ON MR. DENNING'S PAPER

The chief discrepancy between Mr. Denning's conclusions and my own is in the height of the meteors when passing Toronto.

In obtaining my result I used only observations on which I thought I had especial reason to depend. Mr. Hahn, who supplied the drawing for the frontispiece, besides being an artist is an amateur astronomer. He is the son of the late Otto Hahn, of Toronto, who possessed a large and valuable collection of

meteorites. Mr. Hahn's observation was closely corroborated by Messrs. Herman and Marsh, while four others, whose estimates appeared to be especially trustworthy, indicated a height not much greater.

In some of the other cases I had correspondence regarding the altitude, and I found the observer so often in doubt as to the value to be assigned that I decided to depend almost entirely on those few observations which appeared definite and certain.

As to the values in the table on page 157, I may say that in calculating them no account was taken of the earth's curvature. I thought them hardly deserving such refinement, but as the correction for curvature is always additive it would have been wiser to have allowed for it.

Mr. Denning, however, has had such a long and active experience in handling meteoric observations that his interpretation of the evidence is particularly valuable.

C. A. CHANT.