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## VISUAL OBSERVATIONS OF HALLEY'S COMET IN 1910

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Considering its great brightness, and the extraordinary phenomena presented by other comets of recent years which at most only attained the faintest naked-eye visibility, Halley's comet at its return in 1910, though a brilliant and interesting object to the naked eye—especially in the month of May—was, nevertheless, a disappointment when considered from a photographic standpoint. It is safe to say that it did not give us any new information concerning these strange bodies. Photographically, its light was relatively slow in its action on the sensitive plate, and there were few or none of the remarkable phenomena shown by Brooks's comet of 1893, which was faintly visible to the naked eye for about one day, and by Morehouse's comet of 1908, which just attained naked-eye visibility for a couple of days. Had it not been for the previous comets, however, the numerous photographs obtained of it would have put Halley's comet in the first rank among the records of these bodies. While it lacked much in interest as seen with the eye of the sensitive plate, to the human eye it left a lasting impression which, added to its long life-history of more than two thousand years, made it, at its return of 1910, perhaps the most interesting comet of history. The apparent length of its tail when nearest the

earth ( $120^\circ$  or more) was probably the greatest on record,<sup>1</sup> though the actual length was much exceeded by many previous comets. As seen from this observatory it was visible to the naked eye from April 29 to June 11, which was not an excessive duration of visibility. With the 40-inch telescope its visual appearance extended from September 15, 1909, to May 23, 1911, which, though a long period, has been exceeded by several comets that never attained naked-eye visibility.

#### HALLEY'S COMET FROM A POPULAR POINT OF VIEW

In this place it may be well to say a word or two on the popular side of this return of Halley's comet.

It is unfortunate that the newspapers and the general public were so greatly disappointed in the comet—unfortunate from the fact that the general impression left by such reports would be exceedingly misleading when comparing the present return with descriptions of its appearance in earlier times. It was unfortunate, also, from the further fact that even astronomers sometimes have a sentimental side. It would have been a gratification to know that everyone who saw this wonderful object saw it with the same spirit of elation and wonder—one would almost say veneration—with which the average astronomer regarded it. This was, at least, the feeling of the present writer when he looked at this beautiful and mysterious object stretching its wonderful stream of light across the sky.

The great cities that have grown up since 1835, and the smoke and electric lights of today completely robbed the comet of its glory when seen by dwellers in and near the centers of population. The newspapers had excited the public pulse to a high pitch by glowing and sensational accounts of what the comet would do and what it would look like, and had thus raised expectation beyond all reason. When these expectations failed, purely because of local

<sup>1</sup> According to Ellery, comet I 1865, for several days in January, had a tail 150 degrees long (*Monthly Notices*, 25, 220). I find, however, that this great length is simply a printer's error of 150 degrees for 15 degrees. See a note by Ellery in *Astronomische Nachrichten*, 64, 219 (same date as the one in *Monthly Notices*), where he gives the length as 15 or 16 degrees. This smaller length is verified by other southern observers.

conditions, it was not possible for them to pile enough contumely upon the comet and upon the heads of those who had made no prediction whatever as to what the comet might really look like. Were such records as these the only ones to depend upon for comparison at future returns, it would indeed be unfortunate. In reality, to those who under favorable conditions saw the comet at its best at the return of 1910, and who would have been justified in making any prediction, it far exceeded the most sanguine expectations in the remarkable display it presented to us.

There was one fact which was brought forth by the comet with startling vividness. It showed that the superstitious terror formerly attending the appearance of a great comet is by no means dead in the human breast. Cases of this kind developed all over this country and abroad—from the stopping-up of keyholes and cracks in doors and windows in Chicago (according to the daily papers) to keep out the deadly comet gases, to the manufacture and sale, among the negroes of the South, of “comet pills,” which were supposed to ward off the evil effects of the comet.

The “comet gas” scare seemed to be directly due to the incautious and unwarranted statements of one or two men of science who had painted in rather vivid language the direful effects of breathing the deadly cyanogen gas, which had been shown to exist in the tails of some comets.

Such being the case in our present enlightened day, it is easy to understand how terrifying the comet must have been in former times, even if its display then was no more striking than in 1910. In the calm of the spring night, at a time when one is easily impressed with a mystery that is not present in the day, the comet, with its weird streamer of light reaching far into space, was well fitted either to impress or to terrify the observer, just as his mental temperament might suggest. In the Dark Ages, when the mission of these dread bodies was unknown, and when everything in nature seemed to possess a spirit for good or evil—and mostly for evil—there is little wonder that the unheralded advent of a great comet should inspire, at the least, an uneasiness in the minds of those who saw it. The writer was strongly imbued with this thought on several nights while observing Halley's comet when in its most

impressive stage, and it would not have taken much imagination to have endowed it with a guiding spirit. With the enlightenment of today, however, one could see nothing in it that would disquiet or terrify, but rather that which raised a sense of extreme pleasure and wonder at the magnificent mystery it presented.

#### POSSIBLE ENCOUNTER OF THE EARTH WITH THE TAIL OF THE COMET

In connection with this account of Halley's comet and its near approach to the earth, it may be appropriate to add some remarks on the probable encounter of the earth with a portion of the tail at, or closely following, the time the comet transited the sun. Indeed, it seems more than probable that the earth actually did encounter one of the branches of the tail—the southern branch—on, or about, May 18 or 19, and more probably on the later date. There is also a suspicion that the influence of this encounter (if such there was) on our atmosphere was apparent for months afterward.

The double tail seen here on the nights of May 17 and 18, the lower, and probably larger branch of which widened toward the southeast horizon, involved the ecliptic, as will be seen by the diagram on p. 389, and without doubt extended beyond the earth. There are strong chances that the earth passed through this part of the tail about May 19. That the tail was long enough to reach to the earth is shown by the fact that as late as May 25 its length ( $54^\circ$ ) was over 30 million miles, or twice the distance of the comet at its nearest approach to us on May 18.

With the exception of a sketch by Miss Mary Proctor in New York City and a newspaper account by Professor D. P. Todd of Amherst (whose observation seemed to refer to May 16), I have seen no reference from northern observers to the second, fainter and broader tail shown in my drawings of May 17 and 18 south of the bright beam and separated from it by a distinct dark space perhaps 10 degrees wide. In Plate X I have tried to show as accurately as possible the appearance of the tails and their exact location among the stars on these two dates. The head of the comet was, of course, invisible below the horizon. This feature (the broad, faint, southern tail) seems to have been generally overlooked by observers in the Northern Hemisphere. It is, how-

ever, well shown in drawings made in South Africa by Innes and others at the Transvaal Observatory (now the Union Observatory). See *Circulars* 3 and 11 of that observatory. It is also shown in a drawing made by Dr. Frank C. Cook, United States Navy, at Bahia Blanca, Argentine Republic, on May 19, 1910, at 5 A.M. In the South African sketches the south tail is generally shown fainter and very much broader, which agrees with my drawings. In my drawings the north edge of the south branch is well determined, but the south edge of it is evidently lost in the zodiacal light, which fills out the space to the southeast horizon.

Professor C. D. Perrine, at Cordoba, Argentine Republic, calls attention to and describes this second and broader tail (*Astronomical Journal*, 26, 145).

One would have expected considerable parallax in portions of the tail on May 17 and 18. A comparison of the South African drawings with mine, however, does not show any parallax, at least none greater than the uncertainty of the drawings themselves.

During the first part of the night of May 18, as will be seen by the notes, the sky was normal. It is probable that the slight mistiness mentioned on that date was in no way connected with the presence of the comet. The slight aurora, also, was nothing out of the ordinary, and certainly had nothing to do with the comet. In the latter part of the night, when the moon had set, the sky seemed to be free from any decided mistiness to the north of the comet's tail. At the same time the southern and fainter branch seemed to spread its effect over the southeast horizon, but there was nothing especially suggestive in its appearance.

The forenoon of May 19, however, developed peculiarities that were very suggestive (*Astronomische Nachrichten*, 185, 229, 1910). Briefly, these consisted of a peculiar iridescence and unnatural appearance of the clouds near the sun and of a bar of prismatic light on the clouds in the south. This, combined with the general effect of the sky and clouds—for the entire sky had a most unnatural and wild look—would have attracted marked attention at any other time than when one was looking for something out of the ordinary. The sky had been watched carefully during the forenoon of this date but nothing unusual had appeared until close to noon, when the

conditions became abnormal, as stated above. Of course this unusual phenomenon, if seen only at one place, might be considered a coincidence, but something similar was reported on that date at other widely distant places. (See *Transvaal Observatory Circular*, No. 3, p. 19)

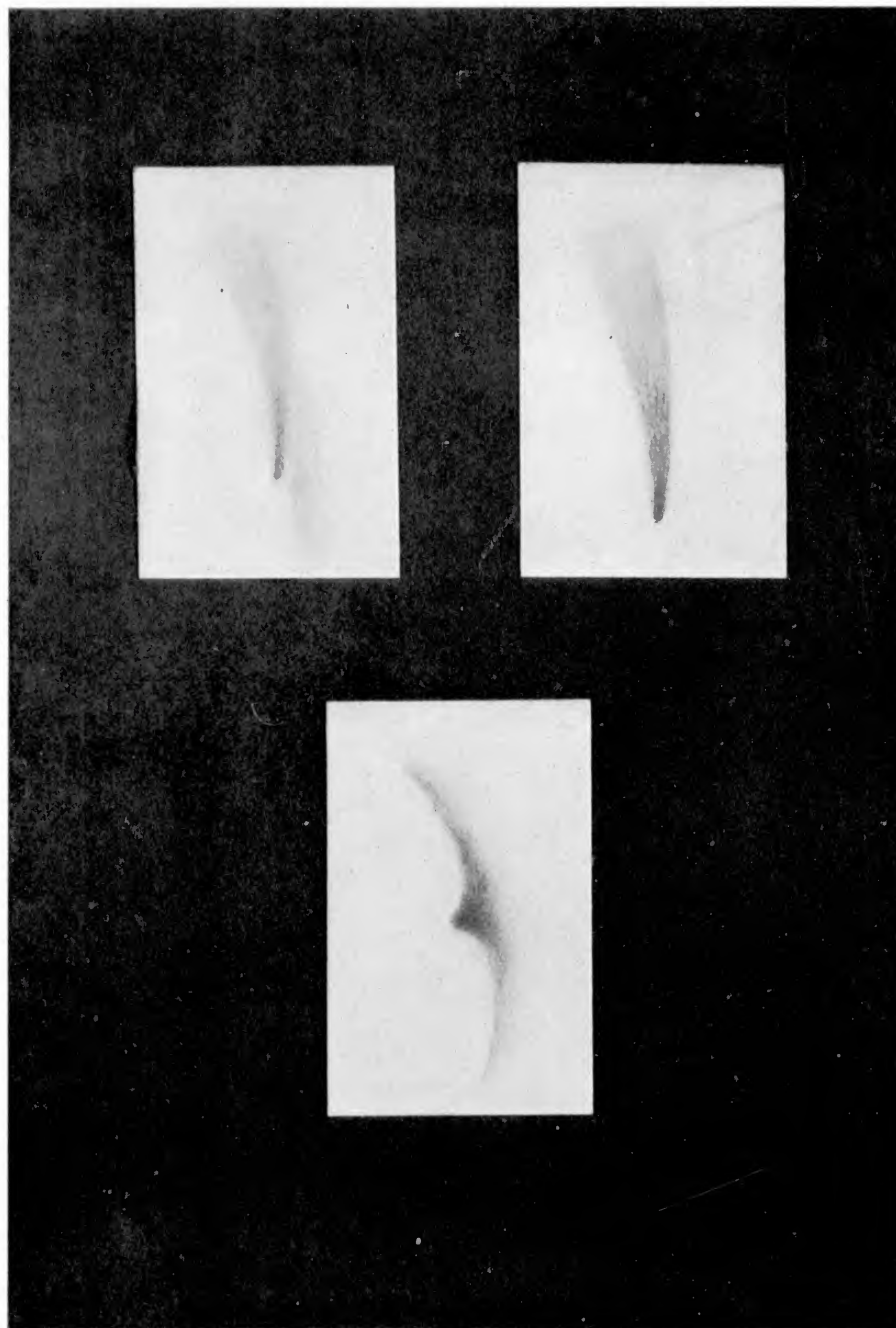
The most suggestive phenomenon, however, was apparent later on, in June and for at least a year afterward. It was first noticed here on the night of June 7, 1910, and consisted of slowly moving strips and masses of self-luminous haze which were not confined to any one part of the sky. I have given an account of these singular features in the *Proceedings of the American Philosophical Society* for May-June 1911. It is true that these peculiarities might in some way have been of auroral origin, but this I do not think is probable, for they do not seem to resemble in any way, either in position or in appearance, any auroral phenomena with which I am familiar. Apparently nothing of the kind has again been visible here since September of 1911. At the same time it is also true that a similar absence of essentially all auroral effects has been very marked here, during the same period. This luminous haze had not been noticed by me in past years previous to 1910—especially in those years in which I was almost constantly out at night comet-seeking.

I would be more disposed to believe that this phenomenon of luminous haze had some connection with the near approach of Halley's comet to the earth were it not for the fact that apparently a similar phenomenon was recorded by Mr. Backhouse at Sunderland, England, through many years (see *Publications of West Hendon House Observatory*, No. 2, p. 109, 1902). Mr. Backhouse's descriptions show that the phenomena seen by him were perhaps of a similar nature to those seen here in the fall of 1910. It is probable, therefore, that this luminous haze was in no way connected with the close approach to us of the tail of Halley's comet. Nevertheless, a record should be made here of the phenomenon for the benefit of posterity. These observations by Mr. Backhouse were not known to me when my paper was prepared for the Philosophical Society.

#### THE COMET WITH THE LARGE TELESCOPE

Observations of the physical appearance might have been very interesting if it had been possible to follow the comet closely with

PLATE VII



DRAWINGS OF NUCLEUS AND APPENDAGES  
Upper figures, May 3; lower figure, May 4

the large telescope. It was necessary, however, for it to have attained a considerable altitude before it could be seen with that instrument. As it was, the comet could be observed with the large telescope only after dawn, when the nucleus and its brighter appendages alone could be seen. The smallness of the field (5'.5) and the great power of the telescope would have militated much against its successful use. From the clouded condition of the sky very few observations could be made during the morning visibility in April and May of 1910. A few rather unsatisfactory views were had, mainly when observing the comet for position later, in the last of May and in June. The most interesting observations, however, were obtained on the mornings of May 4 and 5, when the comet was watched in the coming daylight as it faded from view.

On May 3 (astronomical date), after the exposures with the Bruce telescope, the comet was observed with the 40-inch. Its aspect in the large instrument was rather singular. At first there were two wings to the nucleus, the southern of which was the brighter. The northern one, indeed, was so much fainter that it gave the nucleus and its appendages a very unsymmetrical appearance. Daylight soon blotted out the northern wing, leaving the nucleus with the southern one alone visible. It then very greatly resembled the naked-eye appearance of a great comet, with nucleus and tail. The accompanying sketches show the nucleus and wings as seen in the 40-inch telescope just before dawn obliterated the northern wing, and at 16<sup>h</sup>20<sup>m</sup> when only the southern wing and nucleus were visible (upper two sketches of Plate VII).

On May 4 at 16<sup>h</sup>15<sup>m</sup>, with the 40-inch telescope the nucleus and its appendages were more symmetrical. While on May 3 the matter was nearly all on the southern side of the nucleus, it was evenly distributed on May 4 (see lower sketch of Plate VII).

#### VELOCITY OF THE PARTICLES OF THE TAIL

Of the physical phenomena presented by the comet, the most interesting was shown on June 6, 1910. On that date a long receding mass appeared in the tail. This seemed to be a disconnected streamer. From photographs made here with the Bruce telescope, at Honolulu by Mr. Ellerman, and at Beirut, Syria, by Mr. Joy, the writer obtained the results shown in Table I for the

motion of the object and hence, also, for the motion of the particles forming the tail (*A.N.*, 186, 11, 1910). At this time the recession of the comet's head from the sun was 16.6 miles (26.7 km) per second.

TABLE I

| STATION               | INTERVAL          | HOURLY MOTION | RECESSION PER SECOND |      |          |      |
|-----------------------|-------------------|---------------|----------------------|------|----------|------|
|                       |                   |               | From Comet           |      | From Sun |      |
|                       |                   |               | Miles                | Km   | Miles    | Km   |
| Y.O.-Honolulu . . . . | 4 <sup>h</sup> 25 | 3.60          | 23.1                 | 37.2 | 39.7     | 63.9 |
| Y.O.-Beirut . . . . . | 15.15             | 5.17          | 33.1                 | 53.3 | 49.7     | 80.0 |
| Honolulu-Beirut . . . | 10.90             | 5.78          | 37.3                 | 59.7 | 53.9     | 86.4 |

These results show a decided acceleration in the motion of the mass, which in the last two photographs amounted to an increase of 14 miles, or 22 km, per second. It should have been stated, however, that some uncertainty exists in the results owing to the possible change in the form of the mass. In all cases the end nearest the comet's head was measured, but this end itself may have shortened by dissipation of its material, and thus produced an apparent motion larger than the real one.

I have combined these three photographs (in the negative form) in Plate VIII. They are herewith presented so that the reader may judge for himself of the probability of any change in the actual form of the end of the mass.

Plate IX is a reproduction of the photograph of May 4. Attention has been called in the notes to the fact that heavy smoke from the power-house was drifting over the comet throughout the exposure of this plate, and that in effect it must have cut down the actual exposure-time by one-half. From this cause the full width of the tail is perhaps not shown.

It was unfortunate that May 4 and 5, the only two good mornings on which the whole comet was visible, were both spoiled by the smoke from the power-house that was driven south, directly over the comet, by a heavy north wind.

The tail of the comet on May 29 (Plate XI) shows considerable structure, which is more or less lost in the reproduction.

PLATE VIII



Yerkes: June 6, 15<sup>h</sup>8 G.M.T.

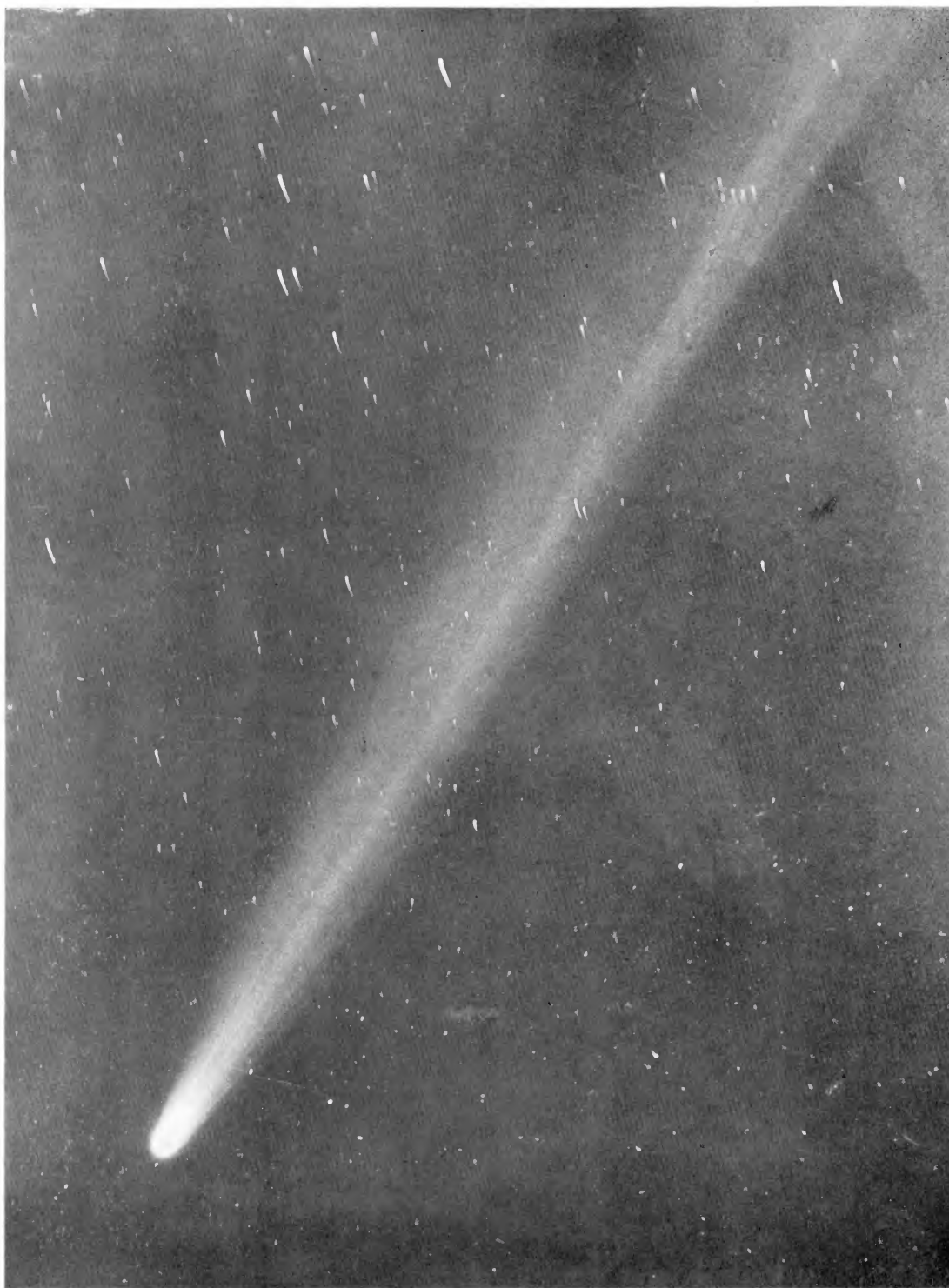
Honolulu: June 6, 18<sup>h</sup>5 G.M.T.

Beirut: June 7, 7<sup>h</sup>0 G.M.T.

DISCARDED TAIL RECEDING FROM HALLEY'S COMET

PLATE IX

North



10-inch Lens. May 4, 21<sup>h</sup> 2<sup>m</sup> G.M.T. Exposure 40<sup>m</sup>  
Scale: 1 cm = 0°.41

Thanks are due to Mr. Leon Barritt, editor of the *Evening Sky Map*, for the loan of the half-tone block made from my photograph of June 6 (Plate XII).

One rather striking feature of the tail during the last stages of its visibility was that the star 87 *Leonis* remained in it or close to it for a long time. The tail seemed to be slipping eastward by or over the star. This, of course, was due to the motion of the comet, and the changing position of the sun.

#### THE RETURN OF THE COMET AND ITS EARLY APPEARANCE IN THE LARGE TELESCOPE

During the fall and winter of 1908-1909, the writer made a careful search for Halley's comet, both photographically with the Bruce telescope, and visually with the 40-inch. At that time it was too faint for either instrument. As if in acknowledgment of the discovery of photography since its last return in 1835 and the wonderful progress made in the application of that science to astronomy, the comet was destined to be seen first by the sensitive photographic plate. It was actually discovered, photographically, by Dr. Max Wolf, with the 30-inch reflecting telescope at Heidelberg, Germany, on September 11, 1909. The first visual observations of the comet were made by Professor S. W. Burnham with the 40-inch telescope of the Yerkes Observatory, on September 15, 1909.

At my first observations with the large telescope, beginning September 17, 1909, the comet was a small and rather faint speck of light, very much like a faint stellar nebula, of which there are so many in the sky. It was by no means at the limit of the great telescope, and under favorable conditions could have been seen much earlier with that instrument. The increase in brightness was not very rapid and as late as the last observations in February 1910, before the comet passed behind the sun, it gave very little promise of the splendid display it was destined to make later, in the month of May. Its reappearance from behind the sun in the morning skies of April and May could not have been under more unfortunate circumstances for observation at the Yerkes Observatory. That part of the year is always unpropitious here, and it seemed as if everything combined, on this particular occasion, to

hide from us the growth of the comet and its approach to the earth. Forest fires in the northern part of the state produced a densely smoky sky which, even when the clouds were merciful to us and would have let us see the comet, cut off with a thick yellow veil all but a glimpse of the bright head. The sky, on every morning, was watched until strong daylight for a chance to photograph or observe the comet. Similarly every care was taken in the evenings to secure results as long as the comet was visible.

The transition from the morning to the evening skies by the passage of the comet between us and the sun on May 18 was coincident with a change in the weather conditions, and we were thus enabled to watch it in its recession from the earth and sun. After a long cloudy period the sky suddenly cleared at midnight, on May 17, and gave us a splendid opportunity that night and the night of May 18, at the most critical time, to observe the phenomenon of its nearest approach to us.

#### NAKED-EYE AND TELESCOPIC OBSERVATIONS

The following notes descriptive of the comet's appearance to the naked eye and with the telescope are given nearly in full in the hope that they may be of value at its future returns. Of course photography took care of the general features of the comet, and thus preserved an accurate record of its appearance to the sensitive plate. At the same time it is a noteworthy fact that the photograph usually gives but little information as to the naked-eye appearance of a comet. A careful description, therefore, of its appearance to the eye alone must have a special value, independent of that of the photographs, and supplemental to them. From a historical standpoint, for comparison with its appearance in times past, it must have a value beyond that of the photograph.

In the descriptions which follow I have, in some cases, gone rather extensively into the details of the naked-eye appearance of the comet. I feel that this is justifiable for the following reason. In looking up the published information concerning its appearance in 1835 to form some opinion as to how the comet would look at the present return, I was surprised at the meagerness of the records, and I determined to prepare as faithful an account as possible of its

appearance to the naked eye for the benefit of observers at future returns. I therefore made as accurate a record as I could of its appearance to the eye alone. These results were obtained while guiding on the comet in photographing it, and at other times when a few moments could be spared to examine it. The descriptions, after the comet came into the evening skies, were written down, from my dictation at the time, by my niece, Miss Mary Calvert, and therefore have the accuracy of the inspiration of the moment.

A pair of large, old-fashioned field-glasses were available in these observations, and were used to supplement the naked-eye views when necessary. These glasses were specially suited for the purpose, and far better, because of their large lenses, than the more modern field-glasses, which for such work are deficient in light, and generally are too powerful.

The Bruce photographic telescope is supplied with a 5-inch visual guiding telescope, with a field of about 20'. When photographing the comet, notes were kept concerning its appearance in this instrument.

#### THE NAKED-EYE AND TELESCOPIC NUCLEUS

One striking fact that was noticeable when the comet was bright in the evening sky, especially noticeable on or about May 26, was that it had a nucleus within a nucleus. To the naked eye the nucleus was stellar and as bright as  $\delta$  *Leonis*, of magnitude 2.7. With field-glasses the nucleus was small, but of sensible diameter, and of a beautiful bluish-white color; it was surrounded by a much fainter hazy nebulosity, which ran out to form the tail—the view being rather an intensification of that with the naked eye. The naked-eye and field-glass “nucleus” was not the true nucleus. In the 5-inch guiding telescope a small planetary nucleus of the magnitude 8 or 9 was seen in a denser nebulosity. It was very well defined and very yellow. About this date, therefore, naked-eye and telescopic observations of the nucleus would refer to two entirely different things of exactly opposite colors. That which formed the nucleus to the naked eye was simply the small denser nebulosity about the real nucleus (see *Astronomische Nachrichten*, 185, 234).

Following is a careful summary of the notes. The records belonging to the earlier part of the observations (containing also micrometer positions), when the comet was visible only in the telescope, and those similarly made in its later stages, have already been printed in the *Astronomical Journal*, **26**, 43, 62, 76, 1909–1910, and **27**, 147, 1912. The present notes all refer to the year 1910.

All the times recorded in this paper are Central Standard Time, or 6<sup>h</sup>0<sup>m</sup> slow of Greenwich Mean Time.

April 11, 15<sup>h</sup>35<sup>m</sup>. Examined the sky but could see no traces of the tail. There was a broad strip of haze in the east, but the horizon seemed clear for about 2° altitude. At 16<sup>h</sup>30<sup>m</sup> the comet was well seen in the 5-inch guiding telescope, but it did not look any brighter than when last seen in March. There appeared to be a dim hazy nucleus with some nebulosity. The brightest part of the comet was at least two magnitudes less than *B.D.*+7°5121 of magnitude 6.3. There was no trace of the tail; the sky was too bright and hazy to show it. The comet was visible in the guiding telescope until 16<sup>h</sup>51<sup>m</sup>, when it was lost. It is probable that it would have been faintly visible to the naked eye if the sky had been clear and dark.

April 13, 16<sup>h</sup>5<sup>m</sup>. It was quite easily seen in the 5-inch telescope as a brightish, ill-defined, nebulous star, with no trace of tail, and was lost in dawn at 16<sup>h</sup>58<sup>m</sup>. The sky at that time was more or less hazy. The comet was certainly brighter on this date than on April 11. Each previous morning, before the brightest dawn, the sky had been examined for any trace of the tail, but none could be seen.

April 16, from 15<sup>h</sup>45<sup>m</sup> to 16<sup>h</sup>55<sup>m</sup>. The comet was bright in the 5-inch telescope. When at a considerable altitude the nucleus was starlike, almost white, and of the sixth magnitude. It was not quite as bright as the star *B.D.*+7°5121 (magnitude 6.3) with which it was compared for brightness, though it was more conspicuous than the star. The tail could be traced for 15' or 20', but the comet was not visible to the naked eye. Judging, however, from its brightness in the 5-inch, it must have been close to naked-eye visibility. Clouds prevented any successful photographs.

April 19. When first seen at about 15<sup>h</sup>20<sup>m</sup> the comet was in a clear space close to the horizon. It was beautiful in the 5-inch, with a bright nucleus and a fine parabolic outline to the head, from

which the tail streamed out of the field of view. It was not visible with the naked eye, but the sky was too poor for one to have seen it.

April 20. The comet rose in dense haze, and was first visible in the 5-inch telescope at 15<sup>h</sup>45<sup>m</sup>, but was very dim. At 16<sup>h</sup>20<sup>m</sup> the nucleus was of the same brightness as the star *B.D.+7°5101* (magnitude 7.0), but did not seem to be so intense in its light—it was more planetary and not quite starlike. The comet could not be seen with the naked eye at any time, the sky being too poor.

April 29. The comet was hidden by clouds until 15<sup>h</sup>45<sup>m</sup>, when it came out on a very bright sky, and could be seen with the naked eye for the first time. The nucleus was bright and was of magnitude 2 or 2.5. The tail was visible for a couple of degrees, but with field-glasses it could be traced for 4° or 5°. The comet remained visible to the naked eye until 16<sup>h</sup>7<sup>m</sup>, when it was lost, but it was visible in the 5-inch until 16<sup>h</sup>30<sup>m</sup>. To the naked eye it did not appear so bright as Daniel's comet in September of 1907 when in a similar position with respect to daylight.

May 2, 15<sup>h</sup>40<sup>m</sup>. The comet was seen for about one minute in a thin streak of clearer sky. The tail stretched out of the field of the 5-inch guiding telescope, but thick haze prevented its being seen with the naked eye.

May 3. The comet was beautiful to the naked eye, with a long tail streaming upward toward the right. The tail, however, was not bright. Before moonrise it could be traced for 17° or 18°. The head and nucleus were of about the second magnitude, and were estimated to be one magnitude brighter than  $\gamma$  *Pegasi*. Even after the moon rose the tail could be traced for nearly 15°. The following notes were made before the comet rose, the sky being examined carefully.

|                                 |                             |
|---------------------------------|-----------------------------|
| 14 <sup>h</sup> 17 <sup>m</sup> | No trace of tail.           |
| 14 22                           | No trace of tail.           |
| 14 29                           | No trace of tail.           |
| 14 34                           | No trace of tail. Sky good. |

The comet was first seen at 14<sup>h</sup>40<sup>m</sup>. The smoke from the power-house was passing over it during most of the exposure, and must have cut the light down seriously.

May 4. The comet was beautiful. The tail stretched about one-half the distance to  $\theta$  *Pegasi*, a length of  $15^\circ$ , and seemed a little shorter than on May 3. It became very gradually fainter toward the end, where it seemed to fade out as if that were really its end, and not so much as if it simply became too faint to be seen. The head, however, seemed brighter than on May 3, and was fully of the second magnitude. At about  $15^h$  it was one magnitude brighter than  $\gamma$  *Pegasi*. At  $16^h 7^m$  the comet was still faintly visible to the naked eye, but one minute later it had disappeared. The smoke from the power-house was passing in front of the comet and partly hiding it during the observations, so that the exposures must have been cut down in effect at least one-half.

May 5. Dense, thick sky. No trace of the comet could be seen with the naked eye. It was very faintly visible in the 5-inch telescope.

May 6. The sky was very thick. The comet was fairly well seen with the naked eye when it rose, but hazy clouds at once covered it. At first the tail could be traced, even in the hazy sky, for a distance of  $17^\circ$  or  $18^\circ$ . The whole comet must have been brighter than at previous observations. It could still be seen faintly between the clouds with the naked eye at  $14^h 53^m$ .

May 8. The sky was very thick and was constantly being covered with heavy clouds. The comet was seen with the naked eye several times between the clouds. After  $15^h 10^m$  it seemed pretty bright with a long tail. The views were fragmentary through the breaks in the clouds.

May 9. The sky was very thick. At  $15^h 5^m$  the comet was seen very faintly with the naked eye. It must have been very bright to be seen at all under the conditions. The tail could be traced for  $15^\circ$ . The head was at least of the second magnitude. At  $15^h 48^m$  it was still faintly visible with the naked eye.

May 13. No trace of the comet because of dense haze and smoke all around the horizon. If the tail had been very long it would perhaps have been seen above the smoke bank.

May 14. The sky was very thick and bad. At  $14^h 40^m$  the tail could be traced slightly beyond  $\theta$  *Pegasi*, a distance of about  $53^\circ$ , and passed about  $2^\circ$  or  $3^\circ$  to the right of and below that star. It must

have been  $3^\circ$  or  $4^\circ$  broad near the south side of the square of *Pegasus*. It was fairly noticeable when looked at with averted vision, but could not be traced anywhere near the head, which was invisible in the haze.

At  $15^h40^m$  the comet was faint in the 5-inch telescope, while *Venus*, at the same altitude, was fairly well seen with the naked eye, but was very dull and red. At  $16^h0^m$  the nucleus, which was yellow and starlike, with some coma, was quite noticeable in the 5-inch telescope, but neither the head nor any of the tail near it could be seen with the naked eye at any time, because of the smoky haze. Where the tail could be seen it was very straight and broad.

From the foregoing observations the head must have been many times less bright than *Venus*. The observations also show that the tail must have been about  $50^\circ$  in length.

May 17. After a stormy period the sky cleared brilliantly at midnight. As observations at this time are of the utmost importance in connection with the nearest approach of the comet to the earth, the notes will be given nearly in full.

$13^h0^m$ . A narrow twilight (which later proved to be the tail) seemed to extend along the eastern horizon. This was more marked at  $13^h5^m$ . "There is a diffused dawn effect near the east horizon about  $4^\circ$  or  $5^\circ$  high." At  $13^h10^m$  this seemed either to have risen rather rapidly or to have become more pronounced. The sky was very clear, but the moon was still above the horizon. At  $13^h25^m$  this "dawn" effect was as high as  $\epsilon$  *Pegasi*. At  $13^h30^m$  distinct traces of the tail were certainly visible a little south of the square of *Pegasus*, and reaching nearly to *Altair*. At  $13^h35^m$  the axis of the tail would pass through  $\theta$  *Pegasi*. It was perhaps  $5^\circ$  or  $6^\circ$  broad near  $\theta$  and apparently rose to a point  $10^\circ \pm$  southeast of *Altair*. At  $13^h45^m$   $\theta$  *Pegasi* was in the axis of the tail. At  $13^h55^m$   $\zeta$  *Pegasi* was on the north edge of the tail. At  $14^h15^m$   $\theta$  *Pegasi* was close inside the south edge and slightly in the tail, while  $\gamma$  *Pegasi* was in the tail and perhaps one-half degree north of its middle or axis and  $\theta$  *Aquilae* exactly on its north edge. At  $14^h20^m$  the tail between  $\zeta$  and  $\gamma$  *Pegasi* was perhaps brighter than any portion of the Milky Way. It seemed somewhat brighter in the middle and faded slightly toward the edges. It joined the Milky Way and could be

traced beyond  $\theta$  *Aquilae*. At this time it appeared straight, but at about  $13^h40^m$  it was thought to be slightly convex to the north. The width of the tail was a little greater than the distance from  $\beta$  to  $\eta$  *Pegasi* ( $5^\circ$ ). At  $14^h25^m$  the tail, beyond  $\epsilon$  *Pegasi*, was about one-fourth as bright or less than that part between  $\zeta$  and  $\gamma$  *Pegasi*. The star  $\gamma$  *Aquilae* (*B.D.*— $1^\circ40'16''$ ) was in the middle or axis of the tail. At  $14^h47^m$   $\alpha$  *Equulei* was just free of the north edge. At  $15^h10^m$  the tail was faint from dawn and could be seen only by averted vision. At  $15^h12^m$  it was still feebly visible near  $\zeta$  and  $\gamma$  *Pegasi*, and could be traced as far as  $\epsilon$  *Pegasi*. The sky was very clear. At this time  $\gamma$  *Pegasi* seemed to be still a little north of the axis. Miss Calvert watched it a little longer while I went to the 40-inch. She says that at  $15^h18^m$  she could no longer see the tail, though she had seen it one or two minutes earlier.

The tail was only a little brighter toward the axis—it was very flat and did not diffuse much at its edges. Indeed it seemed to be nearly uniform in light with respect to its width, but it tapered very much toward the end, near which it would not be over three-fourths as wide as at a point near  $\zeta$  *Pegasi*. This of course was an effect of perspective. Streamers or irregularities were carefully looked for but none was seen. The edges of the tail were smooth and uniform. At about  $13^h15^m$  or  $13^h30^m$  I could see the sky dark, below and above the tail, and there appeared to be a brightening along the southeast horizon, as if another portion of the tail were present. At  $14^h45^m$   $\alpha$  *Equulei* was just free of the north edge of the tail. The head of the comet could not be seen when it rose, either with the 5-inch or the 40-inch telescope, because of the thick sky near the horizon. The observations show that the tail was at least  $107^\circ$  long on this date.

May 18. Beautifully clear all day, with a few flecks of clouds in the afternoon. A beautiful night with a three-fourths full moon. Every preparation had been made to photograph any phenomena that might develop during the night. There was a slight mistiness in the air. This was noticed only when, on hiding the moon, a feeble illumination was seen near it. At  $8^h37^m$  and later, certain phenomena developed which are believed to have been auroral. The notes on these have been collected and are given later. At this

# PLATE X

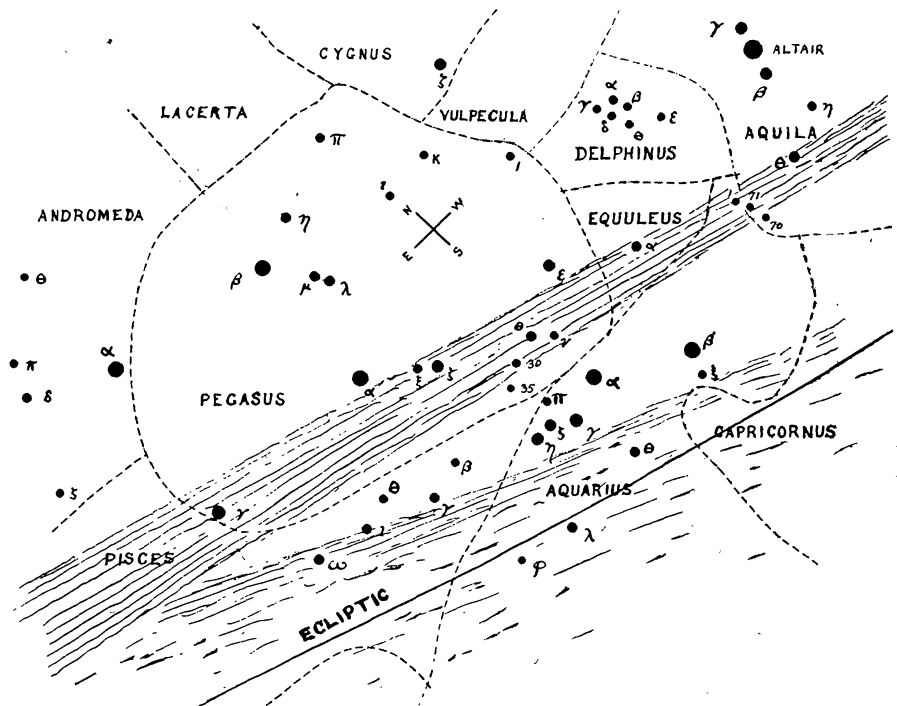
May 17, G.M.T. 21<sup>h</sup>



May 18, G.M.T. 21<sup>h</sup>

DRAWINGS OF TAILS OF HALLEY'S COMET

time the sky appeared unusually good. There was still a considerable twilight effect in the low northwest. At  $8^{\text{h}}56^{\text{m}}$  some faint luminosity was visible under *Cassiopeia*. The sky had a feeble misty look everywhere, which was not due to ordinary haze, for apparently the sky was very clear. Up to  $10^{\text{h}}35^{\text{m}}$  nothing out of the ordinary was noticed in the appearance of the sky, except the faint mistiness which had been visible since dark. At  $10^{\text{h}}40^{\text{m}}$  the eastern horizon was bright with a diffused luminosity while the



Key-map for drawings of the tail of Halley's Comet, on May 17 and 18

western horizon was free from anything of this kind. At  $12^{\text{h}}0^{\text{m}}$  the illumination of the eastern horizon seemed to be a little brighter. At  $12^{\text{h}}42^{\text{m}}$  the eastern horizon for perhaps one-fourth the way up was very bright. (This later proved to be the comet's tail.) At  $14^{\text{h}}10^{\text{m}}$  the tail was certainly visible just east of  $\epsilon$  *Pegasi*. Sky still moonlit. At  $14^{\text{h}}20^{\text{m}}$  the tail was surely visible in the east. It was quite noticeable at this time, even in the moonlight. It seemed to be a little north of its position of the previous morning (A.M. of May 18). At  $14^{\text{h}}23^{\text{m}}$   $\gamma$  *Pegasi* was just inside the south edge of the

tail, while  $\alpha$  *Pegasi* was just inside it on the north edge. It lay between  $\theta$  and  $\epsilon$  *Pegasi*, nearer to  $\theta$ . It was strongly visible (moon nearly down). At  $14^{\text{h}}27^{\text{m}}$  the north edge of the tail diffused very gradually and reached halfway from  $\gamma$  *Pegasi* to  $\alpha$  *Andromedae*. Both  $\theta$  *Aquilae* and  $\zeta$  *Pegasi* were in the axis of the tail. At  $14^{\text{h}}42^{\text{m}}$   $\gamma$  *Pegasi* was  $3^\circ$  inside of the south edge of the tail. The north edge diffused three-fourths of the way to  $\alpha$  *Andromedae*, and was  $10^\circ$  wide near that star. At  $14^{\text{h}}52^{\text{m}}$  the tail could be traced to the horizon, widening out toward the east horizon. At  $15^{\text{h}}4^{\text{m}}$  the tail could still be seen (though it was dim) and the dark region in it. At  $15^{\text{h}}10^{\text{m}}$  the tail and the dark space were still feebly seen, but they were badly dimmed by dawn.

The brightest portion of the tail near  $\alpha$  and  $\gamma$  *Pegasi* was as bright as the Milky Way, but did not seem to be more than half as bright as on the previous morning. The tail could be traced to the Milky Way beyond  $\theta$  *Aquilae*, where it became faint and somewhat tapered. It could not be traced across the Milky Way. Several times the impression was given—I was almost sure of it—that the brightest part of the tail fluctuated in brightness as if its light were unsteady. The illumination below the dark space in the tail, though feeble, I think was real. It apparently extended to the southeast horizon as if it passed below the horizon, and there seems no question that it was a separate part of the tail, and that the dark space was a rift that separated the tail into two parts. There was no evidence of any streamer north of the bright tail. The south edge was rather definite, though softly blended, but the north side was very diffused. At times it seemed to diffuse beyond  $\alpha$  *Andromedae*. The light of the tail was very similar to that which forms the *Gegenschein*, or like light reflected from dust particles; that is, it did not have a nebulous appearance. The bright northern part of the tail could be said to be roughly cone shaped, with its base along the horizon, and tapering out and becoming faint toward  $\theta$  *Aquilae*. As dawn approached, say a little after  $15^{\text{h}}$ , the whole sky seemed to assume a feeble glow that did not appear to be entirely due to dawn. The observations, located on a celestial globe, make the length of the tail at least  $120^\circ$ .

On both nights (May 17 and 18) there was no decided light north

of the tail, that is, all the sky above the tail was apparently pure and free from unusual illumination, with the exception of the slight mistiness mentioned in the preceding paragraph. The illumination below the brighter part of the tail was decided. It was soft and seemed to reach to and beyond the southeast horizon.

Although the slight aurora which developed on May 18 certainly had nothing to do with the proximity of the comet, it seems best to give it here as a part of the record for that night for comparison with observations that were doubtless made elsewhere and for other reasons. I have therefore collected all the phenomena that certainly seemed to belong to the aurora in the notes that follow.

At 8<sup>h</sup>37<sup>m</sup> there seemed to be some horizontal streaks of diffused light in the north above *Cassiopeia*. They had disappeared five minutes later. At this time considerable twilight effect still remained in the northwest. At 8<sup>h</sup>56<sup>m</sup> some feeble luminosity was visible under *Cassiopeia*. At 9<sup>h</sup>2<sup>m</sup> apparently a slight aurora was visible to the right of and below *Cassiopeia*. At 9<sup>h</sup>14<sup>m</sup> a faint luminous band was visible halfway from the horizon to the stars of *Cassiopeia*. This seemed to be an auroral effect. At 9<sup>h</sup>20<sup>m</sup> an active aurora with streamers flashed up very suddenly. By 9<sup>h</sup>28<sup>m</sup> it had become a uniform glow extending almost as high as *Cassiopeia*. There were feeble attempts at activity at 9<sup>h</sup>40<sup>m</sup> consisting of a great number of short streamers. At 10<sup>h</sup>4<sup>m</sup> the altitude of the bright part of the arch (which was fairly strong) was exactly halfway from the horizon to *Cassiopeia*. At 10<sup>h</sup>12<sup>m</sup> streamers were ascending to the left of the summit of the arch and moving to the left. At 10<sup>h</sup>16<sup>m</sup> the arch was rather strong but indefinite. At 10<sup>h</sup>18<sup>m</sup> the aurora was again active (but not bright), with diffused streamers. At 10<sup>h</sup>28<sup>m</sup> there was no definite arch, but a diffused general illumination was present reaching nearly as high as *Cassiopeia*. At 10<sup>h</sup>32<sup>m</sup> still diffused, with no definite arch, and one streamer moving west. The brightest part of the illumination extended halfway to *Cassiopeia*. By 10<sup>h</sup>40<sup>m</sup> the aurora had almost faded out—apparently dead. At 11<sup>h</sup>10<sup>m</sup> a very slight auroral glow. At 11<sup>h</sup>24<sup>m</sup> there seemed to be no aurora. At 11<sup>h</sup>32<sup>m</sup>, no aurora. At 13<sup>h</sup>52<sup>m</sup> the aurora started up again with a very low feeble arch. At 14<sup>h</sup>14<sup>m</sup> the altitude of the arch was 3° or 4°.

There are no other notes on the aurora, and I assume that it finally disappeared about this time.

Notes were also made of the appearance of any meteors, but they are not given here because but very few were seen on May 18 and none was noted on May 17. They seemed to have no connection with the comet.

May 19. Cloudy at night. No observations of the comet possible.

May 20. At 7<sup>h</sup>50<sup>m</sup> to 8<sup>h</sup>30<sup>m</sup> with the naked eye the head was one-half degree in diameter. The head and nucleus were of about the second magnitude, and resembled a yellow nebulous star. There seemed to be a faint diffused tail. The sky was muggy, and the comet was in clouds most of the time.

In the 5-inch the nucleus at first was very stellar and very yellow, with some of the hazy yellow light about it, but no tail was seen with certainty.

The sky was examined repeatedly as late as 11<sup>h</sup>, but no trace of the comet's tail was anywhere visible. The moon was nearly full.

At 14<sup>h</sup> the sky was hazy in the west. At about 14<sup>h</sup>30<sup>m</sup> a hazy luminous streak 4°–5° broad extended from  $\theta$  *Aquilae* to the east—fainter toward  $\theta$  *Aquilae*—through  $\alpha$  *Pegasi*. This resembled the comet's tail, but was doubtless a strip of haze. I looked at it several times, taking it for a strip of haze, but it did not seem to move. There were masses of moving haze overhead toward the north. To all appearances it looked like the comet's tail of the mornings of May 18 and 19. I cannot be certain that this was not haze, but it was a singular coincidence of position, appearance, etc., if it was. It was visible for fully 15 or 20 minutes. Then the sky got worse with the haze and moonlight and it disappeared. At the same time there seemed to be a similar strip in the low south which stretched from the Milk Dipper in *Sagittarius* to *Antares*. This was 3° to 4° wide. I think these must have been merely strips of haze, and had nothing to do with the comet, but they are given here as a matter of record. It may be well to note, however, in this connection that the tail—both branches—was still visible in the morning sky in South Africa on this date, at 15<sup>h</sup>30<sup>m</sup> G.M.T., or

only five hours earlier than the supposed observation recorded above (see *Circulars* 3 and 11, Transvaal Observatory). Both tails were also seen by Perrine at Cordoba on the 20th at the same moment as my observation (see *Astronomical Journal*, 26, 145).

May 21 and 22. Cloudy.

May 23, 8<sup>h</sup>40<sup>m</sup>. Sky cloudy, but the comet shone for a few minutes through a break in the clouds. It was very bright—perhaps brighter than the first magnitude. To the naked eye the nucleus and coma appeared like a nebulous star. There was some faint tail. During the exposures the sky was white with a full moon and haze, patches of which frequently covered the comet. The total eclipse of the moon on that night unfortunately came too late to aid in the observations of the comet.

May 24. At 7<sup>h</sup>55<sup>m</sup> the comet was quite bright to the naked eye, with traces of the tail. It was bluish white and a striking object. The head was large and hazy and about 15' or 20' in diameter. The nucleus resembled a first-magnitude star in haze. The tail was 25° long. For 5° or 6° it was noticeable and then became rapidly fainter. At 8<sup>h</sup>35<sup>m</sup> it was quite noticeable for 10° or 15°. At 10° from the head the tail was about 2° wide. The light of the comet was still bluish white. At 8<sup>h</sup>50<sup>m</sup> the tail could be traced with the naked eye for 29°. At 9<sup>h</sup>10<sup>m</sup> the sky was very bright with moonlight and did not seem to be very clear, but the tail was still noticeable to the naked eye. Ten minutes later the tail was very feeble for want of contrast and at 10<sup>h</sup>0<sup>m</sup> it was scarcely visible to the naked eye, but the head was still very bright like a hazy star. At 10<sup>h</sup>30<sup>m</sup> the comet was still visible, very low and dim.

In the 5-inch telescope the nucleus was sharply defined, not a point, but more like a small bright planet with coma. At 8<sup>h</sup>45<sup>m</sup> it was nearly white. It also appeared white to the naked eye. In the last part of the exposure the nucleus was about five times greater in diameter than when the exposure began, and more ill defined—it seemed to swell in size.

[The last part of the foregoing paragraph is in accord with the observations of Professor A. E. Douglas at Tucson, Arizona, who later, on this same date, saw the nucleus double. See *Harvard Observatory Bulletin*, No. 412.]

May 25. At 8<sup>h</sup>30<sup>m</sup> the tail could be traced for 21°. The head was decidedly less intense than  $\epsilon$  *Hydrae* south of it. The sky was quite good. At 8<sup>h</sup>50<sup>m</sup> the tail could be traced for eight-tenths the distance between the head and *Jupiter*, or a length of 43°. At 8<sup>h</sup>55<sup>m</sup> the comet was seen on a fairly dark sky, only a little twilight effect remaining. It was very beautiful, though the head did not seem relatively so bright as on other nights. The tail, for about 20°, was pretty bright, and increased very much in width. At 9<sup>h</sup>0<sup>m</sup> it seemed to extend in a very diffused manner nearly to the same right ascension as that of *Jupiter*, a distance of 54°. Prolonged, its axis would pass about 8° south of *Jupiter*. The tail was very diffused at its end and seemed to extend northward nearly to *Jupiter*. At 9<sup>h</sup>10<sup>m</sup> the central brightness of the head was almost bluish white in the field-glasses. At 9<sup>h</sup>30<sup>m</sup> the sky had begun to whiten with moonlight, but the comet was still in good relief, the moon being behind clouds in the east. At 9<sup>h</sup>35<sup>m</sup> the tail could be faintly traced several degrees beyond 87 *Leonis* = *B.D.*—2°3360 (magnitude 5.0), which at this time was in the axis of the tail, or for about 43°. At 9<sup>h</sup>55<sup>m</sup> the tail was very dim on the bright moonlit sky, but was still faintly visible for 10° or more.

At 8<sup>h</sup>30<sup>m</sup> with the 5-inch telescope the nucleus was very small, like a ninth- or tenth-magnitude star. The coma was very large and fairly bright. Before the wires were illuminated the nucleus did not appear double, nor were there any other nebulosities in the field of view. It was very dim and hazy. At 8<sup>h</sup>50<sup>m</sup> the nucleus was of the same brightness as *B.D.*+7°2055 (magnitude 8.4). At 9<sup>h</sup>15<sup>m</sup> the nucleus was a little brighter and hazy. At 9<sup>h</sup>35<sup>m</sup> it was fairly stellar and a little brighter—brighter than any of the stars in the field of view: (*B.D.*+7°2048 [magnitude 9.0], +7°2052 [magnitude 9.2], +7°2055 [magnitude 8.4]). At 9<sup>h</sup>50<sup>m</sup> the coma was very dense and extended perhaps 5' all around the nucleus, which was very small and dim.

May 26, 7<sup>h</sup>55<sup>m</sup>. The comet was visible to the naked eye as a faint hazy star. At 8<sup>h</sup>5<sup>m</sup> it was quite noticeable, with perhaps faint traces of tail. At 8<sup>h</sup>22<sup>m</sup> the tail was showing faintly to the naked eye. The comet seemed less bright than on the previous night. At 8<sup>h</sup>30<sup>m</sup>, with field-glasses, there seemed to be a central

nucleus, fairly well defined, large, and bluish white, surrounded by much fainter hazy nebulosity which extended from it to form the tail. It had the same appearance to the naked eye. This, however, was not the true nucleus, which was very small and seen only in the telescope. The tail was visible for  $10^\circ$  or  $15^\circ$ . At  $8^{\text{h}}40^{\text{m}}$  the tail was very noticeable for about  $15^\circ$ , but it faded very rapidly toward the end. To the eye the nucleus was bright—of the second magnitude. At  $8^{\text{h}}45^{\text{m}}$  the sky was very good and the tail was very noticeable. It could readily be traced to  $\delta$  *Leonis*. With field-glasses the nucleus was an intense bluish white. The whole head seemed to be of a bluish-white color. At  $8^{\text{h}}50^{\text{m}}$  the tail was conspicuous halfway to  $\delta$  *Leonis*, after which it became diffused and faint. It seemed a little brighter in the middle near the head. No streamers were seen. The sky was fairly dark and the comet a conspicuous and strikingly beautiful object. But the nucleus was very much inferior to *Regulus*. At  $8^{\text{h}}55^{\text{m}}$  the tail was conspicuous as far as  $\delta$  *Leonis*, and, though rather faint near that star, it could be traced feebly  $10^\circ$  beyond it. To the naked eye the nucleus was very much brighter than the rest of the head. At  $9^{\text{h}}0^{\text{m}}$  the tail could be very feebly traced beyond *Jupiter*. The axis would pass  $6^\circ$  or  $7^\circ$  south of the planet. At  $9^{\text{h}}10^{\text{m}}$  the nucleus was about as bright as  $\delta$  *Leonis* (magnitude 2.6). The comet was a very striking object to the naked eye, with the tail, which seemed to be straight, reaching as far as  $\delta$  *Leonis*, where it became faint. At  $9^{\text{h}}15^{\text{m}}$ , by hiding *Jupiter*, the tail could be feebly traced to  $\alpha$  *Virginis*, or a length of about  $65^\circ$ . The nucleus was perhaps one-half a magnitude less bright than  $\gamma$  *Leonis* of magnitude 2.6. At  $9^{\text{h}}20^{\text{m}}$  the sky was still good. The tail for  $15^\circ$  from the head was everywhere brighter than *Praesepe*. Within  $5^\circ$  or  $10^\circ$  of the head it was 4 or 5 times as bright as *Praesepe*. At  $9^{\text{h}}45^{\text{m}}$  the comet was seen on a fine dark sky and was very conspicuous. In the field-glasses the tail widened out very much. The nucleus was large and bluish white and was surrounded for a short distance by a hazy glow of the same color. There seemed to be no structure in the tail. At  $9^{\text{h}}50^{\text{m}}$  the moon was whitening the eastern sky, but the tail was still noticeable as far as  $\delta$  *Leonis*, where it became faint. It gradually widened out, with the south side perhaps a little the

brighter. To the naked eye the nucleus was rather dull. In the field-glasses it was still bluish white and hazy, like a star shining through a bluish-white mist. There did not seem to be any evidence of streamers, either with the naked eye or with field-glasses. At 10<sup>h</sup>20<sup>m</sup> the sky was very bright with moonlight, but the comet's tail was still noticeable (though not very strong) for some 10°, and could be traced faintly as far as 87 *Leonis*. At 10<sup>h</sup>30<sup>m</sup> the tail could still be traced feebly for 10° or more from the head. At 10<sup>h</sup>50<sup>m</sup> the comet was very near the horizon and disappearing in some tree tops, and nothing could be seen of the tail with the naked eye.

At 7<sup>h</sup>55<sup>m</sup>, with the 5-inch telescope the nucleus was small and planetary, and with the coma was very yellow. The nucleus was larger and perhaps slightly brighter than *B.D.*+6°2129 (magnitude 8.0), which was in the field. At 8<sup>h</sup>40<sup>m</sup>, though less intense, it was brighter, and more yellow than the star. It seemed to be very much brighter than on May 25. The nucleus was estimated to be decidedly brighter than the star at 9<sup>h</sup>5<sup>m</sup>, and at 9<sup>h</sup>10<sup>m</sup> it was stated that it must have brightened since the exposure began. It was ill defined and perhaps 5'' ± in diameter. At 9<sup>h</sup>35<sup>m</sup> the nucleus was very much brighter. It seemed to have increased greatly in brightness but was very ill defined. At 10<sup>h</sup>5<sup>m</sup> it was decidedly more yellow and perhaps a little brighter than the same star, though its light was not so intense. It was very hazy and much larger than the star. At 10<sup>h</sup>50<sup>m</sup> the comet and nucleus were both very faint.

May 27, 8<sup>h</sup>0<sup>m</sup>. To the naked eye the comet resembled a small dim cloud, in which the nucleus was small and faint. The sky was smoky, and had been so almost all the late afternoon. At 8<sup>h</sup>15<sup>m</sup> the comet was dull to the naked eye, like a dull nebula some 10' or 15' in diameter. One could not be sure of seeing any tail at this time. At 8<sup>h</sup>25<sup>m</sup> the tail could be feebly seen for 4° or 5°. At 8<sup>h</sup>35<sup>m</sup> it was only feebly visible for perhaps 5° or 6°, but it could be seen fairly distinctly. The sky was very poor with some twilight illumination. At 8<sup>h</sup>38<sup>m</sup> the tail could be seen rather dimly for about 10°—sky still luminous. In the field-glasses the condensation or nucleus was of a bluish-white color. The rest of the head and

tail were whitish. At 8<sup>h</sup>42<sup>m</sup> the tail could be traced faintly to 87 *Leonis* (about 33°), and near the head for 6° or 8° it was quite noticeable. The comet did not seem as bright as on May 26, but the sky was poor and whitish. The nucleus was about midway in brightness between  $\gamma$  (magnitude 2.6) and  $\zeta$  *Leonis* (magnitude 5.1), or about magnitude 3.8. At 9<sup>h</sup>0<sup>m</sup> the tail seemed to be brighter on the south side and could be traced quite distinctly to 87 *Leonis* (which star was apparently in the axis, or perhaps a little south of it), after which it became faint. For one-half that distance it was conspicuous. The sky was fairly dark but it was not pure. With the field-glasses the tail near the head was feebly brighter in the middle. At 9<sup>h</sup>10<sup>m</sup> the condition of the sky, though not pure, was fair. Possibly the tail was slightly curved, with the convex side south. It was quite noticeable as far as 87 *Leonis*. At 9<sup>h</sup>15<sup>m</sup> there did not seem to be any structure in the tail as seen with the field-glasses. To the naked eye the comet was a conspicuous object. The tail near the head was very much brighter than *Praesepe*, but it faded off rapidly near 87 *Leonis*. By hiding *Jupiter* it could be traced to a point halfway between *Jupiter* and *a Virginis*, or for a distance of 53° or 54°. It seemed certainly to be curved when the whole tail was considered, with the convex side toward the south. Near *Jupiter* it was perhaps 3° in width and faint. At 9<sup>h</sup>30<sup>m</sup>, with the field-glasses, what appeared to be the nucleus was of sensible diameter and hazy and was very strongly conspicuous. At 9<sup>h</sup>35<sup>m</sup> there seemed to be a diffusion from that part of the tail near *Jupiter*, extending to the north as high as the planet ( $\alpha$  12<sup>h</sup>19<sup>m</sup>,  $\delta$ —0°31'). The star 87 *Leonis* was perhaps a little south of the middle of the tail. The nucleus was in pretty strong contrast to the tail near the head. At 9<sup>h</sup>40<sup>m</sup> the tail, from 87 *Leonis* to the end, became exceedingly faint and diffused. At 9<sup>h</sup>45<sup>m</sup> the comet was still a conspicuous object, with the tail extending to 87 *Leonis*. The nucleus resembled a dull hazy star of the third magnitude. The sky was fair, though not specially pure. At 10<sup>h</sup>20<sup>m</sup> the comet's head was getting down into the haze near the horizon, but was still strongly conspicuous. By 10<sup>h</sup>30<sup>m</sup> the head was becoming dim to the eye. The tail was still noticeable and could be traced readily to 87 *Leonis*. At 10<sup>h</sup>40<sup>m</sup> the head

was very dim. The tail also was very dim, but could still be traced to 87 *Leonis*. The sky up high and overhead was very clear, but near the horizon there was a good deal of smoky haze.

At 8<sup>h</sup>5<sup>m</sup> the nucleus, in the 5-inch telescope, was faint and ill defined, with some haze about it. It was very much fainter (perhaps two magnitudes) than the star *B.D.*+5°2171 of magnitude 8.1, which was in the field with it. At 8<sup>h</sup>45<sup>m</sup> the nucleus was very dim, and was very feebly contrasted with the nebulosity. At 8<sup>h</sup>50<sup>m</sup> what was so conspicuous as a nucleus to the naked eye could not have been the true nucleus, for in the 5-inch the nucleus was very small and faint and was apparently only a condensation in the coma. It must, therefore, have been the brighter part of the coma which formed a nucleus to the naked eye. At 9<sup>h</sup>10<sup>m</sup> it seemed to have grown dimmer. It was rather difficult to guide on and was very small and ill defined. At 9<sup>h</sup>35<sup>m</sup> the nucleus and coma appeared very much like the nucleus and close nebulosity of the Great Nebula of *Andromeda* when seen in an ordinary telescope, and showed about the same amount of contrast, the bright part of the coma being about 1'-2' in diameter and very diffused. At 9<sup>h</sup>50<sup>m</sup> the true nucleus was very small and dim, and was several times fainter than the star *B.D.*+5°2171. It was surrounded by a dense nebulosity 1' or more in diameter. This nebulosity must have been what appeared to the naked eye as the nucleus. At 10<sup>h</sup>5<sup>m</sup> the nucleus was difficult to guide on. The glow about it was very strong and there was no contrast. It was simply a central condensation of the coma. At 10<sup>h</sup>15<sup>m</sup> the nucleus was just discernible, being all but lost in the coma. At 10<sup>h</sup>35<sup>m</sup> it was no longer visible to guide on. I do not think its faintness was due entirely to the condition of the sky.

May 29. At 10<sup>h</sup>5<sup>m</sup> the tail was conspicuous as far as 87 *Leonis*, a distance of 27°, its axis passing about one-half degree north of that star. It could be feebly traced beyond the line between *Jupiter* and *Spica*, or about 52°, but only feebly. It was noticeably curved—convex to the south. The southern side, from the head to 87 *Leonis*, was a little the brighter and more definite. The nucleus was about as bright as  $\eta$  or  $\theta$  *Leonis*. The tail seemed to diffuse to the north to *Jupiter*, and perhaps beyond. The southern

PLATE XI



North

10-inch Lens. May 29, 15<sup>h</sup>39<sup>m</sup>, G.M.T. Exposure, 1<sup>h</sup>57<sup>m</sup>  
Scale: 1 cm = 0°.55

edge would about bisect the line between *Spica* and *Jupiter*. The comet was decidedly less bright than on May 27.

In the 40-inch the nucleus was not yellow, but was pale in color. The measured diameter north and south from one setting was 2".6.

May 30. At 8<sup>h</sup>5<sup>m</sup> the comet could be feebly seen with the naked eye like a faint nebula. At 8<sup>h</sup>20<sup>m</sup> it was not as bright nor as noticeable as the star  $\pi$  *Leonis*. There was no tail visible at this time. The sky was very clear. At 8<sup>h</sup>30<sup>m</sup> with the field-glasses the tail could be traced for a couple of degrees. The head was quite bright and seemed to be a nebulous mass without any special nucleus. There was perhaps a faint suggestion of a tail for a couple of degrees, but very faint. The head was about as bright as  $\pi$  *Leonis* (magnitude 4.9), perhaps a little brighter, but more noticeable than that star. At 8<sup>h</sup>40<sup>m</sup> the tail could be traced as far as 87 *Leonis*, a distance of 25°, but was faint toward its end. The sky was still bright with twilight. At 8<sup>h</sup>50<sup>m</sup> the comet was quite conspicuous. The tail was noticeable as far as 87 *Leonis* and was seen faintly 7° or 8° beyond that star (which seemed to be nearly in the axis of the tail). For about 15° it was conspicuous. The head was of about the third magnitude, and with the field-glasses resembled a bright hazy nebula. At 9<sup>h</sup>15<sup>m</sup> the tail seemed decidedly curved between the head and 87 *Leonis*, with the convex side to the south. At about 5° from the head it was of about the same brightness as *Praesepe*. Nearer the head it was brighter. With the field-glasses the condensation in the head looked like a large diffused nucleus, bluish white in color, surrounded by a fainter nebula which extended back to form the tail. The central brightness was very strong as compared with the rest of the head. At 9<sup>h</sup>25<sup>m</sup> the comet, to the naked eye, was very dull as compared with its appearance a few nights earlier, but it was still conspicuous. The tail, where it passed below *Jupiter*, had the same appearance of diffusing and spreading out toward that planet previously noted, but *Jupiter* was too bright to make this certain. The sky was very transparent, especially in high altitudes. At 9<sup>h</sup>40<sup>m</sup> the comet was a striking object. The tail was conspicuous as far as 87 *Leonis*, after which it became faint, but by hiding

*Jupiter* it could be feebly traced as far as the line between *Jupiter* and *Spica*, a length of  $47^\circ$ . With the field-glasses no structures or irregularities could be seen in the tail, which diffused very softly toward the edges and was not especially brighter in the middle. No streamers were visible either with the naked eye or with the field-glasses. At this time it was still a conspicuous object. At  $10^h30^m$ , the comet, though low, was still conspicuous. The sky seemed to be very good in its direction. The head was quite bright, and the tail could be readily traced to  $87\text{ Leonis}$ . At  $10^h45^m$  the head was quite bright, like a second- or third-magnitude star, but the tail was lost in clouds.

During the exposures on the comet there seemed to be a denser part some  $10^\circ$  back from the head, as if the tail sagged a little south at that point.

At  $8^h5^m$ , though the head was distinct to the naked eye, it was very small and faint in the 5-inch guiding telescope. At  $8^h35^m$  the nucleus was very small and starlike and shone in the middle of a dense nebulosity about  $0.5$  in diameter. It was one magnitude brighter than the star  $B.D.+3^\circ2273$  of magnitude  $9.2$ . At  $9^h10^m$  the nucleus was very small and starlike in a very dense nebulosity which diffused gradually for  $1' \pm$ . It was very much brighter than  $B.D.+3^\circ2273$ —about  $1\frac{1}{2}$  magnitudes brighter. The sky was very clear. At  $9^h45^m$  the nucleus was very small and stellar with some haze close about it. It was not very much brighter than  $B.D.+3^\circ2273$ . At  $10^h17^m$  the nucleus was almost lost in the strong condensation about it.

May 31. The comet was first seen with the naked eye at  $8^h17^m$ . The sky was covered more or less with hazy clouds, but at about  $10^h45^m$ , when seen for a few minutes below the clouds, it was conspicuous.

In the 40-inch telescope at  $8^h42^m$  the measured diameter of the nucleus, north and south, was  $4''.9$ .

June 1. At  $8^h10^m$  the comet was faintly visible to the naked eye. At  $8^h40^m$  only faint traces of the tail could be seen. The sky at this time was covered with hazy clouds from the northwest. At  $9^h0^m$ , in spite of the condition of the sky, the tail could be traced to  $87\text{ Leonis}$ , a distance of  $22^\circ$ . The comet was covered with hazy

clouds nearly all the time. There were long strips of these clouds moving southwardly, which were, most of the time, only a few degrees wide, and if they had been displaced  $4^\circ$  or  $5^\circ$  the comet would have been seen on a good sky throughout the observations. Once in a while it came out for a few minutes only to be covered again. The rest of the sky was good. After 10<sup>h</sup> it got on to a better sky and there was very little interference from clouds, but the sky was not good in the direction of the comet. The tail could be traced for several degrees beyond 87 *Leonis*, or perhaps for about  $25^\circ$ , and was noticeable as far as that star. The head, which seemed brighter on this date, was about midway in brightness between  $\gamma$  and  $\eta$  *Leonis*, or 3<sup>m</sup>. At 11<sup>h</sup>0<sup>m</sup>, though the comet was very low and dim, the tail, in moments of freedom from clouds, could be seen up to 87 *Leonis* fairly well, and could be traced some degrees farther. Its axis passed slightly north of that star.

At 8<sup>h</sup>10<sup>m</sup> in the 5-inch the nucleus was very faint and small—just visible—in a strong condensation. At 8<sup>h</sup>58<sup>m</sup> it could no longer be seen to guide on.

June 5, 9<sup>h</sup>7<sup>m</sup>. To the naked eye the head was about one-half magnitude brighter than the star 15 *Sextantis* = *B.D.* +  $0^\circ 26' 15''$  (magnitude 4.1) and more conspicuous than that star. The tail, which seemed to be straight, could quite readily be traced to 87 *Leonis* and perhaps a few degrees beyond, but it was dim. It was visible in a diffused manner to the star  $\chi$  *Virginis*, or about  $33^\circ$ . To the naked eye a faint nucleus was doubtfully visible. The head was about as bright as 87 *Leonis*, and not much more noticeable than that star.

The comet was first seen in the finder of the 40-inch at 8<sup>h</sup>9<sup>m</sup>. With the 40-inch telescope itself at 8<sup>h</sup>20<sup>m</sup>, the nucleus was very small, 2'' or 3'' in diameter, and surrounded by a dense nebulosity. At 9<sup>h</sup>0<sup>m</sup> it was a very small point in dense hazy light which was placed in a very strong nebulosity which faded away rapidly, and was perhaps 3' or 4' in diameter. The minute nucleus was about three magnitudes less than the comparison star (estimated magnitude 9 $\pm$ ; see *Astronomical Journal*, 27, 149, 1912), but the general brightness of the head would be about  $2\frac{1}{2}$  magnitudes less than the star.

In the 5-inch telescope no nucleus was visible. There was only a strong condensation which was rather hard to guide on.

June 6. At about 8<sup>h</sup>27<sup>m</sup> the comet became visible to the naked eye as a faint hazy spot. At 8<sup>h</sup>47<sup>m</sup> the tail was not yet visible. The head was not quite as noticeable as the star  $\rho$  *Leonis* (magnitude 3.8). At 8<sup>h</sup>50<sup>m</sup> the tail could be traced for a distance of 5°. At 8<sup>h</sup>57<sup>m</sup> it could be seen faintly to 87 *Leonis*, a distance of 18°. At 9<sup>h</sup>10<sup>m</sup> it was noticeable as far as 87 *Leonis*, which was on its upper (north) edge, and could be seen feebly several degrees beyond. Sky good. At 9<sup>h</sup>57<sup>m</sup> the tail could be traced to  $\chi$  *Virginis*, or for 32°. Though very faint, it was noticeable as far as 87 *Leonis*. The comet had faded sadly, however, since June 1, and though a noticeable object, was only the ghost of its former self.

At 8<sup>h</sup>25<sup>m</sup> it was quite conspicuous in the 5-inch telescope, with a bright starlike nucleus, which was about one-half magnitude less bright than the star *B.D.+0°2641* (magnitude 8.0). At 8<sup>h</sup>35<sup>m</sup> the nucleus was beautifully starlike, and imbedded in a very strong condensation that faded rapidly and was itself nebulous. When best seen at 9<sup>h</sup>42<sup>m</sup> the nucleus was about one magnitude less than *B.D.+0°2641*, or about the ninth magnitude.

June 7. At 9<sup>h</sup>40<sup>m</sup> the tail was faint, but could be traced to 87 *Leonis* (which star was in the north edge of the tail), a distance of 17°. The entire comet was fainter than on June 6. The head was of about the same brightness as the star  $\rho$  *Leonis*. It was relatively fainter with respect to the tail than at previous observations. The sky was poor and the Milky Way dull. There were no clouds, however.

The comet was first visible in the finder of the 40-inch at 8<sup>h</sup>8<sup>m</sup>. In the 40-inch telescope itself the nucleus, which was in a very strong condensation, was very ill defined and blurred.

June 9. At 10<sup>h</sup>35<sup>m</sup> the sky was murky and broken with clouds. The comet was only fairly visible to the naked eye. At best the tail could be very faintly traced to 87 *Leonis*, or for 15°. In the latter part of the observations the sky was good everywhere else but in the region of the comet, which was covered with misty clouds.

PLATE XII



North

10-inch Lens. June 6, 15<sup>h</sup>49<sup>m</sup> G.M.T. Exposure 120<sup>m</sup>  
Scale: 1 cm = 0°.44

June 10. Crescent moon. At 8<sup>h</sup>47<sup>m</sup> the comet was not visible with the naked eye, but later it could be seen faintly, with possibly a trace of tail. It was very faint in the 5-inch telescope.

June 11. The sky was clear at dark but a crescent moon was shining. From about 9<sup>h</sup>15<sup>m</sup> the comet could be seen faintly at intervals for perhaps half an hour. The head alone was visible as a dim hazy star, and was only just seen with certainty. Clouds kept covering the place so that the exposures were badly interrupted.

A faint small nucleus could be seen in the 5-inch telescope.

This was the last date on which the comet was seen with the naked eye.

June 12. In the 40-inch the nucleus was very ill defined—not stellar. It was placed in a small dense nebulosity 5'' in diameter, which diffused into the general nebulosity of the head. The nucleus was of about the same brightness as the comparison star (estimated magnitude 10±; see *Astronomical Journal*, 27, 149, 1912), or a little less bright, but was less definite. The sky was very white with moonlight.

June 14. With the 40-inch telescope the nucleus was almost stellar and about one-half magnitude less than the comparison star (estimated magnitude 9.5–10; see *Astronomical Journal*, 27, 149, 1912). It was in the center of a strong condensation about 1' in diameter. The sky was thick and bright with strong moonlight.

June 15. Only the faint nucleus and central condensation were visible in the 5-inch telescope. The comet was very faint and dim throughout the exposures.

June 24. At 9<sup>h</sup>10<sup>m</sup> in the 5-inch the comet was somewhat strongly condensed with no nucleus, and was perhaps of the eighth magnitude. It was not certainly seen with the naked eye. At 9<sup>h</sup>42<sup>m</sup> it became too faint in dense haze to guide on with the 5-inch.

June 25. At 8<sup>h</sup>40<sup>m</sup> it was of about the eighth magnitude and rather small and dim in the 5-inch telescope. By 9<sup>h</sup>52<sup>m</sup> it could no longer be followed. The sky was very good. The comet could not be seen with the naked eye, but it was quite noticeable in the field-glasses, with which perhaps faint traces of the tail could be seen.

June 27. At 9<sup>h</sup>0<sup>m</sup> the comet, though seen in the 5-inch telescope, was very feeble and too faint to attempt an exposure.

## GREATEST VISIBLE LENGTH OF THE TAIL

For the convenience of those interested in the matter, Table II contains the greatest lengths of the tail as seen with the naked eye during these observations.

TABLE II

| Date |         | Length of Tail |                 |
|------|---------|----------------|-----------------|
| May  | 3.....  | 17°-18°        |                 |
|      | 4.....  | 15             |                 |
|      | 6.....  | 17-18          | On hazy sky     |
|      | 9.....  | 15             | On very bad sky |
|      | 14..... | 53             |                 |
|      | 17..... | 107            |                 |
|      | 18..... | 120 or more    |                 |
|      | 24..... | 29             |                 |
|      | 25..... | 54             |                 |
|      | 26..... | 65             |                 |
|      | 27..... | 53             |                 |
|      | 29..... | 52             |                 |
|      | 30..... | 47             | On poor sky     |
| June | 1.....  | 25             |                 |
|      | 5.....  | 33             |                 |
|      | 6.....  | 32             |                 |
|      | 7.....  | 17             |                 |
|      | 9.....  | 15             |                 |

A list of the photographs obtained with the various lenses of the Bruce photographic telescope is given in the catalogue of the report of the Comet Committee of the Astronomical and Astrophysical Society of America.

YERKES OBSERVATORY  
WILLIAMS BAY, WIS.  
March 7, 1914