TRANSACTIONS

OF

THE TORONTO ASTRONOMICAL SOCIETY

FOR THE YEAR 1901

INCLUDING TWELFTH ANNUAL REPORT.

ARTHUR HARVEY, F.R.S.C., EDITOR.

TORONTO:
Z. M. COLLINS,
PUBLISHER TO THE SOCIETY.
1902.

The Toronto
Astronomical Society.

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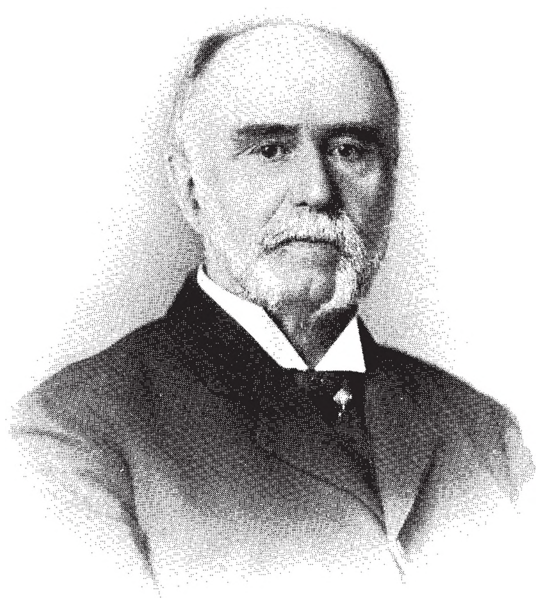

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TRANSACTIONS OF

The Toronto Astronomical Society

FIRST MEETING.

1901, January 10th. This eleventh annual meeting of the Society was held in the Library of the Canadian Institute. The President, Mr. G. E. Lumsden, F.R.A.S., occupied the chair during the business part of the meeting, when the following were elected Associates of the Society :

Dr. P. H. Bryce, M.A., Bracondale and Toronto,

Mr. R. W. King, 503 Markham Street, Toronto.

A letter was received from one of the Past Presidents, Dr. Larratt W. Smith, K.C., which, after expressing the learned doctor's regret that the growing infirmities of age, especially deafness, would prevent his attending the Society's meetings, contained the following sentence : "If you will substitute for my presence my large telescope, I shall with pleasure present it to the Society, as an indication that my interest in your Society has not flagged, but still continues, and will do so to the end."

The Society's satisfaction with the promise of such a generous donation, the telescope being an exceedingly fine three-inch refractor, was naturally offset by regrets that such a valued member was suffering from the attacks of Time.

Mr. Lumsden then yielded the chair to First Vice-President R. F. Stupart, F.R.S.C., and delivered the Annual Address, as follows :

THE THRESHOLD OF A NEW CENTURY.

It is related that upon a certain occasion a traveller was wrecked on the coast of an unknown country and that after long buffeting with the waves he reached the shore at nightfall, utterly spent by swimming and by hunger and exposure, when, failing to find a human habitation, he flung himself upon the grass and sank into slumber so sound and prolonged that before he wakened, the Lilliputian inhabitants who had found him in the morning were able to pin and tie him fast to the ground, where he lay at their mercy. The veracious narrative, however, goes on to explain that once the traveller became alive to his position he bent his physical strength and mental powers to the task of securing his release, and having finally gained his freedom he rose from his sleep a giant among the pygmies who had imprisoned him, and who, as they came to perceive his ability to serve them, were ready to accept his friendship and appoint him their champion, rallying behind him gladly when their land was attacked and lending him all the assistance in their power.

May not the incident be used as an illustration of the mental condition of Europe during many centuries prior to the revival of Learning ? Utterly exhausted by long struggles and overwhelmed by disasters, independence of spirit was so crushed out of the human breast that the intellect of man sank into a lethargy profound and long enough to allow it to become bound down to the very earth. A day of awakening did arrive, truly, but the evidences of consciousness were the merest glimmerings of returning intelligence—glimmerings which were sought to be concealed rather than revealed. However, the old spirit gradually revived, and the sagacious exercise of restored mental powers enabled it to shake off its shackles one by one until at last, only after several centuries, the human intellect was free. Once itself again, it grew to gigantic proportions in the same ratio as the old hostile influences lost their ascendency, and presently those very influences were glad to accept an unfettered intellect as their best friend and champion. The pulse that was scarcely discernable at the close of the XVth Century and still feeble at the close of the XVIth, had undergone a marked change at the close of the XVIIth, and by the end of the XVIIIth had become quite strong. At the close of the XIXth its beats were regular and full and indicated prime health and vigor. To-day Knowledge is untrammelled, and as Tennyson sings :

> Who loves not Knowledge? who shall rail
> Against her beauty? may she mix
> With men and prosper! who shall fix
> Her pillars? let her work prevail.

My subject seems to demand a brief review of the development during the XIXth Century of that great branch of general science popularly spoken of as "Astronomy," and of its allied branches now known as "Astro-Physics." This is by no means unpleasing, for it must be a story of progress everywhere, at some periods steady, at others by leaps and bounds. Results were almost invariably substantial ; occasionally brilliant, as if the patient workers had caught some inspiration, or as if the very hand of Providence had in the interest of the human race suggested the means or pointed out the lines along which investigation should succeed.

The XVIIIth Century was progressive too. Art, Science and Letters flourished as they never had before, in spite of, perhaps by reason of presumably untoward conditions, consisting of long and disastrous wars, from the effects of which no country escaped ; wars which overturned thrones, uprooted states, shattered nations, re-drew boundary lines and changed social and economic conditions of men and things. It may be that the often rude awakenings of the time had their influence upon the arts of Peace as much as upon the arts of War. Be that as it may, the scientific men who one hundred years ago had crossed the threshold of a new century could point to a brilliant and useful past and predict a promising future. They could speak of the splendid achievements of men like Newton and Halley, Bradley and Napier, Hooke, the elder

Dollond, the Cassinis, father and son, D'Alembert, Leibnitz, Bianchini, Galvani, and others who had not long passed away, while among those who had made or were to make their mark were such original workers in Great Britain as Brewster, who at 20 had turned aside from the Church, for which he was intended, and while engaged in editing *The Edinburgh Magazine*, had taken up optics as a subject for special research ; Davy, sometime an apprentice to an apothecary, who at 23 had gone up to London to lecture at the Royal Institution, then in its infancy, and, like an infant, weakly and needing fostering care ; Wollaston, who, beaten in a contest for the post of physician in St. George's Hospital, had vowed he would not write another prescription, even for his father, and had become an ardent student of optics and spectroscopy. There were Peter Dollond, who was endeavoring to perfect his father's work in constructing large achromatic object-glasses for telescopes ; and Young, a Quaker doctor, who had begun to practice in London, and to lecture at the Royal Institution ; and Dalton, who had grown famous as an observer and a lecturer at New College ; and Faraday, who had just entered upon his apprenticeship to a bookbinder, and who, by reason of his own poverty and that of his family—his father being a journeyman-blacksmith—could only slake his thirst for knowledge as he best might with such scientific information as he could find among the scraps of printed paper given him to be used as the linings of the books he bound. On the continent, there were Arago, who had recently been appointed secretary to the Paris Observatory, where he was to pass many years and to become famous ; Lagrange, who, a few years before, had drifted into Paris, and, as some reward for his splendid mathematical work, was about to be loaded with honors ; Laplace, the ambitious son of a poor farmer in Normandy, rapidly rising to eminence, having just published the first volumes of the *Mecanique Celeste ;* Daguerre, still a lad in Normandy, interested in Science, but unconscious of the great services he was yet to render her by means of his discoveries in the practical application of photography. There were Bessel, still laboriously working his way to the highest place as an observer and computer ; and Gauss, who had published his first work on Numbers, but was turning his attention to Astronomy, owing to the general interest being taken in the search for the hypothetical planet between Mars and Jupiter ; and Olbers, who though practising an arduous profession, had become famous for his work as an amateur astronomer ; and Volta, who was still Professor of Philosophy at Padua. And yet no mention has been made of Herschel, who, by virtue of his hunger for knowledge, his fixed resolution to acquire knowledge, his great natural talents, acumen, unwearied application, indomitable will and ability (though a mere amateur) to construct for himself telescopes which were the envy of professional instrument makers, all at once burst upon the astonished gaze of scientific Europe like a splendid meteor, or the great comet of 1843, which suddenly appeared in broad daylight and nearly matched in brilliancy the Sun himself. Such were the men who were leading, or were soon to lead, the van of original workers during the XIXth Century—workers who, in numbers alone, were to become a host.

In venturing to describe some of the scientific achievements of the busiest century the world has ever known, I must, of necessity, pass in silence over a multitude of facts and incidents which must be excluded from a paper to be read in less time than one hour. But if I must exclude these facts and incidents, I may take leave to refer you to the books which have recently been published by astronomers and physicists of the highest rank, including the works of the Astronomer Royal, of Sir Robert Ball, Sir William Huggins, Professor George Darwin, Professor S. P. Langley, Professor Simon Newcomb, Professor E. C. Holden, Reverend T. W. Espin, Messrs. W. F. Denning, F. R. A. S., and J. E. Gore, F. R. A. S., and last, but by no means least, the volumes of Miss Agnes M. Clerke. All of these books are lucid in expression and attractive in style, and most of them combine, in a delightful way, with accuracy of statement, the charm of the best light literature. This Society is happy in the knowledge that all of these distinguished persons are members of it, being either Honorary or Corresponding Fellows, an intended distinction modestly conferred, and as modestly, without a single exception, accepted. The volumes of Miss

Clerke have became classic, three of them being her well known "History of Astronomy during the XIXth Century" to which I gladly confess my own obligations; "The System of the Stars," and "The Herschels." In addition to manuals and numerous articles and papers, this able woman has written a work entitled "Familiar Studies in Homer," and has successfully undertaken to translate into verse some of the finest passages in the Odyssey.

At the end of the XVIIIth Century, there was practically no Science of Astronomical Physics, and theScience of Astronomy itself was limited to the confines of the solar system, though Herschel was raising sidereal astronomy to a higher level, and the stars were becoming something more than mere points of light by which the motions of the sun and planets could be determined. Nothing was known of the composition of the sun, or of the stars, or of nebulae or comets. That was awaiting the development of spectroscopy.

For the purpose of this paper, it is necessary to refer to but two of the closing years of the XVIIIth Century, 1796 and 1800. The first was rendered notable by the enunciation by Laplace of his Nebular Hypothesis, which Miss Clerke calls one of the bequests from the old to the new century. In 1800, a force of astronomers sometimes alluded to as the "Celestial Police" was formed, to search for the planet, which was believed to revolve between the orbits of Mars and Jupiter. But the event of the year was the publication of the *Monatlische Correspondenz*, the first magazine to be devoted to Astronomy, a fact which reminds us that throughout the past century Astronomy had a firm and true friend in the periodical press, which in both hemispheres has become a power for the dissemination of interesting and useful knowledge of all kinds, and to which Science owes a vast debt of gratitude.

The very first day of the new century was made glorious by the discovery at Palermo, by Piazzi, one of the "Celestial Police," of the first of the hundreds of planetoids now known to exist. Three other events may be mentioned, namely, the publication by Lalande of his Celestial History; Herschel's efforts to establish a relationship between sun-spots and the weather, wheat being found to be dearer during the years when there were few ; and the gift by the Duke of Bavaria to Fraunhofer, a poor boy, of the money which enabled him to buy the books he needed to prepare him to enter upon a scientific career which became one of the most famous of the century. The Duke's present was intended as a charity, he having witnessed an accident which nearly cost Fraunhofer his life, but his gift, small as it may have been, was really one of the finest bequests Science has ever received.

In 1802, in the course of spectroscopical work, Wollaston, by a stroke of genius, substituted a slit for the round hole through which, since Newton's time, it had been the custom to pass the solar rays for the purpose of studying the spectrum. For the first time, dark lines, now familiar enough, were detected by human eyes, but, possibly because he saw seven of them, Wollaston was content to suppose they formed the boundaries between the seven primary colours, and, satisfied with this view, he let the matter drop. Had he been animated by the exacting spirit of Bradley, who took nothing for granted, the world might not have had to wait sixty years for the revelations due, in the first place, to the investigations of Fraunhofer, and, in the second place, to those of Kirchoff.

Herschel, having again addressed himself to the subject, announced in 1805, and for the second time, that the sun has a motion of his own among the stars, and that he is travelling towards a point in Constellation Hercules. From the platform of the last car of a moving train, we shall see converging to a point the rails over which we have been carried, and shall notice that objects we pass on either side gradually close in behind us. So with the sun. Careful measurements of certain stars show that they are gradually converging upon a common centre and that others in the opposite portion of the heavens are widening out. The theory was not Herschel's, but to him must be ascribed the honor of having proved its truth. But Herschel's announcement in 1805 was not better received than in 1783, and it was not admitted as true until Argelander, who based his results on the observation of thirty-nine stars, confirmed Herschel's statement.

The year 1807 is notable because of the delivery by Young of a course of lectures in which he expounded the doctrine of interference, which established the undulatory theory of light and destroyed the corpuscular theory of Newton.

The great comet of 1811 appeared on the 26th of March and remained visible 510 days. Some conception of its grand proportions may be formed from the statements that its head measured 127,000 miles in diameter, and that its tail was 100 millions of miles in length. Naturally, the presence in the sky for so long a period of so magnificent a comet caused many scientific men to turn their attention permanently to astronomy. The period of the comet was calculated by Argeländer to be more than 3,000 years. "Thus," says Miss Clerke, "when it last visited our neighborhood, Achilles may have gazed on its imposing train as he lay on the sands all night bewailing the loss of Patroclus ; and when it returns it will perhaps be to shine upon the ruins of empires and civilizations still deep buried among the secrets of coming Time."

The year 1812 was remarkable for an incident which, while it does not exactly bear upon the subject of our paper, admonishes us to be careful how we decline to lend a helping hand when in our power to do so. Sir Joseph Banks was by far the most prominent scientific man of his day. He equipped at his own expense an expedition, and went around the world with Captain Cook, to study botany as widely as possible. By means of his wealth and position and work, he had become deservedly famous, and during forty-one years held the Presidency of The Royal Society of London. To him, in his extremity, turned Faraday, who was still working at his trade of bookbinder, but was as ambitious as ever to improve himself, and to be at work as an investigator of electrical phenomena. He wrote to Sir Joseph, stating his desire, and offered to perform the most menial duties in return for any opportunity that might be afforded him for study or experiment, but when he called at the great man's door, the footman told him there was no answer for him. Those of you who have read an account of Faraday's life and know his modest, sensitive nature, may form some idea of his bitter mortification. But, though discouraged and disheartened, his yearnings for knowledge goaded him on to try again, for in December of the same year he wrote to Davy, some of whose lectures he had heard. Davy at once replied: "It would gratify me to be of any service to you. I wish it may be in my power." When Faraday called, Davy advised him to stick to his trade, and promised to send him books to bind. Davy was so much impressed by the youth, however, that in the following month he gave him some secretarial work, which was so carefully and neatly done that it may be said to have opened the door for a scientific career of the greatest usefulness.

In 1814, Guinand invented the process by which large discs of optical flint-glass are made, but this and the following year are noteworthy because, during their course, Fraunhofer, by means of a slit and telescope, made the momentous discovery that the solar spectrum is crossed, not by seven dark lines only, as Wollaston had been content to suppose, but by thousands of transverse streaks, of which he counted 600 and mapped 324. Fraunhofer examined the light of the moon, planets and brightest stars, and found in the spectra of Pollux, Capella, Betelgeuse and Procyon the solar line D, which, to his astonishment, exactly coincided in position with the yellow beam, itself afterwards indentified with the light of glowing sodium, already found by him to accompany most kinds of combustion. Moreover, the dark solar line and the bright terrestrial D line were displayed as double. This correspondence laid the foundation of solar chemistry, but as Fraunhofer was an optician, and not a physicist, he pursued the subject no further than suited his purposes, and the true significance and the overwhelming importance of these discoveries were not known for nearly half a century.

In 1816, the elder Herschel was knighted, and the younger Herschel, having been won away from the law, to which he had been bred, turned to astronomy and science—determined, with Peacock and Babbage, "to leave the world better than they found it." On the 29th of August, died Schröter, who for 34 years had studied the topography of the moon with a thoroughness never rivalled, and laid the foundation of the comparative study of the lunar surface.

Pons, in 1818, discovered a comet which ultimately became known as that of Encke, who calculated its orbit and predicted its return in three and a quarter years, the second prediction of the kind ever made, which was fulfilled in 1822. During the same year Repsold perfected machinery for the division of hour and declination circles for equatorially mounted telescopes.

In 1821, on Christmas Day, Faraday showed his wife his discovery of electro-magnetic rotation, which brought him international fame, he having succeeded in making a wire, through which an electric current was flowing, move under the influence of the earth's magnetism alone.

In 1823, Faraday succeeded in liquifying chlorine-gas and hoped to liquify oxygen and hydrogen, and in the following year Fraunhofer constructed a fine telescope, having an aperture of nine and a half-inches, which became known throughout the world as the "Great Dorpat Refractor," to which, for the first time in the history of such instruments, a clock-driving appliance was attached.

In 1826, Schwabe, tired of his hereditary business as an apothecary, began his forty years' observation of the sun, which resulted in his being able to prove that there are sun-spot-periods with more or less regular maxima and minima.

In the Autumn of 1831, Faraday discovered the magneto-electric current, the principle upon which all our modern dynamos and transformers are constructed, and the foundation of all the systems of lighting by electricity, and for the transmission of electrical power.

In 1828, at a scientific congress at Berlin, Humboldt, advocated the establishment of a net-work of magnetic-observatories over the world, for the purpose of attacking the complex problem of terrestrial magnetism. In 1836, the practical sympathy of England was gained, so that, by 1841, there had been erected throughout the British Dominions a series of similarly equipped observatories, of which that in Toronto is one. Having mentioned this fact, it may be added that, based upon the results obtained here and at Hobarton, Van Dieman's Land, our antipodes. Sabine, in 1851, found that once in about ten years magnetic disturbances or storms reached a maximum of violence and frequency, and that a coincidence existed between this result and Schwabe's already announced ten-year period in sun-spot maxima and minima.

On the 6th of August, 1835, the second prediction of the return of Halley's Comet was verified by the discovery at Rome of a misty object which by the middle of September had become a great comet with a tail thirty degrees in length. The nucleus or head had the brilliance and reddish hue of Aldebaran. An outrush of luminous matter, resembling a partly opened fan, issued from the nucleus towards the sun, and, at a certain point, like smoke driven before the wind, was vehemently swept backwards in a prolonged train. Bessel said this fan oscillated like a pendulum across a line joining the sun and the nucleus, and that the repulsive force was twice as great as gravity, thus stating a fact but lately explained by the studies of the ether and of cathode rays made by Deslandres, J. J. Thomson, and Fessenden.* Bessel declared the emission of the tail to be a purely electrical phenomenon. This splendid comet will return in 1911, and I hope you may all see it in the glory with which, at intervals of about seventy-five years, it has during many centuries visited this world.

In 1680, Newton reasoned that the heat of the sun was about 2,000 times that of red-hot iron. In 1837, the younger Herschel, at the Cape of Good Hope, and Pouillet, in France, made observations and computed that the heat received by the earth from the sun in one year is sufficient to melt a layer of ice covering the entire world to a depth of 100 feet, while the heat emitted by the sun would in each minute of time melt on the sun's surface a sheet of ice 35 feet thick. Herschel further calculated that if the ordinary heat from the entire solar surface could be concentrated for one minute, it would have power to melt a column of ice 184 feet in diameter reaching from the sun to α Centauri, the nearest fixed star. Recent investigation shows that the column should have been estimated at 250 feet in thickness, and that it

*Professor Fessenden's claim to priority in this discovery is printed towards the end of this volume. (See INDEX).

would require an ice-rod 45 miles in diameter fed into the sun with the velocity of 286,000 miles a second to exhaust his heat.

In 1837, the inventors who had been working upon telegraphy succeeded in making some practical use of their discoveries, little dreaming of the splendid services they were conferring upon mankind.

In 1839, Daguerre and Niepce made the first really useful application of photography and therefore took the first practical step in a branch of Knowledge which, though apparently in its infancy as yet, has already been of the greatest benefit to Science and Art as a whole.

The year 1840 was remarkable for the first application of photography to celestial objects, Dr. J. W. Draper having succeeded in taking a few moon pictures, but their value was so small that the results were not encouraging.

In 1842, Baily, after years of experiment, announced that the weight of the earth was nearly five times that of a globe of the same bulk of water. This remarkable man, like many others who have made to Science contributions of profound value, was an amateur. His name is inseparably connected with phenomena he had noticed during eclipses and now known as "Baily's Beads." Indeed, his lively description of the phenomena aroused attention to that degree that for the first time great efforts were made to properly observe the very next total solar eclipse, on which occasion the corona and streamers and protuberances were well seen. From this time onward solar appendages were regarded in a new light, for eclipses had been esteemed as little more than tests of accuracy in predicting these phenomena. The year is further notable because Meyer and Joule discovered the equivalence between heat and motion, the corollary of which is the grand idea of the "Conservation of Energy."

In 1843, Mitchell, the eloquent Cincinnati professor of mathematics, delivered, in the United States, that splendid series of lectures on Astronomy which sowed the seed for the 150 observatories which presently sprang up in a country where ten years before his time there had been none. Possibly his eloquence was helped by the sudden apparition of the magnificent comet of 1843, already mentioned. In this year also, Schwabe announced his theory of a ten-year period in the waxing and waning of sunspots, but, being an amateur, no one paid any attention to him.

In 1845, Lord Rosse's six-foot telescope was put in place, and the first spiral nebulæ were discovered. In the same year solar daguerreotypes were taken at the Paris Observatory, but the results were not satisfactory, there being too much light to contend with. At Harvard, however, Bond photographed two stars of the first magnitude, viz., Vega and Castor. In October, Adams communicated to the Astronomer Royal the results of his marvellous computations, made in his efforts to find the place in the sky of the unknown body which was causing perturbations of the Planet Uranus, and which, when discovered, was named Neptune. Adams succeeded in pointing out its position within about one breadth of the full moon, but he was an amateur, and the professional astronomers did not take him seriously, and the prize, which should have been his, was snatched away by Leverrier, who had been asked by Arago to look into the matter. Leverrier, nearly a year behind Adams, reached very similar conclusions, which were by him communicated to the German astronomer, Galle, and the planet was picked up, at Berlin, on the 20th of September, 1846.

In 1850, Bond re-discovered the crape-ring of Saturn, found by Galle, in 1838, and, this time, the announcement was accepted, it having on the first occasion been ignored. During the year, Bond successfully daguerreotyped the moon and opened the splendid career of celestial photography.

In 1851, at the total solar eclipse of the year, the true character of the rose-flames was conjectured, and a creditable and useful daguerreotype of the sun, showing the corona, was taken. Humboldt published Schwabe's solar statistics, and the neglected amateur at once became famous. It may be noted that this year Faraday declined to recommend Tyndall as a suitable candidate for a professorship in Toronto University. Had Faraday given the testimonial, would Tyndall have been appointed? and if appointed, what would have been his Canadian career? We can but conjecture. However, it should be stated that Faraday, as a matter of principle refused to commend any candidate for any position. But was he consistent in this? Would he have liked the rule applied to his own case fifty years before, when he was a struggling lad? That Tyndall harbored no ill-will, however, is shown by the fact that his life of Faraday is, perhaps, the best that has been published.

Fraught as they were with practical results, and really typical of many other years, I must pass over 1852, 1853, 1854, and 1857, in order to speak for a moment of 1859. In the autumn of that year, Kirchoff made the classic discovery that if the light of a sunbeam be thrown across a space occupied by the vapor of sodium, the dark Fraunhofer line *D*, instead of being effaced by flame giving a luminous ray of the same refrangibility, is deepened and thickened by superposition, and that a dark furrow, corresponding in every respect to the solar *D* line, is instantly seen to interrupt the otherwise unbroken radiance of its spectrum. The inference was irresistible that the effect thus produced artificially was brought about naturally in the same way, and that sodium forms an ingredient of the solar atmosphere. Other metals were similarly detected. Curiously enough, almost the same results were arrived at by Brewster in 1833, by Miller in 1845, by Foucault in 1849, and by Stokes a little later. But they stopped short of verification. Here I may pause in my enumeration of discoveries, for the list has been brought down to the time within the memory of many of our members, and besides, the great men that would be mentioned are, in many cases still amongst us. It is, however, a fair presumption that the chief recent scientific events are not unknown to any one here.

As the century grew apace so did investigation and results. The mountain torrent of 1801 has swollen into the broad, steadily flowing river of 1901. In one hundred years the company of scientific students has, in numbers, become an army in Europe alone, and another army has been formed on this continent. Compared with the first quarter of the century, progress during the last quarter moved forward with a resistless rush. Invention and discovery have gone hand in hand. Nothing has escaped improvement.

In 1801, and perhaps as late as the death, in 1871, of Sir John Herschel, it was possible for one man to become master of all known astronomical and astro-physical knowledge. In 1901, this is no longer possible. To-day, the Science of Astronomy may be likened to a tree having many great branches—some as large as the tree itself was one hundred years ago. Inseparably connected with the recent growth of the tree and its branches are the names of Huggins, Birt, De la Rue, Dawes, Schmidt, Wolf, Henry Draper, Rutherford, Carrington, Secchi, Angström, Balfour Stewart, Lockyer, Dewar, Flammarion, Loewy, Langley, Young, Burnham, Helmholtz, Clerk-Maxwell, Hertz, Lodge, Lords Kelvin and Rayleigh, Pickering, Newcomb, Barnard, and many others.

Amid the flood of light which, to us, appears to be streaming over the landscape, we are apt to boast of the present splendid position of Science, and to be tempted to look back upon the past in a condescending way. But let us ask ourselves whether our sky is brightened by the effulgence of the true noon hour, or, after all, by a dawn only a little more rosy than that of our forefathers. Did not the noon-day of Aristarchus seem to Hipparchus one hundred years later as merely dawn? May not the noon of Hipparchus, in turn, have glimmered but as the dawn as seen by Ptolemy and the philosophers who came after him for 1500 years? The noon of Copernicus, Tycho Brahe, Galileo, Kepler, and Newton, may have been the dawn of 1801, as the noon of 1901 may be only the dawn of 2001, by which year shall have been made discoveries of which we no more dream than did our predecessors dream of the great discoveries of which many have been made within our own time. It would be idle for us even to conjecture what shall be known when our successors have crossed the threshold of another century. The splendid telescopes, spectrocopes, cameras and other apparatus, now our boast and pride, may then be found only in museums, other apparatus of which we have now no conception having taken their places.

Science has been for ages busily engaged in erecting the Temple of Truth. From the earliest times men have been contributing of their labor and materials for this purpose. They have been engaged in digging deeply, so that the foundations might be laid on the living rock, which they did not always reach. The result was, that as centuries rolled away, it became necessary to pull down an arch here or a piece of wall there, and even to take up the very foundations in places, and to dig deeper. Sometimes a whole wing (as, for instance, Astrology) has had to go. But allowances must be made where the workmen are in earnest. We must remember that none of them had even such light as we enjoy, and that they often groped in darkness. To them, the noble outlines, the splendid proportions and the perfect symmetry of the building were not visible as they are to us; and even to us the Great Architect of the Universe has not yet revealed them wholly. But the workmen have grown in numbers, in knowledge, in skill. The foundations are probably complete and well laid. The superstructure is rising rapidly. For the first time in the history of the world a band of Canadians has joined the army of artificers. It may be that for want of skill, or tools, or numbers, the labors of the band may not be, at the moment, of great value, but its members give place to no one in their devotion, in their sincerity and in their resolution to render good service. It is but ten years since this Society came into existence as an incorporated body; but those ten years have been years of preparation; and if our future be worthy of our past, there is hope that this Society will become a really useful adjunct to Science. May the President of the Toronto Astronomical Society who stands in my place one hundred years from to-night be able to speak to his audience of that usefulness, and may he be able to point to some beautiful arch, the keystone of which was cut and put in place by a member of this Society; some noble column which was erected and completed by the Society; some turret, pinnacle or spire that the Temple of Truth shall owe to those who come after us.

But this will all depend upon the accuracy of our plans, the exactness of our knowledge, the soundness of our foundations, the suitability and adaptability of our materials, and the resolution and skill of our workmen, who must be earnest and true to themselves and their beloved science. As Cowper says :

> None sends his arrow to the mark in view.
> Whose hand is feeble, or his aim untrue :
> For though, ere yet the shaft is on the wing.
> Or when it first forsakes th'elastic string,
> It err but little from the intended line,
> It falls at last far wide of his design.

And now one word personal to ourselves. As a Society, we have just crossed the threshold of a new century, and we have set our faces towards the threshold of the next. We know that we are studying the most ennobling of all the sciences. We are gathering apparatus and improving our facilities. We have opened our doors to every one. We are endeavoring to dispel the idea that Astronomy is a science reserved for the mathematician, for the learned, for the man with leisure and money ; in other words, for the favored few. We are cultivating, as we think, a general love for Nature in her most glorious form, and, we trust, in such a way that it shall redound to the benefit and advantage of us all.

Mr. J. A. Paterson, M.A;, Mr. Arthur Harvey, F.R.S.C., Mr. A. Elvins and Rev. T. C. Street Macklem, D.D., expressed their high appreciation of the eloquent address, and a vote of thanks was cordially offered to the President, who then terminated his first year of office and entered upon the second.

The Society's lecture room and library (in the same building) were then visited by many of the members and guests, the valuable lunar-photographs made by Messrs Loewy and Puiseux at Meudon, Paris, France, and presented by the Government of France, being on exhibition. In the lecture-room Mr. D. J. Howell shewed on the screen many of the beautiful lantern-slides the Society owns, including some fine slides made from the lunar-plates just mentioned. The Society's new electric projecting lantern was used in public for the first time. And after partaking of light refreshments an unusually pleasurable annual meeting was dissolved.

SECOND MEETING.

January 22nd ; the President in the chair.

The following were elected as associates.

Mr. John Bertram, Ex-M.P., 9 Walmer Road, Toronto.

Mr. Charles B. Petry, 61 Isabella St., Toronto.

Mr. Garnet H. Meldrum, Prince Arthur Avenue, Montreal.

Regrets having been expressed that the Society had lost the Services as Recorder of Mr. Thomas Lindsay, that feeling found expression in the presentation to him, at this meeting, of a stop-watch. In reply to the congratulations of the President and Mr. Elvins, Mr. Lindsay said he had been largely the gainer by the knowledge obtained while acting for the last ten years as Secretary and Editor.

THE SUN.

Mr. Arthur Harvey, commencing his paper on The Sun, said—Nobody can think seriously about him without a feeling of awe. For the Sun it is which holds together his family of worlds, and through his influence all things live, move and are. From the first blush of the dawn which heralds him to the more garish tints which follow his setting, all the processes of life and thought are ruled by him. His are the dews of evening, the purling of the brooks, the soughing of the forests. He it is who tinges the meadow with verdure and tips the flower with color. He regulates the roar of Niagaras, summons the tornado and lets slip the lightning. No astronomer can write of the sun without what seems like rhapsody, and as for the physicist, hear Nikola Tesla :

" We see the ocean rise and fall, the rivers flow, the wind, rain, hail and snow beat on our windows, the trains and steamers come and go ; we hear the rattling noise of carriages, the voices from the street; we feel, smell and taste, and we think of all this. And all this movement, from the surging of the mighty ocean to that subtle motion concerned in our thought, has but one common cause; the sun is the spring that drives all. The sun maintains all human life and supplies all human energy."

The latest determination of the sun's mean distance from the earth is 92,874,000 miles. His disc subtends at that mean distance 30′ 31″, which determines his diameter at 865,246 miles. Assuming the earth to weigh five and a half times as much as water, the materials composing the sun, expanded equably, so as to fill up a globe of the diameter named, weighs little more than water (1·4). This at once compels an examination of the circumstances under which such a seeming anomaly can exist. The governing condition appears to be the temperature of the sun, as to which there are many very different calculations—one of the latest being that of J. Scheiner, whose "Strahlung und Temperatur der Sonne.—Leipzig, 1899"—is reviewed in the *Astrophysical Journal* for November, 1900. He gives the effective temperature as 8000° centigrade, or 14,400° Fahr., much more than enough to vaporise all the elements we know, and, perhaps, to dissociate some of those we consider simple. The sun must therefore be a huge ball of intensely glowing vapors and gases. How comes it then that the edges are so distinct, as well defined in the telescope as those of the moon? As to this there are several theories—one optical, not to be discussed now, and others physical, e.g, that the limit is where the cold of space compels the condensation of these heated vapors, as our clouds are similarly permitted to rise so high and no higher.

The surface of the sun is a wonderful sight. Sir John Herschel says it resembles a flocculent chemical precipitate, subsiding in a clear fluid. It has a mottled look, which some liken to a lot of rice grains lying side by side, and others to willow leaves strewn thickly on the ground. Mr. Pursey, one of our members, a very constant solar-observer, thinks there are numerous pores in the shining envelope. It has been suggested that this appearance is due to air-waves within the telescope tube, to undulations in our upper air, to movements in the solar atmosphere outside the photosphere. I think these ideas have been disproved by the photographs taken of parts of the solar surface, at short intervals, by Janssen, at the Meudon (Paris) Observatory, for they show much similarity, if not identity, in the distribution of these grains in two successive views : the photospheric *reseau* or network appears to differ, too, considerably, in different parts of the disc. When magnified 200 diameters the granules average about a tenth of an inch across ; they are as close together as you could pack grains of wheat, the interstices being slightly less luminous than the grains. If they are cloud-areas, of such gases as just indicated, then, as they are about 5,000 miles across, they are many times as large as the largest cloud-areas which on earth attend the "lows" of the barometer, and, whereas there are seldom more than twenty-five or thirty "lows" at one time upon the earth, there are some 35,000 of these rice-grains upon the visible half of the sun, and without any intervals at all.

This photospheric surface must be as tenuous as the smoke of a cigar, and that is the reason for the great apparent magnitude of the changes which are seen to take place upon it, just as we know that air-waves at a height of fifty miles above the earth may be a mile across, whereas in the dense air at the surface a few yards will measure them. There is evidently a brisk circulation between the surface of the photosphere and the layers just below it, but probably quite gentle, and there is no reason for insisting upon awful falls of iron rain, or tremendous solar thunder-storms. Doubtless there is a loss of heat, leading to solar contraction, unless the loss is balanced by receipts from other sources, and it is interesting to know how great this emission is. It has recently been re-calculated by Count de la Baume Pluvinel at the observatory on the summit of Mount Blanc. He says that the sun's rays received on a surface a centimetre square will, on the average of the year, raise a gramme of water from 0° to 3°.4 centigrade. That means that the heat radiated on a square inch will, in one minute, raise 1.4 ounces from freezing point just one degree Fahr. For the whole earth this means 600,000 times as much heat as is developed by all the operations of mankind—steamboat and railway service, smelting of ores of metals, factory work, generating heat, light and power in every way. Camille Flammarion says that in six hundred thousand years spent in burning coal, wood and other combustibles at the present rate we should only have produced as much heat as the sun flings upon us in one year, and he regrets that mankind makes as yet but little use of all this energy. It is true that no solar engines have yet been commercially successful, except the wind mill and the water wheel, which are such only in a secondary sense, but we should not forget that this heat does serve us, though uncontrolled, and that owing mainly to the interposition of a screen of moistened air between the earth's surface and its upper atmosphere—a screen which permits incoming heat rays to freely pass, but puts obstacles to their escape after reflection,—the world has become the Paradise it is.

The tenuous, flocculent surface of the sun is disturbed in three ways ; Great dark spots appear upon it, also shining streaks called faculae or torch-lights, while prominences like flames are usually visible at the edge of the huge disc. All these features are more frequent at one time than another. We are now at a time of minimum activity, which may last another year. In 1896 there were but 8 days on which the sun was clear of spots, in 1897, 32, in 1898, 48 and in 1899, 85. The number of prominences observed in 1899 was the same as in 1898, but their size and extent were much diminished. In 1899, the faculous areas only measured 52 per cent. of those of 1898.* Thus it is safe to infer a common cause for these phenomena. What causes the irregular pulse-beat which so affects the sun that there is a maximum of activity about every eleventh year cannot be guessed as yet ; it was thought the position of the planets might afford a clue, but that has been dropped. The spotted area, the size and number of faculae, the number and height of the prominences, the magnetic disturbances upon the earth, the auroral manifestations North and South, the brightness of certain comets and a variety of other

* The solar activity continued to decrease during 1901, and was less in that year than in the minima of 1878–1889. The last quarter of 1891 and was the quietest of the whole period-

minor and dependent occurrences increase for four or five years and then diminish for half a dozen. Even the Chandler period of variation in Terrestrial latitude seems to depend upon it.* The period is irregular, though, perhaps, there is an ultimate rythm in this irregularity. It is thought that increased solar activity implies also an increased emission of light and heat.

Spots ought to be considered as an effect of some interior change, not as the cause of any disturbances, solar or terrestrial. The change is possibly brought about by a convection current bringing from within different matter to that which floats on the shining surface. Through some of the pores or interstices in that netted surface the new vapors pour and swiftly spread over the area they can cover, or from which they can displace the luminous layer. It is seldom the outbreak of great spots are seen, it even appears to the writer that they usually form on the side remote from the earth and come over the limb full grown. The disintegration of a spot is readily watched. It often breaks up into several, which drift a little apart, the photospheric clouds resuming their sway, pressing in from the outside. The spot may re-appear by rotation half a dozen times, alimented perhaps from the original source ; oftener it is seen for a couple of rotations only. Frequently another appears in a few months, near the same place, as if the interior eruption had broken out again. They are only seen in the spot zones, up to about ± 45° from the equator,* not on, though often very close to it ; sometimes there are more in the Northern than the Southern hemisphere, sometimes they are a little further from the equator on the average than at other times. Dark as the penumbra seems, and still darker as the nucleus is, they are only so by comparison. The brightest light we can manufacture would show black against the nucleus as a back ground.

It was for a long time thought that by these spots the rotation period of the sun could be determined, and the latest of the

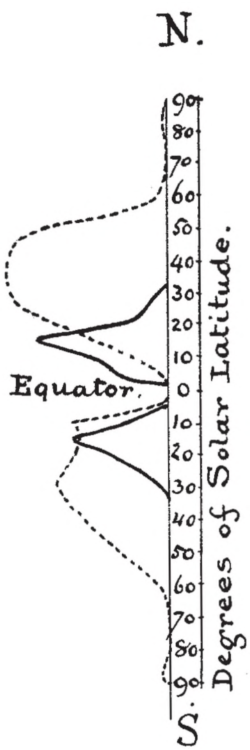
* A spot was reported by La Hire at 70°, but the accuracy of the reduction is doubtful. It is rare to see spots more than 40° from the equator, and since the midsummer of 1889 only nine have been above ± 45°. Of these one was at − 60° and another at + 57°.

"Greenwich Observations" which has reached us, gives the solar longitude of every spot as if it were still thought possible, but the most careful average computations have been shewn to be of doubtful value, for the photosphere does not rotate as a whole. Spots are now said to rotate at the equator in 25 days; at ± 30° of latitude in 26·5 days, while the solar surface beyond the spot zone at ± 45° rotates in 27 days, and near the poles in from 30 to 31 days.

The faculae are brilliantly illuminated patches, occurring in the spot zones, and sometimes appearing to belt the sun. They are often closely connected with spots, and look like ridges or wave crests in the photosphere, brighter and whiter than the rest. They are often very beautiful objects, and it does not require much imagination to liken them to billows in an ocean of seething molten matter, though this they certainly are not. It is highly interesting to draw with crayons a fine sun spot, with faculae beside if not around it, and that is what every observer should do at least once. Wilsing, of Potsdam, from an examination of 244 groups, has calculated the rotation of faculae to be 25·23 days, which corresponds to the motion of spots in 10° latitude. From this it would seem that they may be in a slightly different layer from the spots—disturbed areas in an upper envelope.

Solar prominences are the most frequent form of surface disturbance. They can be seen with the naked eye, or with a low-power telescope at times of eclipse, as crimson projections from the sun's edge when the moon just covers it. They can also be seen at all times with the spectroscope. They are not confined to any region, polar or equatorial; but they occur chiefly in belts, two on each side of the equator, and these belts shift each year, like the belts of Jupiter, There is sometimes a polar belt besides, as near the pole as ± 75° to 80°. As seen at the edge of the sun there is first a swelling which may perceptibly disturb the circular outline, and after a time, from a few minutes to an hour or more, there issues a great jet of what looks like smoke or steam, which reaches a height of from 2′ to 4′ of arc, very rarely 5′, though Prof. Young measured one of 7′. The figures represent respectively 55,000, 110,000, 275,000 and 385,000 miles. Prof. Young calculated the mean velocity of the up-rush at 165 miles a second, and Italian observers have noted velocities of 350 to 450 miles a second. On attaining full development, the prominence usually bends over at the top, droops and soon disappears. Notwithstanding the fact that a body starting with a velocity of 380 miles a second might, by overcoming gravity, leave the sun, I cannot think there is a transference of matter going on through explosive violence. I prefer to believe there are electrical influences at work, as I have often said there are in the development of comets and auroræ, and Deslandres has supplied the key, mentioned in our Transactions for 1898, page 41, when he discovered that cathode rays carry with them particles charged with negative electricity.

The red color of the prominences is, I think, due to what is termed the chromosphere. During total eclipses, no sooner has the moon shut out the last rays from the photosphere than a brilliant edging of scarlet or crimson shews around her forward edge, and the same appearance is seen on the other side just before totality ceases. This must indicate a layer of this color just outside the photosphere, quite shallow, say from 2,000 to 5,000 miles. It cannot be a deeply tinted gas, or we should always see the whole sun red; but it must appear of a brilliant red because we only see it on the limbs, and must look through a great deal of it owing to its position. In the same way sea water and air are not highly colored in small quantities, but appear of a fine green or a sky blue when we look into the deeps or at the vault of heaven. It almost seems as if some element which burned with a red flame was always coming through all the pores of the *reseau* and undergoing combustion as soon as it had passed them. The prominences may consist of this same element, or not; in any case the beautiful red of this chromosphere would illuminate them, as a red light will color a column of white steam. It has been suggested that the prominences aliment the corona, the pearly envelope which surrounds the whole glorious sun as if with slowly waving wings, but the prom-



(See Foot Note †)

inences show to the spectroscopist chiefly hydrogen and calcium.* The corona is said to shew principally coronium and very little hydrogen.

Mr. Harvey next addressed himself to the subject of more or less permanently active regions on the sun, of which he found three—one very marked—also regions of comparative calm. Some of the tables which shewed the probability of this conclusion had been published in former Transactions of this Society, and charts shewn at its meetings. He said he was pleased to find support for his views in Wolfer of Zurich's maps, strikingly similar to his own, published in the Transactions of the Italian Spectroscopists for Dec. 1900. He then proceeded to combat the view, still too commonly held, that when great spots broke out, magnetic disturbances were the immediate consequence. He gave the well known instance that, "while Professor Young was observing the sun on August 3, 1872, a sun-spot broke out, his magnetic compass being at the same time much disturbed; and, on enquiry at Greenwich, he found a grand magnetic storm was raging." The inference was hastily drawn that the spot caused

* I read that they can be seen by using either the hydrogen or the calcium lines, and that their shape differs very much when looked at in these two ways, which indicates that the respective vapors are not intimately associated, or that the negative and repulsive influence of the concomitants of the cathode rays is differently exerted on the two elements.

† The dark line in this diagram is the curve of sun-spot frequency, the dotted line that of prominences, 1895, thus showing the latitudes in which these phenomena respectively occurred. See pages 22 and 23.

the magnetic disturbance, but it was really a return of a storm which could be seen in the magnetic records of the 7th and 8th of the preceding July. In 1898, Tacchini said the sun-spot of September, which was central on the 10th, caused the magnetic disturbance of that date, but the storm could be seen forming on the previous August 13th. Sometimes a magnetic disturbance could be traced for months before it broke into a storm. There were magnetic storms which it was not easy to connect with any spots, and spots which could not certainly be connected with magnetic storms ; but the cases in which the tie could be noted were so many that doubt as to the reality of the connection must vanish. The following table shewed the chief magnetic disturbances and the condition of the sun, since the observatory here began to keep track of the principal spots :

Chief Magnetic Disturbances.	Condition of the Sun.	
1895—Aug. 10	Large sun-spot.	Central at date.
Sept. 4	" " "	Sept. 2, 3 and 4. (This shows a return of the disturbance as well as of the spot).
1896—May 3	No spots.	
Sept. 18	A very large group.	Central 16th or 17th.
1897—Jan'y 2	A great spot.	Central Jan. 9.
May 11, to 21	Continuous magnetic disturbances. No spots.	
July 31	An important spot.	Central July 25.
Dec. 11	Fine group.	Central at date.
1898—March 16....	A great collection.	Central March 11.
Sept. 10	A very large spot.	Central at date.
1899—July 12	No spot.	
1900—March 9 & 13	A small spot.	Central March 3, Increasing in size until it passed off on 10th or 11th.
May 1 to 5 ..	Fair sized group	Central on May 2.
Oct. 25	Large spot.	Central on Oct. 21.

Thus the spots usually drifted ahead of the focus of disturbance, as in September 1896, July 1897, March 1898, October 1900, they occasionally lagged, as in January, 1897 ; centrality was noticeable in August, 1895, December, 1897, October, 1900. This table, he thought, ought to dispel the erroneous ideas handed down from earlier days, and, incidentally, prove that the storm is not the cause of the spots but that both of them are effects of an as yet hidden cause.

Mr. Harvey next developed the theory announced by him in previous papers, that the electric energy of the sun was the cause of changes in the brightness of comets' tails and of his own corona. He said that few observations of importance could be made during a solar minimum, but we could not hurry the sun's pulses. Meanwhile, it was agreeable to feel that the theory he was the first to announce, viz., that the sun is the magnetic ruler of his system and emits radiations which influence every planet and comet belonging to it, was becoming recognized, and seemed by this time to be accepted as a proposition so self evident as not to have needed proof. The view was enunciated in a controversy in which Prof. F. H. Bigelow, of Washington, and the lamented Dr. M. A. Veeder, of Lyons, N.Y., were interested. Prof. Bigelow maintained that the sun, being a great spherical magnet, sent out all-embracing lines of force, and thus acted on the earth ; while Mr. Harvey contended that the dissipation of energy in the enormous spherical shells postulated would not leave enough power to produce the powerful effects involved in the vibrations of our magnets. Dr. Veeder thought space was studded with meteoric matter so thickly that electric energy could, by means thereof, be inductively transmitted from sun to earth, which Mr. Harvey denied, because even during a shower of falling stars they were miles apart. Mr. Harvey doubted that these meteors were all magnetic, or, indeed, of a solid nature at all. He, moreover, failed to find any effect on the magnets from the heaviest showers of Leonids, Perseids or Andromedids. He argued, therefore, that it must be a direct radiation which produced a magnetic effect. When Deslandres announced his discovery the horizon cleared. In *Nature*, May 24th, 1900, Mr. F. H. Loring (without crediting Deslandres) speaks of Prof. J. J. Thomson's experiments, and argues that the sun is a magnetic centre of electro-static radiation, and that if a comet's tail is composed of the parts of atoms Thomson calls "ions," the gravitational force it may suffer when in proximity to the sun would, perhaps, be very small in comparison with the electro-static force existing throughout the vast congregation of these extremely minute particles, and thereby account for the repulsion of the tails of comets when they approach the sun. Next, Fitzgerald, in his address of April, 1900, to the Dublin section of Electrical Engineers: "The corona is an aurora round the sun, due to an emission of a similar character to that of a gas transmitting an electrical discharge." And then Lenard, in *Annalen der Physik*, No. 3, 1900: "Not only the cathode rays first alluded to by Deslandres, but also Becquerel rays can render air electrically conducting, and sun-light contains radiations effective in this respect." And the demonstration by Hertz of the similarity in nature of light waves and electrical impulses removed another stumbling-block. For the ether can transmit one as well as the other. Not that corona or prominences were merely electrical manifestations, there was surely matter of some kind in both.

Mr. Harvey then proceeded to speak of the chemistry of the sun, and the remarkable work of Sir William Huggins and others in tracing out the similarity of composition of our sun and of other stars, also the differences in their spectra, by which they were classified as to age and forwardness of development.* He concluded by recommending to members of the Society the study of the sun. It involved the reading of all that is known of the nature and properties of the ether—that all pervading perfect fluid in intensely energetic motion, which, in Prof. Geo. Fraser Fitzgerald's words, we are already "harnessing to the chariot of human progress"—that "subtle spirit," according to Newton, "which pervades and lies hid in all gross bodies." It involved an acquaintance with the nature of the various radiations through that ether, the so-called waves, of many lengths and several kinds. It involved much close observation and the labor-

* This being the special subject of a paper given later by another member, the Editor refers to it for the information.

ious tabulation of magnetic and meteorological facts here, as well as of solar phenomena. But if any took it up, there would be plenty to learn and plenty to dream about. In this paper he had studiously avoided dreams—merely shewing facts and simple deductions therefrom—the lesson of the whole, if there were one, being that the cosmos, from its stars to the dust of the earth, from the huge sun and the still larger stellar orbs to the smallest vagrant comet, is the development of one design, the operation of one law.

THIRD MEETING.

February 5th ; the President in the chair.

Mr. Albert Horton, 64 Howard Street, Toronto, was elected an Associate.

Mr. R. F. Stupart, Director of the Weather Service, forwarded the following note by the observer connected with the department at York Factory, Hudson's Bay, who is understood to be experienced and trustworthy. The isolation of that far-off station had prevented an earlier receipt of the Report :

November 15th. Very general display of shooting stars ; some very big ones N.W. to S.E. They fell in shoals.

November 16th. Shooting stars seen until daylight. Scared the people. They thought it was the end of the world.

The hour when the meteors of the 15th were seen not being given, uncertainty must prevail as to whether they were Leonids.*

* The appearance of showers of Leonids is usually, perhaps always, local—confined to a small area. In 1901 the finest display seems to have been in Southern California, and is reported in "Popular Astronomy" for January, 1892, by Mr. C. Edgar L. Larkin, of Mount Lowe Observatory, Echo Mountain, Cal. The largest numbers were seen before the radiant rose, and the sight of bouquets of celestial fireworks shooting upwards from behind the mountains must have been strikingly beautiful.

Mr. Elvins then read "Notes on World Formation by Accretion." He has for many years believed and asserted that the atom (as usually reasoned of) is not the smallest possible subdivision of matter. He has also used the term "physical atom," to distinguish the least conceivable parts of matter, in contradistinction to the "chemical atom." This term, it was pointed out, could no longer be applied without confusion, and the paper was withdrawn, in order that, together with one printed in the Transactions for 1899, it may be revised and presented as a whole, with a nomenclature in accordance with the latest usage. The substance of the remarks was that the ether had been regarded by one as "an elastic solid as rigid as steel," and by another as an assemblage of extremely small particles, moving with enormous velocities, colliding and rebounding according to the well known laws of motion. Mr. Elvins could not imagine planets and comets moving through a rigid solid; he, however, received the latter theory as correct. These particles moved with a velocity compared to which that of light was a snail's pace. He believed that masses gravitated towards each other because they were driven or pressed together by the motion, *i. e.*, force of impact of such particles. If weight were a property of matter, ether, not having weight, was not matter, and as these particles were necessarily self-repellant while in motion, they could not form matter. But in space there were aggregations of matter, and if there were only two molecules they would be driven together and would form a mass and revolve around their common centre of gravity, and the pressure of the ether would impel them towards the nearest other mass. Thus in time a world was formed. He thought gaseous molecules could not leave the mass to which they had been impelled and joined, and that even small planets and satelites might retain an atmosphere. If there were none upon the moon, it might have united with metallic bases and become solid.

These ether particles striking the atoms revolving in their free paths, with their own special velocities, would rebound, and wave after wave of them would be thrown off at each revolution. The velocity of the rebound would be in all cases the same, the wave length would depend upon the nature of the element or elements forming the mass; and, if the atoms were crowded in parts of such a mass, there would be waves of differing length produced by the same element in different parts of the body, and a continuous spectrum would be produced.

He believed that the earth and the planets of the solar system were still in process of being formed, and that the sun and other suns than ours were being daily added to. The constant impact of ether particles on all of them set their molecules in motion and produced heat; and he thought the heat of sun and planets was increasing. As the molecules on the surface, when hit, must communicate the blows to those below, tier upon tier, all this energy would be concentrated in the centre of the sphere, and make it the hottest part of the whole. Part of the energy was returned to the ether, part produced surface phenomena, such as wind, tides and rains, and the rest went to the increase of the earth's interior heat, which he believed was the cause, through expansion, of the raising of mountain chains and volcanic eruptions.

He attributed solar prominences also to matter, such as that we see in meteors, being driven in upon the sun and volatilized, thus causing an uprush of gaseous matter.

As stated, Mr. Elvins intends to revise his papers and add his views as to the extinction of systems and their reconstruction.

The next paper was by Mr. W. F. Denning, of Bishopston Observatory, Bristol, England, one of the Society's corresponding members. It was entitled "The Planet Jupiter and his Markings."

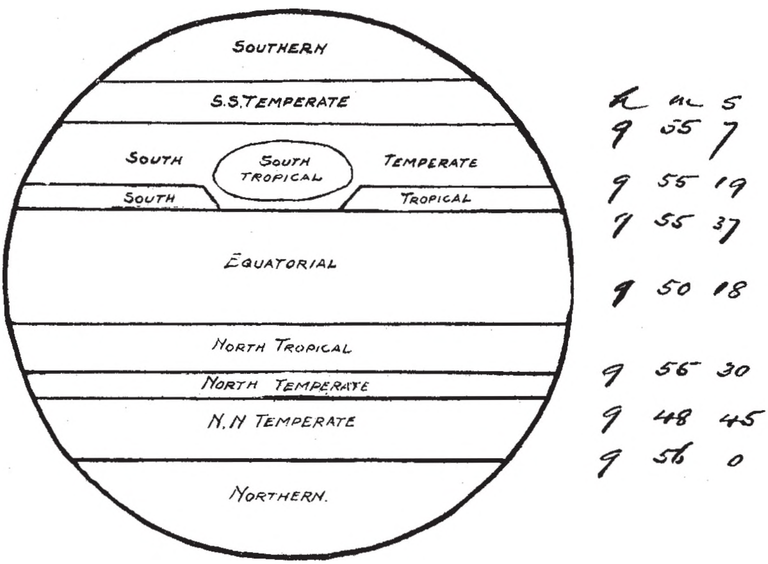
JUPITER.

This planet, said Mr. Denning, had received an immense amount of attention in recent years, but though we were tolerably familiar with its visible aspect we were still far from comprehending with certainty the origin of the markings we perceived or the influences by which their changes and motions were regulated. They were probably drifted into currents parallel with the equator, owing to the planet's very rapid rotation. The various objects we perceived were undoubtedly atmospheric and their rates of rotation ranged between 9h. 48m. and 9h. 56¼m. We knew nothing of the actual disc, since its formation was veiled from our scrutiny. The dark and light spots, the blue and red markings, and others of different and differing tints and tones were probably evolved from the surface of the planet which seemed likely to be in a very active and heated state. The true rotation period of Jupiter was therefore unknown, for the objects from which it had been approximately determined were elastic features circulating round the disc at rates which were not consistent with that of the actual sphere. The true period was probably about 9h. 56¼m. and the shorter periods exhibited by certain spots were induced by a rapid westerly drift.

The great red spot came generally into notice as a conspicuous red ellipse in 1878, and retained its striking aspect for several years. It was about 25,000 miles long and there had been no material change in its shape or size, but its glory had departed, for it was only visible now as a feeble dusky stain on the southern side of the great southern equatorial belt.

It was certainly visible long before 1878. Schwabe, in 1831 and subsequent years figured the curious depression in the southern belt lying north of the spot. There was little question that it was figured by the Rev. W. R. Dawes in 1857, Sir Wm. Huggins in 1859, and by many others from 1869 to 1877. The motion of the spot and of the hollow in the belt had retained perfect consistency with each other, and the rate had varied from about 9h. 55m. 33s. to 9h. 55m. 42s. From 1831, Sept. to 1899, Sept., they completed 60,074 rotations and the mean period was 9h., 55m., 36s. From 1899, Sep. 15th to 1900, Sep. 3rd, another 851 rotations had been effected with a mean period of 9h., 55m., 41.6s.

The south temperate zone in which the spot is situated is about 5 lat. 20°, was moving more swiftly than the spots, its period being 9h. 55m., 19s., as shown in the annexed diagram. In about 12° north latitude there were numerous series of light and dark patches fringing the N. borders of the great north belt and rotating in periods from 9h., 55m., 25s., to 9h., 55m., 38s. In N. lat. 20° to 25°, there was usually a narrow dark belt, the spots on which moved with greater rapidity than any others on the planet. In 1880 they travelled at a rate of 9h., 49m., and in 1891 at about 9h., 49½m. Further north there was an exceedingly slow current which rotated in about 9h. 55m., 50s. to 9h., 56m., 15s.



But different spots in the same latitude did not nearly coincide in their times of rotation. He (Mr. Denning) had watched, in 1899, two markings in N. lat., 25° to 30°, one of which had a period of 9h., 55m., 29.8s., and the other of 9h., 55m., 53.5s.

Several of the currents had hitherto been little studied, and their rates as mentioned in the diagram were only approximate. Observations of the motions of spots in the polar regions would be of special value. The aspect of the spots should be carefully recorded and their line of transit across the central meridian of Jupiter noted as frequently as possible. The transits could be estimated by the eye with accuracy almost equal to that derived from micrometric measurement, the axial rotation of the planet being so rapid that a spot became rapidly displaced. Estimated transits should average less than two minutes of error. There were so many markings that the work of drawing and registering the chief features entailed a somewhat laborious work. Capt. P. B. Molesworth, in the fine climate of Ceylon, had obtained 2000 transits of different spots on Jupiter during a few months in the Spring of 1900. To reduce the observations and compute the individual rotation period of about 150 spots was no small undertaking.

Phenomena of a special kind sometimes occurred. In 1860, February, a curious oblique streak appeared between the North Equatorial and Temperate belts, which lengthened out and in sixty-four days formed a complete belt around the planet, In 1880, October, a group of bluish spots formed on the N. temperate belt, and increased in numbers until in about three months they formed a new belt around Jupiter.

Some of the markings were undoubtedly recurrent, (monthly notices, R. Ast. Soc'y, Dec. 1898, p. 76.). Remarkable disturbances appeared to affect the N. Temperate belt about every ten years. The red spot was very likely a recurrence of a similar phenomenon discovered by Hooke in 1664, May, and observed by Cassini in 1665 and many subsequent years. It seemed to have appeared and disappeared at irregular intervals. He believed that many of the visible features of the planet were more durable than was usually thought to be the case; some markings seemed to possess the faculty of temporarily disappearing and then re-intensifying in the same position, which was certainly true of the large spot seen by Hooke, Cassini and Maraldi between 1664 and 1713.

Jupiter was not well placed for Northern observers now, bnt the study of the surface phenomena should not be relaxed, and when he was again in opposition, the rotation periods should be closely observed, so as to have a connected series for comparison.

FOURTH MEETING.

February 19th, 1901. The President announced that this was intended as a meeting of a popular character. and he was pleased to see a large number of visitors. Mr. J. A. Paterson spoke on "Taurus and the Pleiades," Rev. R. Atkinson on the "Spring Constellations," Mr. Andrew Elvins on the "Zodiacal Light," and the President discoursed on "The Belt of great Stars, from Sirius to Vega," and on "The Milky Way, its Clusters, Nebulæ and Coal Sacks." All the lectures were illustrated by lantern-slides, many of which had been specially prepared by Mr. D. J. Howell.

SPECIAL COUNCIL MEETING.

March 2nd, 1901. As Dr. Larratt Smith was unable to meet the Society at its evening sessions, a Special Council meeting was held in the afternoon, to meet that much esteemed Past President, who had recently been elected a Patron of the Society, and had acknowledged the compliment, as follows :

"I have to tender the Society my earnest acknowledgements for their kindness in having elected me a Patron of the Society, in whose interest I am so deeply concerned."

Dr. Larratt Smith was received, on his arrival, by the President and his full Council, and escorted to the Society's lecture room, where he presented to the Society a very fine and valuable telescope. He expressed his regret that increasing years prevented him from taking the active interest in astronomy he once did, but he felt a satisfaction that an instrument which had given him so much pleasure was now placed where it would do better service than in his own hands.* He would always follow with interest the notices of the Society's proceedings which appeared in the daily press.

* Description—An astronomical telescope of 3 in. aperture, brass body, mounted on brass pillar and claw stand, with slow motion in altitude by rack and in azimuth by screw. Three astronomical oculars and a terrestrial ocular with two powers. Has been altered by the Society to fit a wooden tripod.

The Recorder, Mr. J. Edward Maybee, was then called upon to read an address of thanks, which the Society had caused to be illuminated and bound in the form of an album. It referred to the pleasant days when Mr. Smith had so acceptably presided over the young Society, and to the regret felt when that relation was broken, and said the telescope was accepted with special gratitude, as it would continually remind the members of the generous donor, to whom the Society wished many more happy years.

Various members, among whom were Mr. A. Elvins, Mr. J. A. Paterson and Rev. R. Atkinson spoke in appreciation of the past services of Dr. Larratt Smith, and of the continued interest he felt in the Society, as shewn by this generous donation.

FIFTH MEETING.

March 5th. The President in the chair.

Mr. J. Cleland Hamilton, M. A., LL.B., 86 Glen Road, Rosedale, Toronto, was elected an associate.

Mr. A. F. Miller gave an account of his observations of the new star in Perseus, which he first saw on the evening of 22nd ult.., on which evening it was observed also by the President and Rev. R. Atkinson, who were shown its spectrum by Mr. Miller at his observatory. These early, valuable and detailed observations are not given here, as Mr. Miller continued observing and reporting throughout the year, and has summarised the whole in a paper which is printed in its place, towards the end of this volume.

SIXTH MEETING.

March 19th. The President in the chair.

Mr. Geo. Ridout gave an account of his visit to the Cambridge (Eng.), Observatory, and his courteous reception by Sir

Robt. Ball, an Honorary Fellow of this Society. He described the interesting photographic work being done there with an equatorial *coude*.

SYNCHRONISM OF NORTHERN AND

SOUTHERN AURORÆ.

Mr. Arthur Harvey, referring to his paper in last year's Transactions which stated that from the reports of Mr. Henry Arctowski, meteorologist of the *Belgica* Antarctic Expedition, and from the records of the *Weather Reviews* of Toronto and of Washington, he had constructed tables and curves showing the absolute synchronism of Auroræ Australes and Boreales, said that Mr. Arctowski had forwarded to him detailed accounts of the character of each display and called on him for an examination of the character of the corresponding auroræ here at the North—the position of Toronto being roughly homologous with respect to the north magnetic pole to that of the *Belgica* with respect to the south magnetic pole. He asked the members of the Society to favor him with any notes of Auroræ here during the spring, summer and autumn of 1898.

Mr. Harvey added that this synchronism had been suspected by some but denied by most, who thought all the phenomena of a given season in one hemisphere would be reproduced in the corresponding season in the other. The importance of his discovery, to the credit of which Mr. Arctowski, who went through the hardship of making observations in the Antarctic ice fields, was in great part entitled, lay in the fact that we now knew that in the aurora we were dealing with a cosmic manifestation, not a mere local incident.

Taking this in connection with his papers on the sun and on the connection between solar activity and terrestrial magnetic disturbances, he hoped he had made it clear that the aurora was a consequence of excessive electrical charges conveyed by the fragments of atoms, described by Deslandres, from the sun to the earth—flung upon it suddenly, as the magnets said. These excessive charges had to be distributed throughout the earth's crust, and while this distribution lasted, which was as long as the outbreak of solar activity was on the increase, sometimes several days, electric currents were induced in the atmosphere, in both hemispheres, of course, and auroræ were seen. He thought it would be found, upon further examination, that the magnets in our observatories were really registering all the time the varying intensities of these earth currents, and were only acting as galvanometers. This form of energy was doing work during distribution, and there was a field for discovery as yet, he thought, untouched, in finding out of what nature it was.

A letter was read from Dr. Adam Paulsen, director of the Danish Meteorological Institute, Copenhagen, enclosing his Report on the Danish Mission to Iceland to make auroral observations. It had been thought, when in Iceland, that a continuous spectrum had been observed, but on returning it had been discovered that it arose from the reflection in the atmosphere of lunar or other light not connected with the aurora borealis. The part of the spectrum contained between $426\mu\mu$ and $337\mu\mu$ was absolutely identical with the corresponding part of the cathode spectrum of nitrogen. Dr. Paulsen further said that the researches made in Iceland were being continued in North Finland by Lieut. la Cano, who had telegraphed that a new line had been photographed in the ultra violet part of the auroral spectrum, the wave length being about $316\mu\mu$.

THEORIES OF THE AURORA.

Mr. Z. M. Collins, whose paper was on "Ancient and Modern Theories of the Aurora," referred to the ideas current in the middle ages that great auroral displays portended political changes, and briefly described the "inflammable sulphurous vapor" theory. Dr. Halley's "magnetic effluvia" hypothesis, and Beccaria's "electric fluid" ideas. The displays did not always seem to be high above the earth ; at times they appeared quite close to the observer, and occasionally seemed to almost touch the ground. Numerous records had been made of sounds accompanying the phenomenon—cracking, hissing, whizzing or swishing. He has himself seen a beautiful display a few years since, in which the chimneys of houses, including those on his own dwelling, seemed to be enveloped. On that occasion sounds had been distinctly heard, and though some of them resembled what might be produced by wind, the peculiar cracking or snapping sound common in electrical manifestations could hardly be mistaken. Mr. R. Dewar also reported hearing sounds. Not only from Toronto came reports of sounds having been heard, but from Dovercourt as well, a village two and a half miles away. Mr. Elvins stated that he had witnessed streamers between his house and a neighboring tower, while Mr. A. Harvey was convinced he saw them shoot up between him and his garden fence, one hundred feet away. It was now known that electricity was always connected with these displays, if not their cause. They were always associated with disturbances of the magnetic needle, and had been found by Mr. A. Harvey (a past President of the Society) to appear in the antarctic at the same time as in the arctic regions. This discovery was made by comparing the records kept for many months by Mr. Henry Arctowski, in the *Belgica* antartic exploring vessel, with our own.

A series of short papers were read relating to the planet Mars.

Captain J. G. Ridout discussed the ellipticity of the Martian orbit, and of planetary orbits in general.

Mr. Phillips spoke of the satellites, Phobos and Deimos.

The President described the general telescopic appearance of the planet, with special reference to his polar ice-caps, and Mr. J. H. Weatherbe explained the "loops" of his path in the heavens.

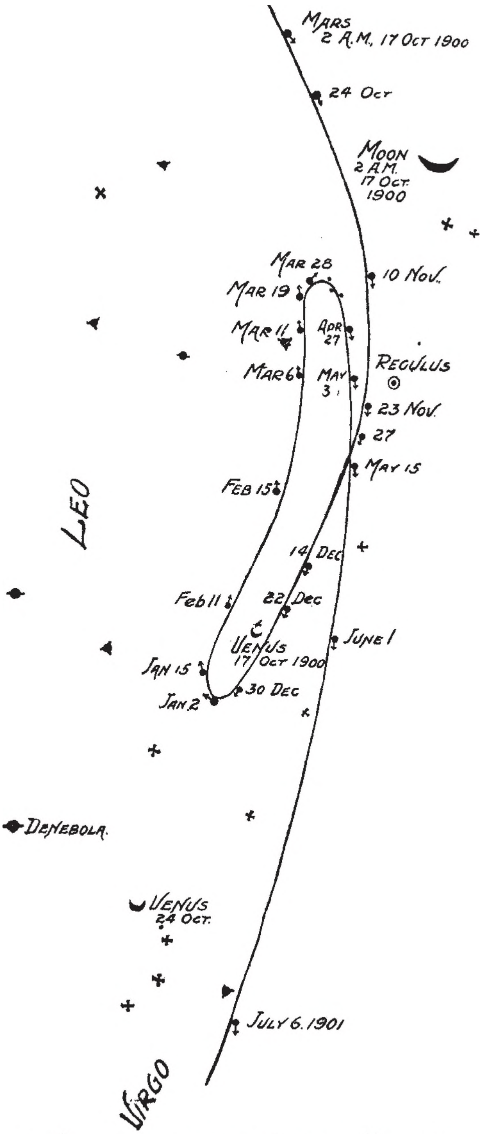
PATHS OF THE PLANETS IN THE SKY.

Nothing in astronomy, said Mr. Weatherbe, was more interesting to a novice than to chart the motions of the planets, and he advised every member of the Society, who had not yet done so, to devote a short time to work of that kind each clear night, if only for a few months. A practical acquaintance with such movements was a very different thing from merely reading about them, and it led to an endearing as well as an enduring knowledge. A real observer had the enjoyment of continually making discoveries, new to him though known to others ages before.

If we were able to take our station at the centre of the sun, we should see the planets all moving round from west to east—those near the sun taking less time for a revolution than those further away. This heliocentric view was the simplest and most scientific, but we could only see it by mental vision. We were actually placed upon one of these revolving globes, and had to look at the system in section. The effect of the different periods and rates of revolution was to make some planets at times apparently move eastward and trace out intricate but rythmical figures in the sky, which could be seen against a background of stars.

Mr. Weatherbe advised beginning with Mars, and thought it best for the observer to make for himself a map of the stars in the neighborhood of the planet, using a card of about twelve by eighteen inches. This would give some useful experience in measuring distances and angles. The relative brightness of the stars might also be noted. The more care taken to place the stars correctly, the better, and not until finished should a comparison with published star-charts be made. It would be easiest to work at this when the planet and attendant stars were near the meridian. Mars himself should be placed on the card last, marking angles and distances from several of the stars nearest to him. Twenty-four hours would be enough to show that these angles and distances had changed, and the new position should in the same way be accurately marked down.

As the earth took a year to go round the sun, and Mars nearly two, Mars appeared to retrograde about every two years, and as the planes of the two orbits differed, his path at such times was a peculiar loop. In 1898-9 the loop was seen against



THE APPARENT LOOP IN THE ORBIT OF MARS 1900-1
OBSERVED WITHOUT INSTRUMENTS

Gemini as a background, in 1900-1 (chosen for illustration) it was in Leo. In 1903 it would be in Libra, and work should be commenced in January. In some seventy years Mars would have completed the cycle and be seen describing the loop in Leo again. Jupiter and Saturn made loops of a very different shape; also Venus aud Mercury, but the latter was always too near the sun to mark down companion stars without a powerful telescope.

For, said Mr. Weatherbe, none of the observatitons he had spoken of needed any aid to vision. They were made by the primitive astronomers of Chaldea, Egypt and Greece, and had given the reason for the name planets, "wanderers," but he did not think this was the best translation, it should rather be "moveable," for there was no uncertainty or irregularity about their courses.

Mr. Weatherbe closed a much appreciated paper by stating that he had been observing Neptune as well as some other planets. His motion was so slow that he seemed to have made little progress in a year. His curve would be interesting in 1902 to those who had telescopes. Quite a low power was sufficient to see him with.

SEVENTH MEETING.

April 2nd. The President in the chair.

Mrs. A. S. E. White, 132 Empress Crescent, Toronto was elected an associate.

The Hon. G. W. Ross, L.L.D., Premier of the Province, was good enough to write, by his secretary, and place in the custody of the Society an orrery and a celestial globe belonging to the Government.

Mr. R. F. Stupart, F.R.S.C., then spoke of a local relation between sun-spots and rainfall. This was thought to be of especial interest, as it is in line with important meteorological work in India. Mr. Stupart's paper, entitled "Sun-spots and Precipitation." is as follows:—

SUN-SPOTS AND PRECIPITATION.

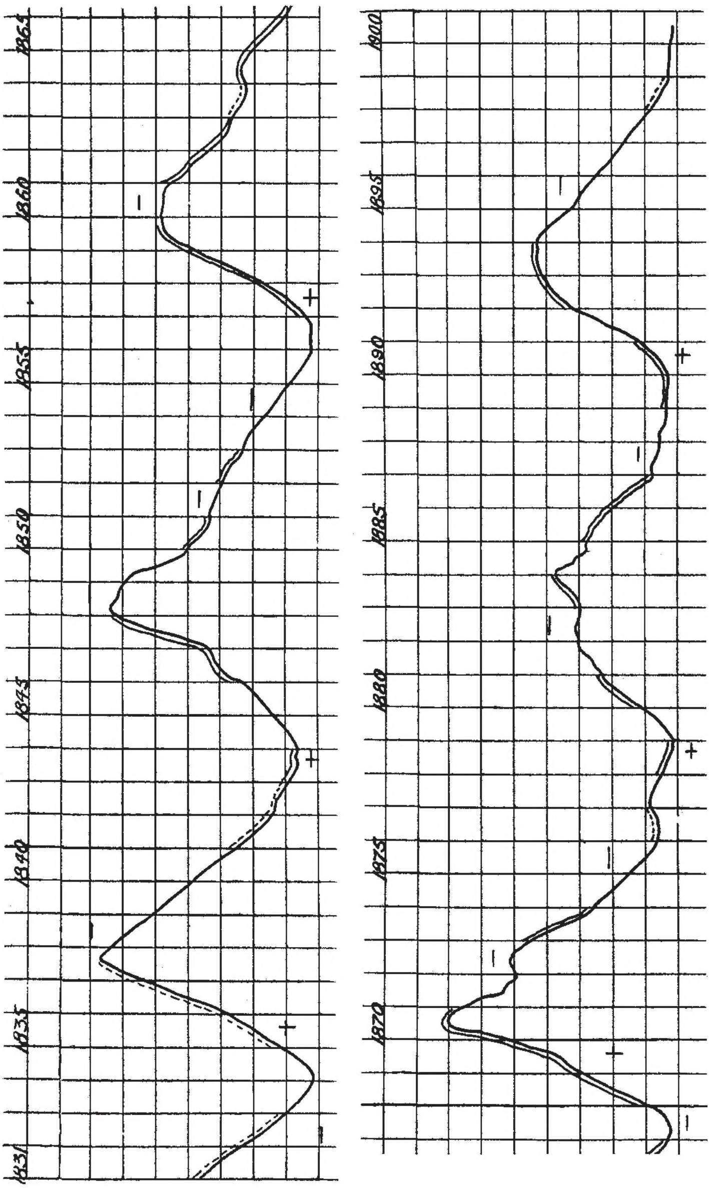
In order to test whether any probability of a connection existing between sun-spot periods and precipitation is indicated by the records of Toronto and neighboring stations, the writer has charted the sun-spot curve from 1830 to 1901, and also a precipitation curve obtained from the annual amount registered in the Lake Ontario Basin. Between 1830 and 1842 an approximate value for the precipitation has been obtained from the records of Rochester and Marietta; from 1843 to 1860 the complete records at Toronto and Rochester, together with broken series at Buffalo and Oswego have been used. From 1861 to 1873 continuous records at Toronto, Buffalo, Oswego and Rochester were available, for the period between 1874 to 1901 Woodstock and Kingston, Ont., were also considered. The sun-spot curve is that by Mr. William Ellis, F.R.S., published in the Proceedings of the Royal Society, March 1898, vol. xiii., p. 78.

The sun-spot curve had been doubled in those years that the precipitation exceeded the average mean amount of the whole series. Finally the + sign was placed opposite the years of greatest precipitation in each sun-spot period and the – sign opposite the years of marked deficiency. The result obtained is apparently instructive, as the combined sun-spot and precipitation curve seems to indicate a precipitation larger than normal for the two or three years immediately following the sun-spot minimum, and another pulse, less pronounced and more irregular, about midway between maximum and minimum; the sign + was found in every instance either at the sun-spot minimum or within three years following, and minus signs were in each case found at sun-spot maximum or within two years of it, and again just previous to the minimum.

Summing up these results it would appear that in the Lake Ontario Basin the precipitation is likely to exceed the normal during two or three years immediately following the sun-spot minimum and again about three years after maximum, and that it is likely to be somewhat less than normal about sun-spot maximum and during a few years preceeding sun-spot minimum.

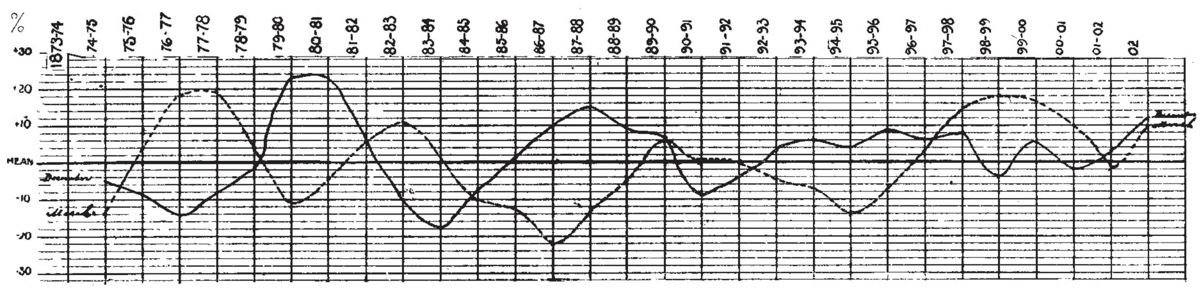
As a close connection probably exists between precipitation and the movements of high and low pressure, and indeed between precipitation and mean pressure values, as a preliminary investigation, the movements of low areas during the months of December and March in each of the years between 1873 and 1901, were tabulated, the total number in each year being divided into groups comprising those areas which were first observed in the North-West States or Territories; those which were first observed in the Western States and those which were first observed in the South-West States or Gulf of Mexico; percentages shewing the relative frequency of the areas in the various groups in each of the months of the whole period under consideration were thus

SUN-SPOT CURVE.



STORM CURVE.

Curve indicating periodicity in storm tracks over America, and also an apparent tendency of the March per centage to have the reverse sign to that of the preceeding December.



Average percentage of low areas in the month of March which do not originate in the North-West Territories equals 59 per cent.

Average per centage in the month of December which do not originate in the North-West Territories equals 49 per cent.

obtained and a curve drawn. A very evident maximum of South-West areas in December is shewn in 1878–1879, 1884–5, and 1894–5; and for March in 1876–8, 1883–4, 1890–92, 1897–1900. On plotting curves shewing percentages of areas other than from the North-West States and Territories, it would seem that the March curve is very nearly the reverse of that for December. Corresponding curves for June and September are in course of preparation, and subsequently all months of the year will be considered.

It is conceivable that a varying solar heat radiation during a sun-spot cycle may cause appreciable changes in the movements of high and low pressure areas, changes perhaps largely influenced and governed by a fluctuating intensity and position of the sub-tropical belt of high pressure in corresponding seasons of different years. While the curves already plotted seem to indicate a connection between annual precipitation and sun-spots, it is quite possible that a comparison of the corresponding seasons during several sun-spot cycles may show a much more evident connection between sun-spot and meteorological phenomena. Possibly a contraction of the subtropical high during sun-spot minimum may tend to a more than average number of low areas developing in the south-west while the sun is south of the equator, and a diminution in the number and intensity of storms during the warmer seasons when the sun is north.

EIGHTH MEETING.

April 16th, 1901. The President in the chair.

The evening was in great part devoted to the elucidation of lunar features, for the benefit of the younger members of the Society.

THE MOON.

The changes in the aspect of the moon, due to libration, were explained by the Rev. R. Atkinson. The President pointed out on lunar maps some of the most interesting objects for observation, and gave an account of the more important lunar mountain ranges; Mr. J. E. Maybee discussed lunar rills, their nature and probable origin, and Mr. Elvins spoke of the deformed craters often met with on or near the floors of the lunar maria.

On this last subject Dr. J. J. Wadsworth, M. A., Director of the affiliated Simcoe Astronomical Society, expressed his views in writing. "Every observer," he thought, "must have noticed the the fact that the walled-plains, the ring-plains and the larger craters seldom present an unbroken rampart. Ptolemy, Gassendi, Clavius and many others show many deformities in the line of circumvallation. Fracastorius is conspicuously deficient on its northern side. Besides these, we frequently see narrow defiles, something like canyons, cleaving the circumjacent wall of rock, and bearing some analogy to the famous mountain passes of the earth, such as the Khyber Pass, the Pass of Thermopylæ, and some well-known passes in the Rocky Mountains. Such is the double cleft on the north east borders of Gassendi, and another similarly situated in the grand mountain chain of Walter. We profess astonishment at these breaks in the uniformity of the crater walls, but truly it would be more wonderful if every ring were perfect. Whatever theory we adopt to account for the formation of the circular craters, whether we ascribe them to the action of the water or to volcanic agency, or to vapours escaping through a plastic crust, it is but reasonable to suppose that variation in force and in resistance would occasion diversity in form and irregularity in outline. Again, the great chemical and physical changes which time has wrought in temperature and in fluidity must have been accompanied by much upheaval, much depression, and many slips and faults. Also the great range of the thermometer between the lunar day of two weeks and the lunar night of two weeks, without atmosphere or cloud to mitigate the heat or retard radiation, must have contributed to the formation of fissures in the ramparts of rock."

CHARACTERISTIC LUNAR FEATURES

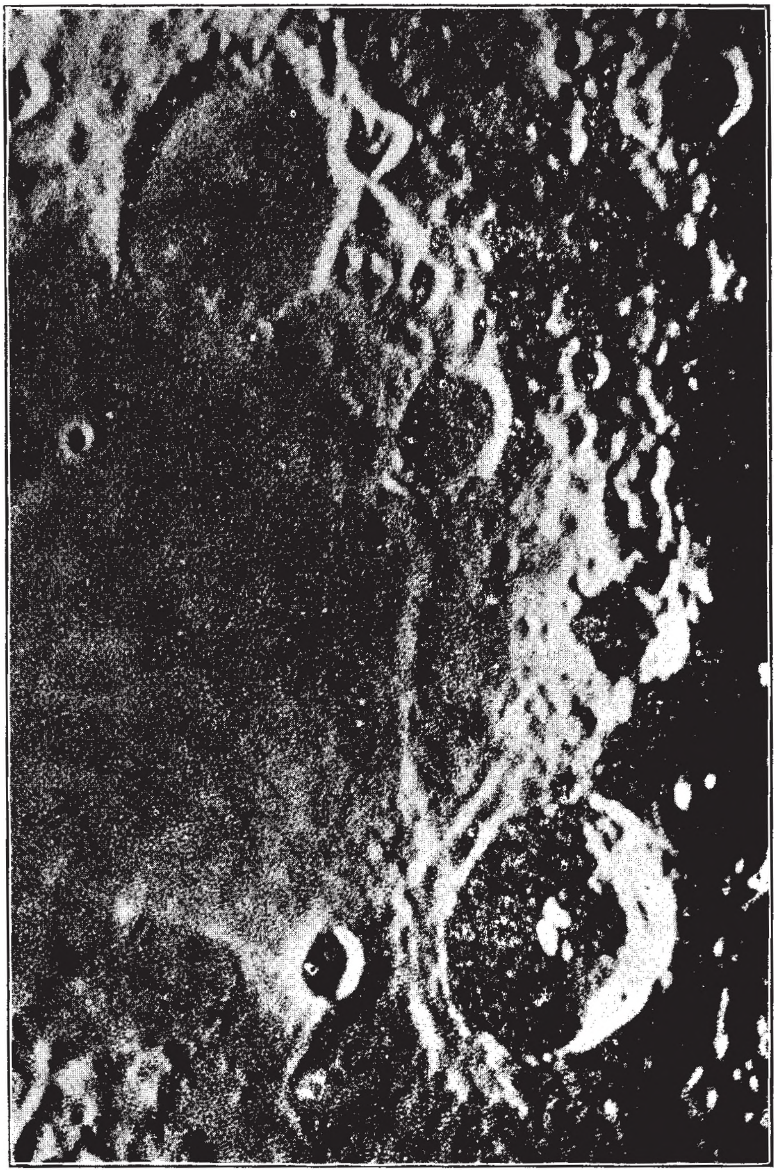
PHOTO FROM THE PARIS OBSERVTORY.

The engraving on the opposite page shews several of the most characteristic lunar features. The sun-light coming from the left has just brightened the inside of the eastern rim of the great ring-plain Theophilus; all to the right of it being still in shadow except the tips of some high hills. The division between light and shadow, called the terminator, extends along this plate from its upper or southern to its lower or northern edge. Theophilus and the companion ring-plain Mädler, to its left, are in the lower part of the plate.

Theophilus is thus described by Neison (The moon): "A magnificent ring-plain, 63·81 miles in diameter, with steep, lofty, much terraced walls, rising in grand peaks to an immense height —18,238 feet. * * * The interior contains a grand bright central mountain, divided by valleys into several masses. * * * From the wall extends to Beaumont a strong ridge across the mare."

The Mares, or *maria*, are not as at first thought, seas, but low-lying plains. That above and to the left of Theophilus is the Mare Nectaris, about 250 miles across, with a fine, very deep and steep crater on it, called Rosse (near the left edge of the plate) where two "light streaks" cross.

To the south of Rosse (above it, on the plate) is a formation called Fracastorius, "one of these great, nearly circular, walled plains, abutting on the lunar Mares, whose wall nearest the dark grey plain has been destroyed in some manner, and, except at sunrise, very close to the terminator, resembles a great bay of the Mare Nectaris; but at sunrise or sunset the ruins of the northern wall can be seen as a row of hills and mounds."



THEOPHILUS AT SUN-RISE.

NINTH MEETING.

April 30th. The President in the chair.

Mr. Archibald Blue, of Ottawa, was chosen as the Society's Representative, to present the annual statement of its work to the Royal Society of Canada, soon to meet at the Capital.

This evening was in part devoted to biographical notices of deceased astronomers and physicists.

Miss E. A. Dent treated of Caroline Herschell's life of devotion and self-sacrifice in the interests of the great work of her brother, Sir William.

Mr. J. R. Collins presented the claims of Michael Faraday to be considered the greatest of modern pioneers in the fields of electricity and magnetism.

Mr. A. F. Miller gave an account of the life of W. H. Wollaston, who, by his discovery of the dark lines in the solar spectrum, prepared the way for the work in spectrum analysis subsequently done by Fraunhofer, Kirchoff and Sir Wm. Huggins.

Dr. A. D. Watson chose Heinrich W. M. Olbers as the subject for his paper. He was not a professional astronomer, but, like Wollaston, a medical man, though unlike Wollaston, who abandoned medicine, he continued his practice. The point insisted on by Dr. Watson was that good work may be done in Astronomy even by those who are actively engaged in business or professional life. Olbers' work in the discovery of the Asteroids Pallas and Vesta, his calculation of the orbit of the comet of 1779 and his observation of many other comets, caused him to be better remembered as an astronomer than as a physician. One comet is indeed named after him.

All the papers were illustrated by lantern slides, including portraits and scenes in the lives of the various astronomers. Several of these were contributed by Dr. Watson.

TENTH MEETING.

May 14th. The President took the chair at 20 o'clock, as usual. The Society approved of the advice of Council to purchase a 4-inch refracting telescope of Messrs. Cooke & Sons' make.

As it was reported that a bright comet had been seen in the Southern hemisphere and that it was moving north, the evening was appropriately given up to papers and discussions connected with these visitors, once called erratic.

Mr. R. Dewar treated of the nature and composition of comets so far as explained in text-books.

Mr. A. F. Miller spoke of the changes in the nature of a comet's light, caused by its varying distance from the sun.

Mr. J. A. Paterson discoursed of the changes sometimes made in cometary orbits by the attraction of the larger planets.

Mr. Joseph Pope, C.M.G., F.R.S.C., of Ottawa, contributed the following paper on

HALLEY'S COMET.

Lovers of astronomical science who are still in middle life cannot fail to have noticed that, as regards the manifestation of those wonderful phenomena known as comets, they have been less favored than the generation immediately preceding our own. It is of course true that with the constant additions to the number of watchers of the sky, and with improved means of observation on every hand, the actual number of known comets has been largely augmented during the last half century and increases year by year.

I refer, however, to those splendid apparitions which, from the beginning of recorded history, have periodically excited the wonder and interest of mankind. It is now nearly twenty years since a really great comet flamed in our skies. Our fathers, perhaps I should say our grandfathers, were more fortunate in their day. To them was given to behold the great comet of 1811, one of the most brilliant of modern times, which, contrary to the reputation of comets in general, was attended by bountiful harvests, abundant vintages, and a general plenty, including, it is said, an unusual number of twins born that year.

In 1835 astronomers were gladdened by the reappearance of the comet known as Halley's, of which more hereafter. Eight years later brought the great comet of 1843, perhaps the most splendid object of its class ever presented to the eye of man. Its tail extended over seventy degrees of heaven, and its brilliance was such as to render it distinctly visible to the naked eye at noon. Donati's comet in 1858 was the next imposing visitor, and the spectacle afforded by its transit over Arcturus formed a beautiful and impressive sight. Once more, in 1861, a large comet made its appearance, and thirteen years later another, known as Coggia's, traversed our skies. Then followed the comets of 1881 and 1882, since which latter date no comet of striking appearance has been seen. It is therefore not surprising that on the threshold of the twentieth century we should begin to realize the dearth of these phenomena in our own times, and to enquire how soon we may expect to be again favoured with the glorious spectacle of a great comet blazing in the heavens. To this question science can furnish no positive answer. The number of comets is legion. But an insignificant fraction of this number is known to us. The apparent size and brilliancy of these objects depend largely upon the nearness of their approach to our globe. It is quite possible that one of the myriad wanderers in the realms of space may dash into our system at any time, and in its headlong journey to the sun may cross our path at a point sufficiently near the earth to cause it to outvie in magnitude and splendour all previous apparitions. Apart from such a sudden and unlooked for contingency we shall have to possess our souls in patience for some years to come, for of nearly all the noted objects that have appeared in recent times, either their periods are infinite or are of such duration as to preclude the possibility of our beholding them again. at any rate in this mortal life. The great comet of 1811 has a period of something like 3000 years. That of 1843 will not revisit our skies before the close of the 24th century, and a cycle four times as great must go round before Donati's comet comes again within hailing distance of the earth. Thus all we can ever hope to know of these bodies is already recorded in our libraries. Of them the future has naught in store for us. Fortunately the orbits of all the great comets are not traced on such ample lines. One—that associated with the illustrious name of Halley—is known to complete its elliptic course within the span allotted to human life. It last visited our system in the year 1835 and its reappearance in 1910 is confidently looked forward to.

As Halley's is the solitary known example of a conspicuous comet with a fixed period of less than a century, and as we all enjoy a reasonable expectation of beholding it with our own eyes, it may not be out of place to devote a few minutes to a consideration of its past history and approaching visit.

One sometimes meets with the reflection that the development of astronomical science has had the effect of dwarfing the human race—that in the light of the knowledge which a just conception of the universe reveals, man shrinks to absolute insignificance, and in his puny state is comparable only to a microscopic insect crawling on the rind of an orange. I confess that the impression which astronomy produces on my mind is rather the reverse of this. It is of course true that science acquaints us with the fact that our globe is but one of a host of worlds, and that *a fortiori* the dwellers thereon must, both in respect of their physical size and the shortness of their duration, occupy but an utterly insignificant relation to the sum of things. But humanity, I take it, is not to be gauged by pounds *avoirdupois.* 'The mind's the measure of the man,' and I submit that, judged by man's intellectual capacity, the disparity we are considering is by no means so overwhelming as some of our poets and philosophers are given to represent. The unaided intelligence that has reasoned out the plan of the universe—that has measured and weighed the earth we live on and the sun round which it moves

—that has determined the relative positions of the various planets and unlocked the mysteries of their complex motions—that, transcending the bounds of the solar system, has pierced the profoundest depths of space and proclaimed the nature and composition of those distant spheres which roll in the realms of the infinite—speaks to me rather of the godlike attributes of the great Creator than of the humblest works of His hand. And assuredly not the least wonderful of man's intellectual triumphs is afforded to us by him who has given his name to that most famous of all comets, to the reappearance of which we are already beginning to look forward.

At the time when Newton was engaged in developing his theory of gravitation a brilliant comet appeared, which, from its size and splendour, excited unusual interest. Suddenly flaming into view, it traversed the heavens with almost inconceivable rapidity, its speed exceeding at perihelion 350 miles a second. Approaching the sun within half the distance of the moon from the earth it swung round that luminary in two hours, and throwing off a train of light more than a hundred million miles in length, swept outwards into space and has never since been seen.

This mysterious stranger arrested the attention of the prince of philosophers himself, who sought to ascertain whether it too might not prove to be obedient to the controlling principle which (he had lately found) regulated the solar system. Its amazing velocity, however, rendered it an unsuitable object for his researches, and it was reserved to another illustrious Englishman —Edmund Halley—to complete the application of the law of universal gravitation to the cometary world which Newton had begun.

In 1682, the year following that which the comet observed by Newton disappeared, another came into view, affording Halley the opportunity for which he had been waiting. Having observed its position and compared its orbit with great care, he remarked that it showed a striking resemblance to the comets of 1531 and 1607, in fact their elements were nearly identical. Further investigation led him to extend his comparison to the comets which appeared in 1456 and 1380. All the information he could gather of these earlier apparitions led him to suspect that they were but re-appearances of one and the same comet. His inference did not rest merely in the correspondence of the intervals. "Many things," he tells us, led him to believe that the comet of 1531, observed by Apian, was the same as that described by Kepler in 1697, and which he himself saw in 1682. The comet of 1456 was not observed astronomically, but the chronicles of the period record its motion being retrograde. Now, it is a peculiarity of Halley's Comet that with, I think, one exception, and that unknown to Halley, it is the only comet having an elliptical path and a period of less than a century, whose motion is from east to west. Struck by these coincidences he set about tracing the comet back to its first recorded appearance when it signalized the birth of Mithridates, 130 B.C., on which occasion it is said to have been visible twenty-four days and to have surpassed the sun in brightness; its tail extended forty-five degrees and it occupied four hours in rising and setting. Halley noted its successive visits in the years 323, 399, 550, 930, 1006, 1082, 1155, 1230, 1305, 1380, 1456, and so up to his own times which witnessed the twenty-fourth return from its first recorded appearance. He found it moving in a plane but little inclined to the ecliptic and in an ellipse of a very great eccentricity approaching the sun within about 55,000,000 miles and receding therefrom more than twice the distance of the planet Neptune. Becoming more and more convinced of the identity of the comet he was observing with those whose appearance I have mentioned, he set himself to work to compute its next return, and after long and laborious calculations announced that it would re-appear about the close of 1758 or the beginning of 1759. He was then a young man and outlived his prediction, made in 1705, nearly forty years. He could not, however, hope to see its realization and his words on this head are almost pathetic.

> "Wherefore if it should return according to our prediction about the year 1758, impartial posterity will not refuse to acknowledge that this was first discovered by an Englishman."

As a matter of fact he had been dead seventeen years when his prediction was fulfilled.

As the time for the verification of this announcement drew near, much interest prevailed in the astronomical world, and efforts were made to fix the date with greater precision than Halley had attempted. That eminent man realized that the imponderable, almost spiritual texture of a comet must be powerfully swayed by the attraction of the larger planets, but knowledge of the law of gravitation was in its infancy when Halley toiled over the problem as to the exact amount of perturbation his comet would be subjected to from this cause, and it was reserved for later investigators to solve it with that rigorous accuracy in which astronomers delight. The skilled French mathematicians, Clairaut and Lalande, undertook the task, which was one of enormous magnitude, involving the computation of all the perturbations the comet had undergone throughout a period of two revolutions, or 150 years. At length the laborious task was completed and the announcement made that the comet would be retarded 518 days by the influence of Jupiter, and 100 by Saturn—Clairaut fixing the date of its perihelion passage for the 13th April, 1759, with a margin of thirty days for possible error.

These results were communicated to the Academy of Sciences on the 14th November, 1758, and on the 25th September following the comet was seen by one George Palitsh, a Saxon peasant in the environs of Dresden. It arrived at perihelion on the 13th March, 1759, just thirty days earlier than the date of Clairaut's prediction, but within the limits of error which he had assigned.

This certainly was a wonderful intellectual feat, and of a nature to make us proud of our race. The intervals between the comet's previous re-appearance had not been uniform. Considerable discrepancies existed. This visit was 586 days longer than the previous revolution, which makes the triumph of the astronomer all the greater. In a burst of enthusiasm Lalande exclaims :

"What are thirty-two days to an interval of more than 150 years, during only one two-hundredth part of which observations were made, the comet being out of sight all the rest of the time? What are thirty-two days for all the other attractions of the solar system which have not been included; for all the comets, the situation and masses of which are unknown to us; for the resistance of the ethereal medium, which we are unable even to estimate, and for all those qualities which of necessity have been neglected in the approximations of the calculation? . . . A difference of 586 days between the revolutions of the same comet, a difference produced by the disturbing action of Jupiter and Saturn, affords a more striking demonstration of the great principle of attration than we could have dared to hope for, and places this law amongst the number of the fundamental truths of Physics, the reality of which it is no more possible to doubt than the existence of the bodies which produce it."

Lalande's gratification is all the more legitimate when it is considered that at the time when these predictions were made, the existence of neither Uranus nor Neptune was known. Yet the comet's path cuts the orbits of both these planets and consequently is more or less perturbed by them.

In the interval between 1759 and 1835, the date of the next appearance of Halley's comet, great strides had been made in the science of astronomy. The planet Uranus had been discovered, the masses of the larger planets were more accurately ascertained, and the methods for computing perturbations largely improved. Taking the perihelion passage of 1759 as the point of departure, and following in the steps of Clairault, two French savants, Messrs. Damoiseau and Pontecoulant, independently undertook the necessary calculations anew. Their results agreed within a few days, Mr. Damoiseau fixing the date of the comet's perihelion passage for the 4th November, 1835, and Mr. Pontecoulant ten days later. Two other astronomers, Messrs. Lehmann and Rosenberger, respectively; fixed the dates at November 11th and 26th. On this occasion not only was the perihelion passage computed, but the exact path of the comet among the stars mapped out, and the precise point indicated at which it would first be seen. The last of these predictions was published on the 25th July, 1835. On the evening of the 5th August Mr. Dumouchel, of the Observatory at Rome, directed his telescope to the prescribed spot, and there, within a degree of the place fixed by Rosenberger, was the comet, as yet but a faint stain of light on the deep blue of the heavens. It arrived at perihelion on the 16th November, the difference between the observed and the mean of the computed dates being less than three days. On the 5th May, 1836, it finally ceased to be visible.

Once more, and with greatly improved facilities, astronomers addressed themselves to the task of tracing this wanderer in his mighty pilgrimage. The duration of the last period was found to be seventy-six years and 135 days. An equal period would bring the next perihelion passage to March 29th, 1912. It has been ascertained, however, that the next return will be somewhat accelerated by the attraction of Jupiter, and that the period of the revolution which the comet is now performing will be nearly two years less than on the previous occasion, and shorter than any hitherto predicted. According to the best authorities the next perihelion passage will take place on the 24th May, 1910.*

Accounts of past appearances of Halley's comet vary considerably in respect of its size and brilliancy. These discrepancies may no doubt be accounted for to a considerable extent by a comparison of its distances from our globe at successive visits. These necessarily ranged between wide limits. In 1835 the comet approached the earth within four and a half million miles. Doubtless there have been occasions when the earth was on the far side of its orbit at the time the comet crossed the ecliptic, in which event it would be separated by a much greater interval than in 1835, and consequently present a less conspicuous appearance.

Apart, however, from the apparent effect due to changes in relative positions, Halley's comet is remarkable for singular and sudden changes of aspect. During some time before and after its perihelion passage on November 16th, 1835, it appeared quite destitute of tail. Yet in the preceding October it had a tail extending twenty-four degrees, which Bessel describes as having been produced by emanations at first issuing from the comet in

* I have also seen the date given as the 16th May.

the direction of the sun, and being swept ronnd as if by some repulsive force. Again, in the twenty-four hours from the 23rd to the 24th January, 1836, the brightness of its nucleus increased twenty fold.

These changes, indicating as they do the operation on a vast scale of mighty forces unknown to man, add to the interest with which we look forward to the next return of Halley's Comet.

GREAT COMETS.

Mr. Arthur Harvey forwarded a memorandum, of which the main points were as follows :—

A fair account is given in Suetonius of the comet which appeared very soon after the assassination of Julius Cæsar. It shone with brilliancy for seven days in the northern part of the sky, and was thought to be an evidence that the decree of the Roman Senate, raising the dead Imperator to Divine rank, was recognized by the heavenly gods. The people said it was Cæsar's soul taking its place among the immortals. Virgil says that after Cæsar's death, (Geor. I., 488) there were a number of comets, many earthquakes and volcanic eruptions.

The comet of 1665 was thought in England to have some connection with the great plague. It soon disappeared and its tail was stubby, wherefore the astrologers argued that the visitation would be short, as it was, for it had diminished before the great fire of London in 1666.

Mr. Harvey remembered his father's describing to him the great comet of 1811. That was the year in which the Duc de Reichstadt, Napoleon's son, the unfortunate "Aiglon," was born and crowned king of Rome. The comet was thought to be an unlucky presage for him and for Napoleon, and the next year was that of the terrible Russian campaign, when the winter setting in prematurely brought ruin on the host gathered by the French Emperor, and ultimately on him and his son. He himself recollected the Donati comet of 1858, which he thought extended at its best over 80° of arc. It could be seen as soon as the sun was down, a great curved scimitar. The comet's head was to the north, not far from the horizon ; the end of its tail to the south, also almost resting on the horizon, and the great luminous arch spanned the sky between. It was as bright as the brightest aurora. The width of the tail increased regularly from the head to the end, which was not defined. It rapidly dwindled, not being more than ten days " in the public eye." A few years ago he saw it stated in Dunkin's " Midnight Sky " that on October 3rd, this body was noticed to be in a continual state of local excitement, which was the date of a terrestrial magnetic storm. He was then enquiring if comets were often subject to excitement during magnetic storms. Finding this to be the case in many striking instances mentioned in previous papers, he was enabled to claim, at the " Centralstelle " of astronomy at Kiel, as his discovery, that in some way the solar disturbances which produced great spots and great magnetic storms, also produced changes in the brightness of at least some classes of comets. This view had been generally adopted since, for Deslandres' discovery showed how particles of matter could be driven from the sun or other bodies emitting Cathode, Becquerel, or other such rays, with the velocity of light, under the influence of charges of negative electricity, which removed the difficulty--how electric impulses from the sun could reach the subject bodies of his system.

ELEVENTH MEETING.

May 28th. The President in the chair.

Mr. William Tedford, Empress Crescent, Toronto ;

Mr. Weston Wetherbee, Barre Centre, New York, were duly elected associates.

The attention of the Society was called by Mr. J. H. Weatherbe to the fact that Jupiter and Saturn would soon be so close as to be visible in the same field of a telescope, the event being a curious and unusual one. With a low power in a 3-inch telescope they were indeed seen by several members, as predicted. With a high power, the field is smaller, and they had to be looked at separately.

SUN-SPOTS.

Some time was given to the discussion of the large sun-spot which had become visible on the 20th, and was now about central on the disc. Mr. J. H. Weatherbe had made a drawing of it, which was exhibited. It was a very active spot, and on the morning of May 23rd changed visibly in a very short time. The same peculiar rapidity in change was observed also by Rev. Father Moreux, in France, and was thought by him to indicate the end of the solar minimum spot area. He said that years with many spots meant an increased temperature on the earth, and the public became quite excited. The magnetic disturbance connected with the spot was, however, so inconsiderable, as pointed out at the next meeting, that Mr. A. Harvey, could not agree with Father Moreux, and did not look for the speedy termination of the minimum. This was the view generally taken by the members, who thought the rapid change shewed the spot to be superficial and short-lived, which proved to be the case.

SHAPE AND SIZE OF THE EARTH.

Mr. A. T. De Lury, B.A., gave an account of the method of determining the size and shape of the earth, which was supplemented by a statement from the President of the ways devised for weighing it—notably the plan followed at Schiehallion, in Perthshire, Scotland.

The papers were called forth by the departure of the French expedition for South America, to re-measure the so-called Peruvian arc. The question to be decided is the length of a degree at the equator as compared with one near the poles. It was the measurement of the Peruvian arc by Delambre and Mechain, in the middle of the eighteenth century, as compared with an arc measured in Lapland, which proved the polar diameter of the globe to be less than the equatorial. Many arcs have been measured since that time, but not in equatorial regions.

TWELFTH MEETING.

June 11th. The President in the chair.

Mr. Robert Duncan, 516 Ontario Street, Toronto, was elected an associate.

TYPICAL ASTRONOMERS.

Mr. A. F. Miller and Mr. W. B. Musson seconded the nomination of M. Maurice Lœwy, of the Paris Observatory, as an Honorary Fellow of the Society ; which being carried, the enrollment was ordered.

The Society was also given to understand that Mr. Camille Flammarion had also been requested to allow his name to be submitted for honorary fellowship.

To those who know these eminent French astronomers only by their writings and work, no greater contrast seems possible than appears to exist between them. They would be typical champions of the aims of the two parties in our society, if a contest were being waged between what may be called its right and left wings. Some, feeling the enjoyment and profit of knowing even the elements of astronomy, and moved by altruistic impulses, would make it the main object of a body like ours to popularize the science, to bring under Urania's influence, if only for a time, all who wish to know a little about the heavenly bodies, their telescopic appearance, their general movements and their composition. Others, wishing to carry the study to a point beyond the standard of ordinary illustrated lectures and feeling that a society cannot rise above the grade of its average membership, are careless about its numerical strength and would prefer the adhesion of a few real students to the casual membership procured under temporary excitement. M. Flammarion would lead the *vulgarisateurs.* He would argue, truly, that without a warm public interest in scientific thinkers and workers, and especially in patient observers, such men would lack the support and appreciation which are indispensable. M. Lœwy, while not disagreeing with such a view, would be content that others should discharge this duty and allow him to pursue in quietness the work he loves.

M. Maurice Lœwy was born in Vienna, and was a distinguished astronomical student at the observatory there, but in consequence of his Jewish parentage he was debarred from pursuing a scientific career in his own country. Le Verrier, the celebrated French astronomer, whose name will be remembered while the planet Neptune exists, offered him a post in the Paris Observatory. He became in due time a naturalized French subject, and in 1872 was appointed a member of the Bureau of Longitudes. In 1873 he was placed in full control of the instrumental outfit of the observatory, and was elected a member of the Academy of Sciences. He naturally became sub-director and in due time director of the observatory. His determinations of the longitudes of Vienna, Berlin, Marseilles and Algiers were made by a method he invented, and his papers on determining the orbits of comets and other intricate mathematical subjects caused honors to be heaped upon him. He is a Commander of the Legion of Honor, an Associate and gold medallist of the Royal Astronomical Society of London, and a member of the academies of Berlin, St. Petersburg, Vienna and Washington.

We know M. Lœwy best by his lunar work. It was decided by the Government of France that a lunar atlas should be issued under their auspices, and Messrs. Lœwy and Puiseux collaborated in the work. It is photographic throughout. Not that the drawing of lunar features by hand has become valueless, but the beauty of these photographs and the care with which they are taken and enlarged, makes them truly remarkable specimens of selenography. When a photograph is taken with a large instrument, infinite patience is needed. Suppose a given lunar region has to be taken with a certain degree of illumination ; if the heavens are not clear, a delay of at least a month must occur until the moon can be seen at just that age again. Nor are all ordinarily clear nights suited to the work ; there may be air waves up aloft, or some mass of transparent vapor, which, invisible to the naked eye, makes telescopic "seeing" bad, and the photograph, if taken, has to be rejected. The plates are, of course, specially prepared, and in the present state of the photographic art, no finer views could be taken in series, for the fineness of the grain of the gelatine limits the size, with the object-glass actually used, while if it were larger, the opportunities for procuring perfect photographs would be so few that the work would not be finished for a generation.

Our society, which began its course only twelve years ago, with a small membership, no meeting place but private houses, without an instrument or a single book, but which now has several fine instruments for our members' use, and a library of some 1000 astronomical and physical works,* cannot but feel grateful to our sister societies and the government institutions which have liberally given us much in return for our little, and one of our chief treasures is the magnificent lunar atlas, issued from the Paris observatory, of which we already have thirty-four plates, and trust in due time to receive the rest, as issued.

*Text books, elementary books and books for circulation - -	165
Books of reference, being chiefly the Transactions of sister Scientific Societies and Reports of Observatories, including twelve volumes with two hundred monographs, indexed - - -	500
The great Lunar Atlas, published by the French Government, in part completed. Plates received - - - - - -	34
Lunar plates from the Lick Observatory - - - -	19
Photographic survey of the heavens—charts from the Paris Observatory	245
Other maps and charts, planispheres, etc, - - - -	363
Solar charts, showing the position of sun-spots, faculæ, etc, by Mr, G. G, Pursey, (1100 observations) - - - - -	19
Album of photographs, sketches, diagrams, etc,, of celestial objects -	2
Celestial globes - - - - - - -	

Messrs. Lœwy and Puiseux' own opinion as to what these photographs tell us about the moon's past and present have, from time to time, been laid before the French Institute and published in their *Comptes Rendus*. As printed, they have been reported on to this Society, but it does not appear that the late lamented Editor of our Transactions has embodied the reports in any of our volumes—intending, perhaps, to wait until the atlas should be finished, and the last word said by the distinguished astronomer who honors us by accepting the tribute of honorary membership respectfully offered him. The omission will in due time be made good.

DISAPPOINTMENT IN OPTICAL WORK.

A letter was read from Dr. J. A. Brashear, F.R.A.S., of Allegheny, Pa., a Corresponding Fellow of the Society, giving an interesting account of some of the work being done in his workshop in connection with prisms for spectroscopes and object-glasses, and mirrors for telescopes. As illustrating the disappointments which often happen in the manipulation of optical-glasses, he mentioned that he has recently endeavored to bore one of the 37-inch mirrors for the Crossley reflector of the Lick Observatory, intended by Dr. Keeler to be mounted on the Cassegranian plan. Though bored while very tightly surrounded by a steel band the glass split when the tool had entered about half an inch, owing to strain in the glass, and the mirror, worth $2,500, was totally destroyed. (Dr. Brashear on a subsequent visit to Toronto, showed the Society one of the many pieces of this mirror, so that the peculiar lines of fracture from the centre outward, like the spokes of a wheel, could be examined.)

THE ALBEDO OF THE MOON.

The President reported that on March 22nd the dark part of the new moon was so bright that he had written to Prof. Cleveland Abbe, director of the Weather Bureau, Washington, to ask if there was any reason for the peculiar appearance. Prof. Abbe replied that he had requested his assistant, Prof. H. H.

Kimball to work on the problem and the result was a paper forwarded to the Society and read. It was then published in the U. S. *Weather Review* in July.

Mr. Lumsden's letter was as follows :—

"On the night of the 22nd of March, the moon, owing to the earth-shine, was so bright that a member of the Astronomical Society called me up by telephone and asked me to make observations with the naked eye and with an opera-glass, with a view to comparison on other occasions. . . . . . We were surprised at the brilliant illumination which enabled us to identify, even with the naked eye, certain well known lunar-formations. On thinking the matter over, it occurred to me that this brilliancy might have been due to reflection from a very large area of clouded surface, which possibly at the time was true of the western American continent and the Pacific Ocean, inasmuch as shortly after midnight the weather changed and was succeeded by cloudy skies, which lasted for some little time."

Mr. Kimball's paper showed that the illuminated portion of the earth from which the moon received light lay between lat. 75° S. and the North Pole, and longitudes 90° W., and 122° E., being practically the whole of the Pacific Ocean, nearly all of Australia, Japan, Eastern Siberia and the larger portion of North America—an area which did not differ sensibly in character or extent from the normal reflecting surface when the moon is two or three days old and observed at about 7 p.m. from Toronto.

The albedo of the moon must be a constant (owing to the absence of atmosphere) the variable elements being only the albedo of the earth and the distance of the earth from the moon.

The illuminated part of the earth comprised about 15 per cent. land and 85 per cent. water. Under average conditions for March, four-tenths of the ground was covered with cloud and perhaps two-thirds of the remainder with snow. Over the ocean the average cloudiness was six-tenths. The albedoes of various surfaces, as given by Dr. J. C. F. Zollner (Leipzig) supposing an angle of incidence of 20° were—

Fresh fallen snow........	0.785	Clay marl........	0.156
White paper	0.700	Moist earth	0.079
White sand-stone	0.237	Water	0.021

Assuming the value of the albedo of cloud surface to be the same as white paper, and diminishing that of freshly fallen snow to meet the case of forests, dust or other causes by reducing it to the mean between naked clay and snow, we arrived at the following as the average albedo of the illuminated hemisphere :—

	Proportional Parts		Albedoes.	Reflecting Power.
Continents........	15	Cloud 6	0.70	4.20
		Snow 6	0.47	2.82
		Ground 3	0.16	0.48
Ocean	85	Cloud 51	0.70	35.70
		Water 34	0.021	0.71
	100	100		43.91

There were no evidences of unusual cloudiness over the water at that time, and though there was an extended area of cloudiness over the western part of North America, yet, allowing for this the total could not be increased to over 44.45 a difference which would not produce an appreciable effect on the light reflected to the moon and back again. If the cloudiness over the ocean had been a maximum, averaging ·7, the result to be 50.20.

But the distance between the earth and moon would make a great difference; at mean distance it is 239,000 miles, at perigee 221,000, at apogee 253,000. The intensity of earth shine must vary inversely as the fourth power of these distances, or as 2385 to 3263 for the moon at mean distance and at perigee, and as 4097 to 3265 for mean and apogee. In other words, the intensity of earthshine on the moon when the latter is at apogee, at mean distance from the earth, and at perigee, may be expressed in percentages by 80, 100, and 137, respectively, showing a total variation of 57 per cent. due to the eccentricity of the moon's orbit, the intensity of mean distance being assumed as the standard.*

Now on March 22nd the moon was just past perigee and the earth-shine should have appeared at least a fourth brighter than

* An error in the original calculations was detected by Mr. J. Edw. Maybee, and is rectified above. Mr. Maybee would, however, have preferred working from the apogee as a standard, which would show that the earth-shine is 71 per cent. brighter at perigee than at apogee.

the average, if the conditions for seeing were normal, which seems to have been the case.

The *new* moon will not again be favorably situated for bright earth-shine until some time in 1902.

The rest of the evening was devoted to the consideration of the aurora and the exhibition of views of its characteristic forms —some of them colored.

THIRTEENTH MEETING.

June 25th., 1901 The President in the chair .

DOMINION GOVERNMENT OBSERVATORY.

Letters were read from Dr. J. A. Brashear, of Allegheny, Pa., and from Mr. W. F. King, of Ottawa, Government Astronomer, describing the instruments to be supplied to the Dominion Government Observatory at Ottawa. The Society has learned with much interest and pleasure of the intention of the Government to establish at the Capital an astronomical observatory of the highest order. It is gratifying to know that the optical parts of the apparatus have been entrusted to one of its most esteemed members, who, under a recent date, writes to say that the spectroscope, the eye pieces and minor accessories have been finished and that the discs of glass for the 15-in. and 8-in. objectives have been received from Paris, France ; that prisms have been made, constants determined, curves computed and that workmen are ready to begin operations on them. The outfit will consist of one 15-in. refracting telescope, one 8-in. wide-angle astro-photographic objective, one 4-in. finder, one 2¼-in. finder, one diagonal prism, one wide-angle eye-piece, one helioscope, five positive eye-pieces for parallel wire position micrometer, five negative eye-pieces with sun glasses, one standard spectroscope with special battery of prisms, complete for laboratory and astro-physical research, and one registering wedge photometer The mountings will be made by the celebrated firm of Warner

& Swasey, of Cleveland, Ohio, which is tantamount to saying that the instruments will be perfectly mounted and set up. As for Dr. Brashear, he writes: "We shall do our very best to make this instrumental equipment second to none, and inasmuch as they have given us until the first of next May to complete it, it will give us an opportunity to do our work without hurry."

Observations of sun-spots were reported—the May spots having returned, though mnch diminished, and another group having broken out on the 23rd.

The remainder of the evening was devoted to short papers on the constellations. Lantern-slides of the chief summer constellations, mapped by himself, were shown by Mr. J. H. Weatherbe. Mr. D. J. Howell described the circumpolar constellations and gave an account of the mythology of that part of the sky. Mr. A. Harvey warned the members that there were many variants to these legends, especially in the case of star clusters such as the Pleiads and Hyades, as to which there were hundreds of myths current among ancient peoples of high civilization and the savages of every part of the world to-day. Rev. R. Atkinson chose "Summer-Suns" for his theme, and spoke of the enormous size, as compared with our sun, of many of the stars. At the suggestion of the President the Society then adjourned during the months of July and August, and subject to his call, as many members were to be absent for their summer holiday tours.

ANNOUNCEMENT OF OUTDOOR MEETINGS.

He announced that the new 4-inch Cooke telescope was expected daily, and that as soon as it arrived out-of-door meetings for practical work would be arranged—these meetings to be open to the public as well. He said the experience of other years warranted a continuance of the practice, and that the following members had offered, not only their own services, but the use of their telescopes, which included the following: His own 4-inch Brashear, Mr. A. F. Miller's 4-inch Wray, Mr. J. H. Weatherbe's 3-inch Refractor, Rev. R. Atkinson's 3-inch Bardou, Mr. A. Harvey's 3-inch, Mr. Henderson's 3-inch, Mr. A.

Elvins' 3-inch Wray, Mr. J. E. Mabee's 3-inch Banks, Mr. Solomon Michael's 3-inch Bardou, Mr. J. D. Collie's 3-inch Philp, Dr. A. D. Watson's 3-inch Bardou, and the Messrs. Collins' new 4-inch Monoplane and their 6-inch Reflector, both their own make. The Society's telescopes, the "Sir Adam Wilson" 6-inch reflector would be in the charge of Mr. J. D. Howell, and the "Larratt Smith" 3-inch refractor in that of Mr. J. A. Paterson. The President intimated that his 10¼-inch reflector was at the service of the Society for special occasions as well as for the use of individual members. Mr. Vice-President Stupart said he would be pleased to allow the 6-inch Cooke refractor of the Toronto Observatory be used whenever required. Some suggestions were made by the President as to the lines of work to be undertaken by members going out of town. Those who expected to spend their holidays in Muskoka and other northern favorite summer resorts were requested to pay particular attention to solar observations, as, owing to the puritv of the air there, the disc of the sun was very white, and even minute objects upon it could be well studied. It was a further advantage that stars could be followed down to the very horizon, and that the night skies, when cloudless, were amazingly fine. Auroræ, too, often were visible when no displays were noticeable at Toronto. Gorgeous sunsets were of frequent occurrence. In a word, he said, a good 2-inch telescope would almost do the work of a 3-inch further south. In this view he believed he was sustained by Dr. Brashear of Allegheny, Pa., who was taking up to his beautiful island home, Isle Urania, near Beaumaris, a fine 5-inch refractor, made by Pragmousky. The President had also heard Mr. Stupart, Dr. P. H. Bryce. Mr. J. C. Hamilton, the Misses Elsie and Lilian Dent and other members of the Society, extol the attractions of Muskoka for astronomical study and observation.

FOURTEENTH MEETING.

Sept. 3rd, 1901. The President welcomed the members after their vacation and hoped they had not forgotten to scan the heavens assiduously—such, at least, as had had the enjoyment of out-door summer life.

On motion from the chair, seconded by Mr. Arthur Harvey, M. Camille Flammarion, of Paris, France, was elected an Honorary Fellow of the Society.

M. CAMILLE FLAMMARION.

This distinguished astronomer, perhaps the most popular in the world, was born in 1842, at Montigny-le-Roi (Haute Marne) in a house which already bears a marble slab recording the event. It is said that at six years of age he sent off a balloon at some village fete, and being told that balloons could be made large enough to carry people, became fascinated with the idea that some day he would ascend in one; an idea afterwards realized in the many ascensions he made with the famous Godard. His mother must have been of a scientific turn of mind, for she placed a tub of clear water in front of her house during the eclipse of the sun in 1851, so that her children might see what was taking place in the sky. This eclipse turned the attention of the nine-year-old lad to astronomy, to the very great advantage of the world. He seems to have been only two years at the Langres Seminary before being admitted as a student at the Paris Observatory, where he remained four years. Meanwhile, at the age of nineteen, he published his first work, "La Pluralite des Mondes Habites," which caught the public taste and was at once translated into several languages. From 1862 to 1866 he was attached to the Bureau des Longitudes, which answers to our Nautical Almanac Office, and had in addition the direction of *Cosmos*, a Review of Science and its applications, which has reached its fifty-first year, and of which a copy is now before the writer, a curious and happy coincidence. He also published "Les Mondes Imaginaires et les Mondes Reels," another of the partly scientific, partly visionary and romantic works which have of late years popularized science and made the names of their authors as familiar as household words. Our irrepressible subject, leaving the Bureau, established an observatory of his own on the top floor of a house in Paris, finding time also to translate Sir Humphrey Davy's "Last Days of a Philosopher," and to write "Dieu dans la Nature," "Contemplations Scientifiques," and "Voyages en Ballon." The last he must have published with especial pride, remembering his early days at Montigny-le-Roi. He was also becoming known as a public speaker, being one of the first to introduce the lecture as a form of public instruction and entertainment. Then came the Franco-Prussian war, when he enlisted, and in 1871 became captain of a special corps. At the conclusion of hostilities he was invited to stand for the Legislative Assembly, but declined, and turned his attention entirely to astronomy. His published works are literally too numerous for mention here. His "Astronomie Populaire," with 840 octavo pages, 360 engravings, and 7 colored plates, is the best known of the larger books, and next to it we may place "Les Etoiles et les Curiosites du Ciel,"—(The Stars and the Wonders of the Sky). "Les Terres du Ciel," which we may translate as "dwelling places in the heavens," is an imagined voyage to the various planets and a description of the conditions we may suppose to exist there. "The Planet Mars" is a synthesis of all the Martian observations and a discussion whether the planet is habitable and inhabited. The catalogue before us mentions eighteen works, including planispheres, lunar maps and globes, celestial atlases—the last, if not drawn by him, prepared under his direction. He had time, too, (the busiest men are those who can spare the most) to superintend and contribute to an astronomical almanac and year book, now in its ninth year.

But in this Society we know M. Flammarion best by the Bulletins of the Astronomical Society of France, of which he was the founder and the first president, in 1878, a place he held for two years, when he was succeeded by M. H. Faye for two more. M. Faye was then already a member of the Institute, President of the Bureau of Longitudes and of the Council of the Observatory of Paris. He became Honorary President and remains so to this time, succeeded in the chair of the Society by MM. Bouquet de la Grye, F. Tisserand, J. Janssen, A. Cornu, O. Callandreau and H. Poincare—all "of the Institute," which is the blue ribbon for French Science. As with our Society, the Past Presidents remain members of the Council. The Vice-Presidents for this year are M. M. Lippman, the first to succeed in photographing colors, of whose work the society saw a specimen in 1891, which the owner treasures as one of the jewels of science ; Gen. Bassot, who, as the director of the Geographical Service of the Army, is now actively engaged in the superintendence of the expedition which is re-triangulating the Peruvian arc ; Ed. Caspari, Hydrographic Engineer to the Navy ; and Ch. Lallemand, Director of Levelling (nivellement) for France. M. Flammarion became the General Secretary in 1892, and M. H. Deslandres, of the Meudon Observatory, is now Recorder. The monthly Bulletins are instinct with the vivacity of M. Flammarion—seldom one without a contribution from him, either a paper or some valuable remarks by way of discussion. The number for January, 1902, contains fifty-six pages, in which thirty-six subjects are treated of, all of interest, and two of them are devoted to a description (with plate) of the Observatory of the Society. The learned societies have a home in Paris—the Hotel des Societes Savantes, Rue Serpente—and at the desire of M. Flammarion they have built on the roof, with a suitable revolving dome, 4·4m in diameter (14½ feet) an equatorial of 108 mm. (4¼ in.), a transit instrument, a clock, and even a room close by for observers to retire for rest after late or early labors. Thus every member can familiarize himself with easy astronomical work and members from other cities and countries have instruments at their command when visiting Paris. The equipment is such as we hope to have here when the Public Library, the Museum the Technical Schools should have, the Canadian Institute and other such bodies join in building a home for Literature and Science. To conclude : M. Flammarion has shown that imaginative powers can be sometimes combined with practical scientific achievements. He would be a leading man if he had either as well developed as we find them to be; but, possessing both, we deem it a doubled honor to have his kind acceptance of our Honorary Fellowship. His letter of acceptance is characteristic—he cannot write without testifying energy as well as good nature. He says in the communication to President Lumsden:

[TRANSLATION.]

OBSERVATORY OF JUVISY, August 20, 1901.

DEAR AND EMINENT COLLEAGUE,

I have been so absorbed, of late, preparing my second volume on the planet Mars, in the work of my observatory, and of the Astronomical Society of France, that my correspondence is much in arrears, and, for that reason, I must ask you to excuse any delay that has occurred in acknowledging your letter.

I accept with thanks your gracious and honorable proposition to confer on me the title of Honorary Fellow of the Toronto Astronomical Society, and I beg you to share the thanks I I convey to you with the members of your Council.

I have received and read with much interest the *Transactions* of your fine Society, and I have remarked, among other matters, the drawing of the eclipse of 28th May, 1900, published on page 21 of the Report for 1900, which is strikingly similar to the drawing I made in Spain. (Bull. S. A. F., 1900, p. 294.) Apropos of this, if any of our issues have failed to reach you, I beg you to let me know, and I will have them made good.

We have been observing falling-stars all the week, and have been able to determine the parallaxes of several.

With my very best wishes,

FLAMMARION.

M. Georges Sogler, of Viroflay, near Versailles, a member of the French Society of Exploration, who was present, addressed the Society in French and spoke of M. Flammarion, whom he had met, as "no less modest than distinguished." He promised, should he meet M. Flammarion on his return, to inform him of the unanimous sentiment of respect and esteem felt for him by the Society. The President requested Mr. A. Harvey to convey to M. Sogler, whom he had introduced, the pleasure experienced by the Society in welcoming to Toronto any representative of the scientific world of France.

OBSERVATIONS.

Mr. Elvins reported seeing meteors in August of which some were Perseids. No organized count was made.

Mr. A. F. Miller remarked how finely placed for observation Jupiter and Saturn had been for some time. Jupiter's belts had been undergoing changes, for the southern dark belt was now darker than the northern, and other parts had altered. Saturn was, as regards his rings, in about the same position as in 1886. He was also able to report a personal observation of the motion of a double star. From 1883 to 1887, the star π Aquilæ could be readily divided; and from 1890 to 1895 it could not be divided by the highest powers on his 4-inch Wray refractor; now, with a power of 120, the stellar point is seen elongated; and with a power of 200 the star shines out double, as when first observed.

VACATION OBSERVATIONS.

The President said this was the first meeting after the summer vacation. Most of the members were still out of town, but he had learned from those who had returned, that good use had been made of the holidays. For these and other reasons, there was good ground for believing that when the meetings of the Society resumed their ordinary character as to attendance and otherwise there would be numerous interesting observations to report. He himself had spent a short vacation in Muskoka, to which he was about to return immediately, and where he had been able to observe with the advantages peculiar to that interesting region, the Moon and the planets Saturn and Jupiter. He announced that it was proposed to name a Point in Lake Rosseau in honor of M. C. Flammarion, who had in many ways shown his interest in the Society, and who, he was proud to say, had accepted at the hands of the Council, nomination as one of its Honorary Fellows. He added that this would be fitting, as Dr. Brashear had named the site of his summer cottage in the adjoining lake (Muskoka), in honor of the Muse of Astronomy, "Isle Urania."

FIFTEENTH MEETING.

September 17. The Vice-President, Mr. R. F. Stupart, F.R.S.C., in the chair.

Mr. Napier Denison, of Victoria, B.C., was appointed delegate from the Society for the meeting of the British Association, Glasgow.

Rev. R. Atkinson exhibited a photograph of the bore on the Petitcodiac River. Mr. A. Harvey, who had seen it, said it would require a kinematograph to give a proper idea of the stampede of cattle towards the shore, the rush of the wave up-stream and the general hurry on the river. He understood that some devotee of science had lately kinematographed the bore on the English Severn.

DIFFERENT MOTIONS OF THE EARTH.

Mr. J. A. Paterson read a memorandum enumerating the twelve different motions of the earth, as to which Mr. Harvey said that if the Lothian–Green theory were true, and it had lately received the approval of distinguished members of the French Academy, there was another to be added, viz., the slip of the crust, as a whole, upon the liquid nucleus, by which it had come to pass that parts of the crust, once near the equator, were now near the North Pole. This was one way of accounting for fossils near either pole which must have required a high mean temperature to live in.

THE PLEIADES.

Mr. J. C. Hamilton, M.A., LLB., then read a paper on "The Pleiades in the Classics and Mythology." The use of the large library of the Canadian Institute had been graciously given to the Society for the occasion, and was filled by a large audience of members and their friends. The title refers to a part, only, of Mr. Hamilton's work, for he has collected references to the Pleiades from many lands other than those to whose language term classical is usually applied. It seems that in old Egypt, the mother of civilization, and in darkest Africa to-day, among the aborigines of the two Americas, in Polynesia and Australia, in China, India and Japan, as well as among Semitic people, and in all European countries, especial notice is and has always been taken of the Pleiades. References and often quotations from scores of authors, ancient and modern, followed each other rapidly in the course of the paper. It would seem there is a general impression that there once were seven easily visible stars in the cluster, and many and various are the myths to account for the disappearance of the "lost Pleiad," some poetical and romantic, others course or comical. The appearance of the Pleiads in the early hours of evening or their sinking just after dusk below the western horizon has been to all half civilized people a sign when to plough or sow their grain, when to put to sea or seek the harbors. Mr. Hamilton, referring to the photographs of the Pleiades which showed the stars to be connected by nebulous wisps, said that Elihu Vedder, the American illustrator of Fitzgerald's translation of the Rubaiyat of Omar Khayyam, had beautifully depicted the group of stately sisters, twining around themselves an endless band of drapery in swirls meant to typify the mystery of existence. This was a poetical prophecy of the encircling nebulous stream ssubsequently found on the photographic plate, an "enchanted vision" which revealed a vast nebula and some 2,300 stars within the limits of the famous cluster. He drew a clear-cut picture of the watchman who in the "Agamemnon" of Æschylus had been watching on the King's palace-roof, "crouching on his elbows like a dog," every night expecting to see the blaze, which, starting from Mount Ida and repeated from mountain-top to mountain-top should tell of the fall of Troy. This watchman had seen the Pleiades pass ten times over the sky, thereby numbering his years and the change of seasons—the passage and the development of the play when the Queen sees the signal having, perhaps, inspired Sir Walter Scott to write of the Fiery Cross. Then the subject of star worship was taken up, from the orienting of Egyptian and of Greek temples to particular stars, to the beliefs of astrologers that certain stars, Algol, Antares, etc., were maleficent, and others beneficial to certain individuals. Traces of star worship—and the Pleiades were often the particular objects of it—had existed until recently, even in Europe, and Mr. Hamilton unearthed relics of it in some parish records in North Britain as late as 1673. The particular stars of the cluster were then named and described, Alcyone, the largest, being of enormous dimensions, several times larger than our sun.

We hope Mr. Hamilton's paper will some day be published in full ; it was so highly appreciated by the audience. It closed with the reading of the stanza by our Canadian Lampman :—

In the silent depth of space,
Immeasurably old, immeasurably far,
Glittering with a silver haze
Through eternity,
Rolls a great and burning star
With a noble name,
Alcyone.

SIXTEENTH MEETING.

Oct. 1st, 1901. The President in the chair.

THE LATE THOMAS LINDSAY.

The Society was much pained at the loss of a very faithful and valuable member, Mr. Thomas Lindsay, whose serious illness from an affection of the brain was announced at the last meeting. Mr. J. A. Patterson, a Past-President, seconded by Rev. R. Atkinson, moved a resolution of condolence with his family, which contained the following reference to his connection with the Society :

"In the passing of our former Secretary, there passed an earnest student, who sought to open the treasury of Science with the key that was given him, a hard and earnest worker, thoroughly devoted to our interests, a faithful friend, an honest, conscientious man."

Several members spoke to the resolution, and Mr. W. B. Musson read a short biographical sketch of the late Secretary, who was born in Edinburgh in 1854, was brought by his parents to Canada quite young, and was educated at the George Street Public School and the Jarvis Street Collegiate Institute, where his name repeatedly appeared in the honor and prize lists in Greek, Latin, French, history, antiquities and mathematics. He then spent several years at sea, and had a somewhat chequered career, being one of the survivors of the ill-fated *Virginius*, which was taken by the Spaniards during the Cuban revolutionary war of 1868–78. When he had a narrow escape from being shot. It was during his life at sea that he became interested in nautical and mathematical astronomy. In Toronto he settled down to duties at the desk, and was connected with a savings company, and afterwards with a life assurance company, by the staff of which he was highly esteemed and much relied upon.

Mr. Lindsay became a member of the Astronomical and Physical Society of Toronto in he year of its incorporation, was

The Late Thomas Lindsay.

elected Assistant Secretary and Editor in 1894, and Recording Secretary and Editor in 1897, holding those offices for four years. During this period the editing of the Society's *Transactions* devolved almost entirely on him. The members have only to open these volumes to recognize his care and judgment. He contributed several papers himself, and took especial interest in a series on "The History of the Nautical Almanac." The writer often urged him to complete this valuable work, if only in MSS., but he preferred to wait, while gradually collecting biographical and other information, and it is much to be regretted that his untimely and unexpected death cut short his work and leaves it fragmentary. It is hardly to be expected that another Canadian will take up the threads where he left them ; it will probably be done in England, Mr. Lindsay was not an infrequent contributor of articles on various branches of science to magazines and educational periodicals. His great interest in astronomy may be inferred from his having found a way to visit Wadesborough, N.C., to witness the total eclipse of the sun there, May 28th, 1900, and this was perhaps to him the most enjoyable hour of his life. A kind and genial disposition was his, ever prompting him to make plain the path of those he met, either as business associates or seekers for knowledge in the Society. His funeral was numerously attended by the members, who will ever hold him in affectionate remembrance.

MINUTE BOOK OF THE ORIGINAL ASTRONOMICAL SOCIETY.

Mr. Elvins presented to the Society the Minute Book of the Astronomical Society, founded here in 1868. It began its existence at a meeting in the Mechanics' Hall, Dec. 1st,, as the "Astronomical Club," the word "Society" being substituted for "club" on May 4th, 1869. The date of the last minute is December 7th, of that year.

The members were D. K. Winder, President ; Mungo Turnbull, Andrew Elvins, Robt. Ridgeway, Chas. Potter, G. Brunt, Saml. Clare, and J. L. Hughes, who attended the first meeting. Afterwards electing W. Long and W. Thompson. The first paper was read by Mr. Turnbull, on "Optical Science—Its Bearing on Astronomical Telescopes and Celestial Discovery."

The club seems to have been well informed on astronomical and physical subjects as then understood, but one can see by its minutes what great progress has been made. For example, Mr. Winder read a paper on the spectroscope (he had made one for himself) and its application to celestial chemistry, in which he alluded to "the deep interest attached to his subject owing to its being yet in its infancy." There was an eclipse of the sun on Aug. 7th, when seven-eighths of the disc were obscured. Interesting observations were made as to the temperature, which was taken every five minutes. (The writer has worked out the curve, which is quite similar to that of his observations during the eclipse of 1900. There are also accounts of fine auroræ on April 15th and May 3rd, and Mr. Elvins reported seeing an aurora in daylight, as the sun was setting, May 6th. The streamers were quite distinct against some clouds, one "seeming to join the top of St. Michael's spire, was very distinct. * * Its color was darker than the red of the sky, a strange, dark, transparent form, exactly like aurora at night, but instead of being brighter than the rest of the sky it was darker." Mr. Elvins hoped to have been the first to record the appearance of a daylight aurora, but Prof. Loomis had referred him to the Smithsonian notices of 1865, where one or two such intances are mentioned. The writer has also seen one such display in Toronto, but cannot state whether the streamers, which were playing among golden sunset clouds, were darker or brighter than the background.

ELECTION OF DR. BRASHEAR.

Dr. J. A. Brashear, of Alleghany, Pa., wrote to acknowledge his election as an Honorary Fellow, and forwarded a monograph on the Carnegie Technical School. He also said he had intended to leave with the Society, for this fall's work, his 5-inch Pragmowsky telescope, but he had found that its object-glass required some retouching before its performance could be regarded as perfectly satisfactory.

The acceptance by Dr. Brashear of election as an Honorary Fellow afforded the Society much gratification, the more so as he is one of the two Honorary Fellows, the other being Dr. E.E. Barnard, the members have had the pleasure of meeting. Visiting his Muskoka home every summer, Dr. Brashear is often in Toronto. On one occasion he addressed the Society upon the work of the late Dr. Rowland and of himself in ruling gratings on glass for spectroscopic purposes, and presented to the Society a superior specimen of their joint skill. The following personal sketch will be of interest :

Dr. Brashear was born in Brownsville, Pa., Nov. 24th, 1840, and received a common school education. Having learned the trade of a machinist, he served twenty-one years as a so-called "Master Mechanic," in the Rolling Mills of Western Pennsylvania. He began the study of Astronomy, i.e., the constellations, when only ten years of age, and having become intensely interested and desiring to own a telescope, he commenced the grinding and polishing of a five-inch object-glass while at the rolling-mill ; finishing it in 1874, after three years' labour. He then ground and finished several six-and-a-half-inch reflectors. A twelve-inch which he finished in 1877 was broken in attempting to silver it. A second twelve-inch was, however, completed in 1877, in time to observe Mars at the famous opposition of that year, in which his old friend, Professor Asaph Hall, discovered its satellites with the twenty-six inch refractor at Washington. Between 1877 and 1888 the subject of this sketch made many observations of comets and nebulæ, and a systematic study of the lunar crater Plato. In 1880 he commenced the business of making astronomical instruments, mostly reflecting telescopes. He slowly developed into lines allied to astro-physical work, and has constructed nearly all the large and important spectroscopes, spectrohelioscopes and spectrophotoheliographs made in America. He took up work on grating plates for Professor Rowland in 1883, and has distributed the gratings all over the world. During the past twelve years he has finished many of the largest and finest astronomical and physical outfits for astronomical observatories in the United States and abroad. One of these is the 20-inch reflector in Mr. Percival Lowell's fine observatory, at Flagstaff, Arizona, where careful observations of Mars and his markings and of Venus and Mercury were made. Dr. Brashear has been greatly interested in the development of the astronomical camera, of which instruments he has made many. Two of sixteen-inch aperture are now in the hands of Dr. Max Wolf, of Heidelberg, Germany, with which he has discovered new asteroids, and is adding many new nebulæ to the list already known. He has also constructed a large number of concave-grating-spectroscopes, some of the most important being in use at the Royal Institution, London ; Manchester University, Cambridge University, Royal University of Dublin, etc., etc. This is but a rough outline of the work at Dr. Brashear's establishment, one of the most famous in the world. Save for the first ten years, Dr. Brashear has been assisted by his son-in-law, Mr. James B. McDowell, to whose splendid skill much of his success is due. As this Report goes to press, it is learned that the Doctor is grinding a new 37-inch mirror for Professor W. W. Campbell, Director of the Lick Observatory, to replace the Crossley mirror which was shattered when being bored for conversion into the Cassegrainian form. (See page 66) The new mirror is to be a Cassegrainian of about 17 feet focal length, and is to be taken by Dr. Campbell to Chili, South America, to assist in the study of the motion of stars in the line of sight.

Mr. A. Elvins read a paper on deformed lunar craters.* He illustrated it by drawings of his own, in the excellence of which he is without a rival in the Society, which shewed how the walls of many craters had in very ancient times been broken down, often at one side only ; while sometimes there were traces left. Mr. Elvins holds to his view that this was the effect of erosion by water, and he explained the theory of the deprivation of the moon of both air and water by tidal action.

* See illustration, also description thereof, pages 48 and 49, and Dr Wadsworth on this subject, page 46.

SEVENTEENTH MEETING.

October 15th, 1901. The President in the chair.

Miss Jean Gilchrist, 56 Scollard Street, Toronto, was elected an Associate.

After routine, and the announcement of time and places for out of door meetings for observation, Mr. A. F. Miller drew attention to the excellence of the telescope by T. Cooke and Sons (Limited), London and York, imported for the Society by Mr. Charles Potter, the well-known Toronto Optician. Mr. Charles D. Petry, a member of the Society, who has charge of Mr. Potter's business, was kind enough to hand the instrument over at its cost to him, laid down in his establishment; this he did entirely at his own suggestion, which the Society fully appreciates. Mr. Miller said the telescope had been subjected to various tests, and had met every demand upon it. The makers had carried out their promise that the object-glass should be of the highest quality for astronomical purposes and of the very best defining power. It was a thoroughly "up-to-date" instrument, with the additional advantage of having a short focus.*

Mr. W. B. Musson then read a paper which he had been asked to prepare on "Stellar Evolution," dealing with the present state of science upon that subject with special reference to the work of Sir William Huggins, who had been for ten years an honorary member of the Society.

This paper, of which the following is a much condensed abstract, was illustrated by lantern-slides in the preparation of which the writer had received the valuable aid of Mr. D. J. Howell.

* A 4-inch refracting telescope with bright black brass tube and rack adjustment to focus, finder, dewshade and cap, three astronomical eyepieces (powers 60, 120 and 300), one solar eyepiece and three sunshades. Since its arrival, it has been mounted on a very solid alt-azimuth tripod.

STELLAR EVOLUTION AS INDICATED BY SPECTRUM ANALYSIS.

Between the birth of stars from nebulæ and their death from loss of heat there would appear to be a gradual and regular progression, and certain well known stars have been taken as types of the stages of this "life history." The singularly complete and rapid change of opinion regarding nebulæ is well illustrated in the following letters.

Writing to Prof. Nichols in 1846, after an examination of the Orion Nebula, Lord Rosse said,

"I think I may safely say that there can be little if any doubt as to the resolvability of the nebula. Since you left us there was not a single night, when, in absence of the moon, the air was fine enough to admit of our using more than half the magnifying power the speculum bears; still we could plainly see that all about the trapezium is a mass of stars; the rest of the nebula also abounding with stars, and exhibiting the characteristics of resolvability strongly marked."

"Thus," wrote Prof. Nichols, "doubt and speculation disappeared from this great subject forever."

The general opinion at that time was that all nebulæ were resolvable provided sufficient optical power could be secured, Lord Rosse's great reflector then being the final court of appeal.

Hear, however, Sir William Huggins' account of the examination of a similar object eighteen years later. (1864.)

"On the evening of August 29th, I directed the telescope to the planetary nebula in Draco. I looked into the spectroscope —no spectrum such as I expected; a single bright line only; at first I suspected some displacement of the prism. * * * This thought was scarcely more than momentary; then the true interpretation flashed upon me—the light of the nebula was monochromatic, the riddle was solved, the answer which had come to us in the light itself, was read—not an aggregation of stars, but a luminous gas."

Prof. Nichols' rash assertion was thus finally contradicted, and the period separating the two observations may fairly be taken to represent the gap dividing the old astronomy from the new.

Notwithstanding the keen intellectual insight of the elder Herschel, and the marvellous reasoning of Herbert Spencer, both of whom to some extent anticipated the revelations of astro-physics, astronomers might have continued seeking greater and greater optical power with which to resolve suspected clusters, but for the story told by the spectroscope.

To Sir William Huggins belongs the honor of being among the pioneers in the new field of research. Sir William from his youth possessed a love for science, and at the age of twenty-eight was elected a member of the Microscopical Society, and worked for a few years at animal and vegetable physiology, but fortunately for astronomy he turned his attention to the latter pursuit, and built an observatory for his own use at Upper Tulse Hill, London, beginning what has proved to be the most useful work of his life. He has twice received the medal of the Royal Society and twice that of the Royal Astronomical Society.

The fascinating history of his astrophysical researches is contained in the beautiful Vol. I., of the publications of the Tulse Hill Observatory, with a copy of which the Toronto Astronomical Society has been favored, as a gift from the hands of its distinguished authors—for the name of Lady Huggins must ever be associated with that of her husband's.

The Observatory was equipped in 1856 with a five-inch Dollond, and two years later with an eight-inch Alvan Clark, and Sir William, becoming interested in Kirchhoff's discoveries respecting the constitution of the sun, applied the German's method of examination to other heavenly bodies.

Only those who have closely followed the history of the work can realize the difficulties that were overcome in modifying the method to the necessities of the case.

The slender quantity of light available for the examination of stars and nebulæ, the necessity for producing suitable comparison-spectra, the lack of proper maps of the spectrum, and the drawbacks of the wet-plate process of photography, then the only one practised, were obstacles which might well have dismayed a less persevering and enthusiastic worker, but obstacles were surmounted, and the volume referred to is the noble record of many years of severe and devoted labour.

To the examination of the stars were added observations of comets and nebulæ, of the Sun and its surroundings, and of Mars, Uranus and Saturn, whilst a close study of the chemical elements was of course indispensable.

Among the problems Sir William set himself to solve are these : Is the original nebula of a relatively high or low temperature? Can the connection between nebulæ and stars be reasonably established? Can the evolution of one type of star from another be traced and the order of progression determined? Can the comparative stages of the components of a binary system be known and the approximate age of the system calculated?

Sir William saw reason to agree with Helmholtz that the original temperature of the nebulæ need not be high, as, he argued, in view of their enormous extent a comparatively small number of molecules might produce the observed brightness while the mean temperature remained low, and this assumption was harmonized with the high temperatures indicated in the stars, by the application of Lane's law, which shows that a condensing gaseous mass must gain more heat by condensation than it can lose by radiation, up to a certain degree of density, after which the reverse would be the case.

Taking into consideration the effect produced by increasing density, as well as by temperature, one would therefore expect the spectra of stars in an early stage of development to more nearly resemble the spectra of the nebulæ than do those of stars in a later stage—an expectation apparently confirmed by facts.

Star systems exist, such as that in Orion, which appear to be involved in nebulous matter, and their stars almost invariably show lines of Helium absorption. Respecting these, Sir William wrote in 1897 : *

* Astro-physical Journal.

"In our original photographs of the spectrum of the great nebula of Orion, including that of the trapezium stars, we observed and measured in the continuous spectra of these stars a number of bright lines which appeared to extend into the nebula on both sides, and which consequently justified us in concluding that these stars are, or have been, physically connected with the nebula itself."

And writing again in 1899, after further observation, he says:

"The conclusion of the whole matter seems to be that our assumption in 1897, that the stars of the trapezium were physically and evolutionally connected with the great nebula, and not merely optically associated with it, is satisfactorily sustained as the result of a more complete examination of their spectra."

A second example is offered in the cluster of the Pleiades, the characteristic stars of which appear to be entangled in a wisp of nebulosity, and show spectra of Secchi's first type. The Harvard photographs show Pleione to exhibit narrow bright hydrogen lines superposed upon the Sirian spectrum, indicating a highly nebulous condition. The presence of the complete series of hydrogen lines may be considered a test of stars of the first type.

The weakening or disappearance of these lines and the incoming or strengthening of the metallic lines marks the transition to the second or solar type. This change may be imagined to occur in consequence of the mixing of the elements under the influence of gravity, and the setting up of convection currents. Of these stars Sir William says:

"The photospheric radiations of the solar stars must be more intense than those of the white stars which came nearest to them in brightness as estimated by the eye, for the solar stars are relatively at an enormous disadvantage. They may be compared to a sunlit sky as darkly seen through a Venetian blind, and the same sky pouring its light through a window having no other obstruction than the narrow bars between the panes. In the solar stars the light of the photosphere can only filter to us through the dark lines of a very close absorption screen, a screen of so close a grating that Rowland's map of the solar spectrum contains no fewer than some twenty thousand dark lines, each of which intercepts a portion of the light of the photosphere."

As the more refrangible rays suffer to the greatest degree from this absorption, the cause of the yellow, orange, and red colors of second, third and fourth type stars will be at once apparent.

Stars of the third and fourth types are those of which the spectra show bands or flutings, which are thought to be due either to chemical compounds or to elementary substances at comparatively moderate temperature, although the band spectrum of carbon is now regarded, as was maintained by Sir William Huggins in 1868, as due not to a hydro-carbon but to the carbon molecule itself. Stars having band spectra, however, are, as a general rule, those which for other reasons are to be regarded as of relatively low temperature.

The spectra of these stars may therefore indicate an increase in the absorbing atmosphere, since, as the bands probably originate in a region of lower temperature, this region must be considered to be at a greater distance from the stellar photosphere than the layer producing the dark lines, also visible in such spectra.

The actual extent of this atmosphere is probably shallow in comparison with the absorbing gases surrounding Sirian stars. Indeed it is questionable whether the latter can be regarded as possessing a photosphere in the true sense of the word. The atmosphere of stars of the fourth type is so absorbent as to almost destroy the violet radiations, and leave but a very faint and red light. There is a fifth type known as the Wolf-Rayet stars, of which about a hundred have been discovered since 1867, when the first examples were noticed by the astronomers after whom they were named. A remarkable feature of these stars is that they are almost invariably found to lie along the axis of the milky way.

Their spectra are characterized by bright, and, in some instances, by absorption bands and lines; although the bright lines stand out distinctly on, what in ordinary instruments, appears to be a continuous back-ground, Prof. Keeler observed this in the Lick instrument to be made up of a combination of absorption bands and faint bright lines.

The light from these stars is yellowish in color, the magnitude being about 8 or 8½. A special feature is the tendency they exhibit to collect in groups. In some respects their spectrum closely resembles that of planetary nebulæ, and there appears to be reason for the inference that they are largely nebulous in character. A quarter of a century seems to show no change of their spectrum. Sir William Hnggins' researches are probably not yet far enough advanced to justify a definite expression of his opinion as to their probable stage of evolutional development.

It may be assumed that stars are cooling bodies, and that the course of their life history is to be traced by the gradual exhaustion of their temperatures, both potential and actual.

Any indications as to the density of stellar vapours are of the highest importance, as in the words of Sir William:

"Concurrently with a rise and then a fall of temperature other considerations brought about by increasing gravity, especially the potent one of density, will come in which must modify and may even mask, more or less, the changes in the spectrum which wouid follow directly from differences of temperature."

The dominant changes marking this process in the absorbing layers are, as above stated, in the lines of hydrogen and calcium. Now the relative feebleness of the blue line of calcium at λ4227, as compared with the H and K lines, gives some indieation of this density. The feebleness of the blue line had been regarded as a criterion of a higher temperature, but Sir Willam Huggins being of the opinion that this conclusion was erroneous instituted a series of experiments which resulted in demonstrating that the changes which had been attributed to increased temperature could be produced by a reduction of the density of the calcium vapour, thus furnishing an important basis for the determination of the order of transition from one type of star to another. He advises great caution, however, in reasoning from laboratory experiments to the phenomena of the heavenly bodies.

Mass has probably an important effect in determining the rate of evolutional development, stars of small mass being generally held to run their course quicker than stars of greater mass, although the question is a disputed one, strong arguments having been urged in favor of the reverse view, i.e., that mass has an accelerative influence in promoting those changes which mark the different spectral types as evolution advances. In this connection the study of binary systems is one of absorbing interest, since a careful determination of the masses of the components of such a system, taken in conjunction with a study of their spectra, would probably solve the problem. Unfortunately the data for such comparison have not yet been provided.

In estimating the age of a binary system the eccentricity of orbit and the type of spectrum offer a comparison which may prove of interest. In the cases of β Persei and γ Andromedæ some such comparison is possible, and the results appear to be in harmony. Helium stars then, merge into Sirian, which in turn pass through solar into post solar and Antarean stages, the temperature rising until it reaches its maximum in the solar type, and then falling away to gradual extinction.

Sir William sums up his conclusions in cautious but distinct language. He affirms that—

"The great differences which appear at first sight to exist between the spectra of the principal classes of stars, when carefully considered, are clearly not of such an order as to compel us to take the view that they certainly point to essential differences of chemical constitution. In the photographic region the passage of one spectrum into the next in order is so gradual as to leave little room for doubt that the actual differences of stellar spectra do represent, in the main, successive epochs of star life rather than so many fundamental differences of chemical constitution."

All must partake of the enthusiasm of the astronomer when they read of that wonderful night when, having at length made plainly visible the spectrum of a star, he line-matched it with the spectra of terrestrial iron and sodium : the bright lines of hydrogen with absorption lines of the same gas in Sirius and Vega—yes ! the universe was one, a star at its outer confines was formed of constituents similar to those of our own earth ! In expressive language Sir William confesses that—"The time was indeed one of strained expectation and of scientific exaltation for the astronomer, almost without parallel; for nearly every observation revealed a new fact, and almost every night's work was red-lettered by some discovery"—and in describing the ever memorable night of the 29th August, 1864, he continues: "The observations remain associated in my memory with the profound awe which I felt in looking for the first time at that which no eye of man had seen, and which even the scientific imagination could not foreshow."

EIGHTEENTH MEETING.

October 29th, 1901. The President in the chair.

The Rev. R. H. Abraham, D. Sc., 67 Winchester Street, Toronto, was elected an Associate of the Society.

Mr. Andrew Elvins, finding that his health required him to expose himself but little at night, expressed his wish to present his fine 3-in. Wray refracting telescope and tripod to the Society, to be placed in charge of the curator, with instructions to lend it to members who desired to use it for such length of time as might be thought reasonable—the curator to instruct borrowers how to adjust the eye-pieces, etc., and to request them to report their observations to the Society.

The letter was referred to the Council, and at the next meeting the following Address, then prepared, was adopted by the Society and ordered to be engrossed and illuminated:

To Andrew Elvins, of the City of Toronto, Esq., Past President and Life Fellow of The Toronto Astronomical Society,

Sir:—The members of The Toronto Astronomical Society desire to express their appreciation of your kindness in generously presenting the Society with the telescope you have so long and so efficiently used. While fully concurring in your desire that the instrument shall be freely at the disposal of those members not possessing telescopes of their own, they recognize as their duty the careful preservation and keeping of this telescope as one of the earliest used in the Province of Ontario for astronomical observation and research. They trust you may be long spared to make use of the instrument yourself under the principle you have laid down, and they welcome this opportunity of putting on record their appreciation of the service which your life-work has rendered to Astronomy, in the keeping of this and kindred sciences before the public during the long period in which you were almost the only telescopic worker in this Province.

Signed on behalf of the Society,

J. EDWARD MAYBEE, Recorder.

G. E. LUMSDEN, President.

ETHER WAVES.

Mr. C. A. Chant, M.A., (Tor.), Ph. D. (Har.), then addressed the Society on "Some New Aspects of Ether Waves." Dr. Chant explained that as one cannot believe that light, heat and electricity can be transmitted through nothing, scientific men have imagined that space must be filled with a substance, and they have called it ether. It must be highly elastic, to account for the rapidity of motion transmitted by it, and of very small density, or the movements of the heavenly bodies must soon cease. The waves transmitted took the same time to pass through a given distance, but they were of various lengths, commencing with the extremely short vibrations, which produced no effect on the human eye, but made themselves felt on the sensitive plate when the spectrum of sun-shine was photographed. Then came the lengths visible as colors, from violet through yellow to red, in infinite combinations, and afterwards invisible radiations again, heat rays, and electro-magnetic impulses, which were now proving so serviceable in wireless telegraphy. This long bridge was practically without a gap, reaching from the shortest photo-chemical to the longest electro-magnetic waves, and it must be considered one of the triumphs of modern science to have demonstrated the relationship of these numerous radiations.

NINETEENTH MEETING.

November 12th, 1901. The President in the chair.

MIRAGE OBSERVATIONS.

Mr. J. C. Hamilton reported having seen in Muskoka an extraordinary and very beautiful mirage or picture on the glowing clouds facing the setting sun, which took on the semblance of an eastern walled city. At one end was a great round tower, while bastions, steeples, cupolas and minarets were near by. At the other were more battlements and towers, some little higher than the walls, others soaring high above them. Mr. Hamilton once thought the buildings at the Pan-American Exhibition, Buffalo, might have been the original of the mirage, but has abandoned the idea because the electric light was not turned on at the Buffalo Exhibition on the 13th August until after sunset in Muskoka, though if it was a mirage and not a mere cloud-picture, the Editor cannot see the necessary connection, since it was daylight at both places. A full account of the mirage is to be found in the *Anglo-American Magazine* for November. Mr. Hamilton being informed by Mr. Arthur Harvey that a mirage was frequently seen on the Alaskan coast which had been thought by sea-faring men to resemble the city of Bristol, Eng., took the trouble to further investigate the subject and has sent the results to the Society.

There is a letter from Mr. A. Bronskil of the Toronto Technical Schools who says, "I have in August seen at Little Metis, P.Q., more than once, a mirage of Murray Bay, a small town some 160 miles distant on the opposite shore. It showed the church, bridge, hotels and other houses, as well as Cape L'Aigle, a distance of about eight miles from Murray Bay. Pictures of ships were often seen, many of which could not be located with telescopes. Mirages seen by me in the Gulf of St. Lawrence have the reverse of the natural figure, some of them distinct and clear of line and capable of reproduction by photography."

This allusion is to a supposed photographic representation of the Alaska mirage, printed in the Victoria, B. C. *Times*, January 26, 1901, of the "Silent City of Alaska." The impression is very indistinct, whatever the photograph may be, but the outlines of houses with their chimneys and windows can be made out. The editor of the *Times* says the mast of a vessel can be seen, and a tower, the exact duplicate of St. Mary's, Radcliffe, appears in the background.

There seems to be littte doubt that on the glacier of Mount Fairweather a mirage occurs between June 21st and July 10th, which often resembles a city. The Duke of the Abruzzi saw it and made a sketch which the editor says corresponds with the photograph. But Mr. Napier Denison, of our meteorological service, Victoria, writes to Mr. Hamilton and says he is not satisfied as to the authenticity of the photograph, which he has seen. An English lady, recently principal of one of the Ladies' Colleges at Cambridge, told him that she and all on board the vessel she was upon had seen the mirage as that of a large Eastern city, whose towers and flat roofs could be seen sufficiently clearly to be awe-inspiring. She took two snap-shot photographs, which were not developed when she saw Mr. Denison on her way to Japan. As to the Duke of the Abruzzi, Capt. Walbran, of our D. G. S. "Quadra," received a letter from him to say that he, when last there, distinctly saw a mirage resembling a large city upon this glacier.

Several members spoke of mirages seen on our lakes, The City of Rochester, sixty miles from Toronto, across Lake Ontario, had been distinctly seen this year.

TWENTIETH MEETING.

November 25th, 1901. The President in the chair.

Mr. W. D. McPherson, 540 Dovercourt Road, was elected an Associate of the Society.

Dr. J. T. Tyrrell, of Toronto, wrote, presenting eight rare old copper-plate prints of star-charts, and Mr. W. B. Musson was instructed to express the Society's heartiest thanks and to hand to the doctor a complete set of Transactions, handsomely bound.

An interesting conversation respecting the Leonid Meteors of the middle of the month took place. The weather in Toronto had been unfavorable for observation.

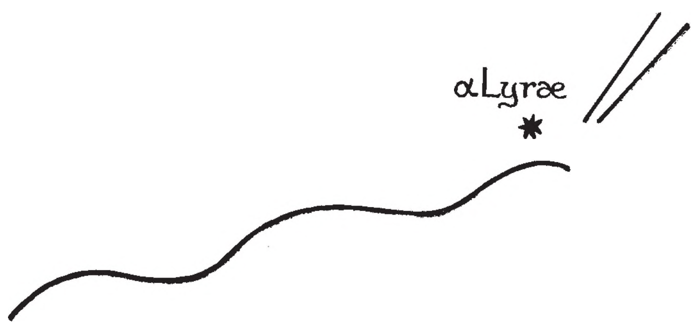
Capt. J. G. Ridout drew attention to the fact that Capella, first shewn by the spectroscope to be a binary, had been divided by the large telescope at Greenwich. Its period was very short.

METEOR OBSERVATIONS.

The President asked for observations of a fire-ball which had passed westward over Toronto, on July 9th. He and Mr. Miller, who were in the Toronto Observatory, saw nothing more than a flash of light which filled the dome. On descending, the appearance of the meteor was described to them by the still excited janitor.

But few observations have been handed to the writer, who regrets that more were not obtained when they could have been had, for they are insufficient to draw the conclusions which more and more accurate observations might have warranted.

In Toronto and vicinity Rev. R. Atkinson noted the brilliant illumination of the landscape by the light of the meteor ; Mr. D. J. Howell remarked the wavy appearance of its trail ; Mr. R. Dewar observed that one-third of this trail was greenish-blue, between the light of incandescent barium and zinc, while the rest was whitish, like the vapors left by these metals when burned. The most exact place-observation was made by Mr. J. H. Weatherbe. That gentleman was in his garden, at the telescope. He saw the meteor appear a little below α Ophiuci, at 22^h, 22^m, E.S.T., and break up about the same apparent distance below Arcturus. It moved slowly, taking half a minute to pass over. During incandescence it gave out a glaring bluish-light something like arc-light vapor, but after bursting, the balls were fiery red. The "cloudy gaseous vapor" in its trail lasted over ten minutes, disappearing as a curling cloud. The night was dark, fairly clear and calm, but he heard no noise. (Fifteen minutes later Mr. Weatherbe observed a second fine meteor, but not so large, which started from the same point but took a more southerly course, leaving a trail about 15° in length.) Rev. Dr. R. H. Abraham, of Burlington, saw the meteor pass overhead, making a noise like that of escaping steam, and giving out light enough to read by. He saw it divide into three parts, of which two soon disappeared; the third passed on and remained visible for perhaps five seconds. The trail was a bright streak, which gradually broadened into a band of light like a burning ribbon.



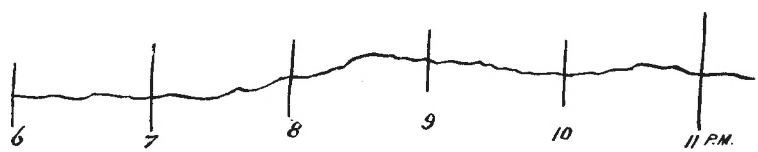
The trail, as seen and drawn by Miss Sarah E. Matthews, Toronto, at 22^h, 30^m. It was fully as wide as the full moon; the two tails, where the meteor was seen to explode, disappeared first.

He walked a mile and could still see it. The meteor was reported from Waterloo County so bright that cattle and sheep in the fields were seen by a clergyman driving on the road.

The only other observation of value was by Mr. R. F. Stupart, who was at Windermere, 100 miles north of Toronto, and saw the meteor pass near Jupiter, going from south of east to north of west.

As Jupiter was about 25° above the horizon, if Mr. Weatherbe saw the meteor at 45° above it, at the same part of its trajectory, it would be about eighty miles high. Its path was probably from somewhere south of Rochester, N.Y., over Burlington, towards Lake Huron.

But there seems to have been a third meteor seen that night. Dr. J, J. Wadsworth sent an account, since repeated and reaffirmed, that at 22^h, 50^m, Mr. G. R. Austin, of Simcoe, eighty miles south west of Toronto, saw a bright light flash out. He, too, was in his garden, and, looking up, saw a brilliant fire-ball about 2° south of β and ζ Lyræ, which far outshone any star or planet he had ever seen. It was stationary for a few seconds and gradually moved in a direction a little west of north, past Vega, through Ursa Major, and sank below the trees. This motion occupied seven or eight seconds. It left a long trail which



Mercurial Barometer reading at 10 p.m., July 9th, 1901, 29.72.

This aero-barograph curve is particularly steady, 1″ = about 0.06″ on mercurial barometer.

looked to be round, like a ship's cable, and gradually spread into a flat band which became wavy, and changed color from whitish to reddish. The trail lasted for ten minutes, and floated west some 20°. There was no noise. Other local observers confirm this report.

This meteor must then have been falling almost directly upon Simcoe, when a piece split off and the atmospheric resistance changed its course a little. There are no means of calculating its height. If it was moving with the ordinary velocity of meteors, the duration assigned to it is probably excessive.

The sinuosity of the trails of both the Toronto and the Simcoe meteors was probably caused by air waves. But it was calm below, and the aero-barometer at the observatory was particularly steady. The waves must have been at a height which does not influence the instrument, although the register is sixteen times as sensitive as the mercurial barometers. Observations of the shape and rate of motion of these trails may be useful to students of the upper air ; they appear to give indications of movements which no air barometer or *ballou sonde* can shew.

Double and multiple aerolites are not so rare as might be supposed. The writer's paper on " Meteorites in Space," (Trans. Royal Society of Canada, 1896) mentions several. They are, perhaps, the analogues of double and multiple stars. If these meteorites were swinging round each other in space, then the thirty minutes difference in time, at, say, twenty miles a second, would place them 36,000 miles apart. Their appearing so close together is the unexpected circumstance. Such a pair would usually fall so far apart that the connection could not be traced. Nor is there any connection certainly traceable in this case. The bodies were both on their way to the sun and from their color and the peculiarly long period their trails lasted, seem to have been of the same composition.

Meteors with the features of these three were probably aerolites, but the fragments may not have reached the ground or the water except as iron dust or spicules. They must have been large and have given out an intense light to illuminate a belt of land and lake more than 200 miles in width. The observations are not complete enough to calculate their size. But they were not so large as the aerolite in Victoria College here, or as the great Brazilian mass found in 1784, and only landed in the Rio de Janeiro museum in 1888. That is seven feet long by four broad and two thick, contains 28 cubic feet and weighs seven tons of 2,000 lbs., and is one of the largest in the world. It was not seen to fall. The most recent large one which has been seen to strike the earth fell near Helsinfors, in Finland—broke through the ice in a shallow bay, and was fished up in pieces weighing in all something under a ton.

The paper for the evening was by the Rev. R. Atkinson (read by Mr. W. B. Musson), on " What May be Done with a 3-inch Telescope."

The paper was practical and, therefore, useful to observers. Mr. Atkinson referred to his own experiences with a fine 3-inch, and lantern slides of some of the objects he mentioned were projected on the screen.

TWENTY-FIRST MEETING.

December 10th, 1901. The President in the chair.

Mr. Wilton C. Eddis, 23 Charles Street, Toronto, and

Mr. John D. Farquhar, 12 King Street East, Toronto, were elected Associates.

Mr. R. F. Stupart read a paper on "Electrical Disturbances during Auroral Displays," shewing the close similarity of the declination curves of the magnetic needle with the curves indicating the intensity of auroral displays for the same period. It appeared from the investigations made (and as the Director of the Meteorological and Magnetic Observatory, Mr. Stupart had, of course, the best Canadian data to reason from), that great electrical disturbances do not necessarily produce auroræ everywhere, but that atmospheric conditions must also be favorable. Thus, great magnetic fluctuations at Toronto were not always accompanied by local auroræ, though the skies might be clear; the aurora often appeared in such a case as far away as the North-West Territories, where some different atmospheric conditions prevailed.

TWENTY-SECOND MEETING.

December 23rd, 1901. The President in the chair.

The Librarian's report for the year was handed in, by Mr. Z. M. Collins. Many new books had come into the Society's possession by purchase, donation or exchange—the first by far the most numerous, as the Society, for the first time, had given a large order for standard works, new and old.

Mr. C. P. Sparling, as Treasurer, handed in a report, which shewed that though the Society during the year had incurred some novel expenditures, such as defraying the cost of a telescope and of many books, it had still a satisfactory balance in hand.

The President announced a course of five lectures on Elementary Astronomy, for the benefit of new members and the general public, by Mr. Alfred T. de Lury, B.A., Dean of the University of Toronto, which course would, by the courtesy of Dr. James Loudon, the President of the University, be given in the Physical Lecture-room of that institution.

The Order of the Day for the election of the officers of the Society for 1902 having been called, the President, who had been placed in nomination for a third term, stated he had definitely decided to follow his already announced intention, and would, therefore, not be a candidate. He thanked the members for their unvarying courtesy and considerate kindness, and for having allowed him to carry out several suggestions he had thought to be in the interest of the Society. He had been President two years, the usual term, and while regretting that he had not been as useful as he could have hoped to be, would ever look back with pride and pleasure upon the period during which he had, he believed, enjoyed their confidence and worn the honors they had, perhaps too rashly, conferred upon him. In view of this announcement, he said it was only necessary to ballot for the election of three members of Council, the other officers having been elected by acclamation. The votes having been taken, the President declared the following officers duly elected :

Honorary President, The Hon. Richard Harcourt, M.A., K.C., M.P.P., Minister of Education, Ontario.

President, Mr. R. F. Stupart, F. R. S. C., Director of the Toronto Observatory and Superintendent of the Meteorological Service of Canada.

First Vice-President, Mr. C. A. Chant, M.A. (Tor.), Ph.D. (Har.), Lecturer in Physics, Toronto University.

Second Vice-President, Mr. W. B. Musson, 37 Yonge Street, Toronto.

Treasurer, Mr. J. E. Maybee, M.E., 103 Bay Street, Toronto.

Secretary, Mr. J. R. Collins, 131 Bay Street, Toronto.

Recorder, Mr. J. E. Webber, 6 Sultan Street, Toronto.

Librarian, Rev. R. Atkinson, 498 Ontario Street, Toronto.

Curator, Mr. R. Duncan, 516 Ontario Street, Toronto.

Council—The above officers, with the following members, Mr. A. F. Miller ; The Rev. T. C. Street-Macklem, M.A. (Cantab), LL.D., D.D, (Trin. Coll., Tor.), Provost of Trinity College, and Dr. A. D. Watson, elected by the Society, and the following Past-Presidents : Mr. Andrew Elvins, Mr. Larratt W. Smith, K. C., D. C. L. ; Mr. J. A. Paterson, M. A. (Tor.) ; Mr. A. Harvey, F.R.S.C., Honorary President and Director of La Institute Solar Internacional, Monte Video, Uruguay, and Mr. G. E. Lumsden, F.R.A.S., and Member of La Societe Astronomique de France.

Mr. J. H. Weatherbe had been observing star occultations by the moon, and had seen one—either of a star or a planetoid—at 21^h, 22^m, on the 21st, not mentioned in the *Canadian*, or in the *Washington Almanac*.

Mr. A. F. Miller, who at many meetings during the session of 1901 had given the Society his notes on the Nova in Perseus, of which he has been a constant observer, had been requested to bring all these notes together into one statement. He kindly consented, and this paper was now read as follows :

OBSERVATIONS OF NOVA PERSEI.

It is my intention to give in this paper an account only of such studies of this very remarkable object as I have myself been able to make. At the time when I began my observations, and indeed till a good while after I had concluded the most elaborate of them, the highly important results attained by professional astronomers everywhere had not been made public. Whatever I noted, therefore, was independently found out. I am fully aware that little or no value attaches to such observations as mine ; but at the oft-repeated request of the Society I have now put into a connected whole the scattered communications which from time to time during the past ten months, I brought forward at our meetings under the head of "observations." For the sake of conciseness I shall arrange my work under the following heads :

1. First view of the star :
2. Variations of color and brightness :
3. Telescopic appearance :
4. Proper motion ; distance :
5. Spectroscopic observations :
6. Conclusions :

1. First view of the star.

On February 22, 1901, at 23^h, 15^m, I perceived in the north-western sky a first-magnitude star which I at once remarked as an unfamiliar object.. In color and brightness it greatly resembled Capella, but it was too near the horizon to be mistaken for that star, which at the time had a considerably greater altitude. The yellow color and the brightness of the strange object impressed me with the idea that it must be a nova, but I did not act on the impulse which I confess I experienced, that I should telegraph to Harvard Observatory ; nor did I make any observation that night beyond noting approximately the place of the star in the sky : Indeed telescopic observation would have been impossible, as it went below the range of my equatorial fifteen minutes after I first perceived it. To settle its place I employed a celestial globe, old, faded, and encumbered with the constellation figures; it served, however, to show me that α and β Persei were the nearest lucid stars to the object of my inquiry. Early the following day a careful examination of star-charts perfectly satisfied me that a bright nova had become visible: I therefore fully expected the press-announcement of its discovery which was published in the evening papers of Saturday, February 23 1901. I figured out at the time that my first view of the star occurred about seventeen hours subsequent to its discovery by Dr. Anderson.

It has been conclusively proven that between February 20 and 22 this star rose from total invisibility to rank as one of the brightest objects in the northern heavens. Its sudden and astonishing outburst seemed to me an opportunity for solving many problems of the highest interest and importance. I could only attempt a few of these, and therefore decided on making systematic observations directed to elucidate the following questions: The nature of the Nova, so far as might be learned from its telescopic appearance, spectroscopic peculiarities and light variations; its possible proximity to the solar system; its proper motion. On February 23, at 19^h 45^m, I commenced this series of observations, and have since then prosecuted the work assiduously, except during those months when the star was invisible during the working hours of the night. The following is a résumé of my observations arranged according to the classification already laid down:

2. Variations of color and brightness.

When first seen by me on February 22, the Nova was of a decidedly yellow tinge; in color and lustre it then closely resembled Capella. On February 23 at 20^h, I recorded the star as decidedly yellow, though in the telescope I thought its tint less pronounced than that of Capella. It was then brighter than α Orionis, much brighter than α Tauri, slightly less bright than Capella. Later the same evening I thought the light was of a reddish shade, though decidedly the star was not red. On February 24, dense clouds rendered observation almost impossible; but, as seen towards midnight through occasional rifts, the Nova seemed nearly as bright as Capella. On February 25, clouds and snow-flurries prevented observation till after 23^h, when the Nova was seen to have considerably declined in brightness, being rated as much inferior to Capella, inferior to α Orionis, and not much brighter than α Tauri. On February 26 a further diminution of light was apparent; the Nova was then far less bright than Capella and not greatly brighter than α Persei. The great decline in lustre was accompanied by remarkable changes in the spectrum, which will be described under the head of spectroscopic observations. Interesting color changes were also noted, which for the sake of brevity I will sum up along with the light-fluctuations in a sort of table:

Dates.		Brightness.	Color.
February	21	2.5	
"	22	1	Yellow.
"	23	1	Yellow, reddish tinge in light.
"	24	1	Yellow.
"	25	1.4	Yellow.
"	26	1.8	Yellow.
"	27	2	Yellow.
"	28	2.2	Yellow.
March	2	2.5	Yellowish white with a very pronounced red border when slightly out of focus.
"	6	3.5	Red, inclining to crimson.
"	9	4	Extremely red.
"	15	4	Red, with crimson border when inside of focus.
"	16	4.1	Reddish.
"	17	4	Very red. with crimsom margin as before.
"	22	4.7	Red.
"	28	5.5	Reddish yellow, crimson margin as before.
"	30	5.5	" " " " "
April	1	5.3	Orange yellow.
"	9	5.5	Reddish yellow.

Here I was obliged to discontinue my telescopic observations, the star being below my horizon before the end of evening twilight. I made many subsequent observations by means of a binocular, but my lack of ability to estimate stellar magnitudes in this way has led me to exclude all the figures so arrived at. According to some able observers there were very sensible fluctuations in the star's light-curve during June, July and August, but on this point I have no observations. When, however, I was able to resume telescopic study on and after September 2, I found the star somewhat below mag. 6, and ever since it has seemed to me gradually but surely declining, so that at present I can rate it no higher than 7·2. The most careful watching has failed to reveal to me any fluctuation in the light-curve since the early days of September. During the same period I have noted the color as greenish white, which tint is quite in accordance with the spectroscopic peculiarities simultaneously observed by me.

3. Telescopic appearance.

When these observations were commenced I thought it quite within the bounds of possibility that the Nova might prove to be a body not excessively remote from our system, in which case the stupendous changes which evidently were occurring in and around it might actually become visible in the telescope: The star might, for instance, be seen to expand, divide or become nebulous. Its sudden brightening and quick decline, together with the remarkable changes occurring in the spectrum, led me to the conclusion that very possibly a dark or very faintly luminous body, rushing into a cosmic cloud, had thereby its surface raised to a most exalted temperature, heat being generated sufficient in a short time to vaporize the whole mass. The resulting gases being enormously heated must then expand in every direction, the expansion, however, involving a quick decline of temperature and therefore of brightness. Early in March last I suggested here that if the Nova were situate at an appreciable distance, say, for instance, no further removed than a star having a parallax of ½″, allowing a quite reasonable velocity to the expanding gases, it might be possible after the lapse of some months to detect a small nebulosity around the object. No such appearance has, however, been perceived by me, (nor I believe by any one else). With my highest telescopic powers the Nova has always shown a fine sharp stellar image, excepting of course those optical appearances due to the peculiarity of its light. For instance, during the period which I term the hydrogen maximum, (February 26 to April 1, or thereabout), the star-image often showed a red border; and now, in what we may well regard as the early nebular stage, there is a tendency to a border of very refrangible rays, which, though not easily visible, seem capable to a certain extent of affecting a sensitive retina, but still more easily of producing photographic action. I need hardly say that the nebulous image detected photographically by MM. Flammarion and Antoniadi, Professor Max Wolf, and others, has by these observers themselves been shown to have originated in the very unequal refrangibility of the light emitted at present by the Nova. As for the extensive and remarkable nebula which the photographs made by the aid of large reflecting telescopes reveal as existing around the star, this cannot by any possibility have spread out from the latter within the brief period during which it has been under observation, for to assume otherwise would involve a transfer of matter at velocities so stupendous as to be of sheer necessity disallowed. A rational explanation of the strange phenomena seen on the plates of the Lick and Yerkes observers may shortly be forthcoming, or these appearances may long remain enigmatical; they are, however, none the less interesting because of their present incomprehensibility. My own supposition as to the possibility of a nebulosity becoming visible about the star after a lapse of some months was of course entirely dependent on the existence of a large parallax for the Nova. The very contrary being actually the case the realization of my supposition becomes an impossibility. Nothing has been found, however, to disprove the suggestion, which only becomes impracticable through the non-existence of the necessary conditions.

4. Proper Motion and Distance.

Among other points suggesting themselves to me at the time when the Nova appeared, was the possibility of detecting proper motion for the star. A great light-outburst, such as was then witnessed, could only be explained by a sudden and enormous rise of temperature, and this, according to the law of the conservation of energy, by the conversion of swift motion into heat. There was however nothing to show that the whole of the star's motion had been so used up, and indeed various observed facts, as for instance, displacements of the spectrum lines, seemed to point to the very contrary. Assuming then once more that the star was not excessively remote, its motion across the line of sight might possibly be observed, or, failing that, its change of position as regards other stars in its vicinity being carefully watched during several months might even reveal a parallactic displacement. With the view of testing these hypotheses, from the very outset I most carefully studied the surroundings of the Nova, and endeavored to fix its position relative to the stars in the same telescopic field. On February 23 I noted two of these in particular, one about the 8th magnitude distant from the Nova some 6′, and another of the 9.5 mag. about as far removed. During the first few nights the urgency and the difficulty of my spectroscopic observations forced all other studies into the background: from time to time, however, I carefully watched and noted the relation of the Nova to these stellar objects, securing micrometer measures of distance and position-angle in one case, as soon as I could spare time for such work. Such measures made by an amateur are, under existing circumstances, of no value; I give them however as evincing my determination to do the very utmost with the instruments at my command:

Distance, 372″.5. P.A. 319°.4.

The distance and position-angle of a pair of stars serve, after the lapse of a period, longer or shorter as may be, as a basis for detection of relative movements in the pair. Such measures alone are never depended on for the discovery of annual parallax, although Herschel at one time supposed they might answer such a purpose, but of course we are now aware that he underestimated the difficulty of such a research and the minuteness of the displacement to be detected. Had it so occurred, however, that Nova Persei was actually a very near star, (a condition which its extreme brilliancy rendered at least possible), it might conceivably suffer a considerable displacement relative to the rather distant companion to which my measures refer, which shift would then have been revealed by my observations. I must of course confess that I really had little *expectation* of reaching such a result, but none the less did I regard it as advisable to test the possibility of such conditions actually existing. After the lapse of six months from the appearing of the Nova I found the star's position still unchanged as regards the companion. Being thus satisfied of its great distance, and feeling assured that a careful investigation of its annual parallax had not been neglected by astronomers, I wrote to Dr. Elkin inquiring as to the results obtained with the Yale Heliometer. In replying Dr. Elkin gave me full information as to the published results of the investigation conducted at Yale Observatory by Professor Chase. For reasons which appear obvious on perusal of Professor Chase's paper he has found it possible as yet to publish only a preliminary result, deferring the final one till a year has elapsed from the star's appearance. His preliminary result points to a parallax so small as to be almost insensible. In fact it is not too much to say that the Nova must lie at a distance practically infinite, the immensity of which is but vaguely apprehended when expressed as 100 light-years or more. Thus we are brought face to face with the fact that the outburst of the Nova was a celestial conflagration on the most prodigious scale, its vastness and its importance entirely exceeding our comprehension. The curious circumstance also becomes highly probable that the various phenomena of the star which astronomers are even yet watching with deep interest must have occurred long prior to the birth of any one by whom they are now being observed.

5, Spectroscopic Observations,

My spectroscopic examination of the Nova began on February 22 at 20^h. 15^m. I then noted the spectrum as very clear and bright, end quite continuous except for dark absorption lines, particularly strong in the blue and violet ; a line in the blue-green appeared nearly to coincide with *F*; other lines in the green seemed to occupy the position of the *b* group ; a faint dark line in the red was thought to agree in posltion with *C*. No bright lines could be detected in any part of the spectrum though looked for with the utmost care. Clouds prevented further observation of the spectrum till February 26, 19^h, 45^m, when though the sky was still covered with a sheet of milky cloud, I directed my equatorial upon the Nova and saw at once that a very great change had occurred in its spectrum during the period since my first observation. Using an ocular spectroscope I saw three very distinct and vivid bright bands in the green and blue-green; a fourth, much fainter, in the violet, was seen at intervals: A very faint bright band could just be discerned in the orange: No bright line could be distinguished with certainty in the red, though its presence was suspected. All the bright bands had strong dark counterparts on their more refrangible edges. The brightest band was in the blue-green, and was set down as $H\beta$. The next in order of brightness was the less-refrangible green band, apparently not far from the position of b_4; These two green bands apparently occupied positions very closely identical with the two nebular lines in the spectrum of the nebula of Orion. The bright line in the violet I inferred to be $H\gamma$. All the bright bands and dark counterparts were superposed on a background of continuous spectrum. On February 27 very similar observations were recorded, the same ocular spectroscope being employed. As seen in this way I had the impression that a maximum of brightness existed in the green and blue-green region of the spectrum where the three brightest bands were also situated; beyond $H\beta$ the blue and violet region appeared to grow faint. Recognizing the great desirability of identifying the bands more accurately than by mere estimate, I substituted for the ocular prism a star-spectroscope with slit, prism of comparison and bright pointer. I found it possible, and even advantageous, to employ this instrument without a cylindrical lens before the slit. Thus viewed the star's spectrum appeared as a fine narrow line of brilliant light on which the positions of the bands were indicated by bright knots. I immediately noticed one of these brilliant spots in the red and another in the orange yellow. A cylindrical lens between the prism and the eye was then employed to widen the linear spectrum: This arrangement at once showed $H\alpha$ as a beautiful bright scarlet line; the bright line in the orange was more difficult to see, though its presence was certain. Clouds put an end to the observation before definite positions could be assigned to this latter and the two green bands. On February 28 from $19^h, 45^m$ to $23^h, 30^m$, the work was continued.

A Plücker-tube of hydrogen being used to furnish a comparison spectrum, I satisfied myself as to the identity of these bands in the star's spectrum with the three characteristic lines in the visual spectrum of hydrogen. A tube containing CO_2 was employed as a reference source of light in settling the positions of the two green bands. The brighter of these was more refrangible than the green line of CO_2, the fainter green band did not approximate in position to any of the lines yielded by the tube. The hydrogen lines seemed to have increased in brilliancy; for instance $H\alpha$, which on February 26 was vainly sought for, was now so brilliant as to be clearly seen with the spectrum ocular which previously would not show it: The orange line, previously seen with some difficulty, had also become very bright and distinct. I noted particularly the very dark counterpart bands bordering all the bright bands on their more refrangible edges. Dark lines were recorded between $H\alpha$ and the orange-yellow line, also between this latter and the first "Nova" band.

On March 2, from 21^h to $23^h\ 30^m$, I continued the observations of the bright bands. My notes record that $H\beta$ was wider and brighter than $H\alpha$, the other bright bands remaining practically unchanged. As a means of arriving at the wave-lengths of the remarkable green bands, I compared their positions with those of the nebular lines in the spectrum of the Orion Nebula, which of course have their places accurately determined. To effect this comparison, I set the bright pointer of the spectroscope micrometer on the brighter of the green bands and then turned the telescope on the nebula. Unfortunately the brilliant moonlight which prevailed that night defeated my purpose by rendering the nebular lines quite invisible. Later I employed as a comparison source the spark-spectrum of magnesium, which led to the conclusion that the green bands in the spectrum of the Nova were not quite coincident with the well-known green magnesium lines.

Spectroscopic observations very similar to those I have described were conducted carefully on every clear night. On March 12 I noted that though the Nova had fallen to the fourth magnitude, its spectrum was still extremely vivid, the brightest bands appearing, however, sharper and narrower than when the star was more brilliant; the continuous spectrum also appeared brighter in the violet. The dark counterparts of all the bright bands still showed very distinctly, always on the blue edge: $H\gamma$ was brighter than usual. Several hours were spent in efforts to compare the green bands of the Nova with those in the spectrum of the Orion Nebula: The inadequacy of my appliances for a study of this character at last compelled me to abandon the work, which to my regret I found impossible to carry to a definite conclusion. The results so far as they extended led me to conclude that the two conspicuous green bands of the Nova-spectrum agreed in position very approximately with the bright lines of unknown origin in the spectra of the gaseous nebulæ, and therefore when speaking and writing on thesubject of the spectrum of Nova Persei, I have often referred to these bands as the 'nebular lines.' The exact determinations of position made with the great instruments of the Lick and Yerkes Observatories have demonstrated that what appeared in my small spectroscope as two bands was in reality a very complex system of widened bright lines due to other substances besides the nebula-material. It seems quite certainly proven however, that the nebular lines were unquestionably present in the Nova spectrum from its earliest bright-line stage, and that they gradually increased in relative brightness as the hydrogen series and other bright lines declined, thus marking the transition from the stellar to the nebular condition. The fading of the hydrogen lines was very evident to me. On April 11 I was no longer able to see $H\alpha$, and the chief "Nova line" was then nearly as bright as $H\beta$; new lines not previously observed appeared in the blue region; they were, however, excessively faint.

Space forbids further details of my spectroscopic studies, which were continued till, by the sun's northward progress, I lost sight of the Nova: They were resumed as soon as it again became visible to me in the beginning of September. It now shows, as you are aware, a system of bright bands, much narrower and fainter than those characteristic of its early stage, yet still perfectly visible to the trained eye even in an instrument so small as mine. The characteristic nebular lines are now much brighter than the remnants of the hydrogen series. The extinction of some of the hydrogen lines and the persistence of others is one of the phenomena dependent on decreasing intensity, very familiar to all spectroscopists and variously explained.

6. Conclusions.

Under this head I will briefly present what I regard as the most probable explanation of the phenomena I have recorded since the apparition of the Nova. Without desiring to insist on a theory I think we are justified in assuming that the outburst of this remarkable object was most probably due to the encounter of a swift-moving dense body with a cosmic cloud or nebula. It cannot be doubted that in such a case retardation of its motion would raise the temperature of the dense mass enormously in a very short time, augmentation of temperature continuing till either the mass had its motion entirely arrested, or until it emerged from the cloud. That the diminution of its motion would be extremely rapid, even in a very rare gas, is unquestioned; its temperature would therefore receive the greatest augmentation during the early period of the encounter. Unless the cloud were dense enough to sweep away the glowing surface as fast as it became molten, the heat would be propagated inward chiefly by processes of conduction and convection and the mass would vaporize in a manner comparatively gradual. Expansion would accompany this process and a decline in temperature would be the direct consequence, made evident, of course, by such changes in the emission of light as correspond to the effects we have supposed. According to this theory, then, spectroscopic study should first reveal a continuous spectrum with absorption lines due to the relatively cool constituents of the cloud, or to the first vaporized material of the mass. Afterwards the formation of an enormous volume of incandescent gas, rapidly expanding, would cause a complete change in the spectrum type, bright bands and lines with intermediate darker spaces being its chief characteristics, though a more or less continuous spectrum would persist as well, for some time, owing to the density of the gaseous products around the central nucleus and the incandescent matter undergoing volatilization more and more slowly as the temperature declined. Rapid diminution in radiation would be an immediate consequence of the temperature-fall due to expansion, and, while all parts of the continuous spectrum would suffer, the effect would be most strongly accentuated in the more refrangible region, the extent and intensity of which are always an index of temperature. While all bright lines and bands would appear relatively more distinct and clear as the continuous spectrum grew fainter, those in the violet would have the greatest advantage in this respect, since there the effect of declining temperature would make itself most perceptible. Nor would even the appearance of new bright lines and bands in the region of short wave-lengths in any way disprove the general conclusion at which we have arrived, since it may be proven in many ways that strong selective radiation in this part of the spectrum may occur when the light-source has but a very moderate temperature.

But while expansion was occurring as an effect of heat in the dense mass, gravity would simultaneously be acting, gathering towards it and condensing round it the nebulous material of the cloud ; and this substance, whatever be its nature, would have its initial temperature augmented as well by condensation as by the intense radiation of the glowing mass round which it was gathering. It would therefore itself become luminous, its light in all probability being of special and characteristic wave-lengths. These radiations would augment those emanating from the main light-source, and thus may have originated, at least in part, the "Nova lines" to which it has been necessary so frequently to refer. Lastly, a decline of heat-intensity, which in the continuous spectrum first reduces the most refrangible rays, in the case of the hydrogen spectrum first affects its red light. Thus falling temperature was evidenced by the disappearance of $H\alpha$, the rest of the hydrogen series still persisting, and, so to speak, dying hard.

I need scarcely point out how closely the observed phenomena are in agreement with the appearances which this theory would lead us to expect.

It may be of interest to consider for a moment another effect of an expansion such as we have been assuming. Allowing to the outrushing gases an average velocity of fifty miles per second, which cannot be regarded as an unreasonable rate of motion during the early stages of the Nova's career, they would in twenty days have expanded sufficiently to occupy a sphere with radius equal to the terrestrial orbit. It is of course improbable that so high a velocity as this would long persist, yet doubtless they would continue to rush outward at great speed for a considerable time. In the 300 days, then, which have elapsed since the Nova appeared, the resulting nebula would certainly have a very perceptible diameter, even in a small telescope, were it no further removed from our system than is, say, β Cygni. That no such enlargement has become visible even in great telescopes is a further proof of the vastness of the distance at which Nova Persei lies.

So wonderful a phenomenon as the appearance of a new star may well rivet the attention of even the most thoughtless. Yet marvelous as is such an event, it cannot be regarded exactly as rare. I, myself, during the past sixteen years, have observed no less than three such objects, and had I begun earlier to devote time and thought to astronomy, I might have seen at least as many during the preceding fourteen years, though indeed none approaching in grandeur the wonderful object regarding which I have had the honor of addressing you to-night. But since there have been so many Novæ we may confidently expect the appearance of more. Let us then set a watch upon the skies, that the next celestial stranger may not rise to the first rank before it is discovered by a Toronto observer. To be successful our vigil must be a labor of love, instigated by no vain and ostentatious desire of ranking as original discoverers, but undertaken as a pleasure and as a duty too, because each hour in the career of an object such as Nova Persei is rich in those lessons which we as men of science desire to learn, pregnant with wonders, full to overflowing with those deep things of Nature which are mysterious to us only because we are lacking in patience to study them and ability to decipher the messages which amid the darkness and stillness of the night she telegraphs to the star-watcher on flying ether waves from the shores of the infinite, or writes in 'patines of bright gold' within the vaulted dome of her vast temple.

PROF. FESSENDEN'S EXPLANATION OF INERTIA AND GRAVITATION.

As a result of a suggestion from the President, the Secretary of the Society wrote to Prof. R. A. Fessenden, late of the Western University of Pennsylvania, and now of the U. S. Weather Bureau, in connection with a subject on which one of the members desired information, and also sent a copy of the *Transactions*, containing his paper on "Theories of Universal Gravitation," Mr. Collins requested an epitome of Prof. Fessenden's recent work pointing toward a possible explanation of the nature of gravitation and received the following courteous and valued reply :

U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU :

J. R. COLLINS,

Secretary, Toronto Astronomical Society, Toronto, Canada.

DEAR SIR,—Your letter is received. I am sending you by this mail copies of two papers which I have at hand.

As the work on which these papers are based extended over about twelve years, they are naturally somewhat involved, as is almost always the case with theories and ideas which have not had time to crystallize, I therefore give below a short summary, which will possibly be of use, as follows :

In 1889 I found* that many physical phenomena could be explained by supposing that *all* atoms had electric charges, instead of only having charges when in chemical combination. It was there shewn that such charges would give effects of the same nature as those of cohesion, and formulæ for the tensile strength, rigidity and Young's modulus were derived which gave results agreeing with observation as closely as the different observations themselves. The mechanical properties of a number of metals, such as cadmium, magnesium, and beryllium, were

* In "Electrical World" and "Science," 1890–1–2.

predicted (and some years later these predictions were verified by Thurston and other experimenters). Also a formula for the electrical conductivity of metals was derived, which has later been found to be very exact, and a number of other metals, not then in accordance with it, as magnesium and aluminium, have been found, on more accurate tests, to follow the law then given, which connects the conductivity of metals with the velocity of sound through them.

It was also pointed out that these charges gave an indication of a way in which gravity and inertia could be explained, though at that time, for lack of data, the subject was not further investigated.

Later it was shewn* that ions, placed in a magnetic field, must rotate and influence light passing through the medium. Some years later this was confirmed by Zeeman and Lorentz.

It was also shewn † that light, especially ultra-violet light, incident on bodies in vacuo, must drive off atoms, these atoms being negatively charged, and that the various cometary phenomena, such as the curve of the tail, the separation of the comet into parts, its apparent retardation, the bridge of Biela's comet, etc., could all be explained by this, thus substituting for the various qualitative hypotheses of Bredechin and others a definite theory worked out quantitatively.

In 1897 and 1898 it was shewn that all electrical phenomena could be comprised in three equations, and that four were needed. It was demonstrated that of the infinite number of theories thus rendered possible, only two could be interpreted so as to be in accordance with dynamical phenomena as we know them. Also, that one of these necessitates a first power relation between magnetic intensity and permeability, and a second power relation between electric intensity and specific inductive capacity.

It was also proved that the only alternative theory necessitated reciprocal relations, i.e. a second power relation between

* "Electrical World," 1894.

† "Astrophysical Review," 1897.

magnetic intensity and permeability and a first power relation between electric intensity and specific inductive capacity.

Experiments were then made to determine which of these two relations actually existed. It was found that a first power relation existed between magnetic intensity and permeability. Six other corroborative relations were discovered and verified. It was predicted that a second power relation between electric intensity and specific inductive capacity and elasticity (of volume) would also be found.

Later experiments were made and this latter phenomena was discovered to actually exist and to be the cause of Kerr's optical phenomenon. Other experiments were made to check this result in other ways, but before the latter (the former results were published in *Science*) results were ready for publication (these being the experiments referred to in the paper in *Science*), the effect was also discovered by Sacerdote, by direct measurements, though his work does not prove this directly, but indirectly, as what he was concerned with and measured was the elongation of dielectrics in an electrostatic field. His formula gives a change of length (which my experiments show is a change of volume), proportional to the square of the electric intensity and to the elasticity.

The electrostatic theory of matter, commonly known as the electron theory, but really originated and worked by me, and known at first as mine, as for example to Ostwald, who writes in 1890 of it as "your theory, according to which all atoms have electric charges," was next extended by me in the following way. From the tests on the first power relation between magnetic intensity and permeability, it was shewn that the volume of the atomic structure must be very much smaller than that of the space occupied by the atoms to the exclusion of other atoms. The volume of the atom was determined with a considerable degree of accuracy, and from this the size of the electrons, which Prof. Thomson's great discovery had shewn to be separable from the atom, and whose approximate mass he had determined. From this, a calculation of the amount of inertia due to the electro-magnetic effect of the electron charge was calculated, and found to be approximately equal to the amount of inertia which the electron is known to possess. Hence inertia, i.e. mass, was shewn to be an electro-magnetic effect.

From the size of the electron, and its charge, it was then further calculated what the effect of the second power relation between electric intensity and specific inductive capacity should be. It was found that it should result in an expansion of the ether in the neighborhood of the electrons, which would give gravitational effects of the same nature and obeying the same laws as those determined by Newton, and that gravitation should travel with a velocity of ten to the thirtieth power, whilst light only travels with a velocity of ten to the tenth power, i.e. the propagation of gravity should be so fast that if light takes one hundred years to come to us from a star, its gravitational effect will reach us in less than the trillionth of a second.

The subject has not attracted much attention, in spite of the very considerable amount of experimental evidence which I have produced, which renders the existence of the phenomenon beyond doubt, but just as it took over ten years for my electrical theory of matter to obtain a foothold, (but it was fianally accepted), so I suppose that in time my explanations of the nature of inertia, gravity, electricity and magnetism will finally be received. Graetz (in the *Phys. Ann.*) has lately shewn that the existing theories of the ether can be modified so as to include this phenomenon, but I had previously shewn this myself, so that he has not added anything.

Trusting that this information will cover the points mentioned in your letter, I remain,

Very truly,

REGINALD A. FESSENDEN.

P.S.—You will see in a number of *Science*, about to be published, another advance in the subject. I have discovered that the difference between positive and negative electrons is entirely one of circulation, i.e. positive electrons being merely negative electrons grouped so as to have a more closed circulation.

Prof. G. F. Hull, of Dartmouth College, Hanover, N. H., also forwarded a paper bearing on a closely connected subject, which was read by Vice-President C. A. Chant, M. A., Ph. D.

Prof. Crookes, as is now well known, was trying to demonstrate, experimentally, the pressure of light, when, in 1873–6, he produced and improved his radiometer, and thought he had succeeded. It was, however, found that the heat of the surface, exposed to the rays of light, produced a lively molecular motion which caused the revolution of the vanes.

In 1901 Prof. Lebedew, of Moscow, and Profs. Nichols and Hull, of Dartmouth, achieved the object, independently. Prof. Hull's paper is an admirably lucid description of the methods employed by Prof. Nichols and himself, and a rapid review of the astronomical effects he attributes to the pressure in question.

THE PRESSURE OF LIGHT AND ITS APPLICATION IN ASTRONOMICAL PROBLEMS.

For three centuries it has been known that the tails of comets, in their motion about the sun, are apparently repelled by that body. Kepler tried to explain this phenomenon by the assumption that light is due to corpuscles of matter, and that these corpuscles, coming from the sun and striking upon the small masses of which comets' tails are formed, produce the observed repulsion. But the champions of the corpuscular theory of light had enough to do in upholding that theory in opposition to the wave theory of light which was strenuously moving to the fore. Moreover, the laws of Kepler and Newton, especially the law of universal gravitation, in which there was nothing concerning repulsion, provided the astronomical world with problems of absorbing interest. When finally the wave theory of light was established the explanation of the movement of comets' tails, as given by Kepler, was abandoned. For it was not evident that a transverse wave motion in an exceedingly attenuated medium could produce, at a surface upon which it fell, any appreciable pressure.

It remained for the genius of Clerk Maxwell to construct a new form of the wave theory, one making light an electrical phenomenon. One of the conclusions of this theory was that light, heat or electrical radiation, falling normally upon a surface, produced a pressure upon the surface equal to the energy of the radiation in one cubic centimeter of the medium. This is equivalent to saying that if the amount of energy falling upon one square centimeter of a perfectly reflecting surface is E, the pressure is $\frac{2E}{V}$ where V equals the velocity of light.

Maxwell worked out the case for sun-light. The resulting pressure was so small that he held out little hope of its experimental discovery. Bartoli, and after him Boltzmann, reasoning from very different grounds, arrived at the same theoretical conclusion.

Though this conclusion of Maxwell had been known for over thirty years, and though his theory had been verified in almost all other particulars, the astronomers did not place sufficient reliance in his conclusion to reconstruct Kepler's explanation of the motion of the comets' tails. Even in the most recent and most comprehensive works on astronomy we find statements like the following: "Since the abandonment of this (corpuscular) theory, others have sought to find in this apparent repulsion of comets' tails, the impulse of the light and heat waves of the ether, without, however, explaining how such waves could produce any such repulsive action. No experiments show any such carrying power of light or any pressure produced by its impact; although when Crookes first invented his radiometer he seems to have thought he had found it." Young, p. 416.

"Light now is conceived to consist of vibrations in the etherial medium, and there is no known way in which they can exert any propelling force upon matter." Newcomb—*Popular Astronomy*.

It is clear, therefore, that astronomers did not care to base their explanation of phenomena in the heavens upon a property of light which remained experimentally unproved.

During the last year, however, the desired experiment* has been performed. It may be interesting here to give a brief description of it :

The light from an arc lamp was passed through condensing lenses and various apertures, to make it both intense and uniform, and an image of an aperture so illuminated was cast by a lens upon either one of two well silvered vanes of glass. These vanes of very thin glass, about 1 cm. in diameter, were suspended from the ends of a slender horizontal glass rod about 1.5 cm. long. This was attached at its mid point to a vertical glass rod, and this was suspended by a delicate quartz fibre. The whole was placed under a bell jar which had glass windows and which could be exhausted by an air pump. The suspended system may be called a torsion radiometer.

The torsion of the fibre, if all outside forces were eliminated, would bring the system to a definite position. As the vertical rod carried a small mirror this position could be read by a telescope and scale. It is a fairly easy matter to determine the force applied to the center of one of the vanes, which is necessary to turn the system through a certain angle. It was found that the force required for $\frac{1}{300}$ of a revolution was equal to 0.000,000,000,1 of a pound. But one hundredth of even this rotation could be observed, so that the one million millionth of a pound weight acting on one of the vanes could be detected. However, the difficult problem was not to measure small forces (very much smaller forces could be observed), but to eliminate forces very much larger than light pressure, which, from the experiment of Crookes, were known to exist.

When light is thrown upon blackened vanes the energy is absorbed, the vanes become heated, the air in contact with them also becomes heated and the molecules are set in livelier motion. The vanes are thereby moved either by repulsion or suction, depending upon the pressure of the air and the distance

* E. F. Nichols and G. F. Hull, Proc. A.A.A.S., August, 1901, ("Physical Review," November, 1901). A similar experiment was also performed by Lebedew, of the University of Moscow, Wied. Ann., November, 1901.

of the vanes from the opposite wall. But by silvering the vanes only five or six per cent. of the radiation is absorbed. Consequently this air effect is cut down twenty times while the light pressure is doubled on account of the energy being thrown back on itself. Again, it requires time for this air effect to come into existence, while the light pressure acts as soon as the light strikes the vanes; consequently, the time for which the radiation was allowed to fall upon the vanes was short—usually six seconds.

Other devices were also used to cut down the air effect. It was finally found that at various air pressures, forces produced by the radiation were always repulsive and approximately the same. The following table illustrates this point:

Gas pressure in mm. of mercury.	Radiation pressure in 10^{-4} dynes.
96.3	0.9
67.7	1.0
37.9	1.0
36.5	1.0
33.4	1.0
1.2	1.0
.13	1.3
.06	1.1
Mean - - -	1.04×10^{-4} dynes.

Thus, though the amount of air present in the jar varied from 1 to 1600, the radiation pressure varied only ten or twenty per cent.

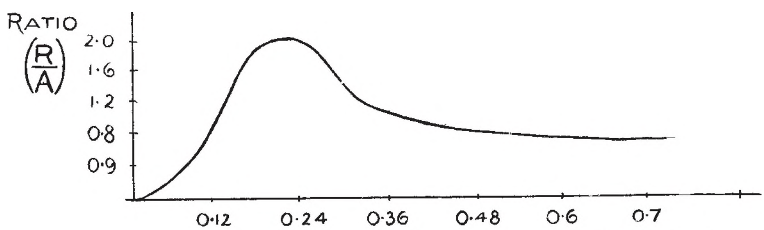
In order to compare this experimental value of the radiation pressure with Maxwell's theoretical value it was necessary to measure the energy of the radiation. The experiments performed during the past few months give an agreement between these values to about 5 per cent.

It is thus seen that what was a theoretical conclusion has become an experimental fact. Ether radiation falling on a surface produces a pressure on that surface, the amount being equal to $\frac{E}{V}$ if the surface totally absorbs, and equal to $\frac{2E}{V}$ if it reflects all the radiation. Astronomers can no longer leave this fact out of consideration in dealing with the forces between two bodies, one of which is luminous. Newton's law for universal gravitation is, for this case, not complete.

Let us see how Newton's law is modified when the large attracting body is our sun. The Newtonian attraction on a spherical body is proportional to its mass, and therefore to ρr^3 where $\rho =$ the density and $r =$ the radius of the sphere. The repulsive force due to light is proportional to the area of a section normal to the direction of the light and therefore to r^2. The ratio of this attraction (A) to the repulsion (R) is thus proportional to ρr. As the mass becomes smaller the attractive force decreases faster than the repulsive force; for a certain value of r (ρ being constant), they become equal, and for smaller sizes the repulsion becomes greater than the attraction. The critical diameter at which the two forces become equal depends only on the density of the body and not at all upon the distance of the body from the sun. Knowing that the mass of the sun is 330,000 times that of the earth, and that the distance from the earth is 2,300 times the earth's diameter, the attraction which the sun exerts upon a sphere of water 2 cm. in diameter is 2.5 dynes. Knowing the amount of energy received from the sun and the velocity of light, we calculate the repulsion of the light on such a sphere to lie between 1.2×10^{-4} dynes for total absorption and 2.4×10^{-4} dynes for total reflection of the light. The average is 1.8×10^{-4} dynes. Hence the attractive force is roughly $\frac{2.5}{1.8} \times 10^4$ or 1.4×10^4 (i.e., 14,000) times the repulsive force on this particular sphere. If we decreased the diameter 14,000 times or to $\frac{2}{1.4} \times 10^{-4}$ cm., or to 0.0014 mm., or to 1.4μ, the two forces would be equal. For particles smaller or less dense than this the repulsion would be greater than the attraction. Such small particles would be *blown away* from the sun. To account for the repulsion of comets' tails, therefore, it is only necessary to assume that they consist of particles, the product of whose diameter, measured in millimeters, into the density, referred to water, should be less than 0.0014. But if we attempt to follow up the

NOTE.—17th line from bottom should read, 23,000 times the earth's radius.

method of reasoning just indicated, to the conclusion that, as the particles grow smaller and smaller, the repulsion (relative to the attraction) becomes larger and larger we would be led into error. For the whole existence of repulsion depends either on the absorption or reflection by the particle of the radiant energy falling on it. It is known, however, that as the diameter of the particles becomes small as compared with the wave length of the radiation, they neither reflect or absorb to any great extent. Indeed we are led upon theoretical grounds to the conclusion that there is a value of the diameter of the particle for which the ratio of the repulsion to the attraction is a maximum; for diameters greater or less than this the ratio decreases. This value * for water particles is about 2/5 of a wave length of light or about 0.00024 mm. The curve shewing how the ratio changes with the diameter is as below:



From the motion and curvature of comets' tails Bredichin calculated the repulsions of various cases to have been 18.5, 3.2, 2.0, 1.5 times the attractions. If $\rho = 1$ and, if the law $\frac{A}{R}$ varies as $\frac{1}{\rho r}$ rigidly holds, the sizes of the drops would be nearly 0.08μ, 0.5μ, 0.7μ, and μ respectively. But if the above curve is correct we cannot have such variations in the ratio of repulsion to attraction on account of the variations of the diameter alone. The only way in which these ratios can occur is to allow ρ, the density, to decrease. Then the result is possible.

To sum up, in regard to comets' tails, we have shewn that

* Schwarzschild, Akad. der Wissenschaften, München, 1901.

their repulsion by the sun may be accounted for on the principle of light pressure ; that greater repulsions, therefore greater velocities and therefore straighter tails may be obtained by assuming the sizes and density of the particles comprising the tail to vary. But what causes the initial projection, from the nucleus, towards the sun, of the material forming the head of the comet, is still a problem.

Other phenomena may be accounted for by the action of light pressure. We know, for example, that the corona consists of detached particles partially or wholly vaporized by the intense heat to which they are exposed. The difficult question is : "How are these particles held up ?" To this question only conjectural replies have heretofore been given. But we know that great disturbances take place on the sun's surface, in which masses of flame are projected thousands of miles outward. There seems to be no reason why the smaller masses, in place of falling back into the sun, should not be blown outwards by light pressure to the great distance to which the corona extends. This will account for the radial, streaky appearance of the corona.

Indeed these small particles would, in some cases, reach the earth. Thus we might occount for the zodiacal light and the gegenschein. Further, it is only necessary to assume these particles to be electrically charged to account, in large measure, for the aurora borealis. But to hold that such particles are the ions which play so large a part in the phenomena of the cathode rays is, in the opinion of the writer, erroneous, since, upon such minute particles, light exerts no pressure.

If a particle is of such a size and density that the repulsion from is greater than the attraction toward the sun, it will be repelled from the sun with greater and greater velocity. It might appear at first sight that there is no limit to this velocity ; that it tends to become infinite. But a little consideration will show that, if the particle is moving away from the sun with the velocity of light, there is no energy falling on it, and therefore the pressure is equal to zero. Consequently the attractive force would cause the velocity to decrease. It is evident, therefore, that there is a limiting velocity, always less than the velocity of light, and depending on the size and density of the particle. From recent observatories made at the Yerkes and Lick observatories on the positions of the patches of nebula around Nova Persei, it was concluded that the nebula was moving with a velocity approximately that of light. No such motion of material masses has been known. It is seen that light pressure will not give rise to such a velocity. How to account for this enormous velocity is, therefore, a problem.

Finally, there is the interesting reflection that if small particles, repelled by light pressure from the sun, should become shadowed by bodies moving between them and the sun, the light pressure at once would cease to act, and gravitation would check the particles in their flight and possibly cause them to return upon their path. We could then have the curious spectacle of floating masses shifting about in space, according to the conditions of light and shadow.

THE PRESIDENT'S CLOSING ADDRESS.

In bringing the work of the year 1901 to a close, the retiring President spoke briefly upon the events, astronomical and otherwise, of the year, and referred to the memorable apparition of Nova Persei, and the observations made by himself and several members of the Society, and particularly by Mr. A. F. Miller, who saw the star early on the evening of the 23rd of February, the night it was discovered by Dr. Anderson. Mr. Lumsden said that on the night of the 24th he had the pleasure, with the Rev. Mr. Atkinson, of spending an hour with Mr. Miller, who was kind enough to let them see the spectrum of the Nova as it was shown in the spectroscope attached to his four-inch refractor. Allusion was also made to the sun, including the results of the observations of the total eclipse on the 18th of May ; to the continued discovery of asteroids, and to the work which had been done upon Eros ; to the Leonid showers of meteors, which, though not seen to advantage in Toronto, had evidently been well observed at Winnipeg and at Echo Mountain, California ; to the Cape Comet, the brightest which had appeared since 1882 ;

to Encke's Comet; to the success achieved at Flagstaff Observatory in photographing the Zodiacal Light; to the synchronism of auroral displays at the north and south poles, and to the investigations of Prof. R. A. Fessenden, in regard to Gravitation.

Referring to this, Mr. Lumsden said Prof. J. J. Thomson was able to show, *Philosophical Magazine*, April, 1881, that electrical charges increased the *inertia* of bodies. And, in *Phil. Mag.*, Dec., 1899, that, under special conditions the atom could, apparently, be split up into numerous parts called "corpuscles," the number in the hydrogen atom being of the order of at least 1000, and the corpuscles were electrically charged. With these two experimental results before him, Thomson then undertook a mathematical investigation to determine whether the "corpuscular" charges would be sufficient to account for the entire inertia of bodies, but was unable to make out corpuscular spaces and surfaces enough to accommodate more than a portion of the requisite charges. Here, Prof. Fessenden took up the work, and assuming the corpuscles to be vortices of a special form and orientated in a special way, appears to have found surfaces and spaces enough for electric charges sufficient to account entirely for the property known as "inertia" of bodies;* at the same time, he undertook to show that these minute corpuscular charges would produce a change of density of the ether surrounding each particle, an effect akin to, though differing from, a magnetic "field" extending outward indefinitely in all directions and decreasing inversely as the square of the distance—producing, in a word, the effect known as gravitation, the velocity of which would be many times greater than that of light, viz., 10^{30}, but it may be asked, Does not an electric charge need to be explained itself? Recent investigations along these lines seem to point towards the conclusion that an electric charge, apparently, consists of a specialized strain, tension or pressure of the ether that may be isolated or stored on the surface of bodies or the particles of which bodies consist, the energy of which strain cannot be communicated to the normal ether except it be in a special condition.

Mr. Lumsden then referred to the loss sustained by the

* See references on page 120.

death of Mrs. A. G. Savigny and Mr. Thomas Lindsay, the latter for many years a member, and for some years a valued officer of the Society, whose kindly disposition, literary abilities and qualifications, especially as a mathematician, had constituted him a most useful member. The President also read a letter from Mr. G. W. Ritchey, of the Yerkes Observatory, on the subject of the construction of large reflecting telescopes, chiefly for photographic purposes, after the manner mentioned in that gentleman's article in a recent number of the *Astrophysical Journal.* In his letter, Mr. Ritchey stated that he looked forward to the construction in the near future of a large reflecting telescope ten or twelve feet in aperture, similar to the five-foot shown in Plate IX. of his article. Such an instrument, of fifty or sixty feet focal length, could, he contended, now be successfully made, "without the slightest danger of failure," which, in a fine climate, would give results immeasurably beyond any attainable at present, adding that "in many kinds of work the two-foot reflector (of the Yerkes Observatory) usually surpasses the forty-inch refractor." This being so, he asked, "What would a ten or twelve foot do?" Mr. Lumsden closed his address by a reference to the more important astronomical predictions for the year 1902, and by thanking the members who, on a dozen occasions, had carried telescopes to various public school grounds in the city, and had assisted in shewing to hundreds of deeply interested men, women and children the wonders of the sky. He also expressed his appreciation of the ready compliance of the Public School Board and Mr. Inspector Hughes in allowing the use of the school grounds and in advancing in every way the convenience of the members who attended the out-of-door meetings. Others might not agree with him, but he regarded this as "good missionary work"—that is, work that benefitted those who gave cheerfully of their time and services with their telescopes as much as it benefitted the public, for it afforded the never-to-be-doubted advantages of practical work and the pleasure of carrying it on, not as individuals but in groups, thus allowing each other an opportunity of comparing notes and entering into a generous rivalry that must be of advantage to the conscientious student of Astronomy.

APPENDIX A.

THE NEBULA SURROUNDING NOVA PERSEI.

THE TORONTO ASTRONOMICAL SOCIETY is fortunate in being enabled to present the latest and most remarkable of the discoveries in the stellar universe in complete and authentic shape. Through the initiative of Mr. W. B. Musson, now a Vice-President of the Society, and the courtesy of Dr. George E. Hale, Director of the Yerkes Observatory, and one of our Honorary Fellows, the original plates from the celebrated photographs of the nebula surrounding Nova Persei have been placed at our disposal.

To grasp the significance of the whole story the reader should refer to three of the papers printed in this volume of *Transactions*. That on The Sun, at page 18, discusses the features of the star which is the centre of our system, and which the myriads of other stars must, in some degree, resemble. It is the only one we can study at short range, if a distance approaching a hundred million of miles can be so referred to.

The paper on Stellar Evolution, at page 87, should be carefully studied, giving, as it does, a summary of the classification of stars, which has been the chief work of Sir William Huggins, and has engaged the attention of astro-physicists all over the world.

That paper, through the exigencies of space in this volume, stops as it approaches the

> "Last stage of all,
> Which ends this strange eventful history."

The end of the once brilliant stars is thought to resemble what Shakespeare speaks of as the end of man, for, having run their course through various conditions, they are believed to continue on as dark masses, dead or sleeping, and awaiting some sort of resurrection.

The rejuvenescence of one such body, under the name of Nova Persei, is the subject of the paper on page 106, and after a consideration of the conclusions arrived at by its author, on page 116, the reader can approach the subject of this Appendix.

We cannot think of the outbreak of a new star as caused otherwise than by—

1. The sudden condensation to the light-emitting degree of a nebula previously invisible—such condensation being brought to pass around a central point.

2. The collision of two dark stars, which, by shattering either or both, would cause a sudden emission of heat and light.

3. The encounter of a dark star with a previously invisible nebula, which is the cause preferred by the author of our paper on the latest Nova.

4. The passage of one stream of nebulosity through another.

Any of these conditions might answer the requirements of the phenomena of the outbreak of a Nova, but in the case of the new star in Perseus we have strange *sequelæ* to consider.

Not long after the short-lived brilliancy of this object had faded, MM. Flammarion and Antoniadi thought they could see on the photographic plate a halo around the new star, but as photographs taken with reflecting telescopes did not show this, it was set down to a defect in the refractor they used. However, it was not long before a real "halo" was noticed, and it was discovered that the Nova was enmeshed in the wisps of nebula; nor did many months elapse before the photographs were seen to exhibit for parts of it an annual proper motion of about 11′ (eleven minutes) of arc! Since that time the patches of light have been noticed to expand in probably all directions.

This expansion, at any of the rates of motion attributed to planets or even stars, must mean that the Nova is exceedingly close to us, and has a very large parallax. But this is not the case, for the parallax cannot exceed a few hundredths of a second. Therefore the star's distance is very great, and the rate of expansion of the nebula is of another order than that of the motion of any form of aggregated matter with which we are acquainted—say a thousand times greater than the mean velocity of the stars, enormous as the spectroscope shews that to be in the line of sight.

The explanation given by Prof. J. C. Kapteyn, in *Astrom. Nachrichten*, 3756, is that the nebula which surrounds the Nova has little, if any, luminosity of its own, but that the light of the first enkindling, travelling from the star outwards, so illuminates it that we now see the effects of the radiations emitted while the Nova was of a high magnitude, spreading, with a velocity due to that light, of 180,000 miles a second. The outer boundary of the visible nebula must therefore increase until the limit of the nebulous masses is reached.

Against this otherwise acceptable hypothesis is the fact that the light from the nebula appears to be not polarised, as it would be were it reflected.

Mr. W. B. Musson has prepared the following notes on the three photographs reprinted, and on some other details connected with this subject :

PHOTOGRAPHS OF THE NEBULA.

The photographs, which first appeared in the March number of the *Astrophysical Journal*, bring the history of this remarkable object, up to 8th February, 1902.

The earliest photographic record of the Nebula is reported from the Lick Observatory, where an examination of the series of negatives, taken with the Crossley Reflector, resulted in the discovery that a plate taken on 29th March, 1901, with an exposure of ten minutes, shewed two faint rings of nebulosity as well as several masses in the vicinity of the star.

Summarizing comparisons of a number of plates taken between 7th November, 1901, and 10th January, 1902, Prof. Perrine reports that "a general expansion of the nebula in all directions" was indicated.*

The second record is from Heidelberg Observatory, Dr.

* Lick Observatory Bulletin, No. 14.

Max Wolf having secured a photograph on the 23rd of August.* On the night of 20th September, 1901, Mr. G. W. Ritchey, of the Yerkes Observatory, photographed the Nova with the two-foot reflector, giving an exposure of 3^h, 50^m, and secured a very good image. † This has been followed by at least a dozen exposures, to date of publication.

It will be seen from a comparison of the plates, Nos. VI., VIII. and X. of the series, that, with the exception of the condensations *a*, *b* and *m*, the principal features of the nebulosity shown in the early photographs have gradually faded away, whilst a new group of "wisps," invisible before January 1st, appears to the north of the central nucleus in the plate of 8th February. The condensation *m* which does not appear to have changed in brightness, is also slowly expanding towards the south, whilst the "wisp *p*" (Plate X.) is rapidly moving outward.

Mr. Ritchey is careful to explain (*Astrophysical Journal*, Vol. xv., p. 131), that in referring to change and motion in the nebula he merely intends to express apparent change, and regards the sudden fading in some parts and brightening in others, as favoring the theory advanced by Kapteyn, that these appearances are due to the illumination of a stationary nebula.

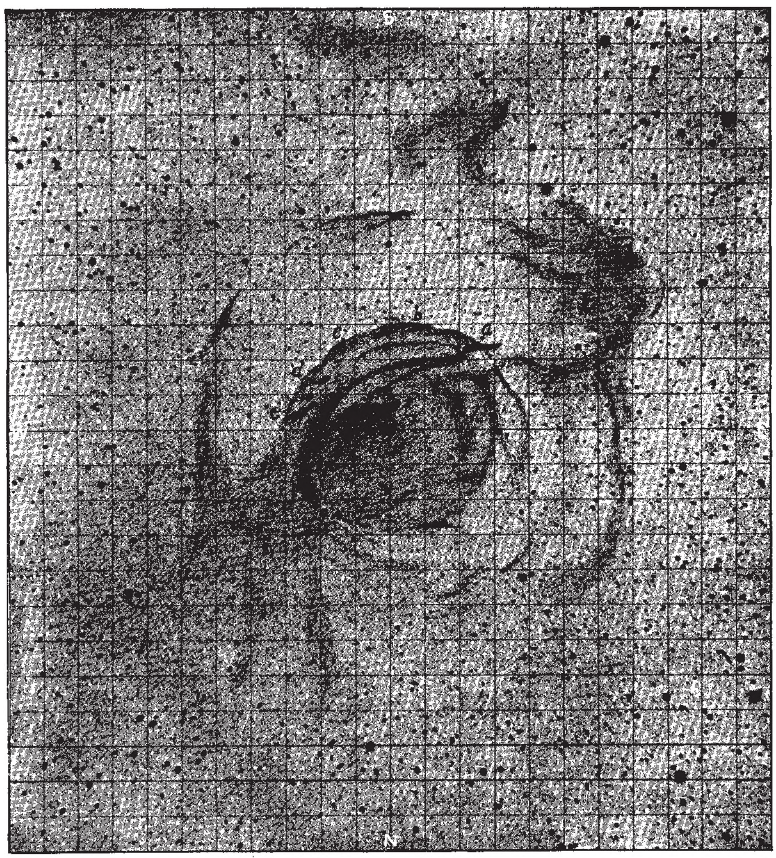
In the *Astronomical Journal*, of 16th April, just received, Prof. F. L. Chase gives the results of his observations for the determination of parallax.

These observations, which were made with the Yale heliometer, cover a period of a year, and indicate the Nova to be not less distant than the comparison (8th mag.) stars employed ; neither was any perceptible proper motion detected. Accepting Kapteyn's estimate of the average parallax of an 8th mag. star, Prof. Chase considers the result "not incompatible with the value deduced by Wolf, on the theory that the apparent displacements of certain condensations of the nebula represent a velocity equal to that of light or electricity."

* Astronomische Nachrichten, No. 3736.

† Astrophysical Journal, Vol. XIV., p. 167.

PLATE VI.



-20′ -16′ -12′ -8′ -4′ 0′ 4′ 8′ 12′ 16′ 20′

NEBULOSITY ABOUT NOVA PERSEI, SEPTEMBER 20, 1901.

Photographed with the Two-Foot Reflector, Yerkes Observatory.

Exposure $3^h\ 50^m$.

PLATE VIII.

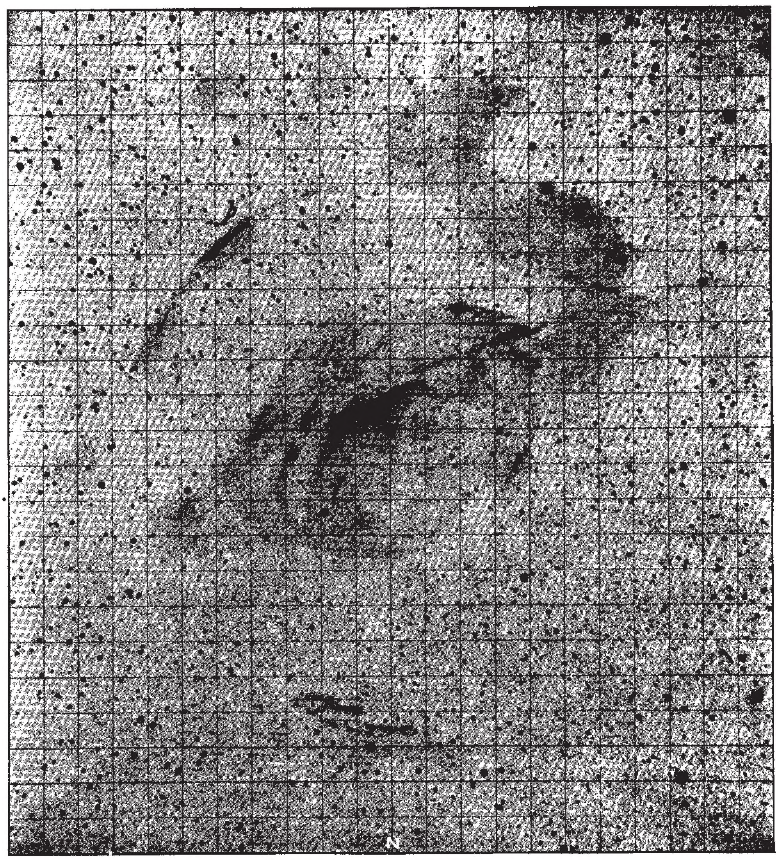
−20′ −16′ −12′ −8′ −4′ 0′ 4′ 8′ 12′ 16′ 20′

NEBULOSITY ABOUT NOVA PERSEI, DECEMBER 14, 1901.

Photographed with the Two-Foot Reflector, Yerkes Observatory.

Exposure $4^h\ 30^m$.

PLATE X.



NEBULOSITY ABOUT NOVA PERSEI, FEBRUARY 8, 1902.
Photographed with Two-Foot Reflector, Yerkes Observatory.
Exposure 2^h 40^m.

It is evident that an examination of the light of the nebula for traces of polarization has an important bearing upon Dr. Kapteyn's theory, since if the light were found to be polarized it would tend to confirm the suggestion that it was due to reflection and not to direct radiation. However, a telegram received at Harvard College Observatory, March 13th, 1902, reads as follows :

" From recent Crossley photograph Perrine finds no evidence of polarization in condensations *a* and *d* of nebula surrounding Nova Persei."

Replying to a letter addressed to him by Mr. Collins, Secretary of the Society, Prof. Campbell explains that the photograph referred to was made through a double-image prism, placed about three inches in front of the photograph plate, in the Crossley Reflector. He further states that photographs of the regions containing Nova Aurigæ, and Nova Cygni, secured by Prof. Perrine during the past winter, fail to disclose the existence of nebulosity about those stars.

APPENDIX B.

THE DOUBLE PULSE OF RAIN-FALL DURING SUN-SPOT CYCLE.

[The authorities quoted in the following were not supplied to the Editor in time for the note to be inserted in its proper place, viz., at page 46.

Mr. W. B. Musson called attention to the fact that in Chambers' *Descriptive Astronomy*, Vol. I., p. 37, credit was given to Mr. A. Elvins for having observed that there were two pulses of rainfall at Toronto during each sun-spot cycle—one at the time of maximum, the other at that of minimum.

Mr. Elvins said that he arrived at this conclusion in 1869. It was published in the Toronto papers, and in the English *Astronomical Register*, in 1870 and 1871. Sir Norman Lockyer and Mr. Meldrum were then investigating the conditions in India, but were looking for an excess in the quantity of rain at maximum only, expecting a gradual and continuous reduction from maximum to minimum. Sir Norman now perceives that "recent work justifies the conclusion that two effects ought to be expected in a sun-spot cycle instead of one." (*Nature*, Nov. 29, 1900).

Mr. Elvins' early observation of the two pulses of rain-fall during a sun-spot cycle is also noted by Mr. Spencer S. Baird, of the Smithsonian Institution, when referring to the work of Lockyer and Meldrum, in 1872. (*Annual Record of Science*, Preface, p. XXIII).

APPENDIX C.

REPORTS OF AFFILIATED SOCIETIES.

Meaford.

The MEAFORD ASTRONOMICAL SOCIETY sent a report, as follows :

In 1900 there were fourteen meetings, held at the houses of the members as well as at the Society's room.

Mrs. Manley having visited Prof. Swift at the Lowe Observatory, in California, gave an interesting account of the telescopic and spectroscopic work done there.

The solar eclipse of May 28th was carefully observed, with telescope, thermometer, barometer and clock.

The temperature curve was sent to Toronto and forwarded to Don Carlos Honoré, of Montevideo, together with the records obtained there.

At each in-door meeting, in default of an original paper, some chapters from standard works were read as the basis for conversation, Rev. Dr. Caswell taking a prominent part in replies to questions.

Solar halos, shafts of light at sunset, also lunar halos and a paraselene were reported upon by various members.* Mrs. Moore and Miss Paul reported peculiar halos around Venus.

In 1901, there were five meetings in the first half of the year, but only two in the last, owing, probably, to the illness of the President, Rev. Dr. Caswell.

Mrs. Manley mentioned the receipt of a letter from Mr. Brown, of Port Elgin, who, though deaf and dumb, is an enthusiastic astronomer.

* As this is the only observing station on the Georgian Bay of Lake Huron, the Society ought to record these atmospheric phenomena, as well as the features of all auroræ, in minute detail.

The last meeting of the year was informal, for the purpose of saying farewell to the Society's esteemed President, Rev. Dr. Caswell and Mrs. Caswell, and of presenting to the former a jewel, in the shape of a golden star, suitably engraved. Mr. J. S. Wilson, M.A., on behalf of the Society, presented the token of affection, and Dr. Caswell, in acknowledging its receipt, urged the members to renew and preserve their interest in astronomy. It will be Mr. Wilson's duty, as the new President, to keep this northern lamp of science alight and well trimmed, in which he will have the aid of Mr. George G. Albery as Corresponding Secretary.

Simcoe.

The Simcoe Astronomical Society sends its reprt, as follows :

In 1901, the number of meetings was twenty ; attendance, from six to eighteen ; number of members, twenty-five.

Work—1. Observation ; 2. Readings ; 3. Original Papers and Addresses ; 4. Discussions.

Personal observations of the heavens and reports thereon, whether by naked eye, opera glass, or telescope have been a prominent feature of the year's work. It may be truly said that every member has been an observer.

Authors read—Todd, Neison, Proctor, Elger, etc.

Journals read—Popular Astronomy, English Mechanic, Scientific American, Knowledge, etc.

Discussions have been numerous, animated and certainly delightful.

The prepared addresses and papers have been accompanied with drawings, diagrams, specimens, and apparatus, for the most part the outcome of the speakers' own labor, and have been very instructive and stimulating.

The summer meetings were generally held at the Observatory of the President, Dr. Wadsworth, whose 12-inch reflector, driven by home-made clock-work, enabled parties of a dozen or more to view the heavens at leisure. Other telescopes and opera glasses were used on the lawn.

Subjects studied and discussed in 1901—Zodiacal light, Gegenschein, Saturn, Jupiter, Mars, Venus, Nova Persei, Sun-spots, Lady Astronomers, The Reported Comet, Meteor of July 9th, Mr. Lumsden's Report of the Total Eclipse of May 28th, etc.

Papers were—How a Telescope is Made, The Globe and the circles of the Sphere, Right Ascension, etc., The Use of a Telescope, and Time, from an Astronomical Standpoint.

Rev. R. Hicks, B.D.—History of Astronomy, The Solar System.

Mr. J. F. Power, M.A.—Parallax, The Precession of the Equinoxes.

Mr. W. L. Innes, C.E.—The Figure of the Earth, The Effect on Sound when the Source is in Motion, Retrograde Movements of the Planets.

Mr. H. F. Cook, B.A.—Meteorites (with specimens found by him in Newfoundland), The Cause of The Moon's showing only one face to us, Dews and Fogs.

Miss Allie Stennett—Report of the Sky as it appeared in Mexico, The Southern Cross, etc.

Mr. R. Galbraith, B.A.—The Attraction of Gravitation, Experiments on Advancing and Receding Sources of Sound, Trigonometry as used to Measure the Distance of Fixed Stars.

Mr. Joseph Brook—How Donati's Comet appeared to me in 1858.

Miss Sarah E. Matthews—The Zodiacal Light as I saw it.

Space will not permit the giving of a list of all the earnest and thoughtful work of the Society. But special mention must be made of the zeal and efficiency of Miss Annie E. Falls, the Secretary, to whose praiseworthy efforts much of the year's success is due.

ASTRONOMICAL SOCIETY OF HAMILTON.

THE TORONTO ASTRONOMICAL SOCIETY is much gratified to know that a strong association, with similar objects, has been formed in Hamilton, Ont. Mr. Adam Brown, whose co-operation in scientific and literary endeavor has ever been ready, is the Honorary President, and Dr. D. B. Marsh, of Herkimer Street, the active presiding officer. It is understood that several of the members possess telescopes. This Society hopes for continuous friendly intercourse, and trusts the Hamilton Society will grow in numbers and attainments.

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