TRANSACTIONS

OF THE

Astronomical and Physical Society of Toronto,

FOR THE YEAR 1891,

INCLUDING SECOND ANNUAL REPORT.

PRICE, FIFTY CENTS.

TORONTO, CANADA:
PRINTED BY BROUGH & CASWELL,
Printers to the Society.

The Astronomical and Physical Society of Toronto.

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Minister of Education of the Province of Ontario.

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Recording Secretary,—THOMAS LINDSAY.

Librarian,—G. G. PURSEY, 189 McCaul Street.

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A. ELVINS, A. F. MILLER, G. B. FOSTER, and J. G. RIDOUT.

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(Limited to Ten).

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Astronomer Royal, Greenwich, England.

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T. S. H. SHEARMEN, Brantford, Ont.

A. F. HUNTER, B.A., Barrie, Ont.

Alexander & Cable Co. Ltd. Toronto.

Jupiter, 1891. September 20. 12·05 E.S.T. = 17·05 G.M.T.

G. E. Lumsden, Del.

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TRANSACTIONS

OF

The Astronomical and Physical Society

OF TORONTO,

During the Year 1891.

FIRST MEETING.

The first meeting of this Society held during the second year of its incorporated existence, took place on March 10th, 1891, Mr. Andrew Elvins, Vice-President, in the chair.

Mr. G. G. Pursey called attention to the fact that at a public entertainment of a literary character, Mr. D. J. Howell, by request, had, with the Society's lantern, exhibited its views. Mr. Pursey added that other applications had been or would be made, indicating, in his opinion, a widening interest in the subject the Society was endeavouring to popularize in Canada.

Mr. A. F. Miller referred to the ingenious method of photographing in natural colours devised by Lippmann, of Paris, which promises to be of great value from a scientific standpoint.

Mr. Miller also read a letter from Mr. John Goldie, of Galt, a Corresponding Member, who authorized the Society to purchase for its library standard astronomical works to the value of $30. On motion of Mr. John Phillips, seconded by Mr. R. Dewar, Mr. Goldie was very heartily thanked for his timely gift. The selection of the books was committed to Mr. Elvins and Mr. Miller. The Librarian reported the receipt of publications from the Astronomical Society of the Pacific and from the Warner Observatory. Messrs. A. Elvins, A. F. Miller, J. A. Paterson, and J. G. Ridout were named a committee to prepare a list of papers to be read from time to time, and to arrange other details of society work.

In the course of a paper on

THE GREAT RED SPOT ON JUPITER,

Mr. Elvins alluded to its appearance as a conspicuous object about ten years ago, and laid on the table drawings made by him at that time. The swift movement of the spot across the disc showed strikingly the rapid rate of the planet's rotation. The dark belt between the spot and the equator seemed to be driven from the spot by some repulsive force. Observation showed that white spots on the belts cross the disc in somewhat less time than the red spot does; the same is true of the belts themselves. Mr. Elvins suspects that the matter composing the red spot is above the atmosphere of Jupiter, and detached from it; if so, it would come under the operation of Kepler's laws, and would revolve slower than the planet rotates. He suggested the possibility of this being the first state of the existence of a satellite as yet but slightly condensed—a new satellite, in fact, in which case it would pass outside of the planet's disc; but evidence of this he had not been able to perceive. The spot ought also to cast a shadow in transit. He thought the spot should be carefully observed for the purpose of ascertaining whether it can be detected beyond the disc, and of catching the shadow, if one exists.

Mr. John Phillips read a supplementary paper on "The Position of the Lunar Orbit."

By projection upon a screen, Mr. Howell exhibited some new and excellent lantern slides, including views of the Saturnian system, sun-spots, and portions of the lunar surface.

SECOND MEETING.

March 24th, the Vice-President in the chair.

Mr. G. B. Abrey, D.L.S., of Toronto, was elected an active member. Dr. J. Morrison, Ph.D., F.R.A.S., of the American Nautical Almanac Office, Washington, an Honorary Member, wrote to say that he was engaged upon a computation of the perturbations of Hyperion by Titan, with a view to preparing tables of the motion of the former for use in computing the ephemeris of Hyperion, as given on page 477 of The Ephemeris, 1891. The paper would be an elaborate one, containing a demonstration of the formulæ, etc. He also intimated that it was his intention to send it to the Society to be read and published by it.

Mr. T. S. H. Shearmen, of Brantford, a Corresponding Member, by letter, stated that his claim to priority in the matter of connecting magnetic disturbances with the appearance of spots on the sun's eastern limb had been admitted by Professor Young, of Princeton, N.J. Mr. Shearmen's letter gave rise to a spirited discussion. The Committee on Routine Matters reported. Among the observations, was one by Mr. T. Lindsay, who had succeeded in taking, with a two-inch non-achromatic telescope, the occultation of 121 Tauri by the moon, then quite seven days old. Mr. Lindsay called attention to the fact that the next new moon, April 8th, completed the one hundred and twenty-second cycle of the Saros, reckoning from the Eclipse of Agathocles, B.C. 380, August 15th.

The following is a summary of a paper read by Mr. Thomas Lindsay on

THE TRANSIT OF MERCURY, MAY 9TH, 1891.

The conditions under which a transit is possible are that the planet shall be in conjunction with the sun, and so near to the node that its latitude is less than the semi-diameter of the solar disc. As Mercury passes the descending node about May 9th, and the ascending node about November 9th, we have at once the seasons at which transits may occur; and reckoning from any one transit, the next at the same season will occur at the end of a period which contains very nearly an integral number of revolutions of the earth and synodic revolutions of the planet. It will be found that 7, 13, and 46 years fill that condition very exactly. As the parallax of Mercury is small, the graphic method of determining the time of contact, as seen from the centre of the earth, involves but a slight error for an observation at the earth's surface. In constructing the figure to illustrate the path of the planet across the disc, it will be found advantageous to take a rather large scale, so that one hour's motion of the planet will be represented by a line easily subdivided into half-minutes, this being about the limit of error by this method. For the transit in question, the hourly motion of Mercury from the sun in declination is 106".3 south, and motion in R.A. 214".9 west, its path being retrograde at inferior conjunction. The resultant 239".8 represents the relative hourly motion across the disc. If we take six inches on the scale to represent this, we shall be able to readily mark upon the figure correspondingly constructed to represent the sun, the position of the planet's centre for every half-minute during the transit by a careful measurement on the hour-line produced. [A diagram constructed as above was here introduced.] To determine accurately the instant of contact, we have the rigorous formula as given in the Greenwich Ephemeris.

First external contact. Greenwich Mean Time:

$$11h\ 53m\ 44s + [1.8579]\ \rho \sin l - [2.2039]\ \rho \cos l \cos (97^\circ\ 31'\ 42'' - \lambda)$$

For Toronto, the radius of the earth, ρ = 9.9993104; and the geocentric latitude, l = 43° 27′ 55″; west longitude, λ = 79° 23′ 30″: thus we have:

		$\cos l$ = . . . 9.8607918
		ρ 9.9993104
constant . . . 1.8579	*and*	cos:
ρ 9.9993104		18° 8′ 12″ = 9.9778683
$\sin l$ 9.8375347		constant 2.2039
1.6947551 = log. 49.5*s*		2.0418705 = log. 110*s*

The correction to the time is therefore − 110 + 49*s* = − 61; and the instant of first external contact will be: Toronto Standard Time, 6*h* 52*m* 43*s*. Similarly, the formula for first internal contact being: Greenwich Mean Time, 11*h* 58*m* 41*s* + [1.8819] $\rho \sin l$ − [22101] ρ

$$\cos l\ (\cos 99^\circ\ 6'\ 42'' - \rho),$$

we obtain the correction of the time − 58*s*, and the contact will occur: Toronto Standard Time, 6*h* 57*m* 43*s*.

THIRD MEETING.

April 7th, the Vice-President in the chair.

Excellent photographs taken by Mr. D. J. Howell, of Mr. John Goldie's private observatory at Galt were shown. Mr. Goldie's equipment includes a very fine 4½-inch equatorial telescope by Cooke, driven by a clock; a transit instrument, a sidereal clock, and other accessories. Mr. A. Elvins and Mr. G. E. Lumsden presented drawings of Saturn made at their telescopes. The latter described a brilliant auroral display, March 30th, which, he thought, might be connected with the appearance, by rotation, of a sun-spot. Mr. A. F. Miller reported having observed faculæ, prior to the appearance of a spot, and referred to the theory that faculæ are directly associated with magnetic disturbances; more so than spots. A member presented, in detail, a relation of certain observations, including the close apparent approach to each other of Jupiter and Venus on April 7th, both planets being visible together in a low power field. The south pole of Venus was of a deep orange color, which shaded off through yellow to intense blue at the north pole—colours only accentuated by eye-pieces of higher power. The disc of Jupiter, which was very pale by contrast, was uniform in tint, indicating, it was thought, that the hues of Venus were not due to the performance of the telescope—a 10¼-inch reflector.

After discussing the subject of university extension in connection with the University of Toronto, it was moved by Mr. J. G. Ridout, seconded by Mr. G. G. Pursey, and "Resolved that, in the opinion of this Society, the subjects of Astronomy and Physics are worthy of more general and systematic attention than they now receive; that regular courses of lectures, delivered under conditions which would enable non-university students to profit by them, and accompanied by class exercises and discussions, would be an effectual means of commending them to the public attention, and that the usefulness of such courses might be greatly increased if recognition by means of certificates for work done were extended to them by the Provincial University." A copy of the resolution was ordered to be sent to the Registrar of the University.

The following is a synopsis of a paper read by Mr. J. G. Ridout on

OCEAN TIDES, CURRENTS, AND WINDS.

TIDES.—It has long been known that the sun and moon are, in some way, instrumental in causing the tides. Pliny refers to the influence of the sun and moon as tide-producing powers; but Newton was the first to demonstrate that the tide-producing power of an attractive mass was directly as the mass, and inversely as the cube of the distance. Now the mass of the sun is to that of the moon as 355,000 to .0125, and the sun's distance from the earth is about 400 times greater than that of the moon. Therefore the relative tide-producing power of the sun as compared with the moon is as

$$\frac{355{,}000}{.0125 \times (400)^3} = \frac{355}{800} \text{ or } \frac{1}{2.25}$$

An imperfect kind of prolate-spheroid travels around the earth in a lunar day, or 24 hours, 54 minutes, its major axis being in the direction of a line from the centre of the earth to the moon. On the side of the earth nearest the moon there is high water, while on the opposite side there is also high water, though not so high as on the side near the moon. The attraction of the moon, on this opposite side, on the water is less per unit of mass than on the solid earth, and the tendency is to pull away the earth. The difference in length of the axes of the wave-spheroid caused by the moon alone is about 58 inches; that due to the sun is 25.7 inches. So that at spring-tide, when the sun and moon are pulling together, we have a tide which is to the lunar tide alone as $\frac{800+355}{800}$, or as $\frac{13}{9}$. During the first and last quarter of the moon, when the sun and moon are antagonistic or pulling against each other, we have a compound tide which is to the lunar tide alone as $\frac{800-355}{800}$, or $\frac{5}{9}$. Thus the height of the spring-tide is to the height of the neap-tide as $\frac{13}{5}$. The question of ocean tides is then a complex one, which does not admit of complete analysis, owing to the facts that the sun exerts a great influence, which is sometimes antagonistic to and sometimes conjoint with that of the moon; that the earth is rotating, and that the water does not cover all and is not of uniform depth; that the shape of the land, estuaries, and gulfs is very diversified; and that there are ocean currents other than tidal ones, and winds of continuance which also keep up the waters. Retardation or acceleration, or "lagging" and "priming," of the tides is caused by the moon passing the meridian before or after the sun; it is also influenced by fluid friction, and the maximum of the observed tide lies somewhere between the consecutive maxima of lunar and solar tides, but nearer the former; owing to these various reasons, the highest or spring-tides come a day or two after the new or full moon. The rise of water in tidal rivers is due to changes of level in the sea, and the water runs up for hours after high water, and down a long time after the period of low water, and is greatly influenced by the width between shores and their shape.

CURRENTS.—The constant currents of the ocean are due mainly to the constant difference produced by temperature and saltness in the specific gravity of the water. The continuous winds, such as the trade winds, help to produce currents, as also rains, and the varying weight of the atmosphere pressing with different forces at different heights. The most remarkable of these currents are the Gulf Stream, which, issuing from the Gulf of Mexico, spreads its warm waters over the Northern Atlantic and tempers the climate of Northern Europe; a similar current in the Northern Pacific, known as the Japan Current, which, as well as the Gulf Stream, runs in the eye of the wind against the trade winds; the Mozambique Current, which runs along the east coast of Africa towards the South Pole; and the great Equatorial Current, which moves from east to west and is affected by the diurnal rotation of the earth. There is also an Arctic current down the coast of America, moving nearest the land in an opposite direction to the Gulf Stream. The waters of the Gulf Stream are of indigo-blue, due to the extra saltness of the water, and the line of junction with the common sea water may be traced by the eye. The highest temperature of the Gulf Stream is 86°, and it loses only 2° of heat in passing through 10° of latitude. The dynamical force that calls forth the Gulf Stream is to be found in the difference, as to specific gravity, of the inter-tropical and polar waters—the difference in saltness.

WINDS.—The winds of the ocean obey certain general laws, the prime factors, governing their direction and force, being the difference of specific gravity caused by heat and cold, and the diurnal rotation of the earth, which gives easting to the winds that are approaching the equator, and westing to those approaching the poles. Hence we have the prevalent westerly winds of the North Atlantic; the calms of Cancer, about 30° north; the North-east Trade Winds, between the calms of Cancer and the calms of the equatorial belt; the South-east Trade Winds, between the equatorial calms and the calms of Capricorn, about 30° south; and the prevalent westerly winds to the south of the Tropic of Capricorn. At the Tropics of Cancer and Capricorn, the ascending and descending counter-currents of air cross one another, while in the equatorial belt the currents ascend, forming the regions of calms and variable winds, of about 5° each in width. The equatorial calm-belt, or Doldrums, is diverted from the equator, being bent northerly from the north coast of South America towards the West African coast. The North-east Trade Winds rarely cross the equator, and are not so strong as the South-east Trade Winds. The South-east Trade Winds, from 5° to 10° south, blow for 329 days out of 365 from the south-east, and less continuously as you get further south; for more than six months in the year, the South-east Trade Winds cross to the north of the equator. Maury, from recorded observations, gives the average speed of vessels in the North-east Trade Winds as 5.7 knots per hours, and in the South-east Trade Winds as 6.1 knots per hour. In the Indian Ocean, the South-west Monsoons blow for half the year, the North-east Trade Winds being here reversed by reason of the arid plains of India. By the charts and sailing directions, deduced from a large number of observations as to the winds and currents, Maury shows that the length of voyages has been greatly shortened; for instance, the average length of the voyage by sailing vessel between England and Australia, which used to be 124 days each way, has, by following the sailing directions laid down, been shortened, in going, to 97 days, and, in returning, to 63 days, in the latter case effecting an average saving of 61 days.

FOURTH MEETING.

April 21st, the Vice-President in the chair.

Among the communications read was one from the Registrar of the University of Toronto acknowledging receipt of the resolution respecting university extension, and stating that it would be laid before the Senate at its first meeting; a second from British Columbia calling attention to the widely distributed circular in which Sir Robert Ball, Astronomer Royal, Dublin, Ireland, solicited information with regard to meteors generally; a third from Mr. T. S. H. Shearmen, of Brantford, supplementing a previous letter respecting the identity of magnetic disturbances with sun-spots; a fourth from the editor of *The Dominion Illustrated*, of Montreal, offering to publish illustrations if sketches of celestial objects were supplied; and a fifth from Professor O. Tetens, of Bothkamp, Germany. Reports of occultations by the moon and observations of sun-spots were read.

"A Plea for the Common Telescope" was the title of a paper read by Mr. G. E. Lumsden for the purpose of showing what had been accomplished by observers with telescopes of aperture less than five inches.* The writer's object was the encouragement of amateurs.

FIFTH MEETING.

This meeting, May 5th, was held at the residence of Sir Adam Wilson, partially for the purposes of observation. The weather proved to be of the most unpropitious character. The President accordingly took the chair.

*This paper has been published in *The Scientific American Supplement*, Vol. 32, No. 832.

On motion of Mr. G. E. Lumsden, seconded by Mr. A. F. Miller, Mr. Charles Carpmael, F.R.A.S., F.R.S.C., and President of the Society, was elected a Life Member. Mr. Carpmael cordially thanked the Society, and expressed the hope that his engagements would permit him to attend its meetings regularly.

On motion of Mr. D. J. Howell, seconded by Mr. T. Lindsay, Mr. John Goldie, of Galt, was elected an active member of the Society. On motion of Mr. D. G. Ross, seconded by Mr. J. G. Ridout, Mr. Goldie was thereupon elected a Life Member also, as some recognition by the Society of his generosity in donating a sum of money to procure books for the library.

Letters were read from Professor S. W. Burnham, of the Lick Observatory, and from Mr. John Browning, F.R.A.S. Mr. Goldie, by letter, called attention to the gradual closing up of Saturn's rings. The Librarian reported the receipt of publications from the Cincinnati Observatory. Among the observations reported by the younger members was the close approach, April 19th, 9 p.m., of the moon to a telescopic star of about the 9th magnitude, which passed just below the lunar disc, and showed sensibly the motion of the moon in her orbit. On the same night, patient observation served to give another member evidence of lunar rotation. References were made to sun-spots and other phenomena. Mr. A. F. Miller had noticed, on the 26th of April, a train of spots resolving into one large irregular spot, which then closed up. He stated that this phenomenon occurred in both solar hemispheres, and was of importance as it indicated that similar forces were at work in different parts of the sun. Mr. G. E. Lumsden exhibited a drawing of Saturn made, May 4th, at 10.45 p.m., at the telescope—a With-Browning reflector of 10¼ inches aperture, power 208; seeing superb, at instants magnificently so; seven satellites, two as merest points of light near ring, distinctly visible even with lower powers; anterior portion of ring roughened along edge and intensely black, no illumination; Cassini's division not visible; belt on southern hemisphere well marked; ball yellow, and very bright between belt and ring; ansæ ruddier in colour than the planet.

Mr. Mungo Turnbull read a paper, illustrated by diagrams, upon Transits of Mercury and of Venus.

Mr. A. Elvins read a paper upon Planetary Rotation, which he illustrated by drawings and a model. The paper was followed by a spirited discussion.

A SPECIAL MEETING

of the Society was held May 9th, 4 p.m., for the purpose of observing the transit of Mercury at 6.57.43. There was a large attendance of visitors and members, the latter including, among others, Messrs. Elvins, Miller, Lindsay, Howell, Ridout, Pursey, Huebner, Lumsden, and Livingston, most of whom brought portable telescopes, which were placed in position. The interest of those present was, in the meantime, sustained by views of sun-spots and faculæ, which were well seen, the sky being clear and the definition good. Shortly before the time of contact, however, objects on the solar disc were distorted by conditions due to the low altitude of the sun. A little later, the cloud-banks lying along the horizon, and behind which the sun was setting, effectually prevented the making of any satisfactory observations.

By means of notices kindly inserted in the newspapers, public interest had been widely aroused, and the Society had, in due time, the gratification of learning that quite successful observations had been made elsewhere in Canada.

SIXTH MEETING.

May 19th, the Vice-President in the chair.

The Librarian reported the receipt from Washington of publications, including the Notes on Saturn made by Professor Asaph Hall. Observations respecting the transit of Mercury were made by Sir Adam Wilson, who sent a large drawing and reported that he had been very successful; also by Mr. Arthur Harvey and Mr. G. H. Meldrum, of Toronto; by Mr. T. S. H. Shearmen, of Brantford; Mr. James Warren, P.L.S., of Kincardine, and Mr. Alexander McEwen, P.L.S., of Bluevale, both sending sketches; and by J. C. Donaldson, LL.D., of Fergus. Dr. Donaldson used a 3½-inch refractor by Cooke, and was singularly fortunate in his observations. He reported that internal contact occurred at 6.57.45 Eastern Standard Time, and that from the time the planet, as a wedge apparently, began to cut into the solar limb until it stood out "clear, black, and distinct on the sun's disc, only a very fine rim of brilliant light separating it from the outer darkness beyond the limb," the "black-drop" was very noticeable, and that evidence of it did not disappear until Mercury was well on the disc. Observations made upon the sun were reported by Mr. A. F. Miller and by Dr. Donaldson. The occultation of κ Geminorum, May 12th, 10.39.20 p.m., had been independently observed by Mr. Miller and Mr. G. E. Lumsden, whose times of contact agreed to a second. The occultation of B.A.C. 3206, May 14th, 8.24 p.m., was also stated to have been well observed with a 10¼-inch reflector.

Printed copies of The Transactions and First Annual Report of the Society were distributed to members. The Committee to which had been committed the preparation of the Report, was formally thanked and discharged.

Mr. G. G. Pursey read a paper on

IMPONDERABLE MATTER,

of which the following is a summary. Mr. Pursey put in a plea for the man of a speculative turn, too often regarded as a visionary, and for theoretical views, too frequently spoken of in disparagement, and claimed that Science should invite, rather than repel, careful examination of alleged facts, pointing out that true analogies can be erected only on ascertained facts, and that the more these are multiplied by investigators, the more perfect will be our knowledge of Nature, and of her active forces, concerning which, he contended, there was much ignorance. Having stated that his paper, necessarily incomplete, would be an attempt to trace phenomena to their source and to get some hold on the relations existing between the dead material and the living forces within or back of it, Mr. Pursey proceeded to say that we survey only effects, causes lie beneath; we conclude that life resides within life, power within power, cause within cause; the nearer we approach the centre, and in presence of the accumulated results of the ages, our cry is still, "Let there be light." Now, what is matter, and from whence? To say that matter is eternal, offers no solution of the metamorphoses through which we know matter is continually passing. In essence, no doubt, matter is eternal, but to all intents and purposes it has had a beginning, and will most assuredly have an end.

There are three or four underlying and overruling principles or doctrines which should be kept in mind while discussing the subject of Cosmogony. I refer to the doctrine of "Forms," the doctrine of "Degrees," the doctrine of "Correspondence," and the function of Atmospheres. I shall have time only to introduce those important subjects. Emerson says, in one of his immortal essays, "We have no doctrine of forms in our philosophy." What do I understand by these words? To answer this question, I must endeavour to carry you back to that point where matter first receives the visible impress of the Divine Hand, where the process is apparently initiated whereby matter is moulded into forms adapted to the particular function each separate congeries is appointed to perform in the physical world; we must get there, if at all, by the inductive or analytic method, from the known to the unknown. There is a family of very minute plants called Diatomaceæ, well known to microscopists, consisting of exceedingly small fragmentary bodies, which seem to form the extreme limits of the animal and vegetable kingdoms, very beautiful objects for microscopic observation. Let us take one of these small diatoms and examine it. To the unaided eye, a mere speck of dust, scarcely visible; through a low magnifying lens it becomes elongated, something like a nearly straight letter **S**, thickened in the middle. Under increased power, a median-line is seen running through it from one extremity to the other; still higher power, and on each side of the median-line you may see transverse lines, intersected by longitudinal lines, forming diamond spaces; higher power still, and each diamond is seen to contain a nucleus; still higher, and this nucleus encloses a nucleolus. Further than this our present appliances cannot take us, but we opine that there is a point, how many degrees within that nucleolus we cannot say, where we must reach the atom, or mathematical point, which is the medium between the infinite and finite; which point, like Janus, looks both ways at once. On the one side, pure infinite or spirit; on the other, pure finite or what we call matter; the point itself, pure motion, or essential activity partaking of the nature of both worlds, spiritual and material. On the spiritual side, our highest mathematics avail not; for there is no high, no low, no great, no small, no time, no space, as we know distance. On this side, geometry may be said to take its rise. This point, motion, or essential activity is the door of egress and ingress, and contains the potency of all motion and of all production. The direct cause of this potency in the atom is the activity of the infinite I Am, the one only Being. Here, at this initial stage, the doctrine of Forms takes its rise, and Science may yet be able to follow the determinations of these atoms in the process of incrassation, culminating in forms answering to the spiritual forces back of them or within them, by which powers they assume geometrical figures, exactly adapted to the varied offices they may be destined to fill. "Give us matter and a little motion," said the Astronomers, "and we will construct the universe." It is not enough that we should have matter; we must also have a single impulse, one shove to launch the mass, and generate the harmony of the centripetal and centrifugal forces. Once heave the ball from the hand, and we can show how all this mighty order grew. "A very unreasonable postulate," said the metaphysician, "and a plain begging of the question." Could you not prevail to know the genesis of projection, as well as the continuation of it? "Nature, meanwhile, bestowed the impulse and the balls rolled. It was no great affair, a mere push, but the astronomers were right in making much of it, for there is no end to the consequences of the act. That famous aboriginal push propagates itself through all the balls of our system, and through every atom of every ball; through all the races of creatures, and through the history and performances of every individual" (Emerson). If it is conceded, then, that each atom contains within itself the tendency to motion, the potency of all the forces to be developed by aggregations of these atoms—magnetism, gravitation, and all other attributes implanted by the Omnipotent, in just proportion and proper balance, and the end, a material universe—then in this womb of Nature, in which the universe might be said to exist in a state of ovo, material atoms, particles, or molecules, will be precipitated; these being attracted to their like will segregate into groups of various forms and diverse polar action, as future use demands. One group may be composed of perfectly round, smooth molecules, capable of rolling freely in any direction without interlocking, being absolutely free of angles. Such will be the form of the fluid particle. Another group crystallizes into cubes, cupped on every side so as to become immovable when the interspaces are filled in by a substance forming a matrix. This would be the form of solid, compact bodies. All other degrees of density can be filled up *ad libitum*, the form of the particle determining its function. The impalpable perfumes from the rose and violet and the disagreeable odors emanating from putrid or decaying bodies produce the varied sensations we experience when they come in contact with the delicate papillæ of the nostrils by the form of the particle in each particular odor, round and smooth, angular, or prickly, in infinite variety. The same property of a coarser grade affect the tongue or taste. Colours, too, are produced by modifications of the rays of light on being reflected from a variety of planes constituting the surfaces of the bodies on which they fall. I must leave this part of the subject for the present with this general remark: From the smallest particle of matter to the highest development of mind, the form of the organ determines the form of its use; the converse of this being also true, that the use, or end, determines the form.

Degrees are of two kinds, continuous and discrete. Continuous degrees are graduated, as from cold to heat, light to shade. Discrete degrees are as cause and effect. Causes do not produce effects by continuity, but discretely. A cause is one thing, an effect is another. When I raise my arm, a thousand nervous fibres concur in each motion, and a thousand things in thought and will excite those fibres to motion; but because they act interiorly, do not appear to any of the bodily senses. The will is not the thought; the thought is not the act, although both are in the act. Power, or tendency to motion does nothing, but acts from spiritual powers corresponding to it, and by these produce motion. Endeavor, power, force, motion, are not the same thing, but are discrete, connected only by correspondence, for endeavour is not power, nor power motion, but power is produced by endeavour being excited, and motion is produced by the excitation of power; wherefore there is no potency in endeavour alone, or in power alone, but in motion, which is their product, or completion. I have been somewhat prolix on this point of the subject because it seems to me that scientists are sadly astray in their terminology, most illogically confounding force with motion, which plainly appears to me as cause and effect. This doctrine of Degree, however, is so intimately connected with the doctrine of Correspondence that it can hardly be touched upon without trenching on the other. Now, what is meant by correspondence? It means that one thing may be affected by another without becoming one with it, being separated by a discrete degree; as the will, the thought, and the act in raising the arm. It means the relation of the waves of ether to the eye, of the eye to the sensory fibre, of the sensory fibre to the cortical gland, of the gland to the common sensory, of the common sensory to the imagination or interior perception, of the perception to the intellect, of the intellect to the soul, of the soul to God. By correspondence things totally different in degree and substance are nevertheless so adapted that motions or tremulations in the one may be continued through the other, or converted into some modification of the other's state. Hence, I am not satisfied with the conclusions of science regarding the correlative or reciprocal relations of force. Much might be said on each of the topics I have merely introduced, but I must pass on, as space will not allow anything beyond a brief definition of the terms used. What special function is served by each of the various atmospheres, or unseen powers which are known to exist, in the production and maintenance of this material universe, we do not at present know. It has been said that, but for electricity, the air would rot. We do know, however, that in consequence of the circumpressure of our atmosphere bodies are held together, and that free liquids glomerate into globes, as water does in air, quicksilver in water, air in ether. Indeed all bodies when dissolved and liquefied by heat, or in any other way, if surrounded by an equable pressure of any element upon all its parts, form themselves into spheres; be it a drop of water or a molten world, the self-same law governs both alike. We are satisfied that respiration and hearing are effected by means of our common air, or what may be called the ultimate atmosphere. Sight is not possible but by means of an atmosphere purer than air; therefore experience dictates the existence of ether, assuredly a discrete degree above air; and, by parity of reasoning, thought and affection cannot exist but by means of a medium discretely separated from any of those named, as thought is prior to and above action. What relation electricity, gravitation, and other mysterious agencies or powers, sustain to each other and to all other matter, and which is of highest and purest quality, we can only conjecture. We know absolutely nothing of them but by their works or effects. We may be allowed to suggest that, in the economy of nature, atmospheres are the active forces, waters and earths being intermediate and passive. If those active powers are clothed with material substance, as no doubt they must be, to be at all appreciated by sensuous beings, is it not reasonable to suppose that the thinner the gross covering the more vital the energy, so that the more subtle and unexcogitable the atmosphere, the fewer removes is it from its spiritual origin; the varied developments and modes of action arising mainly, if not solely, from the form of the particles entering into the composition of each; polarization effecting the diversity of phenomena patent to us? Thus I conceive that this doctrine of Forms lies at the very basis of physical science.

I have so far said nothing about one of the most important factors in world-making, viz., Fire. I know not what it is, if not an omnipresent atmosphere, normally latent, but capable of becoming appreciable through physical or chemical excitation. It seems to be indispensable that heat must be developed in the preparation of matter for use at some particular stage of incrassation; and not only in the physical or material universe does this law obtain, but also in the moral and spiritual departments of human experience, for every man must pass through the fire of trial and temptation in order to the unfolding of his best qualities.

Of the theories advanced as to the origin of this our solar system, I regard what is called the nebular hypothesis as being the most rational and probable. The order of this theory—for it has attained to that dignity—is too well known to require repetition at this time. How, when matter had emerged from a state of imponderability and entered upon its geometrical career, the pressure of particle on particle, massing together in some way not unknown to chemists, evolve an intense heat, resulting in a general fusion of the entire mass into a semi-solid body, which, in its gaseous form, is supposed to have occupied the space bounded by the periphery of the present working solar system. The setting free of this active force called heat, which no doubt existed potentially in each atom, is inevitably followed by rotatory motion—Emerson's original push, from which such vast consequences have resulted. You all know the sequel: the throwing off from the rapidly rotating central body fragment after fragment of molten matter of various sizes, and more or less impetus, thus forming our planetary system with its myriad members. Briefly, then, in conclusion, I have tried to show—very inadequately, I admit—that what we call matter is *crystallized spirit*, precipitated into finite forms to answer the requirements of finite beings, whose plane of life is absolutely a discrete degree below spiritual substance. Hence it follows that when we have done with our finite, gross, material bodies, we will be then discretely separated from all material things, and know substance only in its essence or first principles. I believe that a proper understanding of the subjects I have thus briefly and roughly touched upon in these incoherent remarks would enable Science to rise above the contemplation of mere effects into the region of causes, even to the threshold of the great First Cause; would help us to see that Nature is only the material in the hand of the Builder, separate from Him, though He is omnipresent therein; and would give us an insight above or within this visible extense into that real infinitude which is in more intimate conjunction with Him, and is filled with His more immediate Presence. Then would Science itself become godly, and research true worship.

SEVENTH MEETING.

This meeting, June 2nd, was held at the Observatory, Queen's Park. As the sky was clouded, the Vice-President took the chair.

Mr. Arthur Harvey, President of the Canadian Institute, Mr. A. Aronsberg, of Toronto, and Mr. J. C. Donaldson, LL.D., of Fergus, were elected active members. A report of the transit of Mercury was received from Rev. E. F. Wilson, of Sault Ste. Marie, Ontario. Rev. T. E. Espin, F.R.A.S., Tow Law, England, sent a copy of his report of the work done at his observatory during 1890. Mr. A. F. Miller and Mr. G. E. Lumsden handed in solar observations. The latter showed some drawings made at a 2-inch telescope, for the purpose of showing what could be done with such an instrument. He also reported that on May 25th he had noticed, apparently darting in straight lines across the sun's disc, black lozenge-shaped specks, supposed to be insects. Mr. A. Elvins said somewhat similar phenomena had been observed during the solar eclipse of 1868, and that a Swiss astronomer had endeavoured to account for them by supposing the objects seen to have been snow-flakes floating in the upper atmosphere. The Librarian reported the receipt of books, including those purchased with Mr. John Goldie's donation.

A paper on "Solar Disturbances and Terrestrial Magnetism," contributed by Mr. T. S. H. Shearmen was read. This paper has since appeared in *The Sidereal Messenger* and *The English Mechanic.* A paper entitled, "An Historical Sketch of the Progress of Astronomy from the Earliest Ages to the Christian Era," and contributed by Mr. R. Ridgeway, of Toronto, was read by Mr. Lindsay.

By request, Mr. Elvins read the following paper on the recent transit of Mercury, contributed by Mr. D. K. Winder, of Detroit, Mich., a Corresponding Member:

TELLURIC LINES IN THE SPECTRUM OF MERCURY.

The sun, earth, and planet fell into line at the predicted time on the evening of May 9th, and the planet Mercury had made a digit or two of progress on its way across the solar disc before sunset at Detroit.

The low altitude of the sun and the unsteady condition of the atmosphere, through which views were obtainable from our Campus Martius, rendered it certain that no observation of the moment of contact could be made accurate enough to be of scientific value. I, therefore, determined to devote the few minutes available before sunset to an analysis of the spectrum of the surface of the sun in close proximity to the position of the planet on its disc. I am happy to record what I hope will prove to be another triumph of the spectroscope if it shall be corroborated by the reports of other careful spectroscopic observers, and teach us something regarding the constitution of the atmosphere of the planet Mercury. During the early part of the transit, the spectrum of the light received from the edge or limb of the planet exhibited the telluric lines greatly intensified and unusually dark. This appearance of the spectrum indicates the presence of aqueous vapour in the atmosphere of Mercury. The distinctness of the telluric lines of the solar spectrum, due to the low altitude of the sun at the time of the transit, rendered the conditions specially favourable for the revelation of this interesting fact. The result of this observation also shows that the planet is surrounded by a dense atmosphere, which, in a more attenuated state, must extend two or three hundred miles from its surface; otherwise the spectroscopic results mentioned would not be seen at the great distance of Mercury from the earth. The spectroscope used was in perfect order, and the dispersive power was sufficient to divide the D lines of sodium and reveal one faint line between them. The unsteady character of the atmosphere at my point of observation caused frequent variations in the darkness of all the telluric lines in view, but they certainly were always more distinct in the light received from the edge of the planet and from the dark body of the planet than in the light received from other parts of the disc of the sun. As it may be of interest to some members of the Society, I shall describe the arrangement of the telescope and spectroscope. The image of the sun and planet was received upon a transparent screen attached to the telescope, and its course marked upon the screen as it crossed the field. A narrow slit was cut in the path traversed by the planet, to which the slit of spectroscope was directed. By this arrangement, it was possible to pass the slit of the spectroscope frequently over the planet and note the variations of the spectrum. This arrangement will be found useful in like observations by those who use alt-azimuth telescopes.

EIGHTH MEETING.

June 16th, the Vice-President in the chair.

Letters of acknowledgment, and, in several instances, of a very complimentary character, were read from the following gentlemen, to whom had been sent copies of the Society's first Report:—The Honourable G. W. Ross, LL.D., Minister of Education for the Province of Ontario; the Secretary of The Royal Society of Canada; Professor E. C. Pickering, Director of Harvard Observatory; Professor S. B. Langley, Secretary of the Smithsonian Institute; Professor W. W. Payne, Editor of *The Sidereal Messenger;* Professor Edgar Frisby, of Washington, D.C.; Sanford Fleming, C.E., LL.D., C.M.G., of Ottawa; Professor E. S. Holden, Director of the Lick Observatory; Professor S. W. Burnham, of the Lick Observatory; Professor Daniel Kirkwood, LL.D., of Riverside, Cal.; Captain McNair, Director of the United States Naval Observatory; and Mr. J. A. Brashear, of Allegheny, Penn. Professor Burnham also sent a large number of valuable papers relating to double-stars, for which he received the Society's thanks. The Minister of Education wished the Society success in the work it had undertaken, and, in reply to an enquiry, expressed his willingness to preside at a public meeting, should one be held.

The Librarian reported additional donations from the Royal Society of Canada, the Smithsonian Institute, and other valued sources. He also called attention to the fact that Messrs. Michael Bros., one of the city firms of opticians, had begun to import lenses, prisms, and other accessories suitable for the special needs of members.

Mr. D. J. Howell, seconded by Mr. A. F. Miller, gave notice of a motion having for its object the formation of an Opera-Glass Section for the benefit of those members and others who had not taken up a regular course of observing, and also for the study of the constellations and certain of their features, including coloured, variable, and easy double-stars, stellar-clusters, nebulæ, etc.—instruments to be field and opera-glasses and portable telescopes.

Among the observations reported was that of a large and brilliant meteor seen, June 6th, 10.55 p.m., by Dr. J. C. Donaldson, of Fergus. The meteor, from a little below the arms of the cross in Cygnus, passed overhead "with a kind of whizzing sound, as I thought," and disappeared in the direction of Corvus, leaving in its trail a beautiful narrow ribbon of light, which overarched the sky and was visible for, perhaps, a minute, gradually fading away. The report was transmitted to Sir Robert S. Ball, Dublin. Mr. A. Elvins and Mr. G. E. Lumsden stated that they had seen the bright spots on the rings of Saturn mentioned in some of the English scientific journals. Mr. A. F. Miller reported that on June 14th, at 6.30 a.m, several conspicuous solar prominences were seen, the most remarkable group being at 295°. Two tree-like forms, rising to a height of 25,000 miles, were observed, and a little south of these a curious pillar-like jet, which, in the course of 20 minutes, underwent several remarkable changes. A small, but brilliant, mound was noticed closely associated with the sun-spot group which came round the east limb on the afternoon of June 12th. The spectra of the spots showed only a normal widening of many lines, but a little north of the chief member of the group a region of the photosphere was found which gave a spectrum having the C line considerably widened and displaced towards the more refrangible rays. Subsequently a similar appearance was noted in other places near the spots, and occasionally the C line was twisted in both directions or reversed. D_3 was also occasionally seen as a short bright line. Mr. Miller further stated that since the last meeting, he, too, had observed small objects floating across the sun's disc, but, on careful examination, he had found them to be composed of thistle-down.

A second paper on "The Progress of Astronomy," by Mr. R. Ridgeway, was read.

Mr. A. F. Miller read a paper on "Amateurs' Study of Double Stars." The writer endeavoured to show the advantages derivable by the amateur possessing moderate telescopic facilities from the examination of this class of stellar bodies. His conclusion was that the search for these objects by the aid of an alt-azimuth telescope, while constituting an interesting and delightful pursuit, was eminently beneficial as a training to the eye, and probably formed the best means for acquiring a good knowledge of the starry heavens.

NINTH MEETING.

June 30th, the Vice-President in the chair.

Mr. Howell's motion respecting the formation of an Opera-Glass Section was carried. Mr. Anson Jones, of Toronto, was elected an active member, and several nominations were made. Communications were read from the Astronomer Royal regarding publications of Greenwich Observatory, which were promised; from Miss Whitney, Director Vassar College Observatory; Professor O. Tetens, Bothkamp, Germany; T. W. Backhouse, F.R.A.S., Sunderland, England; and from Mr. G. P. Serviss, of Brooklyn, N.Y., author of *Astronomy with an Opera-Glass.* Mr. Serviss, who had been consulted with respect to opera-glass work, gave much information, and presented a copy of his excellent manual. The Librarian reported additional publications from the St. Louis and Lick Observatories, the latter including further papers from Professor Burnham. A large number of reports on solar and spectroscopic work were made.

Dr. Edward S. Holden, Director of the Lick Observatory, wrote: "I beg to thank you for the copy of your Transactions which you kindly send me. I have been much interested in reading it, as it shows your Society has a vigorous life. I notice on page 12, line 10 from bottom, a conclusion with which I do not agree. I suppose Mercury and Venus to be seen near the sun *because their atmospheres* are illuminated, and the vacant space inside is obviously not in contrast to the corona, but in contrast to the illuminated atmosphere."*

Dr. G. B. Foster read an interesting paper on "Electricity and its Uses in Medicine," and exhibited his different appliances. He showed a large Wimhurst static machine (driven by an electric motor), fitted with six thirty-six-inch plates, giving a twelve-inch spark, and having an electric-motor force of fifty thousand volts. The different methods of treatment by this form of electricity and their therapeutical action were illustrated. It was shown that static electricity could be administered in the form of the indirect spark, static insulation, static breeze, static electro-massage, direct spark, and the static induction current, each of which reaches different diseases, or various forms of the same disease. The doctor also traced the great strides recently made in the uses of galvanic electricity in medicine and surgery. How accurately and delicately the dose of galvanism may be regulated to the individual case was illustrated by the modern inventions of the rheostat and milliampère metre. The difference between the old-fashioned switch-board and the rheostat, and the superiority of the latter, were pointed out, and it was claimed that, owing to the chemical action of the galvanic current and to its form of administration, it is the preferabie form of electricity to use in certain classes of cases where the static

*Mr. Shearmen's paper on "Coronal Photography in Full Sunshine." Transactions, 1891.

is not indicated; it is the current used in surgery and the electro-cautery. The Faradic, or third form of electricity used in medicine, was next taken up and explained. The doctor exhibited, in this connection, new inventions of his own in the way of Faradic batteries, and gave a resumé of the well-defined differences between the Faradic, Galvanic, and Static forms of electricity, showing how each class of diseases is peculiarly amenable to one or other of these different forms. He cited reasons why these preferences should be strictly observed, and why skill and experience are so necessary to the physician who undertakes to administer this potent and mysterious agency of nature. The doctor's electrical appliances are, probably, the finest and most complete in the country.

TENTH MEETING.

July 14th, the Vice-President in the chair.

The first report of the Opera-Glass Section was read by Mr. Clarence Bell, the Secretary. It stated that the Section had met and had organized, that the outlook was satisfactory, and that Mr. G. E. Lumsden had been appointed Director for the remainder of the year.

Messrs. Joseph F. Eby and James Todhunter, of Toronto, were elected active members. On motion of Sir Adam Wilson, seconded by Mr. A. Harvey, Larratt W. Smith, Q.C., D.C.L., was elected a Life Member. On motion of Mr. A. F. Miller, seconded by Mr. Lumsden, the Honourable Sir Adam Wilson, Knight, Q.C., was also elected a Life Member. Communications were read from the Royal Astronomical Society, and from the Directors of the Royal Observatories at Kiel and Uccle. Publications from the former Observatory had been received.

Mr. Miller reported spectroscopic observations of the sun, made July 12th, and stated that the displacement of the C line in the region of the sun's surface just preceding the northern members of the sun-spot group of July 8th, gave evidence of very considerable motion in the line of sight; this observation was made at 9 a.m. The shortening of the wave-length indicated a motion of 56 miles a second. This phenomenon was maintained for about twenty minutes only, but in many parts of the solar surface disturbance of the hydrogen line was noticed.

A continuation of Mr. Ridgeway's paper on "The Progress of Astronomy" was read.

ELEVENTH MEETING.

July 28th, the President in the chair.

Captain Charles C. Bennett and Messrs. Frederick L. H. Sims and Samuel Michael, of Toronto, were elected active members. The Librarian reported the receipt from the Lick Observatory, from Trinity College, Dublin, and from a member of the Society who declined to disclose his name, of a number of valuable volumes, which had been added to the library.

Mr. Clarence Bell read a very lucid paper on "Electricity and Electrical Units," in the course of which he traced the history of electricity from the time of Thales to that of Gilbert. The subject was then treated under the following heads: positive and negative electricity; the different methods by which electricity can be produced; magnetism and its relation to electricity; electro-motive force—its definition by means of illustrations; units of electrical measurement, and definitions, by means of illustrations, of the "volt," "ohm," "ampère," and "watt."

The paper was followed by a lengthy and spirited discussion, in which Messrs. Carpmael, Elvins, Miller, Harvey, Lindsay, Bell, and others, took part.

TWELFTH MEETING.

August 12th, the President in the chair.

The Minutes of a meeting of Council were read, and certain recommendations respecting routine matters approved of. Mr. Robert O. Montgomery, of Toronto, was elected an active member. Among the communications was one from Mr. Arthur Harvey, then in Ottawa, who described the passage over that city on the night of July 31st of a very brilliant meteor. The letter was directed to be forwarded to Sir Robert S. Ball, Dublin. The following letter addressed to the Director of the Opera-Glass Section by Mr. J. Ellard Gore, F.R.A.S., etc., was read:

BALLYSODARE, IRELAND, 28th July, 1891.

DEAR SIR,—Your letter of July 14th received this morning, and also the Annual Report of your Society, for which I am obliged. I am pleased to hear that the Society has formed an Opera-Glass Section, and I have much pleasure in complying with your request for hints on the subject.

The instrument I have used for the last fifteen years in this class of work is a binocular field-glass having object-glasses of two inches in aperture and a power of about six diameters. A somewhat smaller instrument would, I think, answer equally well for the purpose, say, one with object-glasses of 1¾ inches aperture and a power of four or five. I have found my instrument a most useful one in the observation of variable stars, and with it I have discovered four new variable stars during the last six years, viz., U Orionis ("Nova," 1885), S Sagittæ, W Cygni and X Herculis, and have made numerous observations of known and suspected variable stars. The plan I adopt is the method used by Argelander for observing variable stars. Two stars are selected near the star to be watched for variation—one a little brighter, and one a little fainter, than the star to be observed. The interval in light between the two comparison stars is then mentally divided into ten "steps," or "grades," and the variable is compared with them and the observation is recorded as follows: if *a* denotes the brighter star, *b* the fainter, and *V* the variable, the relative brilliancy is registered thus: *a* 1 *V* 9 *b*; *a* 2 *V* 8 *b*; *a* 3 *V* 7 *b*; *a* 4 *V* 6 *b*; *a* 5 *V* 5 *b*; *a* 6 *V* 4 *b*; *a* 7 *V* 3 *b*; *a* 8 *V* 2 *b*; or *a* 9 *V* 1 *b*, as the case may be, the sum of the numbers being always 10. In this way a very accurate estimate may be made of the relative brightness of the star under observation, and if any variation in its light takes place it can be easily detected by a comparison of the observations made at different times. The observations are exceedingly simple, but, of course, require care and practice in the appreciation of small differences of light. This method is probably the best hitherto proposed, and to an experienced eye is more delicate and reliable than observations with a photometer. For the brighter variables, such as Algol, Mira Ceti, L Herculis, etc., the naked eye is sufficient, and no glass of any kind is necessary, except, of course, to short-sighted persons, who will require spectacles or eye-glasses for the purpose. An opera-glass may also be used in the observation of the occultation of stars by the moon in cases where the star cannot be observed with the naked eye owing to its light being overpowered by the moonlight. Observations of comets a little below the limit of naked-eye vision may also be made with an opera-glass, and their brightness with reference to neighboring stars determined. Such observations would have value with reference to the question of sudden variations in the light of these objects, a variation which has been occasionally noticed. I have also found that observations of the minuter details of the Milky Way can be well made with a binocular. This I have found to be especially practicable in Cygnus, Cepheus, Aquila, etc., where the binocular shows details quite invisible to the unaided vision, and which would not probably be conspicuous even with a telescope. If the Society would like any further information on the subject, I shall be happy to supply it. Yours, etc., J. E. Gore.

Among the observations reported was a list of difficult stars divided with a 3½-inch Cooke refractor, by Dr. J. C. Donaldson, of Fergus. Mr. D. J. Howell and Mr. G. E. Lumsden had observed the Perseids on the night of the 10th of August. The latter stated that he had been able to observe only from 10 to 12 o'clock, during which time he had taken notes of sixty-eight meteors, the majority of which were not especially remarkable. Nearly all were clearly Perseids. Some very bright meteors were seen, but these had chiefly short paths. Several were apparently deep red in colour. Six meteors were seen at once, and, several times, pairs travelling in parallel paths were observed. Mr. A. F. Miller reported that while he was studying the spectrum of a small solar spot at 7 a.m., August 2nd, he observed a displacement of lines that indicated an up-rush of glowing hydrogen over a large area immediately south of the spot. The C line was, at times, distorted so as to appear as a dark blotch projected on the continuous spectrum; bright lines were visible at the same time. The upward velocity of the gas streams was not less than two hundred miles per second. Micrometric measures of a large spot, same day, were:—penumbra, 25,600 by 14,600 miles; umbra, 14,100 by 5,900 miles. Commenting upon the phenomenon of the bright lines, Professor Carpmael stated that, if he was not the first, he was among the first who had seen bright lines in the spectrum of a sun-spot.

Mr. Clarence Bell read a supplementary paper on Electricity.

THIRTEENTH MEETING.

August 25th, the Vice-President in the chair.

The letters included one from Dr. Krueger, Director of the Observatory at Kiel, and one in which Mr. T. S. H. Shearmen enquired respecting the use of Cosmic Time. The Librarian reported publications received, including a volume from the Georgetown Observatory, Washington, D.C., descriptive of a new invention for recording star transits by photography. Mr. A. F. Miller reported transits of Jupiter's satellites, the times agreeing closely with those predicted.

Mr. G. B. Abrey, D.L.S., etc., placed some of his valuable surveying instruments out of doors, and very lucidly explained the manner in which they were employed, and the methods by which use is made of the stars in laying out fundamental lines and in determining positions.

FOURTEENTH MEETING.

September 8th, the Vice-President in the chair.

Mr. Robert P. Hall, of Toronto, was elected an active member.

Observations were reported by Dr. J. C. Donaldson, of Fergus, Mr. A. Elvins, Mr. A. F. Miller, and Mr. T. Lindsay. Mr. Elvins had observed, on September 4th, Wolf's Comet, then near Alcyone, in the Pleiades. It appeared to be a small diffused nebulous mass without central condensation. Mr. G. G. Pursey and Mr. D. G. Ross advised the holding of a public meeting, with an exhibition of lantern slides, illustrating astronomical subjects. A committee was appointed to consider the proposition.

Mr. Elvins read the following paper :

MOVING MATTER II.—THE CAUSE OF GRAVITY.

During the last quarter of a century, vast strides have been made in almost every department of knowledge. Ever since Newton's time, it has been known that bodies tend to move toward each other with a force which increases directly as the mass increases, and inversely as the square of the distance increases. Why this should be the case was not known then, and on this subject our knowledge has not increased; *we do not know now.* Two theories exist in relation to the *cause of gravity :* the one supposes matter to possess a property innate in itself, which draws bodies to each other from a distance, even through a vacuum, which may be known as the *Theory of Attraction ;* and the other, which regards action at a distance as impossible, and looks at gravity as the result of the impact of moving material atoms forcing distant bodies toward each other. This view has been advanced by La Sage, and has been brought forward in a modified form, and, I think, in a most able manner, by one of our Corresponding Members, Mr. J. H. Kedzie, of Chicago, U.S.A. We may never know, possibly, what causes gravity, but of one thing we feel sure, men *ought and will try to know ;* and hoping to stimulate enquiry in this direction, we bring forward this to-night. In order that this paper may be understood by any who were not with us when we read the first paper, we read the synopsis of that paper from page 20 of our Transactions of last year :

Mr. Elvins read a paper on "Moving Matter." It was an attempt to form a conception of *matter* and the *ether* of space. The view which regards matter as solid, impenetrable, indivisible *moving* particles, subject to the known laws of motion, was regarded by him as true. Every such ultimate atom occupies space, and no two atoms can occupy the same space at the same time. That which we call *energy* or *force* is simply the momentum of *moving* matter, the word *force* representing the number of atoms and the rate of their motion. He believes that a definite number of such moving atoms exist in the universe, the total sum of the *motion*, like that of the number of atoms, being a constant quantity. He holds that masses are composed of moving atoms, and that the vibration of the atoms consequent on their collisions is what we know as *heat;* any increase of motion must increase the total free path of the atoms, and hence must increase the size of the mass without affecting its weight; hence we see why we must have a *thermo-equivalent* of mechanical force and a *mechanical* equivalent of heat. Mr. Elvins regards the *ether* as matter in its atomic condition; as the free path would be comparatively long, the collisions would be few; but when they collide with masses, they impart their motion to the atoms forming the mass, increasing their number of collisions or *producing heat.*

1. Let us proceed with our enquiry. Of course, we believe all space to be filled with moving atoms, either in a free state as the *ether*, or in groups, as masses; but for the purpose of getting clear ideas, let us suppose all space to be a *perfect vacuum*. Into this mighty vacuum let us suppose a *single atom*, A, to be introduced (no matter how). We assume the atom to be stationary. In such a case, being the *only atom*, and it at rest, it would remain stationary forever; being the only existing atom, it could not collide with any other, and hence there would be nothing to move it from its position.

2. There is nothing, however, to prevent us from supposing the atom not only to *exist*, but to *move*. If it moves at all, it must move in a straight line; nothing exists to change its course, and hence its direction must remain the same forever. The same is true in relation to its velocity; as nothing exists to accelerate or to retard its motion, its rate must continue always the same.

3. This motion of the *atom* is what we call, or in truth is, mechanical force. All moving matter must have it, no matter what its mode of motion may be.

4. Introduce now another atom, B, into the universe, and the possibilities are changed; it *is* now possible that a collision may occur. Two moving atoms exist, and, if they move directly toward each other, they will collide; and being rigid and impenetrable, and as motion cannot be destroyed, they must rebound, as the glass balls did in our experiments. This flows naturally from the Third Law of motion; "action and re-action are equal and opposite." It is not correct to say that equal masses, moving in opposite directions, destroy each other's motion; in the cases of masses, the masses may become stationary by imparting their motion to the atoms; the *all* of the motion exists in another form—atomic motion. With atoms it must be different. An

atom has no parts to set in motion; if it is a solid unit, not composed of smaller atoms, there is nothing to take up and change motion of translation to some other form, *so they can only rebound.* No motion is lost; the direction is changed, nothing more.

5. But the chances are that the centres of the atoms may not be precisely on the line in which they move; in that case, they will not rebound and recede in the same line in which they approached each other. They will be deflected from their former course, and the direction of their future course will depend on the distance of the centres of the atoms from the points of contact.

6. But another result will follow such a collision. The direction of motion will not only be changed, but the atoms will be turned around by friction at the points of contact; part of the motion of both A and B will be changed to motion of *rotation;* the sum of the motion of A and B will now be divided between *translatory* and *rotative* motion, the sum of these motions being equal to the motion of translation before contact.

7. It is easy to see that the amount gained in *rotation* will depend on the distance from the centres of the two atoms at the time of contact; it would be possible for translation to be largely changed to rotation. In such a case the atoms would move slowly through space, rotating very rapidly on their axes at the same time.

8. If only two atoms existed in the universe, I can conceive of no other motion which either could possess, but there are an infinite number of such moving atoms, and the chances of collisions, retardations, deflections, and stoppages are vastly increased, and such changes must be constantly occurring in some part of infinite space.

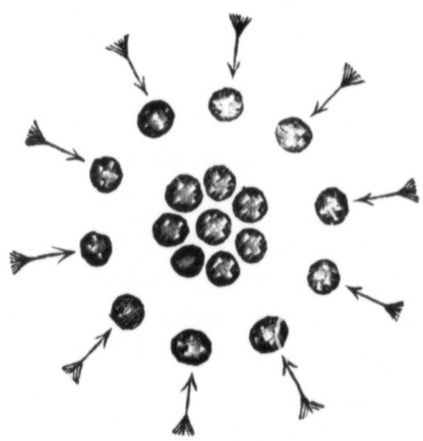
9. Imagine, then, the whole universe filled with such moving atoms; moving in every possible direction, but always in *straight* lines, *never in a curve.* Every translation will radiate from the point where the collision occurred; so atoms will be moving with different velocities, and as if radiated from every point in the universe.

10. But though the sum of the motion remains the same, we have seen that the rate of motion, both in translation and rotation, changes; and this change will pass through all gradations, from the most rapid to the slowest, or even to the one which has been for the time being brought to rest.

11. Now, amongst the vast number of colliding atoms, we may reasonably expect that two or more will be brought to a standstill or

become stationary near each other. Let us suppose several to form a little group, or molecule, and let us ask what would happen to such a group under the conditions in which we have supposed it to exist.

12. Atoms will be moving toward such a group from every direction outside of itself; each incoming atom will have its motion arrested, *wholly* or in *part;* if wholly, the atom will be *added to the mass;* if in part, it will rebound into space, losing some of its motion; and as the mass is struck equally all round, the tendency of every atom must be toward the centre.



13. We see in this smallest group of atoms the first tendency of matter to move toward a centre; or, in other words, we have the first manifestation of *gravity*, and we see its *cause*.

14. Now, if one such mass is formed from such a cause, others must be forming through the universe from the same cause; in fact, in every part of the universe masses must be forming. Let us examine two such masses and see how they act in relation to each other.

15. Draw a line through the centres of two such masses. All the atoms moving parallel to such line which strike either mass will be stopped by it, and will not reach the more distant mass. Call the nearer mass A, the other B. A will prevent the atoms coming in one direction from reaching B, whilst B will prevent atoms coming from the opposite point from reaching A. Thus the motion which both A and B receive from colliding atoms moves the two masses toward each other.

16. The larger the mass the greater will be the number of atoms intercepted. Hence the greater must be the tendency of the masses to approach each other, a tendency that must also increase as the distance of the bodies is diminished.

17. As every atom in a mass will stop incoming atoms, we see why gravitation increases *directly with the mass.* The nearer the masses are to each other, the larger will be the number of atoms prevented from striking the inner side of the masses. We see, further, that the amount of motion of the masses will be inversely as the square of the distance.

18. Gravity, then, is not the result of ***attraction*** between the masses drawing them together, but the result of pressure from the outside, which forces them together.

19. The theories of La Sage and Kedzie are largely similar to the one I have advanced in this paper, and I am satisfied that it is in this manner, with some modification, perhaps, that Nature acts in producing *gravitation ;* in fact, I think that should Kedzie investigate the manner in which atoms of ether act on each other in the formation of waves, or shells of compression and rarefaction, his theory of the causes of gravitation would be no more questioned than the fact of its existence.

20. But this view of the physical universe suggests thoughts in relation to other questions as well as to the cause of gravitation. For myself, I am satisfied that the whole question of what is known as imponderable force is capable of explanation on the foregoing "mechanical principles." Light, electricity, magnetism, capillarity, elasticity, and chemical affinity will, I doubt not, find their true explanation by following this line of investigation, and I hope some of our members will work on these lines.

21. But you will permit me to follow this line of reasoning a little further in one direction, for I fear it may not suggest itself to all; possibly not to any who may take up other points.

22. If gravitation is what we suppose it to be, that is, a pressure from the outside of the masses, increasing directly with an increase of mass, and, inversely, with the square of the distance, then it follows that, as suns (stars) have enormous masses, molecules and masses forming at immense distances would move sunward, and meeting with other masses forming in like manner, as they move onward, would be acted on by each other; and that if they did not unite into a single mass, they would move onward in swarms of greater or less extent. Such masses might be so small as to be invisible even with the aid of the microscope, or they may sometimes be of many tons weight; they would, however, pass sunward, enlarging by accretion as they proceeded.

23. Reaching the solar, or a stellar system, some few masses would collide with the outer planets and fall on them, such as our shooting stars and the meteorites which reach the earth. But by far the larger quantity would, after sweeping as comets and meteoric swarms around the sun, find their way to its surface; and as such bodies coming from vast distances would be subject to the law of falling bodies, their rate of motion, when they reached the sun's surface, would be very great.

24. As the formation of molecules and masses through space will be constant, the inpour on suns will also be constant. The motion given to the sun's atoms, or the heat thus produced, might be so great as to drive the atoms forming masses or molecules asunder, and thus return them as separate atoms to the ether from which they were formed; in which state, as ether, they would be ready to repeat their work of gravitation and mass-building, etc., through cycles which can know no end.

25. Taking this view, the correlation of *forces* is seen to be a necessity from the very nature of force. In fact, the plural form may be abandoned. *Only one force*, that of *moving matter*, *exists*, and the different forms of energy are but different modes of the motion of matter.

FIFTEENTH MEETING.

September 22nd, the Observatory, Queen's Park, the Vice-President in the chair.

The letters included one from Mr. S. E. Peal, F.R.A.S., of Sibsagar, Assam, India, covering transmission of two publications of his upon the lunar surface. Numerous observations were reported. These included two very brilliant auroral displays seen by Messrs. Elvins, Miller, and Lumsden on the early evenings of Sept. 8th and 9th. With respect to the latter, Mr. Miller said that at 9.30 p.m. a luminous arch was seen, which extended from N.N.W. to S.S.E., and remained in view for thirty minutes or more. This arch, though quite bright, did not give the usual auroral spectrum, but several transient luminous patches near it did. There was a bright aurora, with streamers in the north, and here the chief bright lines were very evident. It was remarked that a very distinct after-glow had prevailed at sunset. Mr. Miller suggested sextant observations, taken simultaneously by two distant observers, as a means for obtaining the height of the streamers. Mr. Elvins had also made spectroscopic observations, and agreed with Mr. Miller as to the absence of the auroral spectrum. Dr. Donaldson, of Fergus, handed in a lengthy report upon stellar work, he having succeeded in dividing some very difficult double stars. Minima of Algol and Jovian phenomena were referred to by other members.

Mr. Lumsden reported that about midnight of September 20, he had observed what he conceived to be a double-shadow cast by Satellite I. The seeing was excellent, the transit egress of the satellite was noted at 11.54 p.m., Eastern Standard Time = 16.54 Greenwich Mean Time; the shadow egress at 12.18. During the twenty minutes prior to the shadow egress, he noticed a shadow following the true one, itself round, black, and sharply and steadily defined. The second shadow, which moved uniformly with the first, was not nearly so dark, nor by any means so well defined. It was not round, and was apparently ragged about the edges, as shown in the frontispiece. It repeatedly appeared and disappeared; twenty-two such apparitions and disappearances were counted within a period of a few minutes, the shadow being sharply shown for a few seconds, after which it was invisible for like instants of time. The observer had tried to liken this to some familiar object, but could think of nothing better than the slow horizontal undulation in the line of sight of a long streamer upon which some dark object appeared and disappeared as the folds lifted it into, or carried it down out of, sight. The observer said that after the transit of Satellite I, all the moons were to the west of Jupiter, and he was curious to know whether the second shadow could have been cast by IV, which had transited a few hours before. The observation was made with a 10¼-inch Browning-With reflector; power 256.

The President having arrived, the Society was conducted to the dome of the Observatory, and the remainder of the evening was occupied in observing Jupiter and his second satellite, then in transit. The definition was very good with a power of 240, and the capabilities of the 6-inch Cooke refractor were well demonstrated.

SIXTEENTH MEETING.

October 6th, the President in the chair.

Mr. S. E. Peal, of Assam, India, was elected a Corresponding Member. The Corresponding Secretary was instructed to ascertain by letter whether certain distinguished astronomers, whose names were given, would accept Honourary or Corresponding Membership in the Society. The Librarian reported the receipt of publications from Mr. J. Ellard Gore, F.R.A.S., and from the Royal Society. Mr. Robert

S. Ball, F.R.A.S., Astronomer Royal, Dublin, acknowledged receipt from the Recording Secretary of communications from Dr. J. C. Donaldson and Mr. Arthur Harvey with respect to remarkable meteors observed by them. Mr. D. J. Howell described a brilliant meteor observed by him, October, 1st at 6:30 p.m., ; also a visit paid to the Warner Observatory, Rochester, N.Y., where he had been kindly received by Professor Swift, the Director. The observations reported included solar prominences and a transit on September 24th of Jupiter by Satellite III. The latter, which was very interesting, had been well observed by Dr. Donaldson and others. Mr. A. F. Miller reported that on September 27th, 9*h*., nine interesting solar prominences were visible. At 50°, a very brilliant horn-shaped flame was observed, and at 350° a curious cluster of closely associated stems. He was struck by the fact that on September 13th (or just 14 days previously) shapes almost identical with the above had been noted at practically the same points of the limb.

The Recording Secretary reported that he had received from Dr. Larratt W. Smith, Q.C., a Life Member, a fine three-inch telescope, complete in all its appointments, and in excellent condition for use by the Opera-Glass Section. On motion of Sir Adam Wilson, seconded by Mr. T. Lindsay, Dr. Smith was heartily thanked for this second substantial mark of his sympathy with the work of the Society.

SEVENTEENTH MEETING.

October 20th, the Vice-President in the chair.

The letters included a cordial one from the British Astronomical Association, and another from Professor Simon Newcomb, LL.D., of Washington, D.C., who accepted Honourary Membership. The Librarian reported publications from the Astronomical Society of the Pacific. The Chair announced the importation by Messrs. Michael Bros. of spectroscopes and other apparatus.

Observations on the sun were reported by Dr. G. B. Foster and Mr. A. F. Miller, the latter calling attention to activity in the solar northern hemisphere. Mr. J. G. Ridout, Dr. Larratt W. Smith, and the Chair referred to Jovian phenomena, including the great red spot. Mr. G. E. Lumsden reported that on the 13th of October, at 5.30 a.m., he had seen Saturn apparently devoid of his rings ; he also handed in diagrams of Wolf's Comet, as seen by him with 10¼-inch reflector, on the nights of the 10th, 11th, 12th, and 17th October. At no time was the object visible in the finder. It was picked up by sweeping for it; but, once found, it was easily picked up again, even in bright moonlight. The comet appeared like a small and much diffused nebula with a minute star a little on one side of the centre. Its course was readily traced by reason of its passage near four telescopic stars in a line and near π^2 Orionis.

A Terrestrial Season's Orrery was the name given to a new astronomical device invented and exhibited by Mr. Mungo Turnbull for the purpose of illustrating the four leading elements of celestial motion which characterize our globe in its annual pathway around the sun, viz., orbital motion, axial inclination, axial parallelism, and axial motion. This instrument is divested of all circles hitherto placed on terrestrial globes. One of the principal features is the introduction of a mechanical contrivance to represent the radius vector which unites the earth to the solar disc. This appliance is made to show the daily apparent meridian and the hour circle. A second feature consists of a fine rod to represent a pencil of the direct rays of light from the sun. This, in the hand, will solve all the phenomena of sunrise and sunset for any place between the north and south poles, thus obviating wooden horizons, etc.

LUNAR PARALLAX.

Mr. Thomas Lindsay read a paper on "Lunar Parallax." A model of the star sphere was introduced to illustrate the equatorial horizontal parallax; the reduced parallax of any place other than a point on the equator, which is expressed in terms of the equatorial parallax and the radius of the earth; the parallax in altitude, expressed in terms of the zenith distance and the horizontal parallax; and the parallax in Right Ascension and Declination. The apparatus introduced was designed to illustrate the last phenomenon as follows:—When the moon is on the meridian of a place, it is projected on the star sphere nearer to the horizon than its true place, as seen from the earth's centre. But in this position the vertical circle in the plane of which the true and apparent places of the moon lie coincides with the Right Ascension circle passing through the poles, and the hour angle is zero. When, however, the moon is off the meridian, its true and apparent places, while still in the plane of a vertical circle passing through the zenith, are on different Right Ascension circles. If an observer stood at the pole, then the vertical and Right Ascension circles would always coincide; but to an observer at any other position on the earth's surface two great spherical triangles are formed, one by the arc from pole to zenith (the co-latitude of the place of observation), the arc from the moon's true place to the pole, and the arc from the true place to the zenith ; the other by the co-latitude, the apparent polar distance and the apparent zenith distance. In the former triangle we have given the polar distance, co-latitude, and the included hour angle, which is the difference between the R. A. of the meridian and the R. A. of the true moon. With these data we compute the true zenith distance (the third arc of the triangle) and the angle at the zenith. The apparent zenith distance may be expressed in terms of the true zenith distance and the horizontal parallax, and in the second triangle we then have the arc from zenith to apparent moon, the arc from pole to zenith, and the included angle. With these data we compute the angle at the pole (the apparent hour angle) and the apparent polar distance (the third arc of this triangle). The difference between the real and apparent hour-angles is the parallax in R. A., and the difference between the real and apparent polar distance is the parallax in Declination. In all observations of the moon these corrections must be taken into account, and when they are once understood much of the difficulty in the computation of solar eclipses and occultations of stars is removed. As a practical example of this, the author then presented the following paper on

THE PARTIAL SOLAR ECLIPSE OF OCTOBER 20TH, 1892.

Mr. Lindsay said that in the graphic method of determining the circumstances of a solar eclipse, as popularized by the late Professor Loomis, and which is here closely followed, a small extent of the heavens is considered as a plane surface, and the moon's path for a very short time is regarded as a straight line. The error resulting from these assumptions is very slight, and may be entirely eliminated by a re-computation after approximate results are obtained. To an observer at the centre of the earth the sun and moon would be seen in their true positions, and an eclipse would begin at the moment when the distance between the centres would be equal to the sum of the semi-diameters. But to an observer at the surface of the earth, both sun and moon, the latter greatly, are displaced by parallax, and the problem to the real observer becomes the finding of the moment when the corrections for parallax are such that the apparent distance of the centres is equal to the sum of the semi-diameters.

For the eclipse of October 20, 1892, we have the following terms, which may be considered constant throughout the eclipse, without appreciable error :—

Sun's semi-diameter	16′ 4.7″
Moon's "	14′ 42.7″
Augmentation for altitude	5″
	30′ 52″

The constants for Toronto, the selected place of observation, are :—

Geocentric latitude	43° 27′ 55″ N.
Longitude	5*h* 17*m* 34*s* W.
Radius of earth	9.9993104

We may also consider as constant throughout the eclipse :—

Moon's Equa. Hor. Par.	54′ 2.2″
Sun's " "	8. 6″

In the construction of the figure we will consider the sun as stationary and freed from correction for parallax by deducting its parallax from that of the moon. The difference, 53′ 53″, will affect the moon's position throughout the eclipse. To reduce the equatorial parallax to that of the place, we have

Log. 3233″ , ...	3.5096057
Log. radius	9.9993104
	3.5089161 = Log. 3227″

the reduced relative parallax of the moon.

An inspection of the ephemeris shows us the time approximately * at which the contact of the limbs occurs, and we select two times near to this and take out for these instants the true places of the sun and moon and compute the true hour-angle of the latter. Selecting Greenwich Mean Time,

* For method of computing approximate time of contact from the data at conj. in R. A. see M.S. Eclipse Projection in Society's Library.

we have

	4 hrs. 50 min.	5 hrs.
	h m s	h m s
Toronto mean time . . .	23 32 26	23 42 26
Sidereal time, Greenwich mean noon	13 57 37	13 57 37
Constant correction for Toronto	51	51
Sidereal time, Toronto mean noon	13 58 28	13 58 28
Correction for interval .	27 36	17 36
Sidereal time or R. A. meridian	13 30 52	13 40 52
R. A. moon	13 41 54.5	13 42 12.5
Moon's hour-angle . .	11 02	1 20
Parallax in R. A. . . .	7.6	1
Moon's app. R. A. . .	13 42 02	13 42 13.5
Sun's R. A.	13 43 8	13 43 9.3
Difference moon west . .	1.6	55.8
In arc	990″	837″
Reduced to arc of great circle	976″	825″
Greenwich mean time	4 hrs. 50 min.	5 hrs.
Moon's true decl. . . .	9° 30′ 9″	9° 32′ 19″
Parallax in decl. . . .	43′ 25″	43′ 24″
	10° 13′ 34″	10° 15′ 43″
Sun's true decl.	10° 41′ 15″	10° 41′ 24″
Difference moon north .	27′ 41″	25′ 41″
=	16 61″	15 41″

We now proceed to construct the figure for first contact, making use of any convenient scale.

FIG. 1. From centre *S* with radius equal to sun's semi-diameter, describe a circle. From *S* perpendicular to a meridian set off 825″, the apparent difference in *RA* at 5*h* at *R*. Set off also 976″, the apparent difference in *RA* at 4*h* 50*m* at *R′*. From *R* set off perpendicular to

SR, *RM* equal to difference in apparent declination at $5h = 1541$. From *R′* set off *R′M′* equal to apparent difference in decl. at $4h\ 50m = 1661$. Join *M′M*. Then *MM′* is the relative path of the moon in 10 minutes, and the point in this line which is distant from *S* 1852″ will be the position of the moon at the moment of first contact. Join *SM*. In triangle *SMR*, we compute $SM = 1747''$, angle $RSM = 61^\circ\ 50'\ 12''$, angle $RMS = 18^\circ\ 9'\ 48''$. From *M* draw *Ma* perpendicular to *R′M′*.

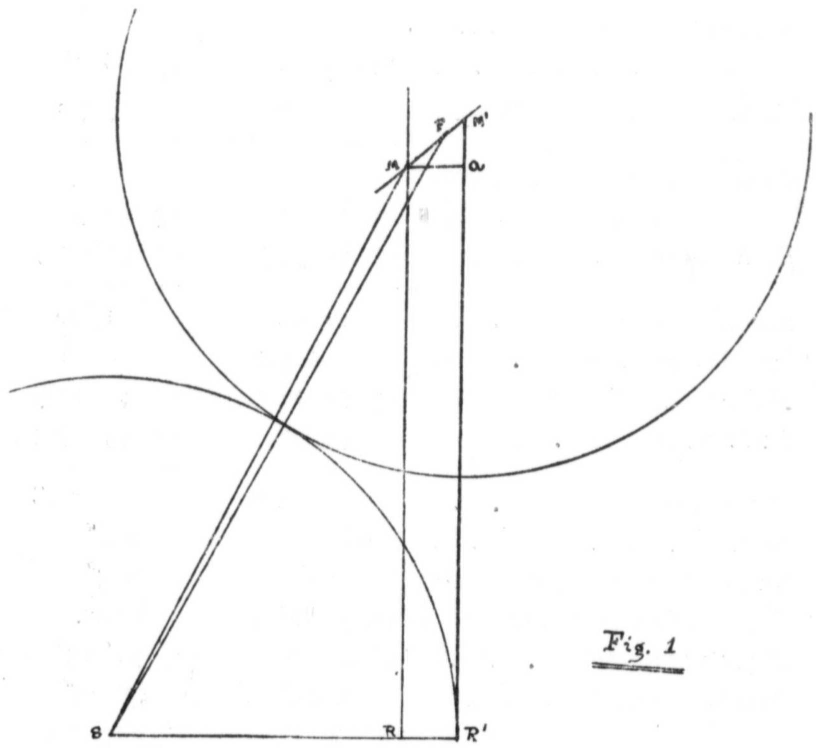


Fig. 1

Then $aM' = 120$, and $Ma = 151$. In triangle *MaM′*, we compute $MM' = 192$ = moon's path in 10 minutes. Angle at $M = 38^\circ\ 28'\ 27''$. With radius equal to 1852, the sum of the semi-diameters, describe an arc cutting *MM′* in *F*. Join *SF*, then in the triangle *SMF* we have $SM = 1747$, and $SF = 1852$, angle $SMF = 18^\circ\ 9'\ 48'' \div 90^\circ + 38^\circ\ 28'\ 27'' = 146^\circ\ 38'\ 15''$, and compute angle $MSF = 2^\circ\ 6'\ 49''$, and $MF = 124''$. Compared with 10-minute line 192″, the line *MF* measures $6.4m = 6m\ 24s$. First contact, therefore, occurs at Toronto at Greenwich Mean Time $= 5h - 6m\ 24s = 4h\ 53m\ 36s$; Toronto Standard Time $11h\ 53m\ 36s$. Angle of contact $= 61^\circ\ 50'\ 12'' - 2^\circ\ 6'\ 49'' + 270^\circ =$

329° 43′ 23″ from north point towards the east. To determine in instant of last contact, we take out the moon's places for *7h 50m* and *8h* as follows:—

Greenwich Mean Time	7 h. 50 m.	8 h.
	h m s	h m s
Toronto mean time . . .	2 32 26	2 42 26
R.A. meridian, Toronto noon	13 58 28	13 58 28
Correction for interval . .	2 32 52	2 42 52
Sidereal time, Toronto, or R. A. meridian . . .	16 31 20	16 41 20
R. A. moon	13 47 19	13 47 37
Moon's hour-angle . . .	2 44 1	2 53 43
Parallax in R. A.	1 45	1 50
Moon's app. R. A. . . .	13 45 34	13 45 47
Sun's R.A.	13 43 36	13 43 37
Difference moon east . .	1 58	2 9
Expressed in arc and multiplied by cosine of decl.	1738″	1900″
Moon's declination . . .	10° 9′ 21″	10° 11′ 31″
Parallax in decl. . . .	41′ 56″	41′ 44″
Moon's app. decl. . . .	10° 51′ 17″	10° 53′ 15″
Sun's decl.	10° 43′ 56″	10° 44′ 05″
Difference moon south .	7′ 21″	9′ 10″
=	441	550

FIG. 2. From centre S set off SR equal to diff. of RA at *7h 50m* = 1738, and set off $SR' = 1900$. From R set off $RM = 441$, difference of decl. at *7h 50m*. From R' set off $R'M'$, equal to difference of decl. at *8h*. Join MM'. From M draw Ma parallel to SR, then in triangle MaR we have $Ma = 162$, $aM' = 109$, and compute angle $aMM' = 33° 56' 3''$; $MM' = 195''$. In triangle SRM we compute angle at $M = 75° 45' 46''$, angle at $S = 14° 14' 14''$, $SM = 1793$. From centre S with radius = 1852, describe an arc cutting MM' in L, then join SL and L is the position of the moon at last contact. In the triangle SML we have

angle $SML = 360° - (33° \; 56' \; 3'' + 90 + 75° \; 45' \; 46'') = 160° \; 18' \; 11''$ $SM = 1793$; $SL = 1852$, and compute angle $MSL = 38' \; 55''$ and $ML = 62.2$. Compared with 10-minute line, $ML = 3m \; 11s$. Time of last contact is, therefore, $GMT \; 7h \; 50m + 3m \; 11s = 7h \; 53m \; 11s$. Toronto Standard Time, $2h \; 53m \; 11s$. Angle of contact$=90 + 14° \; 14' \; 14'' + 38' \; 55'' = 104° \; 53' \; 09''$ from north point towards the east.

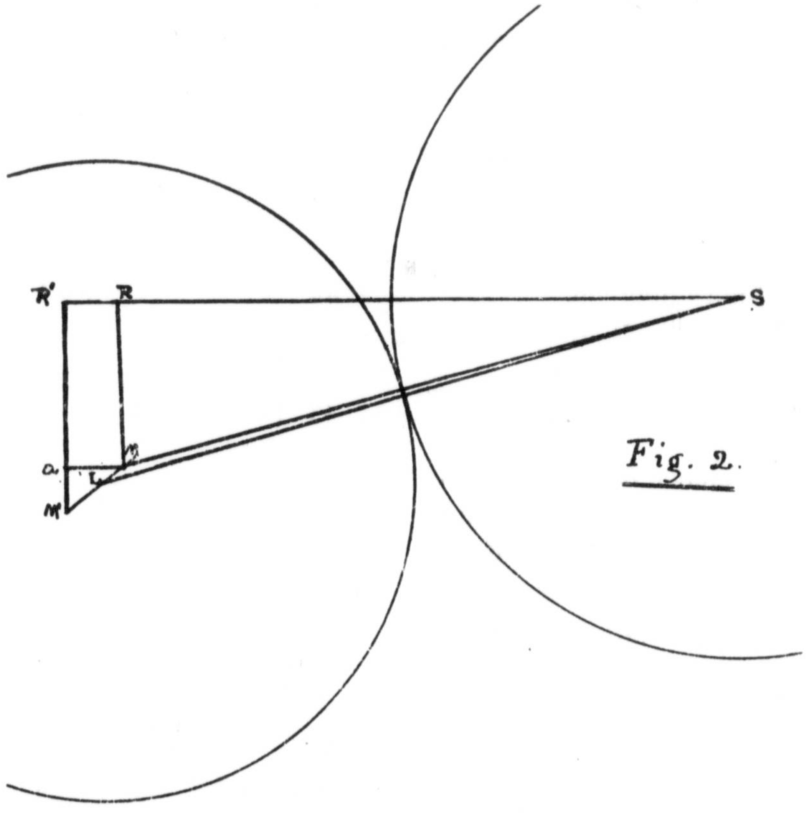


Fig. 2.

EIGHTEENTH MEETING.

An open meeting to receive a visit from Mrs. R. A. Proctor, in Toronto for the purpose of giving a series of lectures on Astronomy, was held on the evening of November 3rd, the Vice-President in the chair. There was a very large attendance of members and friends.

The communications included letters from three celebrated astronomers accepting complimentary membership in the Society. Professor Simon Newcomb, LL.D., Superintendent of the American Nautical Almanac Office, Washington, said : " I have the pleasure to acknowledge receipt of your letter inquiring if I will accept Honourary Membership in The Astronomical and Physical Society of Toronto. In reply, I beg to assure you that I should highly appreciate such an honour." Professor Edward S. Holden, LL.D., Director of the Lick Observatory, wrote: "I beg to acknowledge your very flattering letter and to say that I shall accept with pleasure the nomination to Honourary Membership in your Society. At some future time, it will give me great pleasure to submit a paper for your Reports, but, at the present moment, I regret that I am too much occupied to do more than to promise." Professor Burnham, of Lick Observatory, also gracefully accepted, and intimated that, when time permitted, he would contribute a paper. Dr. David Gill, F.R.A.S., Astronomer Royal, Cape of Good Hope, wrote respecting the exchange of publications. Dr. Sandford Fleming, C.M.G., of Ottawa, an Honourary Member, called the attention of the Society to the desirability of attempting to induce astronomers to reckon the day from midnight in place of from noon. This change, he wrote, was approved by certain eminent men, and opposed by others. Dr. Fleming suggested that the Society might very appropriately move in the direction of having a day fixed for the universal change; the first day of the Twentieth Century was sufficiently near and sufficiently remote to be in every way suitable. The letter was referred to Council.

On motion of Sir Adam Wilson, seconded by Dr. Larratt W. Smith, Q.C., Professor Simon Newcomb and Professor E. S. Holden were elected Honourary Members. On motion of Mr. D. G. Ross, seconded by Mr. J. G. Ridout, Professor S. W. Burnham was elected a Corresponding Member. On motion of Mr. Arthur Harvey, seconded by Mr. G. G. Pursey, Mrs. R. A. Proctor was also elected a Corresponding Member. All of these motions were introduced by remarks of a character highly complimentary to the candidates.

Mrs. Proctor was warmly received when introduced by the Chairman. She said she had not intended to make an address, but she spoke for a few minutes upon astronomical matters of general interest, and exhibited some excellent photographs presented to her by the Observing Staff at Lick Observatory. These included views of the Great Nebula in Andromeda and portions of the Milky Way in Cygnus, taken by Professor Barnard. She also showed an exquisite drawing of Mars made by Professor Keeler during the opposition of 1890.

Mr. T. Lindsay reported observations made of Saturn, October 25th he saw no evidence of rings. Mr. Clarence Bell, Secretary, presented the report of the Opera-Glass Section respecting the meetings held during the summer, the work done, and the plan of observation chosen for the winter. The report was adopted.

Mr. Arthur Harvey read a comprehensive memorandum upon astrolabes, their history, and use, with some reference to individual instruments which he had examined. He then described, as one of "the most interesting relics in Canada," an astrolabe owned by Mr. R. S. Cassels, of Toronto, which was made in 1603, was found in 1867 on the line of an old portage route from the Ottawa to Muskrat Lake, North Renfrew County, Ontario, and has, by a most ingenious induction, been proved to have belonged to Champlain, who must have lost it in 1613. Mr. A. J. Russell traces Champlain's course day by day until June 7th of that year, noting the latitudes as he went, within a few minutes of error. At Gould's Landing, however, he noted a latitude a whole degree astray, $46\frac{2}{3}$ of a degree, whereas the true latitude is $45^\circ\ 35'$; and the next day he was at Muskrat Lake. The day after he made no reference to latitude, but on the next he says of a spot, which is now Pembroke, "It is about 47 degrees of latitude." If he had still had his astrolabe, he would have corrected instead of carrying on the error. During the rest of the long journey he made no more observations for latitude. Mr. Harvey said he had referred to this instrument in an article on the endeavour of Champlain to reach the Hudson's Bay by the Ottawa route, published in *The Magazine of American History*.

Mr. G. E. Lumsden read a paper entitled, "The Face of the Sky for November." The paper was intended to be of some use to local observers during the winter months, and, at the same time, to take some note of interesting features connected with some of the constellations about to disappear, as well as some of those coming into good position for observation.

The Vice-President closed the meeting by speaking at some length upon the subjects brought forward during the evening, and, in the course of his remarks, referred to the work which had been undertaken by Mrs. Proctor, upon whose shoulders had fallen the mantle of her lamented husband, who, by his writings, his lectures, and his great activity, had accomplished much toward making popular the study of Astronomy. As a parallel case, the instance afforded by the death of of Henry Draper was alluded to. Mrs. Draper's work is a noble monument to her husband's memory; with the spectroscope in the hands of Professor Pickering, she has written his name among the stars, where it must remain as long as they endure. It was hoped that Mrs. Proctor would be entirely successful in the work she, too, had undertaken.

NINETEENTH MEETING.

An open meeting of the Society was held on the 16th of November, Mr. Larratt W. Smith, Q.C., D.C.L., in the chair. There was a large attendance of members and of friends to whom invitations had been sent.

Miss Sarah L. Taylor, of Lansdowne School, Toronto, was elected an active member. The following letter from Dr. William Huggins, F.R.S., F.R.A.S., F.R.S.E., Correspondent of the Institute of France, President of the British Association, etc., was read: "I feel it a great honour that your new and promising Society should have selected my name for one of your ten Honourary Members. It will give me great pleasure to accept the Honourary Membership." Very cordial and gratifying letters, also accepting nomination, were read from Mr. J. Ellard Gore, F.R.A.S., M.R.I.A., etc., of Ballysodare, Ireland, and from Mr. William F. Denning, F.R.A.S., etc., of Bristol, England. Mr. H. P. Hollis, F.R.A.S., of Greenwich Observatory, wrote with respect to publications to be sent forward. Dr. Huggins sent a copy of his address, recently delivered, to the British Association. Mr. Gore, in a second communication, transmitted a paper on the Pleiades. Regret was expressed by several members that, owing to clouds and fog, no observations whatever could be made on the night of the 13th of November, when the shower of Leo Minorids was due, or on the night of the 15th, on the occasion of the total eclipse of the moon.

On motion of Mr. Andrew Elvins, seconded by Sir Adam Wilson, Dr. William Huggins was elected an Honourary Member. In support of his motion, Mr. Elvins addressed the Society at some length on the subject of spectroscopy, its history and development, and of the debt owed by Science to Dr. Huggins. Graceful reference was made to the assistance rendered the veteran investigator by his wife.

On motion of Mr. G. E. Lumsden, seconded by Mr. J. G. Ridout, Mr. J. Ellard Gore was elected a Corresponding Member.

On motion of Sir Adam Wilson, seconded by Mr. A. F. Miller, Mr. W. F. Denning was also elected a Corresponding Member. These motions were supported by appropriate references to these gentlemen and to their work as observers and prolific writers.

After routine, the following paper, contributed by Mr. J. Ellard Gore, was read :—

THE PLEIADES.

The Pleiades form perhaps the most remarkable group of stars in the heavens, and are probably familiar to most people, even to those whose knowledge of the constellations is limited to a few of the brighter stars. The cluster is a very remarkable and beautiful one, and forms a striking object in a clear sky. There is no other group in the heavens similar to it in the brightness and closeness of the component stars. It seems to have attracted attention since the earliest ages. Job says :—

" Canst thou bind the sweet influences of Pleiades, or loose the bands of Orion ? "

Hesiod, writing nearly 1,000 years before Christ, speaks of the Pleiades in words thus translated by Cooke :—

" There is a time when forty days they lie,
And forty nights, conceal'd from human eye,
But in the course of the revolving year,
When the swain sharps the scythe, again appear."

This passage refers to the disappearance of the group in the sun's rays in summer, and their reappearance in the evening sky in the east at harvest time. Hesiod also speaks of them as the Seven Sisters, and in Cicero's *Aratus* they are represented as female heads bearing the names Merope, Alcyone, Celæno, Electra, Taygeta, Asterope, and Maia, names by which they are still known to astronomers. The origin of the name Pleiades is somewhat doubtful. Some think that it is derived from the Greek word *pleion*, to sail ; others from the word *pleios*, full, a name perhaps suggested by the appearance of the cluster. Although seven stars are referred to by Hipparchus and Aratus, Homer speaks of only six, and this is the number now visible to average eyesight. A larger number has, however, been seen with the naked eye by those gifted with exceptionally keen vision. Möstlin, Kepler's tutor, is said to have seen 14 without optical assistance, and he actually measured and recorded the position of 11 with wonderful accuracy without the aid of a telescope. In recent years Miss Airy, daughter of the late Astronomer Royal, has seen 12, Carrington and Denning 14, but to most eyes, probably, 6 only are visible with any certainty. There is a tradition that although 7 stars were originally visible, one disappeared at the taking of Troy. Professor Pickering has recently discovered that the spectrum of Pleione, which forms a wide pair with Atlas, bears a striking resemblance to that of P Cygni, the so-called "temporary star" of 1600. The similarity of the spectra suggests that Pleione may possibly, like the star in Cygnus, be subject to occasional fluctuations of light, which might perhaps account for its visibility in ancient times.

The grouping of even six stars visible to the naked eye in so small a space is very remarkable. Considering the total number of stars visible in the heavens without a telescope, Mitchell, writing in 1767, calculated by the mathematical theory of probability that the chances are 500,000 to 1 against the close arrangement of the six stars in the Pleiades being merely the result of accident. He, therefore, concludes that "this distribution was the result of design, or that there is reason or cause for such an assemblage." Although to a casual observer the component stars may appear of nearly equal brightness, there is a considerable difference in their relative brilliancy. Measures with a photometer show that Alcyone, the brightest of the group, is of the 3rd magnitude, Maia, Electra, and Atlas of the 4th, Merope 4⅓, Taygeta 4½, Celæno about 5⅓, and Asterope about the 6th magnitude. Pleione is about 5½ magnitude, according to the photometric measures made at Oxford, but it lies so close to Atlas that to most eyes the two will probably appear as one star. About 30 more range from the 6th to the 9th magnitude, and this is about the number visible with a good opera glass or binocular. Galileo counted 36 stars with his small telescope, but with modern instruments the number is largely increased. Some years since M. Wolf, the distinguished French astronomer, published a chart of the Pleiades showing about 500 stars, constructed from his own observations. Photography has further added to the number of stars in this wonderful group. On a photograph taken at the Paris Observatory in 1887, with an exposure of three hours, no less than 2326 stars can be distinctly counted on a space of about three square degrees. The faintest stars on this photograph are supposed to be of the 17th magnitude. Now as Alcyone, the brightest star of the group, is of the 3rd magnitude, we have a difference of 14 magnitudes between the brightest and the faintest. This denotes that Alcyone is no less than 398,100 times brighter than the faintest stars visible on the photographic plate. If we consider the Pleiades as forming a cluster of roughly globular form, the component stars will be at practically the same distance from the earth. The great difference of brightness is therefore very remarkable, and would suggest that Alcyone is a vastly larger sun than the smallest stars of the group. The difference of brilliancy given above would indicate that the diameter of Alcyone is 631 times greater than that of the faintest stars revealed by photography. This is, of course, on the assumption that all the stars of the cluster are, surface for surface, of the same intrinsic brilliancy, and that their apparent brightness to the eye depends simply on their diameter. As spheres vary in volume as the cubes of their diameters, we have the volume of Alcyone equal to the cube of 631, or over 250 million times the volume of the faintest star of the group. There is, however, some reason for supposing that Alcyone is nearer to the earth than the other bright stars of the cluster.

The late Rev. T. W. Webb noticed the remarkable absence of colour in the Pleiades, most of the stars being white, with the exception of "one minute ruby star, and an orange outlier." Professor Pickering finds that most of the brighter components show a spectrum of the first or Sirian type, and he says, "It is very improbable that chance alone has brought together so many bright stars in the same portion of the heavens. Most of them, probably, had a common origin."

The brilliancy of the Pleiades cluster would naturally suggest a comparative proximity to the earth. Attempts to determine their distance have, however, hitherto proved unsuccessful. This would indicate that the distance is very great, and would, of course, lead to the conclusion that the group is of vast dimensions. An effort has been made to determine the distance indirectly by a consideration of the proper motions of the principal stars. Professor Newcomb finds a proper motion for Alcyone of about 5.8 seconds of arc in a hundred years. This motion is nearly opposite to that of the sun's motion in space, and may possibly be due to that cause. If we assume that the apparent motion of Alcyone is wholly due to the effect of the sun's real motion, at the rate of, say, 14 miles a second, the distance of Alcyone would correspond to a light journey of about 267 years. Placed at this vast distance, the sun would, I find, be reduced to a small star of about 10½ magnitude, or

7½ magnitudes fainter than Alcyone. This would imply that Alcyone is 1000 times brighter than the sun. If of the same density, its volume would therefore be 31,622 times the sun's volume—a truly stupendous globe! As, however, the spectrum of Alcyone is of the first, or Sirian type, it cannot properly be compared with the sun.

There are 6 other *small* stars having proper motions similar in amount and direction to that of Alcyone. As the other bright stars of the group have much smaller motions, it has been suggested that the seven stars with comparatively large motions do not really belong to the group, but are only optically associated with it. This would imply that the real cluster lies much farther from us than Alcyone, and the comparative brilliancy of some of its component stars would still denote enormous size.

In the year 1859 the well-known astronomer Tempel, announced his discovery of a faint nebulosity extending in a southerly direction from Merope, the nearest bright star, to Alcyone. This interesting discovery was partially confirmed by other astronomers, but from its visibility to some observers with small telescopes, and the failure of others to detect it with much larger instruments, the variability of its light was strongly suspected. The question remained in doubt for many years, but has now been finally set at rest by photography, which shows not only a mass of nebulous light surrounding Merope, but other nebulous spots involving Alcyone, Maia, and Electra. Indeed, a photograph taken by Mr. Roberts in December, 1889, shows that all the brighter stars of the group are more or less surrounded by nebulosity. In the Paris photograph a remarkable narrow nebulous ray runs nearly east and west from the Maia nebula, north of Alcyone, and apparently connects some small stars of the 8th to the 11th magnitude. The nebula surrounding Maia is of a somewhat spiral form. The existence of this nebula was not even suspected until it was revealed by photography. It was afterwards seen with the great 30-inch refractor of the Russian Observatory at Pulkowa. Had, however, its existence been unknown, it would probably have escaped detection even with this large telescope, as it is one thing to see a faint object known to exist and another to discover it independently. Maia is surrounded by several faint stars of the 12th to the 14th magnitude, and the Russian observers believe that one of these is variable in light, as it was distinctly seen on February 5th, 1886, when its magnitude was carefully determined with reference to the neighbouring stars, but on February 24 of the same year it could not be seen with a telescope of 15 inches aperture. Some of the other stars of the group seem to be connected by nebulous rays with the principal nebulous centres, and in looking at this wonderful Paris chart it seems impossible to avoid the conclusion that the stars and nebulous masses are actually mixed up together, and not merely placed accidentally in the same direction in space.

At the conclusion of the reading of Mr. Gore's paper, a photograph of the group was thrown upon the screen. This picture was one of Mrs. Proctor's collection, and served admirably to illustrate the description given by Mr. Gore.

Mrs. R. A. Proctor, who was present by invitation, addressed the Society for upwards of an hour on "The Lick Observatory and its Work." By means of many excellent views thrown upon a screen by a lantern manipulated by Mr. D. J. Howell, Mrs. Proctor's description of the observatory and its surroundings was rendered most entertaining. The views included the great Lick telescope, the great spectroscope, the transit instrument, the observatory in summer and in winter, in cloud and in sunshine, the offices and cottages of the observers, Mount Hamilton, on the top of which the buildings are situated, the approaches, and some most charming bits of winter and summer scenery in the neighbourhood taken by Professor Burnham. It appears that Mrs. Proctor was for some weeks the guest of the professors at the observatory, and that she enjoyed exceptional privileges in the use of the telescopes. Every Saturday night the observatory is free to the public, and she stated that she had more than once seen, waiting their turn, a couple of hundred ladies and gentlemen, who had ridden twenty-six miles from San José, the nearest town, knowing that at most each of them would have to be content with but one moment's peep through the great refractor, and that they would all have to return the same night to San José, as there was no accommodation for them on Mount Hamilton. This was thought to be evidence, indeed, of enthusiasm in the study of Astronomy.

Mrs. Proctor received a hearty vote of thanks for her address and the views, which included some very fine ones of Jupiter, certain nebulæ, and portions of the Milky Way. Complimentary remarks were also made by Sir Adam Wilson, Mr. Elvins, and the Chairman.

TWENTIETH MEETING.

December 1st, the Honourable Sir Adam Wilson in the chair.

Among the communications read was the following received from Dr. W. H. M. Christie, F.R.S., F.R.A.S., Astronomer Royal, Greenwich: "It will give me much pleasure to accept the nomination as Honourary Member of the Astronomical and Physical Society of Toronto, with which you propose to honour me; and, if elected, I shall highly esteem the distinction which your Society confers upon me." Miss Agnes M. Clerke, of London, England, also wrote: "I have great pleasure in accepting the flattering offer which you have been so kind as to transmit to me. I shall consider it a high honour to be affiliated, in the manner you propose, to The Astronomical and Physical Society of Toronto, which already gives promise of being a powerful agency for the promotion of astronomical activity in your great country. The first Report, which I had the pleasure of receiving yesterday, is full of interest, and I hope on the first opportunity to offer some small contribution to it. I fear I can suggest little that might be effective for pressing the ladies of Toronto into the service. The means already adopted by you, of *showing off* the heavenly bodies, I should have thought most likely to be successful. Popular lectures might be a further help. The main thing is to kindle a spark, the rest might be left, comparatively speaking, to take care of itself—though, indeed, the really effective workers in astronomy are only a few out of many." Miss Clerke's advice on the point referred to had been sought

On motion of Mr. Arthur Harvey, seconded by Dr. G. B. Foster, Dr. Christie, Astronomer Royal of England, was elected an Honourary Member. In addition to his complimentary references to Dr. Christie, Mr. Harvey dwelt upon the signal honour done the Society by the very cordial manner in which invitations to become associated with it had been acceded to by such eminent astronomers as Dr. Christie, Dr. Newcomb, Dr. Huggins, Dr. Holden, Miss Clerke, and the other ladies and gentlemen nominated and elected. On motion of Mr. A. F. Miller, seconded by Mr. John A. Paterson, M.A., Miss Clerke was elected a Corresponding Member. High tributes were paid by the mover and seconder and the Chairman to the distinguished candidate, whose excellent works were in the Society's library and had been read with much interest. Mr. William A. Mitchell, of Toronto, was elected an active member. Mr. G. E. Lumsden gave notice that at the next meeting he would move that the Society's Constitution be amended in certain respects.

The following is a synopsis of a paper on

PHOTOCHROMY,

read by Mr. Arthur Harvey, who exhibited a photograph of the solar spectrum, received by him direct from Professor Lippmann, of Paris, the discoverer of the new method of photography in colours, and understood to be the first specimen of the art that had crossed the Atlantic. After reviewing the wave theories of light and sound and the theories of "interferences," Mr. Harvey continued: If we place a reflecting surface behind a sensitized film and expose it in the camera, focussed on a red object, each reflected ray must interfere with the direct ray which produces it, and thus planes of interference will be formed, the thickness of the film being divided into just so many parallel sections as there are semi-wave lengths of red therein; for the chemical change in the silver-salt will chiefly occur half-way between these planes of interfering nodes. If we expose the plate to the complete spectrum, each colour will produce its separate series of such strata. It would seem, therefore, that to place a mirror behind an ordinary dry-plate should produce the effect of colour without more ado, and I incline to the belief that this may yet be done, if we work with care and choose special plates. It is found, however, that in drying ordinary plates the substance of the film granulates, and, in practice, a wet plate has to be resorted to; one coated with both collodion and albumen by the "Taupenot" process is preferred. Plunged into a 10 per cent. solution of nitrate of silver, bromide of silver is formed within the surface of the film, and our sensitized plate is ready. For the mirror, a surface of mercury is resorted to, as silver would be immediately dimmed by the chemicals from the film. We are now met by the difficulty of the very different actinic power of the rays of differently coloured light. An exposure long enough to bring out the violet and blue tints will not bring out the yellows and the reds, and when these latter are brought out the blues and violets will be over-exposed. Prof. Lippmann, to overcome this difficulty, resorted to the use of coloured screens in his first experiments, but in later practice he has prepared plates as sensitive to red as to blue, so that he has lately been able to photograph in six minutes a complete spectrum without recourse to screens at all. The spectrum was that produced by an 800 candle power electric light. By concentrating such a spectrum with a lens, it was recently photographed in two minutes by M. Moltein before the Photo. Club of Paris, and I hope next year to repeat the experiment before this Society. The development of the plate thus obtained demands a moment's attention. It is plunged into a bath of pyrogallic acid and sesqui-carbonate of ammonia. When the image becomes visible in black, it is fixed in weak hyposulphate of soda, well washed, and set out to dry. Then comes the magical apparition of the colours, each tint appearing in due sequence. The film being swollen by the washing, the red has its planes of silver too far apart to reflect colour of any kind, while the planes due to violet wave-lengths are so far separated from each other that they reflect a red. As the drying proceeds, this red shifts towards its proper place, and in its stead the green appears, which in turn gives way to blue, and finally, when the plate is dry, the violet shows its lovely tint at one end, while the red has taken up its position at the other, to which it legitimately belongs. It remains for experience to suggest improvements, and I have brought the matter forward here that Canadians may be thinking of it, too. It has occurred to me that a polished plate of aluminum might be used instead of mercury, and it is possible that a coating of mercury and tin, put upon the reverse side of a plate in the usual inexpensive method of looking-glass factories, and then prepared, may give good results.

The paper was followed by a very spirited discussion. With the Society's lantern, partially successful efforts were made to throw the colours of the spectrum on a screen.

TWENTY-FIRST MEETING.

December 15th, the Vice-President in the chair.

Messrs. John M. Clark, M.A., J. W. Horne, and J. McIntosh, of Toronto, were elected active members. Owing to absence, Professor Carpmael wrote to say that he had received from the Canadian Institute an offer to transfer to the Society a paper sent to the Institute on the subject of "The Mitchell Method of Determining Stellar Occultation."

The Secretary was instructed to obtain the paper for examination, with a view to its being read and published. Mr. D. J. Howell, for the Committee, reported progress with respect to securing a set of lantern-slides to be used for popular lectures on astronomy in this city and elsewhere. As the slides were likely to prove to be expensive, it was suggested that a special fund should be raised to procure them. As the revenues of the Society are limited to receipts from very moderate membership fees; as the objects are worthy, and as the slides are to be used for the instruction of the public chiefly, it was thought the fund was one to which citizens generously inclined might, with great propriety, contribute. Mr. Howell stated that very kind letters had been received by him from Mr. A. Cowper Ranyard, editor of *Knowledge*, and others. The Librarian reported the receipt of publications from the Carleton College Observatory, and, through Dr. J. C. Donaldson, of Fergus, of a number of copies of Messrs. Cooke's suggestions regarding "The Adjustment and Testing of Telescopes."

Among the observations reported, was one by Mr. G. E. Lumsden, who had, on the 12th of December, observed the latter part of the transit, in company, of Satellites III and IV across Jupiter's disc—not a very frequent occurrence. The egress of III and IV took place at 5.27 and 6.30, Eastern Standard Time, respectively. Though the sky at Toronto was hazy throughout the observation, the obscuration was not sufficient to efface planetary detail; even the presence of the great red spot could be detected. III emerged from the disc without noteworthy feature. After it was well off, IV was seen within the limb as an elliptical dark object with a heavily-shaded edge toward the planet's centre. After that, for fifty-two minutes, the observer could not be certain that he could see the satellite at all, though the other moons were plainly visible, and of the same golden hue as the planet. Emergence of IV was not detected, nor was any evidence of the moon (save an occasional bit of patchy brown light straggling between Jupiter and III) caught until 7.49, when it was with difficulty glimpsed as a dark-red ball half way between the planet and III. The colour was precisely that of a moon gradually emerging from eclipse. When seen, IV had the appearance of an object at a distance enormously beyond the planet and not connected with it. At no time up to 9.19, when observation ceased, could IV be seen readily like the other moons. The observation was made with a 10¼-inch reflector; power 256.

The peculiar appearance of Satellite IV was also observed by Mr. J. C. Donaldson, LL.D., of Fergus, sixty-five miles north-west of Toronto. Dr. Donaldson, who had a clear sky, wrote:—"On coming back to the telescope (a 3½ inch refractor by Cooke), about 6.35, I fancy, I saw that IV had emerged from transit, and I could not help noticing the great contrast in colour between it and III, and Jupiter itself, being of a dark-bluish colour, apparently so dark, in fact, that when I tried a 2¼ inch glass upon it, I could scarcely detect it all. In the larger glass, the sight was very interesting, the two Satellites looking almost like a close double-star of complementary colours, III being of a golden yellow, and IV of a dark-blue colour."

In the ensuing discussion, it was suggested that the bluish colour seen by Dr. Donaldson might have been due to the use of a refractor—excellent as his instrument is known to be. One of the members called attention to the fact that though III had transited some hours previously, its shadow has not entered on the planitary disc. He asked whether it was possible for this shadow, lying across and in front of the planet, and between it and the observer, to be so illumined by the bright reflected light from Jupiter, as to alter, in any way, the appearance of IV, supposing that Satellite to have been, as it were, projected against said shadow as seen from the earth. The observation was communicated to the editor of *The Sidereal Messenger*, who published it in the January number of *Astronomy and Astro-Physics*, and promised to refer to it in the February number.

On motion, amendments to the following effect were made in the Constitution of the Society:—(*a*) The date for holding the annual meeting was changed to the second Tuesday in the month of January; (*b*) provision was made for the appointment of an Honourary President and of two Vice-Presidents; (*c*) it was declared that the Council should consist of the Executive Officers, of two representatives from each Section, and of five active members to be chosen by the Society, the Honourary President to be a member *ex officio*, six members to form a quorum; and (*d*) that the annual membership fee should be $2, said fee when paid after the 1st of October by a newly-elected member, to cover the remainder of the year as well as the whole of the ensuing one. It was resolved that nominations for executive officers should be made at the meeting next preceding each annual meeting, and that nominees should, upon nomination, state whether they would act if elected. It was arranged that payment of Life Membership fees should be funded and not used to meet current expenses.

The paper of the evening was one contributed by Mr. Joseph Morrison, M.A., M.D., Ph.D., F.R.A.S., of the Nautical Almanac Office, Washington, and an Honourary Member of the Society. The paper, which is given in full, is as follows:—

SOLAR HEAT.

Among the numerous problems which confront the astronomer at every step of his researches into the arcana of Nature, none is of more absorbing interest than that of Solar Heat. The sun has been radiating into space a prodigious quantity of heat for an inconceivably long period of time, and that, too, without any apparent visible source of supply. In the present state of our knowledge of solar physics, only two theories are advanced to account for the source and maintenance of solar energy—the contraction theory first proposed by Helmholtz, and the meteoric theory of Meyer.

In the former, the sun is regarded as a huge globe of incandescent gases slowly contracting under its own gravity, by which a portion of its potential energy is being continually converted into molecular energy or heat. In the latter, the solar heat is ascribed to the incessant falling of meteoric matter on the sun, the mass-energy of the meteoric matter being suddenly converted into molecular energy which appears chiefly as heat. The contraction theory is in entire harmony with the nebular hypothesis of the formation of the solar system—a hypothesis first propounded by Sir William Herschell from a careful study of the nebulæ, and subsequently and independently by Swedenborg, Kant, and Laplace, and now very generally accepted by scientific men as the true cosmogony of our system.

This hypothesis sets out with the assumption that the matter composing the sun and planets once existed as a vast gaseous nebula extending far beyond the orbit of Neptune, and having an exceedingly high temperature; that this nebula, by the combined attraction of similar masses and under the action of its own gravity, would have not only a motion of translation, but also would assume an approximately spherical figure, with a rotation round an axis passing through its centre of gravity; that as the mass cooled by radiating heat into space, contraction of volume would take place, the axial rotation would be accelerated, and, when the acceleration due to the centrifugal force in the equatorial regions became equal to or greater than that due to gravity, a large segment of vaporous matter would become detached or set free, and would eventually condense under the mutual action of its own particles into a planet, and that this planet, too, might, under certain circumstances abandon or set free, in a similar manner, a ring or segment of vapor which would finally become a satellite. If the rings or segments of vaporous matter were not of uniform thickness or density, they might break up in the process of condensation and form several planets, such, for instance, as exist between the orbits of Jupiter and Mars; or if perfectly uniform and homogeneous, they might retain their ring-like character, as in the well-known rings of Saturn. This process repeated would set free one segment after another, each being denser than the one preceding, until the central glowing sun would alone remain.

The solar system furnishes many facts which confirm this hypothesis. All the planets revolve about the sun in the same direction, and in elliptic orbits of small eccentricity, whose planes nearly coincide with the plane of the sun's equator; the sun himself and all the planets, so far as known, revolve on their axes in the same direction, and the satellites revolve about their primaries in the direction of the planets' axial rotation. The planets Uranus and Neptune form an apparent exception; their satellites have a retrograde motion round their respective primaries, and the planets themselves probably have a retrograde motion on their axes, but this circumstance is by no means inconsistent with the hypothesis. The direction of the axial rotation of the planet resulting from the segment set free from the central contracting mass will depend chiefly on the manner in which the matter is distributed in the segment. If, for instance, the segment were of uniform density throughout, so that the resulting planet would be formed at or without the middle, the motion would be retrograde, because the particles on the inner edge would control the direction of rotation, they having a greater moment of rotation with respect to the forming planet than the particles on the outer edge; but, on the other hand, if the inner edge of the segment were the denser, then the particles on the outer edge would control the rotation, which would be direct. Moreover, as will be shown presently, if the sun's mass were expanded until his surface would reach each of the planets in succession, the period of his axial rotation in each position would be exactly equal to the periodic time of the corresponding planet, and so also would the time of rotation of the primary planets, expanded in like manner, be equal to the times of revolution of the satellites. The only exception to this relation is found in the case of the inner satellite of Mars. There are, however, forces at work in the Martian system capable of producing the anomalous circumstances that exist there, and which in time will be fully compensated. The satellite is probably subject to an inequality of an immensely long period, depending on the secular variation of the eccentricity of the orbit of Mars, and its motion is also no doubt retarded, and its periodic time consequently shortened by tidal action. This equality in the axial rotations of a primary planet and its satellite, when the former is expanded until its surface reaches the latter, is easily shown as follows: Take, for example, the earth and its satellite; let r and t denote the radius and time of axial rotation of the earth as at present, and let R and T denote the same quantities when the earth's mass is expanded until it includes the moon's orbit; let also g denote the acceleration due to gravity at the earth's equator, and f and F the acceleration due to the centrifugal force at the equator, when the earth's radius is r and R respectively; then we shall have

$$f = \frac{4\pi^2 r}{t^2} \qquad (1)$$

and

$$F = \frac{4\pi^2 R}{T^2} \qquad (2)$$

therefore

$$\frac{f}{F} = \frac{r}{R} \cdot \frac{T^2}{t^2}$$

$$= \frac{T^2}{nt^2} \quad \text{if } R = nr$$

whence

$$T = t\sqrt{\frac{nf}{F}} \qquad (3)$$

Now t = 86400 seconds = .997269 day, n = 60.27, f = 1.3350 inches, and $F = \frac{g}{n^2}$ = .10628 inch; substituting these values in (3), we find T = 27.4396 days, which is almost the exact period in which the moon makes one revolution round the earth, the slight discrepancy being due to the spheroidal figure of the earth, by which the values of F, f, and r are slightly changed. If the same process be applied to the sun and each planet in succession, using the mean values of the quantities that enter into equation (3), it will be found that the time of the sun's axial rotation will be identical in every case with the periodic time of the planet.

Assuming, then, that the sun has attained his present dimensions by the slow contraction of the original gaseous nebula, in accordance with the nebular hypothesis, let us now enquire how much the sun's volume must contract in any given time in order to generate the amount of heat radiated in the same interval.

According to the observations and experience of the last twenty centuries, the amount of solar heat radiated annually has been sensibly constant, since the same latitudes have preserved the same climate and the same fauna and flora that they had in the earliest historic times.

Heat is measured by an arbitrary unit called a *calorie*, which is the quantity of heat required to raise the temperature of one *kilogram of water one degree* centigrade; and most carefully conducted experiments have shown that each square metre of surface receives from the sun, when his rays are vertical, from 25 to 30 of these calories per minute, allowance being made for atmospheric absorption which amounts to about thirty per cent. of the whole even under the least favorable circumstances, and this quantity, viz., "Twenty-five calories per square metre per minute," has been adopted as the unit in estimating the quantity of solar heat, and is known as the "*Solar Constant.*" It will, however, conduce to a better appreciation of this unit to express it in the English system of weights and measures.

Denoting the calorie as above defined by C, and the quantity of heat required to raise *one pound* of ***water*** through *one* degree *Fahrenheit* by J, we shall have the following relation:—

C = quantity heat to raise 1 kilogram of water $1^\circ\ C$,

= " " 2.20462 lbs. " $1.^\circ 8\ F$,

or, $\frac{C}{1.8 \times 2.20462}$ = quantity to raise 1 lb. of water $1^\circ\ F$,

$= J$

hence, $C = 1.8 \times 2.0462\ J = 3.968316\ J$ (4)

Again, 1 square metre receives 25 C in 1 minute

or, 10.764 square feet receive 25 C in 60 seconds or, 1 square foot receives $\frac{25\ C}{10.764 \times 60}$ in 1 second,

or, " " $\frac{25 \times 3.968316\ J}{10.764 \times 60}$ in 1 second,

or, " " $.15361\ J$ in 1 second;

that is to say, one square foot of surface receives in one second of time .15361 thermal units.

The Quantity of Heat Radiated.

We can now find an expression for the quantity of heat radiated: thus, let D denote the earth's distance from the sun, *expressed in feet*; then, π denoting the ratio of the circumference of a circle to its diameter, we shall have for the surface of a sphere whose radius is D, $4\ \pi\ D^2$, and every square foot of this surface receives .15361 thermal units in one second of time; therefore the whole quantity radiated in one second is $.61444\ \pi\ D^2$ thermal units.

The Quantity of Heat Generated.

In the process of contraction, each particle at the sun's surface moves towards the centre by an amount equal to the diminution of the radius, but the particles below the surface will move less, in consequence of the diminished force of gravity, which within the sphere varies directly as the distance from the centre. The whole mass of the sun then shrinks or falls gradually towards the centre, being, however, intensely resisted by the elasticity of the compressed gases within; but the quantity of heat generated under such circumstances will be the same as if the mass had fallen freely through the same distance and then been suddenly stopped.

Let R, denote the sun's radius,
r, the radius of any point P, below the surface,
x, the linear contraction of the radius R,
x_1, the linear contraction of the radius r,
G, the force of gravity at sun's surface,
g, the force of gravity at the point P,
and Δ, the sun's mean density.

Then we shall have the relations

$$\frac{x}{x_1} = \frac{R}{r} \text{ and } \frac{G}{g} = \frac{R}{r}$$

whence

$$gx_1 = Gx\frac{r^2}{R^2} \qquad (5)$$

The volume of a thin concentric shell whose radius is r and thickness dr is $4\pi r^2 dr$, and the weight is $4\pi g \Delta r^2 dr$; and since every unit of this falls, x_1 feet in one second, the kinetic energy generated in one second by the shell alone is $4\pi g \Delta x_1 r^2 dr$; or eliminating gx_1 by (5), we have

$$\frac{4\pi\Delta Gx}{R^2}\int_0^R r^4 dr = \frac{4}{5}\pi\Delta GxR^3 \qquad (6)$$

which is the kinetic energy generated by the fall of the weight $\frac{4}{5}\pi\Delta GR^3$ through x feet, or by the fall of a weight $\frac{4}{5}\frac{\pi\Delta GxR^3}{772}$ through a height of 772 ft., but one pound falling 772 feet develops heat enough to raise one pound of water through one degree Fahrenheit or one thermal unit; therefore the number of thermal units generated in one second by the entire mass is $\frac{4}{5}\frac{\pi G\Delta xR^3}{772}$, and since the quantity of heat radiated is assumed to be equal to that generated, we have

$$\frac{4}{5}\frac{\pi G\Delta xR^3}{772} = .61444\pi D^2$$

$$\text{whence} \quad x = \frac{592.9346D^2}{G\Delta R^3} \qquad (7)$$

Now the mean density of the sun is about 1.39 that of water, one cubic foot of which weighs 62.424 pounds, and the intensity of gravity at the sun's surface is 27.65 times greater than at the earth's surface; therefore we have

$$G\Delta = 27.65 \times 1.39 \times 62.424$$
$$= 2399.1728 \text{ pounds.}$$

Again, the latest determination of the solar parallax makes the sun's distance to be 92,796,950 miles; and since the apparent angular semi-diameter of the sun is $16' \, 2'' = d$, we have $R = D \sin d$; making these substitutions in the preceding value of x and expressing D and R in feet, we get

$$x = \frac{592.9346D^2}{2399.1728D^3 \sin^3 d} = \frac{592.9346}{2399.1728\, D \sin^3 d}$$

$$\text{or,} \quad x = \frac{1}{4.0462688 \times 92796950 \times 5280 \sin^3 d}$$

$= .000004972$ feet in one second, or 156.9 feet in a year, or 29.716 miles in a thousand years.

Now 450 miles of the sun's diameter subtends at the earth an angle of 1″, and therefore it would require 7575 years for the sun's angular diameter to be reduced by one second of arc, which is the smallest angle that can be accurately measured on the solar disc. The preceding result, derived from the best available data and on the most liberal assumptions, must of course be regarded as only approximate, since an accurate determination of the quantity of heat generated would require a knowledge of the law of variation of the sun's density from the surface to the centre. Since the amount of heat annually received by the earth is sensibly constant, the contraction of volume must be uniform, or very nearly so, but slight changes in this respect could only be detected after long intervals of time. If the contraction exceed 157 feet per year, the sun must be growing hotter, notwithstanding the enormous amount of heat radiated; but if the shrinkage is below this, then the sun must be growing cooler, and this is the more probable supposition. Assuming that the contraction theory is correct, and there appears to be no good reason for rejecting it, the present condition of things cannot be eternal;—a time will come when the sun will cease to radiate heat sufficient to maintain animal and vegetable life on the earth. At the present rate, the sun's apparent angular diameter will attain three-fourths of its present value in about two millions of years, and the density will then be about $2\frac{1}{3}$ times what it is now. The prodigious radiation of heat during this long period and under such changed circumstances will likely reduce the temperature to a point below the critical temperature of some of the gaseous constituents, especially the gases of the metals, and condensation must take place, with a corresponding decline in the temperature.

As soon as a liquid or solid crust is formed on the surface, the radiation of heat must rapidly diminish. Long before this occurs, the human race will probably have disappeared from off the face of the earth. Driven from the temperate zones by the encroaching ice, they will finally be enclosed within the tropics, where they will finally perish from the intense cold, nor will it require a very great change to accomplish this. A reduction of from 60 to 70° Fahrenheit in the mean annual temperature of the earth will be more than sufficient to seal it in eternal ice.

In consequence of the condensation, and the reduction of temperature which must necessarily follow, the light of the sun must also undergo a change of colour. At present the rays of the blue end of the spectrum appear to predominate, which indicates a high degree of molecular activity; but the time will come when the sun will emit a greenish light, and this will be succeeded by yellow, orange and red. The sidereal heavens furnish numerous examples of stars (suns to other systems) in all these stages of development; thus we have bluish stars in great numbers; green stars, as γ Andromedæ and ε Böotis; yellow, as in η Cassiopeiæ and β Cygni; orange, as Arcturus; and, finally, red stars in considerable numbers, the most noted of which are Aldebaran, Betelgeuse, o Ceti, and α Scorpii. Nearly all the variable stars give a reddish light which indicates a low degree of molecular energy; they have probably long since passed their maximum stage of development and are now approaching that of final extinction.

The sun may die, and his light and heat be extinguished, but he will not die eternally, for this would imply the destruction of the entire universe. By some process which far transcends human knowledge or even the power of the human mind to conceive, he will be resurrected as a gaseous nebula, endowed with all its pristine vigour, and destined for the formation of a new sun and a new system of planets and satellites.

Before dismissing the subject, let us examine briefly the meteoric theory of the production and maintenance of solar heat. This theory assumes that there is an incessant shower of meteoric matter falling into the sun. Now it is well known that when a moving body is suddenly stopped, its energy of visible motion, or its mass-energy, as it is called, is transformed into molecular energy, which shows itself as heat or light or both, according to its intensity. We have a familiar and instructive example of this in the case of a cannon ball projected against the side of an iron-clad ship; the ball is suddenly arrested, but the iron plate is melted by the intense heat thus produced.

It is shown in works on dynamics that if a body falls from an infinite distance towards a centre of force whose attraction varies inversely as the square of the distance, its velocity v is given by the very simple relation

$$v = k\sqrt{\frac{2}{r}},$$

where r is the radius of the attracting body and k a constant. In the case under consideration, k is the well known Gaussian constant of solar attraction; and when one solar day and the earth's mean distance from the sun are taken as the units of time and space, we have log. $k = 8.2355814$; when one second and one mile are the respective units, then log. $k = 5.2503688$; expressing r in feet (432794.7×5280), the above formula gives $v = 382.6$ miles per second, which is the greatest velocity a body falling freely into the sun can have. If K denote the kinetic energy of a moving mass, M, we have

$$K = \frac{M}{2} v^2 \qquad (8).$$

Now, the kinetic energy of one pound falling freely through a height of 772 feet develops one thermal unit, or

$$K_0 = \frac{m}{2} v_0^2 \text{ and } v_0^2 = 2gh$$

$$= \frac{mg}{2g} . 2gh.$$

$$= W_0 h = 772 \qquad (9)$$

where g denotes the acceleration of gravity, h the height, 772 feet, and W_0 the weight, 1lb. Dividing (8) by (9) and denoting the number of thermal units by N, we have

$$N = \frac{K}{K_0} = \frac{M}{2 \times 772} v^2$$

$$= \frac{Mg}{2g \times 772} v^2 = \frac{W}{2g \times 772} v^2 \qquad (10).$$

Making $v^2 = 382.6$ miles (expressed in feet),

$g = 32.2$ feet, and $W = 1$lb.,

we get $N = 82,340,000$ thermal units;

that is to say, a quantity of matter which weighs one pound falling freely from an infinite distance to the sun would develop by its kinetic energy no less than 82,340,000 units of heat,—a prodigious quantity, which would be utterly incredible were it not established by rigid mathematical demonstration. We may now enquire how much meteoric matter would be required to fall into the sun in order to produce all the heat radiated. Equating the second member of the last equation to the expression for the amount of heat radiated, viz., $.6144 \pi D^2$, we get

$$\frac{Wv^2}{2g \times 772} = .6144 \pi D^2$$

and solving for W, all the quantities being expressed in feet, we have

$$W = \frac{2g \times 772 \times .6144\, \pi\, D^2}{v^2} \qquad (11)$$

Comparing this with the weight of the earth, which we denote by $E = 83.2\, \pi \delta\ r^3$, (where r is the radius expressed in feet and δ the density) we have

$$\frac{W}{E} = \frac{2g \times 772 \times .6144\, D^2}{83.2\, v^2\, r^3 \delta}$$

and

$$W = .0000000000041956\, E$$

in one second, or in a year

$$W = .01324\, E \qquad (12);$$

that is to say, a quantity of meteoric matter a trifle greater than $\frac{1}{100}$ of the earth's mass falling on the sun annually, with a velocity of 382.6 miles per second, would develop all the heat radiated. While a very small fraction of the solar heat may be developed in this way, the theory is, on the whole, utterly untenable for the simple reason that if such a quantity of matter were annually poured into the sun, its presence would be felt by perturbations in the motions of Venus and Mercury, and observation indicates no such disturbance. Moreover, the earth itself would intercept a portion of this meteoric shower, and would receive therefrom nearly one-third as much heat as it does from the sun. Indeed, the bombardment the earth would receive from such a fall of meteoric matter would render it uninhabitable.

TWENTY-SECOND MEETING.

December 29th, Mr. Arthur Harvey in the chair.

The Corresponding Secretary read the following, among other, letters:—

LICK OBSERVATORY, University of California,
MOUNT HAMILTON, Nov. 16th, 1891.

DEAR SIR,—I beg to acknowledge the receipt of your letter of the 9th November, informing me that the Astronomical and Physical Society has elected me one of its Honourary Members, and to ask you to transmit to the Society my acceptance, with an expression of my high appreciation.

I am, dear Sir, very faithfully yours,

EDWARD S. HOLDEN.

190 UPPER TULSE HILL, S.W., LONDON,
3rd December, 1891.

DEAR SIR,—May I ask you to convey to the Astronomical and Physical Society of Toronto my high appreciation of the honour they have conferred upon me in electing me an Honourary Member, and the assurance of the pleasure which it gives me to be associated with a society which, I am sure, has a great future before it, and will undoubtedly contribute much to the study of Astronomy in Canada.

I remain, yours very faithfully,
WILLIAM HUGGINS.

Nautical Almanac Office, Bureau of Equipment, Navy Department,
WASHINGTON, December 15th, 1891.

DEAR SIR,—I beg to acknowledge, with many thanks and high appreciation, my election to Honourary Membership in your Society. I was indisposed when your notification arrived, hence the long delay.

Very respectfully,
S. NEWCOMB.

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68 REDCLIFFE SQUARE, LONDON, W.C., Dec. 15th, 1891.

DEAR SIR,—Thank you for your kind note of December 2nd, announcing my election as a Corresponding Member of The Astronomical and Physical Society of Toronto. I am very sensible of the honour done me, and feel greatly obliged to Messrs. Miller and Paterson for their evident cordial recommendation of my candidature. I will keep the paper carefully in mind, and try to make it interesting.

Believe me to be, faithfully yours,
AGNES M. CLERKE.

ROYAL OBSERVATORY, GREENWICH, Dec. 17th, 1891.

DEAR SIR,—May I ask you to convey to The Astronomical and Physical Society of Toronto my sincere thanks for the great honour they have done me electing me an Honourary Member of the Society.

Yours faithfully,
W. H. M. CHRISTIE.

The Secretary said he had also received acknowledgments from Professor Burnham, and from Messrs. J. Ellard Gore, F.R.A.S., and W. F. Denning, F.R.A.S.

The editor of *The Sidereal Messenger*, in the course of a communication, intimated that he would be glad to receive for publication, notes respecting interesting observations.

Nominations of members to be elected officers and members of

Council were received. At the request of the Treasurer, the Chair nominated two auditors of the accounts for 1891. Messrs. James Todhunter and D. G. Ross were appointed.

Mr. G. E. Lumsden stated that, with the, perhaps too great, enthusiasm of an amateur, he had ventured to bring to the notice of Mr. W. F. Denning, of Bristol, Eng., and of Professor E. E. Barnard, of the Lick Observatory, some account of his observation of the supposed double-shadow cast on the disc of Jupiter by Satellite I on the night of September 20-21. Those noted observers of Jovian phenomena had been good enough to reply. Leave to read portions of their communications was asked and granted.

Mr. Denning having explained that the phenomena could not have been observed in England under any circumstances, the planet having set, went on to say: "I would suggest that the 'second-shadow,' which followed the true shadow of I, was a dark spot on the southern equatorial belt. A number of such spots have been visible on this belt during past months, and they fade away at the edges and sometimes exhibit a 'ragged' appearance, just as described. I think there is very little doubt that your 'second-shadow' was a spot on the surface of Jupiter. As to its disappearances and re-appearances, we may readily account for them on the theory of atmospheric undulations. The rippling of the image causes the obliteration of the details for short intervals. Moments of steady definition, when the air is quiet, come between, and it is then a spot becomes quite conspicuous. A few seconds later, a wave of disturbance passes over it and the spot loses its definite form. It becomes confused with other markings until another short interval of good definition reproduces it in the same definite character as before. Of course, these changes are only apparent, and are entirely due to the seething vapours in our atmosphere. I merely suggest this explanation as the most feasible that occurs to me. I don't see how we can possibly assume that there is a duplicate shadow to I. And the vanishing and re-appearing of the spot you saw is most easily accounted for by air disturbances. I have often seen Jupiter's spots subject to this intermittent visibility, and from the cause here assigned. The second-shadow could not have been the shadow of IV, as the egress of this shadow occurred at 4.30 G.M.T., Sept. 20. The Nautical Almanac gives 17.18 G.M.T. for the egress of shadow of I, thus agreeing exactly with your observation."

Mr. Lumsden said he feared he had failed to make clear to Mr. Denning his meaning when he asked whether it was possible for Satellite IV, shining by its own light, to cast obliquely, as it were, the fainter shadow to which he had called attention. With great force, Mr. Denning urged that the shadow was really a dark spot on the planet. With much diffidence, Mr. Lumsden ventured to doubt that such was the case. He had, within his means, been a constant observer of Jupiter, but he had never seen any other marking at all comparable to the shade he had noticed. The shadow, or whatever it was, had appeared suddenly. It was not observed prior to the egress of the satellite, though several hours had been spent observing the planet. On page 191 of Volume I of Chambers' Handbook of Astronomy, there is a reproduction of a drawing made by Trouvellot at Cambridge, U.S.A., 1887, April 24. What Trouvellot saw and what he saw were evidently not very dissimilar in appearance, but in the former case, the shadow—and M. Trouvellot seemed to be positive it was a double one—preceded the true shadow, the reverse of what took place on the night of the 20th of September.

Mr. Barnard wrote: "I was extremely interested in your communication of November 28th about the double-shadow of the first satellite of Jupiter. You will have perhaps noticed that a Mr. Hoffman, in the December number of *The Sidereal Messenger*, has also an observation of a double-shadow to the satellite on November 14. There is certainly some mystery about this satellite, and I think, perhaps, next year will go far towards revealing that mystery. I am very glad to see your observation, and thank you for communicating it to me. Such should always be published, and some time they will be very gladly received indeed. I have the opinions of two eminent astronomers on the subject of the possibility of the satellite being double. Each one says there is nothing physically against it, though it is improbable. Much will be known when the satellite again transits a bright part of Jupiter's surface. The new Southern Red Spot, so prominent a few months ago, has disappeared. I am rather sorry, for I had started in to make a special study of it. The Great Red Spot about the middle of November began again to slacken its rotation period. Its action in this is very singular. Perhaps you would care to see the observations which I have made of it this year? I enclose them." They are as follows:—

OBSERVATIONS ON THE LONGITUDE OF THE GREAT RED SPOT ON JUPITER, 1891.

Observed with 12-inch equatorial, Lick Observatory, by E. E. Barnard :—

1891.	June 5	longitude	= 3°.2
	July 14	"	= 2°.8
	August 2	"	= 2°.0
	" 12	"	= 3°.1
	" 20	"	= 2°.5
	" 27	"	= 4°.3
	Sept. 3	"	= 3°.3
	" 17	"	= 2°.4
	" 18	"	= 2°.5
	Oct. 2	"	= 3°.1
	Nov. 17	"	= 4°.7
	" 27	"	= 5°.6
	Dec. 14	"	= 6°.4
	" 21	"	= 7°.5

"These observations indicate that the longitude of the spot remained constant at about 3° from the first of June until the middle of November, and then it began rather rapidly to increase—that is, to slacken the period of revolution, making it considerably longer than ever before."

The Secretary then read the following paper contributed by Mr. W. F. Denning, F.R.A.S. :

NEW NEBULÆ.

Since the time of Messier, Méchain, and William Herschel, about a century ago, the sky has been well swept by a succession of able observers for the discovery of nebulæ. But notwithstanding all their diligence, and the fact that the number of known objects is now so large, there are many nebulæ which have escaped detection even to this day. Since 1883, Dr. Lewis Swift, of Rochester, U.S.A., has effected many discoveries, especially of extremely faint objects, which had eluded the scrutiny of all former observers. But the number of nebulæ is practically illimitable ; we may go on year after year finding fresh ones, but an inexhaustible field lies beyond ; and though our knowledge of the more conspicuous examples may be regarded as pretty complete, there must be some thousands of the fainter class still lying unknown in the distant recesses of the heavens. The region near the north pole has never received a searching examination with a really powerful telescope, for it is inconvenient to use large equatorials upon this district; and though it is one by no means rich in nebulæ, it undoubtedly contains a goodly number of faint objects which have been hitherto unrevealed. Occasionally, a small nebula is picked up by an observer while seeking for comets. He determines its place roughly, and, on comparing it with a catalogue of nebulæ, finds no such object recorded in its pages. He asks himself, "Is it a new comet, or an unknown nebula?" By attentively watching it, he soon finds an answer to the question. The object is stationary; hence it must be a nebula.

I may allude to two instances of this kind. On September 30, 1891, I was looking for comets with a power of 60 on my 10-inch reflector, and found a small, pretty bright, nebulosity about 2° following the star H 48 Cephei. I failed to identity it with any known object, and it proved a new nebula. It is small, very much brighter in the middle, and has a star of about mag. 14 involved in its southern borders. The nebula precedes the star D.M. + 76°, 137 (mag. 8.2), *7m 3s*, and is situated in the same declination, so that its approximate place is

R.A. *3h 31m 13s*, Dec. + 76° 18′ (1890).

It is very obvious under a power of 97, and bears magnifying well.

On November 7, 1890, I found a pretty bright and large nebula near γ Camelopardi, but, at the time, I supposed it to be identical with one of Swift's discoveries. On December 4, 1891, I swept up the same object, and found, on careful comparison, that it was really a new nebula. It is situated a little more than one degree north of the star Lalande 7284 (mag. 6), and its roughly determined place is

R.A. *3h 56m*, Dec. + 69° 29′ (1890).

This nebula lies between two pairs of telescopic stars. There is a bright star (about mag. 7) only 4′ north of it.

As the two nebulæ referred to are pretty bright and tolerably conspicuous objects, it is singular they have not been discovered before.

Bristol, England, December 5, 1891.

The attention of the Society was called to the loss it sustained by the sudden illness and death, on the preceding day, of the Honourable Sir Adam Wilson, a Life Member. The members were reminded that at the last meeting he attended, Sir Adam presided as Chairman, and that he evinced more than usual interest in the proceedings. Appropriate references were made to the long, useful, and upright life of the deceased during his career as a private citizen, as a member of the City Council and as Mayor, as a politician—he having been a member of the Parliament and Government of the late Province of Canada—and as a judge. It was stated that some years ago, when Sir Adam retired from the Chief Justiceship of the Queen's Bench of Ontario to a well-earned rest, he actively interested himself in scientific matters; that a year or so ago he erected and equipped an observatory and identified himself with the Society, and that he materially assisted in forming the Opera-Glass Section. A resolution of condolence was adopted and directed to be sent to Lady Wilson. As a mark of respect to the memory of the deceased, the Society thereupon adjourned.

THE TWENTY-THIRD (AND SECOND ANNUAL) MEETING.

The Second Annual Meeting of the Society was held on the evening of the 12th of January. The attendance was large. In the absence of the President, owing to illness, the chair was taken by Mr. A. Elvins, the Vice-President.

After the reading of the Minutes, correspondence, and notes of observation, the business incident to the meeting was taken up.

The election of officers and of members of the Council for the year 1892, resulted as follows:—Honourary President, the Honourable G. W. Ross, LL.D., Minister of Education for the Province of Ontario, who, on being consulted, had consented to accept the position, and had assured the Society of the interest he had taken, and would continue to take, in its proceedings; President, Charles Carpmael, M.A., F.R.A.S., F.R.S.C., Director of the Toronto Magnetic Observatory, and Superintendent of the Dominion Meteorological Service; Vice-Presidents, Larratt W. Smith, Q.C., D.C.L., and John A. Paterson, M.A.; Treasurer, D. J. Howell; Corresponding Secretary, G. E. Lumsden; Recording Secretary, Thomas Lindsay; and Librarian, D. Geo. Ross. The following active members were added to the Honourary and Executive Officers to constitute the Council:—A. Elvins, A. F. Miller, J. G. Ridout, G. G. Pursey, and Dr. G. B. Foster.

Dr. Larratt Smith being absent owing to indisposition, Mr. Elvins resigned the chair to Mr. Paterson, who gracefully returned thanks for the honour of election. He assured the Society that he would renew the interest taken by him in Astronomy when attending the University, and promised to do all in his power to advance its welfare. Having called for the annual reports,

Mr. Howell, as Treasurer, made a statement of the Society's finances, which showed them to be in a thriving condition and able to meet ordinary liabilities. Attention was, however, called to the fact that the Society could make use of a much larger revenue in extending its work as a popular educator, and members were requested to do all in their power to increase the membership, partially for the purpose of providing for such outlays as were required by the printing of annual reports, the purchase of lantern-slides and apparatus for the use of the Society as a body.

Mr. Lumsden, as Corresponding Secretary, stated that he had endeavoured to discharge his duties to the best of his ability. The performance of those duties had been rendered very agreeable by the indulgence of the Society, and by the marked courtesy with which his communications had been treated by every one to whom they had been addressed. He thought it a matter of no small congratulation on the part of the Society that, with but a single exception, no doubt due to a misapprehension as to the conditions upon which Corresponding Membership was conferred, every one who had been consulted on the subject had, in a most cordial manner, accepted proffered Honourary or Corresponding Membership. Now that astronomers of world-wide reputation had become associated with the Society, it behooved the Society to deserve the distinction so readily and so generously conferred upon it.

Mr. Miller, as Librarian, alluded to the gratifying fact that the contributions to the Society's library had continued to be of the valuable character which had distinguished those of the first year of its incorporated existence. There were now several hundreds of volumes and pamphlets, nearly all of which were most useful for the purposes of reference. He was glad to report that there had been also a greater demand for books, and that some of the works had been in continued circulation. Though retiring from the position of Librarian, he was doing so only because he no longer had the time in which to perform the duties to his own satisfaction. He would not, however, relax his efforts to advance the interests of the Society. In a few neat sentences, he bespoke for his successor the kindness he himself had received.

Mr. Lindsay, as Recording Secretary, gave a condensed report of the membership of the Society, the meetings held during the year, the papers read, etc. The meetings had been very well attended, and a continued and increasing interest was confidently anticipated.

The Annual Address was delivered by Mr. Elvins, the retiring Vice-President, who, in happy terms, alluded to the Society's progress from the date of its formation until the present time. He reviewed its objects, which are to popularize astronomy in Canada, and to its work, and expressed the hope that it would yet be actively associated with all the educational institutions of the country. While it would endeavor to do such original work as was within the ability of its members, it was to be borne in mind that its aims were rather to invite into the field of practical amateur work every one interested in astronomy, and to assist students in their studies of the science. Admission to the Society was within the reach of every one, whether he or she had any acquaintance with the subject or not. All that was asked was that an applicant for membership should have a desire to enter upon, and to explore for himself, or herself, this, certainly not the least delightful and instructive of the fields of Knowledge. As papers read before the Society proved, a little practical work was often of the most valuable and enlightening character. Working in company, too, had been found to be most helpful, and it was hoped there would be, during the year, large additions to the membership of the Society. Mr. Elvins desired to call attention to the harmony that existed in the Society, and had rendered its meetings so agreeable, and, he hoped, profitable. He also alluded to the unity which usually characterizes all associations formed for the purpose of promoting scientific studies, and to the fact that in such bodies all the artificial divisions and distinctions of society are forgotten in the one common desire and end to search for Truth. He referred to the progress of the science of Astronomy during the past year, and to some of the problems which are occupying the minds of workers distinguished for their attainments. With pardonable pride, he alluded to the fact that the Society enjoyed the official recognition and sympathy of the Honourable Dr. Ross, the able and active chief of educational interests in Ontario, and that it had been cordially permitted to enter upon its roll of membership the names of astronomers of the highest rank in their several special fields. In conclusion, he touched upon various matters affecting the welfare of the Society, and assured its members that, though retiring from office, he would as actively as ever engage in securing its prosperity.

Hearty votes of thanks to Mr. Elvins and to Mr. Miller, the retiring officers, were passed and suitably acknowledged.

The newspaper press was especially thanked for uniform courtesy and most valuable assistance in communicating with the public. The seconder of the motion, Mr. J. M. Clark, M.A., stated that it was largely owing to the reports he had read in the daily papers that he had decided to renew his astronomical studies by joining the Society.

After transacting other business suitable to the occasion, the proceedings of the second year were brought to a close by adjournment.

APPENDIX.

SIDEREAL PHENOMENA, 1892.

For the assistance of amateurs in this country who have not recourse to the special publications issued for the purpose, the Society has determined, purely as an experiment, to add to this year's Report a few Tables of interesting and easily observable phenomena predicted for 1892. The events tabulated have been limited to convenient hours, and are such as may be observed without requiring the possession of expensive accessories. Should the experiment prove to have been justified by results, it is probable that future publications of the Society will contain more elaborate tables. Those presented herewith, are believed to be sufficiently accurate for practical purposes.

A glance over the almanacs justifies the assertion that the year 1892 will be one of more than usual interest for the astronomer, including, of course, the amateur observer.

Mercury was a morning star on the 19th of January, and he will be again on the 17th of May, and on the 11th of September; he will be an evening star on the 31st of March, the 29th of July, and the 23rd of November. For a few days before and after these dates, Mercury may be confidently looked for either near the western horizon, or the eastern horizon, as the case may be. He should be well seen during the last week in March, hovering over the west-by-north horizon about an hour and a quarter after a clear sunset. He has a ruddy appearance, and will possibly be brighter than a first magnitude star.

Venus is now in the gibbous phase; in the latter part of May May this gibbous appearance will have been reduced to a thin crescent, the apparent diameter of which will increase rapidly. On the 2nd of June she will have reached her greatest brilliancy. After that date, she will gradually decline and retreat until she is lost in the solar rays, to re-appear as a morning star in August. Venus should be carefully studied during 1892, a much better year for that purpose than often falls to the lot of the astronomer. This planet will continue to be an evening star until the 9th of July, on which date she passes between the earth and the sun, but not sufficiently in a direct line as to appear to transit any part of the solar disc. After July 9th, Venus will be a morning star until the end of the year.

Owing to the eccentricity of the orbit of Mars, that planet and our earth approach each other within the least possible distance only once in about sixteen years; 1892 is one of the years of closest approach. In 1877, the year of the last nearest approach, Hall, with the great refractor at Washington, discovered that Mars has two tiny moons. These moons should be well seen in 1892. This planet will probably be the most lustrous object in next summer's sky, Jupiter himself not excepted. While at his greatest lustre this year, Mars will twice suffer occultation by our moon. These eclipses will occur about 11.15 o'clock on the night of the 11th July, and at about 1.30 o'clock on the morning of the 4th of September. Should the conditions be favorable, both occultations should be carefully observed and noted. There is about the coming near us of this planet another feature, and that is the effect his being within about 35,000,000 miles of the earth, will have upon our weather during the summer. One weather prophet says his neighborhood will be felt by electric changes in our atmosphere, and that he is a "good thunderer" at his solar positions; that he helps to raise the temperature before his oppositions and perihelia, only to check the magnetic current afterwards, and that he first attracts electricity from us and then pours it back. Based upon this and other causes, this gentleman predicts for us a very hot, stormy, and rather unpleasant season, his expression being that "there will be a whole summer in the month of July."

For diversity of phenomena easily observable, no planet approaches in interest the mighty Jupiter. His rapid rotation, his belts, red, black and white spots, and his moons transiting his face, or being occulted by his bulk, or eclipsed by his shadow, form an endless series of subjects for study. About the end of July Jupiter will be well situated for evening work, and will gradually improve until the 12th of October, when he will be in opposition to the sun. About the end of March, Jupiter will cross the equator and remain north of it for some years, a very gratifying fact for northern observers.

Saturn's rings present an appearance they will not exhibit again for seven years and should be observed. They are turned edgewise towards the earth. Saturn will suffer eclipse by the moon about 25 minutes after 3 o'clock on the morning of the 15th of November.

In 1892 there will be four eclipses proper, two of the sun and two of the moon. The total eclipses of the sun on the 26th of April and of the moon on the 4th of November will be invisible at Toronto. On the 20th of October, commencing about noon, there will be a nearly total eclipse of the sun, which, if the sky be clear, may be well seen here. On the night of the 11th of May, commencing about half-past 7 o'clock, as far as Toronto is concerned, there will be a partial eclipse of the moon, which will rise more or less submerged in the earth's shadow. Should the conditions be favorable, the phenomenon may be studied for more than one hour.

OCCULTATIONS BY THE MOON, 1892.

The following Table of Occultations by the Moon has been reduced from the list of phenomena visible during 1892 at Washington. Eight minutes have been added for difference between Washington Mean Time and Eastern Standard Time, in which the predictions are given. The times must, therefore, be taken as roughly approximate. The letters "a" and "p," respectively, stand for "a.m." and "p.m."

1892.	STAR.	MAG.	DISAPPEARANCES.	REAPPEARANCES.
New moon.				
Mar. 4	υ^1 Tauri	5	11.50 p.	12.49 a.
" 4	υ^2 "	6	12.23 a.	1.10 a.
" 8	λ Cancri	6	12.36 a.	1.41 a.
" 14	κ Virginis	6	11.14 p.	12.24 a.
" 15	m "	5	10.00 p.	11.12 p.
" 22	ω Sagittarii	5	5.11 a.	6.06 a.
New moon.				
Apr. 1	κ Tauri	6	8.36 p.	8.56 p.
" 4	ω^2 Cancri	6	9.54 p.	11.04 p.
" 7	i Leonis	6	7.59 p.	9.05 p.
" 10	η^1 Virginis	3	7.02 p.	7.13 p.
" 10	38 "	6	4.16 a.	4.56 a.
" 12	URANUS		11.56 p.	1.22 a.
New moon.				
" 29	125 Tauri	6	9.50 p.	10.36 p.
May 1	C Geminorum	6	10.30 p.	10.58 p.
" 13	A Ophiuchi	5	9.30 p.	10.24 p.
" 13	38 "	7	10.31 p.	11.47 p.
New moon.				
" 29	λ Cancri	6	10.30 p.	11.16 p.
June 4	κ Virginis	6	6.26 p.	7.49 p.
" 4	θ "	5	2.28 a.	3.24 a.

1892.		STAR.	MAG.	DISAPPEARANCES.	REAPPEARANCES.
June	5	*m* Virginis	6	5.18 p.	6.21 p.
"	5	*B.A.C.* 4591	6	10.26 p.	11.19 p.
"	12	ω Sagittarii	5	12.32 a.	12.48 a.
New moon.					
July	6	25 Scorpii	6½	12.55 a.	2.10 a.
"	9	*B.A.C.* 6666	6	7.48 p.	8.31 p.
"	11	35 Capricorni	6	8.58 p.	10.03 p.
"	11	MARS		11.13 p.	12.15 a.
New moon.					
Aug.	2	19 Scorpii	5	8.45 p.	9.45 p.
"	5	τ Sagittarii	4	7.07 p.	8.14 p.
"	10	*B.A.C.* 8274	7	8.18 p.	9.14 p.
New moon.					
"	31	3 Sagittarii	5	8.06 p.	9.28 p.
Sept.	3	MARS		1.30 a.	2.14 a.
"	4	*B.A.C.* 7550	6	11.11 p.	12.14 a.
"	8	96 Piscium	7	5.22 a.	6.18 a.
"	11	A^1 Tauri	4	9.32 p.	10.20 p.
"	11	A^2 "	6	9.41 p.	10.31 p.
New moon.					
"	26	22 Scorpii	5½	5.17 p.	6.06 p.
Oct.	6	*o* Piscium	4	8.44 p.	9.10 p.
"	7	*o* Arietis	6	9.14 p.	9.56 p.
"	8	32 Tauri	6	4.22 a.	5.17 a.
"	12	ω^1 Cancri	6	12.45 a.	1.45 a.
New moon.					
Nov.	11	42 Leonis	6	11.15 p.	11.57 p.
"	14	SATURN		3.27 a.	4.16 a.
New moon.					
"	21	3 Sagittarii	5	5.32 p.	6.14 p.
"	25	35 Capricorni	6	5.39 p.	7.00 p.
"	27	ψ^2 "	4	11.32 p.	12.25 a.
"	30	*o* Piscium	4	6.43 p.	7.53 p.
Dec.	2	*B.A.C.* 1143	6	7.46 p.	8.46 p.
"	2	32 Tauri	6	2.50 p.	3.33 p.
"	5	47 Geminorum	6	11.42 p.	12.42 a.
"	7	*B.A.C.* 3138	6	11.36 p.	12.46 a.
New moon.					
"	28	29 Arietis	6	2.27 a.	3.23 a.
"	30	62 Tauri	6	10.51 p.	11.28 p.

The Astronomical and Physical Society of Toronto.

JOVIAN PHENOMENA, 1892.

Reduced to Eastern Standard Time, and limited to events visible before midnight. Abreviations signify as follows :—*tr. in.*, transit ingress of Satellite; ***tr. eg.***, transit egress ; *sh. in.*, shadow ingress ; *sh. eg.*, shadow egress ; *ec. dis.*, disappearance of Satellite behind planet ; *oc. dis.*, disappearance of Satellite in planet's shadow.

July.

d	h	m		
1	10	39	I.	*tr. in.*
	11	31	I.	*sh. eg.*
4	11	48	II.	*ec. dis.*
6	11	16	II.	*tr. eg.*
9	11	56	I.	*oc. re.*
13	11	09	II.	*sh. eg.*
	11	24	II.	*tr. in.*
14	11	08	III.	*sh. eg.*
17	11	11	I.	*tr. eg.*
20	11	08	II.	*sh. in.*
22	11	34	II.	*oc. re.*
24	10	50	I.	*tr. in.*
	11	42	I.	*sh. eg.*
29	11	23	II.	*ec. re.*
	11	39	II.	*oc. dis.*
31	11	21	I.	*sh. in.*

August.

d	h	m		
2	9	22	I.	*tr. eg.*
5	11	28	II.	*ec. dis.*
7	10	45	II.	*tr. eg.*
8	10	25	I.	*ec. dis.*
	10	30	III.	*ec. dis.*
9	9	58	I.	*sh. eg.*
	11	13	I.	*tr. eg.*
14	10	47	II.	*tr. in.*
	10	52	II.	*sh. eg.*
16	9	37	I.	*sh. in.*
	10	50	I.	*tr. in.*
	11	51	I.	*sh. eg.*
17	10	11	I.	*oc. re.*
19	9	41	III.	*tr. in.*
	11	30	III.	*tr. eg.*
21	10	53	II.	*sh. in.*
23	10	36	II.	*oc. re.*
	11	30	I.	*sh. in.*
24	11	59	I.	*oc. re.*
25	9	17	I.	*tr. eg.*
26	11	06	III.	*sh. eg.*
31	10	34	I.	*ec. dis.*

September.

d	h	m		
1	7	53	I.	*sh. in.*
	8	52	I.	*tr. in.*
	10	07	I.	*sh. eg.*
	11	04	I.	*tr. eg.*
2	8	14	I.	*oc. re.*
6	8	06	III.	*oc. re.*
	11	06	II.	*ec. dis.*
8	9	36	II.	*tr. eg.*
	9	47	I.	*sh. in.*
	10	38	I.	*tr. in.*
9	9	59	I.	*oc. re.*
13	8	49	III.	*ec. re.*
	9	47	III.	*oc. dis.*
	11	31	III.	*oc. re.*
15	8	05	II.	*sh. in.*
	9	30	II.	*tr. in.*
	10	38	II.	*sh. eg.*
	11	41	I.	*sh. in.*
16	8	52	I.	*ec. dis.*
	11	42	I.	*oc. re.*
17	8	22	I.	*sh. eg.*
	9	01	I.	*tr. eg.*
20	10	39	III.	*ec. dis.*
22	10	43	II.	*sh. in.*
	11	47	II.	*tr. in.*
23	10	49	I.	*ec. dis.*
24	8	04	I.	*sh. in.*
	8	33	I.	*tr. in.*
	8	55	II.	*oc. re.*
	10	18	I.	*sh. eg.*
	10	45	I.	*tr. eg.*
25	7	55	I.	*oc. re.*

October.

d	h	m		
1	7	07	III.	*sh. eg.*
	7	58	III.	*tr. eg.*
	8	09	II.	*ec. dis.*
	9	58	I.	*sh. in.*
	10	18	I.	*tr. in.*
	11	09	II.	*oc. re.*
2	7	12	I.	*ec. dis.*
	9	39	I.	*oc. re.*
3	6	40	I.	*sh. eg.*
	6	55	I.	*tr. eg.*
8	8	47	III.	*sh. in.*
	9	27	III.	*tr. in.*
	10	45	II.	*ec. dis.*
	11	07	III.	*sh. eg.*
	11	15	III.	*tr. eg.*
	11	53	I.	*sh. in.*
	11	59	I.	*tr. in.*
9	9	08	I.	*ec. dis.*
	11	23	I.	*oc. re.*
10	6	21	I.	*sh. in.*
	6	25	I.	*tr. in.*
	7	51	II.	*sh. eg.*
	7	53	II.	*tr. eg.*
	8	34	I.	*sh. eg.*
	8	37	I.	*tr. eg.*
16	10	55	I.	*oc. dis.*
17	7	42	II.	*tr. in.*
	7	56	II.	*sh. in.*
	8	08	I.	*tr. in.*
	8	16	I.	*sh. in.*
	10	09	II.	*tr. eg.*
	10	20	I.	*tr. eg.*
	10	28	II.	*sh. eg.*
	10	29	I.	*sh. eg.*
18	7	41	I.	*ec. re.*
23	9	51	I.	*tr. in.*
	9	58	II.	*tr. in.*
	10	10	I.	*sh. in.*
	10	35	II.	*sh. in.*
25	6	05	I.	*oc. dis.*
	9	36	I.	*ec. re.*
26	6	29	I.	*tr. eg.*
	6	52	I.	*sh. eg.*
	7	38	II.	*ec. re.*
	8	54	III.	*ec. re.*
31	11	35	I.	*tr. in.*

November.

d	h	m		
2	5	62	I.	*tr. in.*
	6	32	I.	*sh. in.*
	6	42	II.	*oc. dis.*
	8	15	I.	*tr. eg.*
	8	39	III.	*oc. dis.*
	8	48	I.	*sh. eg.*
	10	13	II.	*ec. re.*
	10	42	III.	*oc. re.*
	10	53	III.	*ec. dis.*
8	10	35	I.	*oc. dis.*
9	7	47	I.	*tr. in.*
	8	29	I.	*sh. in.*

d	h	m		
	8	58	II.	*oc. dis.*
	10	00	I.	*tr. eg.*
	10	42	I.	*sh. eg.*
	11	59	III.	*oc. dis.*
10	7	56	I.	*ec. re.*
11	5	11	I.	*sh. eg.*
	5	15	II.	*sh. in.*
	6	14	II.	*tr. eg.*
	7	43	II.	*sh. eg.*
13	7	12	III.	*sh. eg.*
16	9	33	I.	*tr. in.*
	11	16	II.	*oc. dis.*
	11	46	I.	*tr. eg.*
17	6	49	I.	*oc. dis.*
	9	52	I.	*ec. re.*
	6	05	II.	*tr. in.*
	6	12	I.	*tr. eg.*
	7	06	I.	*sh. eg.*
	7	52	II.	*sh. in.*
	8	35	II.	*tr. eg.*
	10	22	II.	*tr. eg.*
20	5	14	III.	*tr. in.*
	7	28	III.	*tr. eg.*
	9	01	III.	*sh. in.*
	11	13	III.	*sh. eg.*
23	11	20	I.	*tr. in.*
24	8	35	I.	*oc. dis.*
	11	47	I.	*ec. re.*
25	5	47	I.	*tr. in.*
	6	48	I.	*sh. in.*
	8	00	I.	*tr. eg.*

d	h	m		
	8	28	II.	*tr. in.*
	9	01	I.	*sh. eg.*
	10	31	II.	*sh. in.*
	10	59	II.	*tr. eg.*
26	6	16	I.	*ec. re.*
27	7	16	II.	*ec. re.*
	8	45	III.	*tr. in.*
	11	02	III.	*tr. eg.*

December.

d	h	m		
1	10	26	I.	*oc. dis.*
2	7	35	I.	*tr. in.*
	8	42	I.	*sh. in.*
	9	49	I.	*tr. eg.*
	10	52	II.	*tr. in.*
	10	57	I.	*sh. eg.*
3	8	12	I.	*ec. re.*
	5	11	II.	*oc. dis.*
	5	25	I.	*sh. eg.*
	9	52	II.	*ec. re.*
	12	21	III.	*tr. in.*
8	7	08	III.	*ec. dis.*
	6	03	III.	*ec. re.*
9	9	26	I.	*tr. in.*
	10	39	I.	*sh. in.*
	11	40	I.	*tr. eg.*
10	6	42	I.	*oc. dis.*
	10	08	I.	*ec. re.*
11	6	07	I.	*tr. eg.*

d	h	m		
	7	21	I.	*sh. eg.*
	7	37	II.	*oc. dis.*
13	7	37	II.	*sh. eg.*
15	5	48	III.	*oc. dis.*
	8	13	III.	*oc. re.*
	11	11	III.	*ec. dis.*
16	11	17	I.	*tr. in.*
17	8	36	I.	*oc. dis.*
18	5	45	I.	*tr. in.*
	7	03	I.	*sh. in.*
	7	59	I.	*tr. eg.*
	9	16	I.	*sh. eg.*
	10	06	II.	*oc. dis.*
19	6	33	I.	*ec. re.*
	7	43	II.	*tr. eg.*
	7	46	II.	*sh. in.*
	10	14	II.	*sh. eg.*
22	9	38	III.	*oc. dis.*
24	10	30	I.	*oc. dis.*
25	7	38	I.	*tr. in.*
	8	58	I.	*sh. in.*
	9	52	I.	*tr. eg.*
	11	11	I.	*sh. eg.*
26	7	20	III.	*sh. eg.*
	8	29	I.	*ec. re.*
27	5	40	I.	*sh. eg.*
	7	43	II.	*tr. in.*
	10	17	II.	*tr. eg.*
	10	25	II.	*sh. in.*
29	7	02	II.	*ec. re.*

MINIMA OF ALGOL.

(Eastern Standard Time).

Counting onwards for twenty-four hours from noon on designated day; thus, Feb. 7d. 18h. 11m. = 6.11 a.m. on 8th. Forty-four visible minima in 1892.

February.			*March.*			*August.*			*September.*			*October.*			*November.*			*December.*		
d	h	m	d	h	m	d	h	m	d	h	m	d	h	m	d	h	m	d	h	m
7	18	11	1	16	42	3	12	40	13	16	4	2	17	47	3	6	44	7	16	31
10	15	0	4	13	31	6	9	29	15	12	53	5	14	35	14	18	0	10	13	20
13	11	49	7	10	20	23	14	22	18	9	42	8	11	24	17	14	49	13	10	9
16	8	38	10	7	9	26	11	11				11	8	13	20	11	38	16	6	58
			24	15	13							25	16	18				27	18	14
			27	12	02							28	13	7				30	15	2
			30	8	51							31	9	56						

The Astronomical and Physical Society of Toronto.

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