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PROCEEDINGS

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CONTENTS.

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The Cause of the Accumulation of Magnetic Storms when the Earth is Near the Equinoxes. By Andrew Elvins.

(Read 7th February, 1903.)

In a paper read before this Institute about a year ago on sun-spots and the phenomena which seem to be connected with them, I expressed the idea that sun-spots, aurorae, and magnetic storms are caused by matter forming in space, and passing sunward in orbits more or less elliptical, which, when they cross the earth's orbit, produce aurorae and magnetic storms, pass on sunward, and by planetary perturbations and collisions fall in part on the sun and produce solar-disturbances. Supposing the theory then advanced to be correct, I wish to show how it is the fact that magnetic disturbance are *more numerous* at times when the earth is near the equinoxes than at other t nes.

The fact that disturbances are more numerous when the earth is at the equinoctial points, than at other parts of its orbit, shows it to be in some way connected with the earth's annual revolution.

Let us look for a moment at this motion. The sun is at the centre of the path in which the earth moves. We call the plane in which the earth moves the plane of the ecliptic. Whilst the earth is making its annual revolution, it is also rotating on its axis, and this axis is not at right angles to the plane of the ecliptic but about 24° from it.

If the poles were at right angles to the plane of the earth's path, each of the poles would be equally exposed to matter coming sunward from without in each month in the year (and as the planets move near this plane, and reach outward into space, *their action* on incoming cosmic matter will cause the larger part of it to move in this plane also; cosmic matter will be more abundant near the ecliptic than elsewhere); the earth in passing through it will have one pole more exposed to this matter during one half of its orbit, and the other pole most exposed during the other half. But at the equinoxes both poles will be equally exposed, and at any given point, except, perhaps, near the equator, the plus of cosmic matter which produces magnetic disturbances will fall on the outside hemisphere of the earth when *it is near the equinoxes.*

On this theory cosmic matter passing by the earth going sunward is the cause of *auroras* and *magnetic disturbances*: the plus of such matter caused by the action of Jupiter and Saturn, on incoming cosmic matter, is encountered by the earth when it passes us going sunward, and this is the cause of the long 11-year period. The moon's revolution, combined with the earth's motion, is the cause of the 25-day period, and the inclination of the earth's axis is the cause of the *plus of disturbances at the equinoxes.*

The Pleiades as the Hesperides, Isle of the Blest, or Place of Future Bliss. By J. Cleland Hamilton, M.A., LL.B.

(Read 14th November, 1903.)

Mr. Hamilton referred to Dr. Wallace's theory, that the solar system is the centre of the universe, as controverting both scientific and classical notions, and not yet at least generally held. He then took up in detail legends of many nations which pointed to the stars of the Pleiad group as the resting place of their ancestors' spirits and their own heaven. Such were the Arabs, the Berbers of North Africa, and Dyaks of Borneo. The British Druids had an ancient mythology drawn from the same source as that of the Greeks, had gods of characters similar to Pluto, Mercury and Zeus, and, in strange metaphoric poems, referred to the Pleiades. Their midnight ceremonies in the autumn, at the time of our Hallowe'en, commemorated the season when the Seven Stars were highest in the visible firmament.

The lecturer discussed legends of the Adipones, the Hurons, Iroquois, Blackfeet and other native American races, which made their heaven where the sun sets. Hiawatha's departure to the west in his birch canoe was compared to that of King Arthur in the Druid legend, the basis of Tennyson's "Mort d'Arthur." "The White Stone Canoe," an Ojibway legend translated into Hiawathan metre, by the late Sir James D. Edgar, represents the young brave Abeka, seeking his lost love, Wabose, in the redman's spirit land, where he finds her on a beautiful happy island, and here is repeated the Greek legend of the "Isle of the Blest" with a Promethean moral. Such beliefs were found also among the Hydahs, Eskimos, Chippewayans, Salish, Chiwaks, and, throughout the continent, to California. The curious myths of the Polynesians were referred to, and examples given of many strange coincidences with the legends of Egypt and Phoenicia, and paralleling those as to Atlas, Hercules, Pluto and other deities of Greece. They had, too, an "Isle of the Blest," but knew only six Pleiades, which they called "Matariki"—"Little Eyes," or "Tau Ono," The Six. They were objects of worship in these islands until the introduction of Christianity in 1857.

The ideas of the Hindus, Chinese and other Eastern people as to the place of the future were reviewed. The different views expressed by Homer, Hesiod, Lucian, Pindar and Plato were discussed. There were depicted beautiful plains without winter, fear or pain, where fruit of every kind abounded and joys never ceased. They were placed in the West, where the sun goes down, in a happy isle, where gentle sea breezes blow. Plato taught that only those enjoyed such bliss who had spent life in holy philosophical pursuits, useful to their fellow-men. He placed this pure abode in "the upper parts of the earth in places not easy to describe." The conception of the Hurons, Iroquois and Algonquins as to this place of bliss, is described by Colonel Garrick Mallory and Dr. A. F. Chamberlain, the archaeologists, and by the historians, Bancroft and Schoolcraft, in very similar expressions. The essayist quoted several beautiful Greek epitaphs in which such ideas are embodied along with hope of future meeting. He then explained the theory which assigned Alcyone, the chief star of the Pleiades, to the position practically of the centre of the universe and the place of future bliss. This great star was often so regarded and called "the central one" and "the leading one." However much appears to sustain such theory in classic story and in legends of uncivilized tribes, it was admitted that such claim is not as yet supported by science.

The lecturer concluded his discourse, stating that these many widespread traditions furnish a mass of evidence in favour of a common origin of mankind and of the existence of a general belief in life hereafter, where those who had here lived worthily would meet their ancestors and friends in a beautiful happy place somewhere, either on an island in a western ocean or in the most favoured of the great orbs, which, to use Shelley's words, form "Heaven's constellated wilderness."

Interior Therapy: A Case of Leaf-Curl. By Arthur Harvey, Esq.

(*Read 21st November, 1903.*)

I have always had trouble with peach-trees owing to their liability to "leaf-curl." I am not aware that it is annoying to larger growers, or on other than clay land. But in Rosedale I have found more than half my trees affected by it. It is destructive to the crop. I suppose it to be a bacterial disease.

As soon as the leaves are an inch or two long, their substance thickens about and around the point attacked, the swelling soon deforms them, a sort of knot is formed, they curl, turn red and yellow in places, and as most of the leaves are thus affected, the branches look as if blasted by some irritant poison. If left to themselves, the diseased leaves will fall off, others will grow further up the shoots, but even they are liable to be affected, though not to the same extent. If picked off, which with small trees I have tried to do completely, the same result follows; the disease is not conquered even by two years of such drastic treatment. Some trees have this "leaf curl" worse than others, some are quite immune.

Last year a fine Elberta in my garden was beginning to blossom, and it suffered so much that I would have cut it down had I not wished to attempt a cure. This spring, as soon as the evil began to show itself, I bored a gimblet hole in one of the branches, at an angle of 45° with the horizontal. Into this I fitted a quill, and kept the quill full of a saturated solution of copperas. The tree absorbed a quillful in about six hours. In a day, I could see that the leaves in the upper part of the branch were affected, and those which wilted in this manner soon died, and no further vegetation took place to supply the want of them. I soon perceived that the copperas had not been diffused to any appreciable extent, for the injury went along one only of the branches springing from that which was under treatment, and only one of the final tufts of leaves was killed. The particular fibres cut by the gimblet had soaked up the solution, which did not extend to others but only to their own continuations. This, I believe, puts an end to all hope of success in the particular direction attempted. A weaker solution, or one of a different kind, would in like manner affect a few fibres only and their ramifications.

In the fall there was a line of spots, exuding gum, along the whole of the affected fibres, not elsewhere, except that below the boring there were also a few, due to the death of the fibre leading upwards from the root, from want of exercise. Not having any connecting tubes, it got choked. The rest of the tree was not affected by the copperas, it suffered as usual from "leaf curl," and I shall cut it down next spring.

I may say that washing the bark with lye or the usual poisons has no palliative effect, in my experience.

Auroral Phenomena, Sun-Spots and Magnetism. By Arthur Harvey.

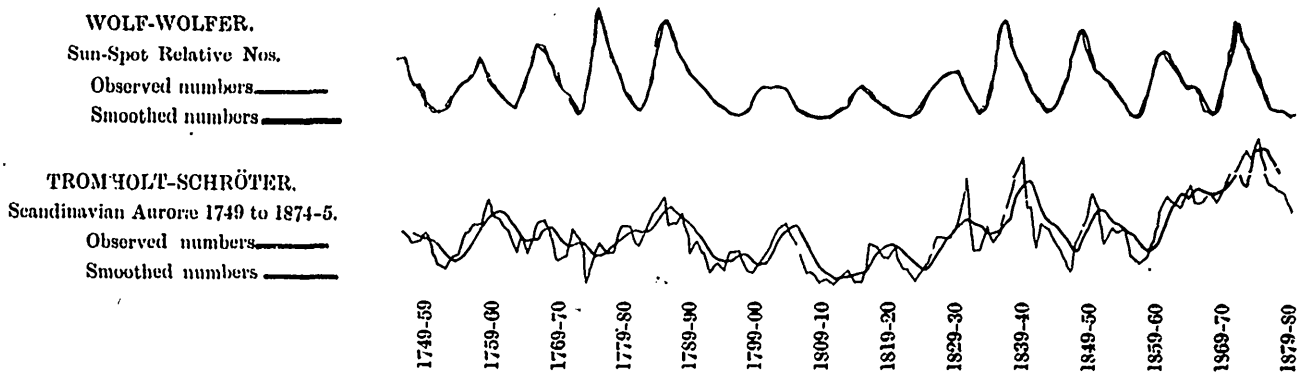
(Read 28th November, 1903.)

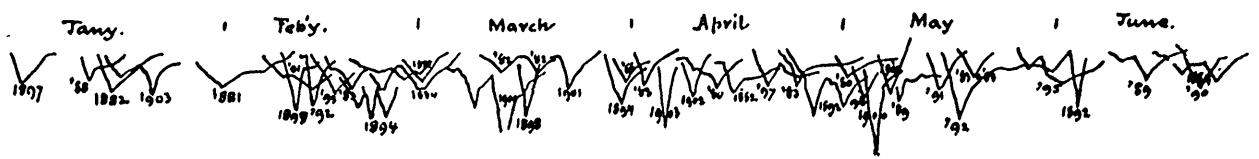
Mr. Andrew Elvins having stated in a recent paper that magnetic storms were more frequent at the equinoxes than at other seasons, I have prepared a diagram to show the times at which such storms have occurred since 1881. Were it not for the encumbrance to distinctness I would have gone back fifty instead of twenty years. There is no greater frequency at the equinox. The points mark the depressions in the curve of magnetic Horizontal Force at Toronto, and indicate not only the dates of magnetic storms but their relative intensity.

Mr. Elvins produced a statement from the Washington *Weather Review* that Tromholt's auroral catalogue showed some excess of auroræ at the equinoxes. I was aware and had myself stated when Mr. Elvins read his paper that there had been a slight excess of magnetic tremors noticed about the equinoxes by the United States observers at Los Angeles—and to see if this were really reflected by a slight excess of auroræ, I made a study of the interesting catalogue of Norwegian auroræ, the life-work of the late Dr. Sophus Tromholt, of Christiania, edited by Prof. I. F. Schroter, of the Observatory there, at the joint cost of the Scientific Association of that city and the Fridtjof Nansen Fund. I found a very slight excess of auroræ observed in March and September, but it was accounted for by quite other reasons than Mr. Elvins supposed, namely, by climatic obstacles to observation in the most northerly regions of the Scandinavian peninsula, where for nearly half the year people do as little outside observation as possible, and during most of the other half, twilight or actual sunlight renders auroræ invisible. It is plain that about the equinoxes the conditions for observation are more favourable, and the wonder is, not that there should be a trifling excess observed, but that the excess should be so very small.

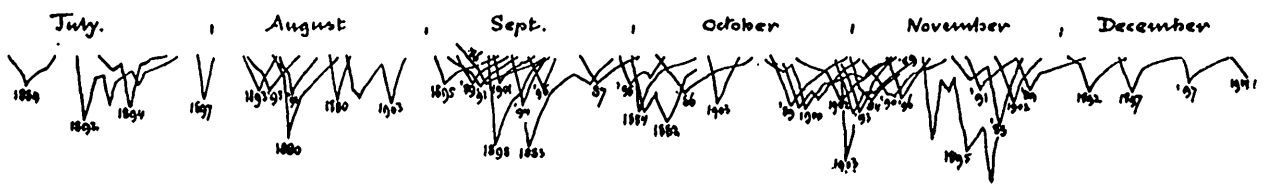
There were, however, other things of interest to be gathered from Tromholt, some of which are to be alluded to in the present paper, which is intended to be a new historical proof that auroræ are especially prevalent during years of solar activity, and that their numbers and brightness correspond accurately therewith: also to illustrate the changed position of observers of such meteoric phenomena in that superstitions regarding them are fading; and lastly to touch on some instances of the wide extension of remarkable auroral displays.

The earliest allusion to Scandinavian auroræ is that in Tacitus ("Germania," chapter xlv.): "On the farther side of Swedes-land is another sea, dark and almost motionless, which is thought to girdle and enclose the terrestrial orb, because there the last light of the setting sun endures until its rising again, so brightly that it dims the stars. Moreover it is credibly reported that sounds are heard there and the shapes of gods seen, with radiance around their heads." Pliny puts us on the track of earlier auroræ when he says ("Natural History," Book I., chapter xxvii.): "There is a flame of a bloody appearance, and nothing is more dreaded by mortals, which falls down upon the earth, such as that seen . . . when King Philip was disturbing Greece." Also that "a bright light has been seen issuing from the heavens in the night time, so that there has been a sort of daylight at night, as was the case in the consulship of L. Valerius and Cn. Papirius." The date of L. Valerius was 462 B.C., when the Romans were having a troublesome war with the Æqui, and, says Livy, "the heavens were seen to be on fire with a very great flame," so a three days' penitential ceremony was ordered, during which crowds of men and women thronged the temples, begging the angry gods to stay their hand. Three years later the sky was seen on fire again, there was an earthquake, and a bull was heard to speak. The King Philip trouble was about 200 B.C. (Livy xxi., cap. 12) when again the heavens were aflame, and the priesthood saw their opportunity for interpreting the natural phenomenon in their peculiar way,





MAGNETIC STORMS SINCE 1881. FIRST HALF OF THE YEAR. THERE IS NO EXCESS AT THE EQUINOX.



MAGNETIC STORMS SINCE 1880. LAST HALF OF THE YEAR. THERE IS NO EXCESS AT THE EQUINOX.

as they had done for thousands of years before, and occasionally persist in doing still. But, coming to Tromholt, we read that in A.D. 1550 the "common people" thought the lights were "a reflection from the schools of herrings which assembled about the beginning of autumn, and, by turning hither and thither, and leaping up and down, threw such a light upon the clouds that the heavens flared up." He transcribes several curious accounts, as of "a glowing sword which thrice smote the earth and swiftly rose again," and of "a black cloud in the north-west with a long neck and a head with a Russian hat and plumes." This was met by another with a Mecklenburg hat, and a third with a Royal Crown, and "one could see that the one with the hat had a long pointed beard and a crooked nose." Next there came "a tremendous big bear which opened its mouth wider and wider and spewed fire, steam and smoke high into the sky. . . . What all this is to betoken is all in the hands of the Lord." There is a case where "a long neck grew from a cloud which became like a living camel, and against it came a fearful beast, which was most like a dragon, with a long, crooked tail." When the dragon attacked the camel, this beast opened its jaws, swallowed the greater part of the dragon, and both vanished. This display does not bear the marks of an aurora so clearly as the other accounts, but it shows how supremely fitting it was for Shakespeare to put into the mouth of a Prince of Denmark the familiar words—

Hamlet—Do you see yonder cloud that's almost in shape like a camel?
Polonius—By the way, and 'tis like a camel, indeed.
Hamlet—Methinks it is like a weasel.
Polonius—It is backed like a weasel.
Hamlet—Or like a whale.
Polonius—Very like a whale.

But we need not go to the Baltic or the Mediterranean for accounts of the superstitious fears with which people once looked on the lovely phosphorescence of the auroræ. Here is a pen picture by the Rev. James Harvey, a Northamptonshire rector, whose "Meditations Among the Tombs" were once classical, who was a fair astronomer, and wrote "Contemplations on the Starry Heavens":—

"Sometimes, at this hour, another most remarkable sight amuses the curious and alarms the vulgar. A blaze of lambent meteors is kindled, or some very extraordinary lights are refracted, in the quarters of the north. The streams of radiance, like legions rushing to the engagement, meet and mingle, insomuch that the air seems to be all conflicting fire. Within a while they start from one another; and, like legions in precipitate flight, sweep, each a separate way, through the firmament. Now they are quiescent: anon they are thrown into a quivering motion; presently the whole horizon is illuminated with the glancing flames. Sometimes, with an aspect awfully ludicrous, they represent extravagant and antic vagaries, at other times you would suspect that some invisible hand was playing off the dumb artillery of the skies, and by a strange expedient, giving us the flash without the roar.

"The villagers gaze at the spectacle, first with wonder, then with horror. A gruesome panic seizes the country. Every heart throbs and every face is pale. The crowds that flock together, instead of diminishing, increase the dread. They catch contagion from each other's looks and words; while fear is in every eye and every tongue speaks the language of terror. Some see hideous shapes, armies mixing in fierce encounter, or fields swimming with blood. Some foresee direful events: states overthrown, or mighty monarchs tottering on their thrones. Others, scared with still more frightful apprehensions, think of nothing but the day of doom. 'Sure,' says one, 'the unalterable bow is struck and the end of all things come.' 'See,' says another, 'how the blasted stars look wan! Are not these the signs of the Son of Man coming in the clouds of heaven?' 'Jesus, prepare us,' cries a third, and lifts up his eyes in devotion, 'for the archangel's trump and the great tribunal.'"

Nor is it needful to leave our own country to find such examples: we have them in the letters of the Jesuits from Canada. Father Biard writes from Port Royal, now Annapolis, N.S., January 31st, 1612:—

"The stars had already begun to appear when suddenly, towards the north-west, a part of the heavens became blood red, and the light, spreading little by little, in spear and spindle-shaped beams, shifted until it was over the settlement of the men from St. Malo, tinging the whole river and making it luminous. It lasted about eight minutes, then disappeared, when the same programme was repeated. Our Indians cried out, 'Gara gara, endirquar, gara gara,' that is, we shall have war, such signs denote war. Nevertheless . . . during the day there was nothing but friendliness. But at even everything went contrariwise—confusion, quarrels, rage, uproar between our savages and the people from St. Malo. I do not doubt that a cursed band of furious and sanguinary spirits were fluttering about us all that night, expecting every hour and moment a horrible massacre of the few Christians who were there, but the goodness of God restrained them, the wretches."

A similar meteor in 1616, when also the sky became wonderfully red, was greeted by the Indians with the exclamation, "Gara gara, maredo." War, war,

there will be blood. A hundred and twenty years later, in 1736, familiarity had deprived auroral phenomena of their terrors, and Father Aulneau, writing from Fort St. Charles, among the Crees, near the north-west angle of the Lake of the Woods, merely says:—

"I have noticed on several occasions, especially while on Lake Huron, grand displays of the aurora borealis . . . scarcely a night has passed but the northern skies have been all aglow with it."

It is improbable that many of us, who have seen some auroral glories, or at least read about them, would be given over to such abject folly as our forefathers, but to populations who take literally the imagery of the Sacred Book of Revelations and look for the actual, physical happening of the poetical prophecies of its author, who beheld the heaven depart as a scroll when it is rolled together, and heard angels sound on trumpets signals for hail mingled with blood to fall upon the earth, and for a great star to fall from heaven, blazing as it were a lamp, and who saw other spirits pour out vials upon the earth, and the sea, and the streams, and the sun, and the air, when there was a great earthquake, and the cities of the nations fell, and every island fled away and the mountains were not found—to such, I say, the sky, luridly red behind light drifting clouds, may cause mortal fear, and so may the fiery arch with flaming coruscations, slowly moving to and past the zenith. Nothing dissipates such terrors more efficiently than travel and scientific study, which are necessary to the growth of civilization, as foreseen by another prophet, Daniel, who said that "many shall run to and fro and knowledge be increased." The car of Science is as merciless as that of Juggernaut. It leaves as victims behind it not the bleeding corpses of votaries, but the lesser miracles, which it destroys one after another, leaving glorified the one great miracle of all, the wonderful order of nature, the living world, which is dying daily but daily being resurrected in obedience to the law of its being. With the six literal days of creation vanishes also the one single day of judgment, and the sudden end of things, and we shall ere long hear that the one has no more Divine warrant than the other. But while there still exists a lingering faith that heavenly displays are signs and portents, science may be charitable to those who look at them in the spirit of Bernard of Morlaix, who was perhaps dreaming of a northern aurora when he wrote of the *bona patria* in his wave-crested dactyls—

"Est tibi consita laurus, et insita cedrus hyssopo:
Sunt radiantia jaspide mœnia, clara pyropo.
Hinc tibi sardius, inde topazius, hinc amethystus
Est tua fabrica concio cœlica gemmaque Christus."

Every one now knows that the aurora is a manifestation of terrestrial magnetism and that both are intimately related to solar activity. But we can estimate the rapid progress of modern science and the length of its recent travels along the pathway of solar radiations by reflecting that some of us, in this very hall, have heard that as there could be no action at a distance without a medium, no electrical energy could be transmitted from the sun to the other bodies in his system. Nobody denies, to-day, that there is a medium we have agreed to call the ether, whose qualities we are beginning to comprehend, nor is there any further denial of a direct rectilinear radiation of energy from the sun. The proof of this action of the sun upon other bodies was given in our semi-centennial volume of "Transactions," page 345. Another step was taken here and noticed at page 107 of our "Proceedings" for 1901, where the synchronism of aurorae australes and boreales was shown, which entitles aurorae to be classed among cosmical events. The bold theory of Dr. Gilbert, one of Queen Elizabeth's physicians, that the Earth is a great magnet, though scouted by Bacon, as was the Copernican system, too, and though it slumbered from its birth to the times of Faraday, has now taken on a new beauty. We can picture to ourselves the round world receiving its electrons or whatever carries or transmits energy through a material ether from the distant sun, and lighting up at night with coruscations about either pole, as this distribution from the cathodic source occurs.* The comparative figures are given in the annexed table. The Antarctic Aurorae are those observed by Mr. Henry N. Arctowski, in the "Belgica."

* The auroral beams seem to emanate from the edge of an irregular elliptical region, which includes both the strong Canadian magnetic pole and the weaker one in Siberia. Thus, by going north, one gets into parts

1898.	March.			April.			May.			June.			July.			Aug.			Sept.			1898.
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25	11	7	1	19	2	1	...	...	...	...	5	4	..	6	...	*	...	...	...	...	...	25
26	38	10	2	...	2	2	...	2	...	...	...	...	...	1	...	5	11	1	...	...	...	26
27	.	4	1	*	6	2	...	5	1	*	2	1	...	3	1	5	2	1	...	...	...	27
28	4	1	3	4	3	...	*	...	2	...	2	1	...	...	2	...	...	1	...	...	...	28
29	4	14	5	...	1	2	6	17	3	...	4	4	...	...	...	...	...	1	...	...	...	29
30	.	4	1	..	4	1	...	7	3	...	...	...	...	2	1	...	...	2	...	...	...	30
31	5	4	3	...	...	...	...	1	...	...	...	...	...	...	4	...	...	...	...	...	...	31

A—Antarctic Observations. Arctowski.
C—Canadian Weather Service Observations.
W—United States Weather Bureau Records.
*—Cloudy all day and night, usually preventing even glimpses of clear sky.
The Antarctic Observations are weighted according to the features reported; the Canadian in the ratio of number and brightness; the American Weather Bureau gives numbers only.

Tromholt gives Norwegian Observations only, but the editor has wisely added the Swedish records collected by Rubenson. The curve from the first is much less instructive than that made from the two sets of figures combined, and the latter is the one I present for examination. I contrast it with the sun-spot curve made from the figures of Professor A. Wolfer, of Zurich.

The auroral year begins with July 1st of one calendar year and runs to June 30th of the next. The difference with the sun-spot year, which follows the calendar, has been duly allowed for in the diagram.

A sun-spot maximum, in 1761, had just passed when these observations were begun. Including it, twelve maxima and as many minima are indicated, echoed by the same number of auroral maxima and minima. The gradients of the two curves are generally alike, and would probably be more so if we could add contemporaneous records from other regions and so mark the irregularities due to

where auroræ are seen to originate to the southward. The "Century Magazine" for February (1903) has a description of one seen March 16th, 1898, a day on which the skies were continuously clouded for Arctowski, in the Antarctic, and no aurora could be seen. At Point Barrow (lat. 71° 17' N., long. 146° 40' W.) Mr. E. A. McIlhenny was "watching a number of Esquimaux playing football. Suddenly they stopped and began to whistle. On being asked why, they pointed to a small bright spot near the south-eastern horizon, and said they were calling the aurora, a marvellous display of which immediately ensued. From the spot in the south-east there shot up a ray of bright rosy light, etc., etc." Mr. F. W. Stokes has an article on the aurora in the same "Century," and he was north of the ellipse in lat. 64° 10' N., long. 55° W., for he writes that when he was called on deck by exclamations of enthusiasm, "a faint film had arisen at a point low on the south-eastern horizon. Then, silently and swiftly, a curtain of light arose," and Mr. Stokes' vivid sense of colour and form enabled him to perceive that in the north "great nature's palette was set with more varied riches than elsewhere."

cloudy weather, moonlight nights and the different lengths of daylight in summer and winter. But the differences are noticeable too, and afford another proof of the statement I ventured to make last session that the extent of spotted areas on the sun is not an exact measure of solar activity. Counting the same spot over and over again, day after day, as it persists, is in my judgment erroneous, being a duplication and reduplication of the credit entry in the solar ledger, whereas the magnets on the earth rarely show continuing storms for more than a couple of days. The auroral curve corresponds more closely to the magnetic curve than to the one showing the spotted areas on the sun.

Professor Wolfer, on being informed of this view, which implies that the special solar energy concerned in the production of a sun-spot does not last throughout its visibility, but is greatest at the outbursting of the spot and during its active growth, and diminishes with the decay of the spot, replied that he believed the force which caused the spot continued until its extinction, but later letters show less confidence in that theory. The general question of sun-activity is of the greatest interest and importance.

Galileo and Scheiner were the first observers of sun-spots early in the seventeenth century, but it was not until the middle of the nineteenth that Schwabe discovered their recurrent frequency in what is known as their eleven year period. The systematic observation of faculæ comes quite within our own times, as does that of prominences, which, indeed, could only be recorded after one of the most wonderful of the many applications of the spectroscope had enabled us to see them as they come on or pass off the sun's limb or edge. These three forms of solar activity are necessarily related, that is, while the spots are at a maximum, there are more faculæ and prominences, but the precise times do not correspond. So magnetic energy on the earth follows very closely the sun-spot curve, and, as might be expected, auroral frequency does the same. But, as compared with sun-spots, magnetic storms tend to "lag." The principal magnetic disturbance is usually a few hours after the centrality of the spot region from which the excess over the daily issue of radiations issues, sometimes even a day or two. Also, curious to note, these Tromholt auroral curves show a usual "lag" of months between the auroral and the sun-spot manifestations. The figures work out, by my calculation, as follows:—

Maxima.		Minima.	
By Sun-spots.	By Auroræ.	By Sun-spots.	By Auroræ.
1750.3	1749.0	1755.2	1755.5
1761.5	1761.7	1766.5	1766.0
1769.7	1769.7	1775.5	1776.0
1778.4	1779.1	1784.7	1784.0
1788.1	1788.3	1798.3	1799.0
1805.2	1805.7	1810.6	1811.0
1816.4	1817.3	1823.3	1823.5
1829.9	1830.7	1833.9	1834.5
1837.2	1839.0	1843.5	1845.5
1848.1	1849.0	1856.0	1856.0
1860.1	1862.0	1867.2	1867.0
1870.6	1870.6	1878.9	1879.0
Average lag, .55 of a year.		Average lag, .24 of a year.	

The determination of the auroral maxima and minima to the fraction of a year is not so precise as that of sun-spots has become, owing to the lack of observations in both hemispheres and all around the earth. We see no auroræ in the far north in May, June, July and August, and have as yet no reliable means of rectifying the irregularity by observations in the far south.

We see in the Tromholt curve, and it is not unimportant to observe, that the wave between the principal auroral maxima appears to embrace two spot maxima. Thus, the great curves from 1755 to 1776, and from 1776 to 1779, seem each to be one wave of influence having two impulses about eleven years apart. So also the quiet time from 1799 to 1823.5 seems one period, while from 1823.5 to 1845.5 is evidently one wave of twenty years length. While from 1845.5 to 1856 is a shorter vibration, it is manifest that from 1856 to 1879 we have the double period again. I have not yet been able with the data at control to prolong the Schroter tables to the present date, for the auroral data on this side of the Atlantic, which are being

fairly well collected now, were in an imperfect state from 1878 for several years. It is, however, fairly clear that the Tromholt tables give but slight countenance to Sir Norman Lockyer's 35-year period between important minima. It appears between 1776 and 1811, and perhaps between 1811 and 1845.5, but the only auroral minimum which could fit in before 1776 was in 1738, which is thirty-eight years before, and the one at this end of the series, following 1845.5, was in 1879, or 33.5 years apart. These divergences are too wide to base a law upon.

The solar prominences are now being sub-classified, I hope. The observations appear to be separating the common form of hydrogen prominence from the metallic prominences. While in our "Transactions" I have recorded my inability to detect magnetic effects consequent upon the former, which are by far the most frequent, I do find a connection with the latter. We are upon the eve of important solar discoveries, and another step in advance towards a knowledge of his constitution and the problem why the Geyser-like intermission of the eruptions upon his surface occurs. It will assuredly not be the sun's passage through matter floating in strata in space, which is an old theory Mr. Elvins has not yet chosen to abandon.

We can see by the Tromholt auroral curve, as well as by the spot curve placed in juxtaposition, what a shamefully irregular body the sun is, and how little dependence can be placed upon his ill-understood whims. Adverting now especially to spots, not only are the periods uneven, varying on the interval before us from 7.3 to 17.1 years between maxima, and from 9 to 13.6 years between minima, but the amounts of spottiness attained during his pulsations of energy vary, too, some maxima being three times as marked as others, that is, the spots cover three times as much solar area. Galileo had no trouble in seeing and drawing sun-spots in 1610-13, but his successors were less fortunate, for, as Miss Agnes E. Clerke tells us, a prolonged solar calm set in about 1643, and only a few solitary spots were seen in 1660, 1671, 1684, 1695 and 1705, which Professor Maunder happily calls "the crests of a sunken spot-curve." As to aurorae, the earliest Norwegian observer says: "When I was a child, about 1550, they were for the first time seen in the southern regions of our country, but since 1570 they have been rising so high that they can even be seen in places to the south-east and south of us, and I think they may now be viewed in other countries, too." It seems, however, rather astonishing to learn that no aurorae were seen in England from 1575 to 1706—a hundred and thirty-one years. From 1790 to 1815 there were very few seen in Norway, and not many for ten years more, after which they again became frequent. The correspondence between the recent solar minimum and the magnetic and auroral minima has not yet been thoroughly examined, but at Toronto the records show, on the magnetic traces, during the rather prolonged and very marked solar minimum, which reached its nadir in 1901.7, an almost continuous straight line. In Christiania, Milan and Prague, the least average variation in declination was in 1902, another "lag" as compared with the spot minimum, and the same feature may be evidenced when the Toronto records are digested. The aurorae observed here in 1901 and in 1902 were equal, but less than in any year since 1878. In this year, 1903, sun-spot activity is markedly revived, also magnetic variations, earth currents and aurorae.

As to the cause of auroral light, the new theory of corpuscles seems to apply—particles shot off from the sun being constrained to move in spiral pulses along the lines of magnetic force as they approach the earth's surface. As they move from the upper regions of the air towards the poles they go through air strata so rarefied that luminosity can be easily excited (as when an electric current passes through a nearly exhausted receiver), but as they approach the earth the density of the air forbids their luminescence. So far the theorists, and perhaps we had better for the present suspend judgment. The rapidity of the motion of electricity would scarcely allow the eye to follow it, as it does in the case of the aurora, even at the ascertained height of auroral displays here, say 100 miles. We should see something resembling the lighting's flash for swiftness. Possibly the radiations which convey electrical charges from sun to usward move more slowly than those we feel as light, which might account for the peculiar "lag" of magnetic effects.

The localization of auroral effects is also very strange. The same aurora is seen differently in different regions. This was made curiously evident in examin-

ing the remarkable aurora of September 2nd, 1898, at the request of Mr. Arctowski, who described it as he saw it in Belgica Straits:

"At 7.50 a fine arch, large, exceptionally high. 8.00, a second arch forms within the first, becoming very intense. Color, green. Rapid movement of the rays from right to left. Fluctuations. Ribands. Snake-like undulations, curving back on themselves. Homogeneous light, white or yellowish, mingles with the rest. 9.30, intensity renewed. Above, a great arch, a single band, clearly defined below, shaded off above, with large waves. 10.15, inside the arch, now much disorganized, is a broad, intense band, bow-shaped, recurved, undulating in the upper part. 10.30, double arch, the outside one whiter than the yellowish but higher one inside. The interior arch bent upwards at one end and fringed with rays. 10.40, the auroral sheen is intense. All the details of the aurora are in a way effaced by a spontaneous effervescence of light. The whole segment is luminous. 10.50, fading, rays distinctly green, distributed all over the part of the sky where it has been, seeming to start from a series of different bands."

The weather in North America was fine and clear on that September 2nd, all over the latitudes where aurorae are to be looked for, except in the State of Maine and the adjoining Maritime Provinces. The observations available are 78, and they are thus distributed—

United States—Idaho, 1; North Dakota, 1; South Dakota, 1; Minnesota, 9; Iowa, 9; Wisconsin, 10; Illinois, 7; Michigan, 10; Indiana, 3; Ohio, 1; New York, 4; New Jersey, 1; West Virginia, 1; Maryland, 1.

Canada—North-West Territories, 5; South-West Peninsula of Ontario, 10; Muskoka and Northern, 4.

Thus the visibility of this aurora was localized in and just around the basin of the great lakes, with a secondary focus of excitation in the far west, on both sides of the boundary line.

Localization is to be noticed in the case, too, of the fine aurora of September 9th, 1898, also brilliant in both hemispheres. Arctowski tells of its "dark segments," "homogeneous arcs," "double arcs," and "rays," witnessed in extraordinary beauty in the Antarctic. Here we had 80 observations, the weather being clear all across the auroral belt of America, except in Nebraska and Iowa. There was a little patch of 16 observations in the North-Western States, and another of a dozen around Pembina and Quesnelle, some brilliant. Then there is a connecting belt of 7 sporadic observations between Winnipeg and Montreal, corresponding to those in Minnesota (4), Wisconsin (2), Illinois (1), and Michigan (1). A scattered single report comes from Kansas. And then comes the great outburst further east: Pennsylvania (3), New York (5), Rhode Island (1), Maryland (1), Vermont (2), Connecticut (2), Massachusetts (7), New Hampshire (10), Maine (5). In Quebec and around the Gulf of St. Lawrence (12), Maritime Provinces (6).

This aurora, then, had its chief American focus by the sea, and a secondary one two thousand miles to the west. It was particularly fine on the European side of the Atlantic.*

Eight descriptive accounts of the aurora of September 2nd have been sent to me from Washington. They are strikingly dissimilar, so much so that the discrepancies cannot arise from errors of observation. Thus, at Dubuque, Iowa, it is expressly said that no arch was visible, and none is mentioned from Duluth or Milwaukee, but there was an arch at Grand Haven, Green Bay, the Sault de Ste. Marie and Rochester, N.Y. At Milwaukee the aurora was highly coloured, green, yellow and yellowish green, at times a red tinge, the whole appearing to be covered with a silvery sheen. At Green Bay "the entire heavens would at times be illuminated with a variety of tints." At Duluth there were "well defined curtain folds and streamers beautifully coloured, constantly changing effects." On the other hand, at the Sault de Ste. Marie, while there was a fine arch and streamers reaching to the zenith, there were no colours noticed; at Grand Haven the arch only gave out faint streamers and no colours are mentioned. At Dubuque there was "a pale, diffuse light," no arch; slender, luminous beams of a pale yellow occasionally rose and suddenly disappeared. The account from Minneapolis differs from both the above classes. "About 9 p.m. two broad parallel bands of light were seen extending . . . across the sky. In the north-east the sky seemed somewhat overcast, and on the edges of what appeared to be clouds there were occasionally patches of bright light which came and went with some rapidity. Sometimes a suggestion of a vibratory motion, but the illuminations were all indistinct. Later in the evening the lights were much more brilliant, with curtain-like movements,

* Bulletin of the Astronomical Society of France, October, 1898.

dark segments, flickering motions, etc. It lasted until nearly midnight." This is the description which offers the closest analogy to Mr. Arctowski's aurora, except that at Minneapolis no colouring is mentioned. But such resemblances are evidently fortuitous. On September 9th the aurora seen on the Belgica was not reported from Minneapolis, but of that aurora, the writer has analyzed eight American reports. Their principal feature was the appearance and persistence of detached masses of auroral radiance, while nothing of the kind is mentioned by Mr. Arctowski. These accounts, too, differ widely among themselves. It will be in order, then, to examine the hygrometric conditions of the atmosphere attendant on these various kinds of display, for differences therein at various levels may cause the variations in the auroral effects of the same magnetic influence—the height of the streamers and their colouring.

Arctowski writes as follows :—

"Dans mes remarques, je n'ai insisté quelque peu que sur l'identité probable des distributions géographiques, par rapport au poles magnétiques, du phénomène auroral, et j'ai posé un point d'interrogation au sujet de toutes les autres analogies qui sans doute seront decouvertes dans la suite. Mais voila que M. Harvey vient de nous demontrer une remarquable concordance entre les aurores observees en 1898 au Canada et dans le Nord des Etats Unis et celles que j'ai notées dans l'Antarctique."

He further says :—

"Mr. Arthur Harvey ayant sous la main des documents beaucoup plus importants que ceux dont je dispose, je ne puis que l'inviter d'étudier, au point de vue auquel il est place, les observations que la Commission de la *Belgica* publiera sous peu."

He formulated several questions which we can now answer—

Q.—Was the duration of the auroræ of September 2nd and 9th, 1898, the same in the Northern United States and Canada as at the station of the *Belgica?*

Ans.—At the points where the auroræ were best noticeable, the duration was about the same, but was not alike at all places.

Q.—Were the fluctuations of intensity the same, north and south?

Ans.—They differed among themselves here, in this particular also.

Q.—Do the maxima and minima correspond, to the moment?

Ans.—No, these too differ here.

Q.—Are the heights to which the auroral arch rises the same, at homologous points, *i.e.*, at points equi-distant from the magnetic pole and on the same magnetic meridian?

Ans.—All we can say is that so far as our observations go, the higher the latitude, the higher the arch and its streamers rise. We cannot say which of the places at which we have observers is to be considered most homologous to that of the *Belgica* with respect to the magnetic pole. The positions are as follows :—

N. magnetic pole lat., 70° 30′ N. ; long., 97° W.
S. magnetic pole lat., 73° 39′ S. ; long., 146° 15′ E.
Toronto lat., 43° 39′ N. ; long., 79° 24′ W.
Belgica lat. (September 2nd, 1898), 70° 00 S. ; long., 82° 45′ W.

Thus Toronto is 1,950 miles from the north magnetic pole, and the Belgica nearly 2,300 miles from the south magnetic pole. Toronto is 600 miles east of the agonic line, the Belgica 1,000 miles west of it.

If, then, anything is to be gained by comparing auroræ in homologous positions (which is very doubtful, as the condition of the air as to moisture, and electrical conductivity at various heights is changeable and seems to govern the brilliancy and colouring and even the character of the movements of auroral displays), better points must be chosen than the Belgica's winter station and Toronto City.

Beautiful auroral displays here are, however, things of the past, owing to the electric lighting which now dims their brilliancy and dulls their colours. One must get beyond the range of arc and even incandescent lights to see the grandeur of the mighty illuminations which formerly often seemed to rival, if not to transcend, the glories of the dawn of day, whose name was for the time usurped. The opaline clouds, delicately tinged with exquisite elusive tints of etherial amber, verging on chrome yellow, Niagara green, rose pink or spring lilac—sometimes

almost stationary and again waving, tripping, dancing, leaping in rapid measures —the embroidered curtains moved by celestial airs in delicate folds of entrancing grace, shedding or dropping a rain of heavenly light so beautiful that one could but gaze in silence and wonder and admire the great bows which spanned the heavens, having one end, it was felt, on the western mountains, and the other on the Atlantic Ocean—these are for the denizens of a large city, like the dreams of youth to the mature man, fond memories of vanished rapture.