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HIGH FREQUENCY RAYS IN THE AURORA BOREALIS AND HIGH ALTITUDE TESTS ON MT. EVEREST

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In a previous paper delivered before the Indiana Academy of Science, a newly discovered penetrating radiation from the Aurora Borealis was discussed, which described experiments in the Hackensack River in Secaucus, New Jersey.

The present report briefly mentions new evidence found since 1927, which explains that these rays are extremely more energetic than first conceived. The data obtained from these experiments is now in preparation and will disclose valuable information of a startling nature. A series of experiments were carried out in Saranac Lake, Adirondack Mountains, N. Y., Lakes Ngantsi-Tso, and Kapur on Mt. Everest, N. Tibet, India and in Secaucus, New Jersey.

Previous data showed these rays capable of piercing nearly thirteen feet of pure solid lead before being stopped, while the latest evidence discloses values far in excess of what was formerly considered remarkable. The present paper explains what has been done in the way of advancing the study of this radiation.

Formerly experiments were conducted at the base of a concrete pipe shaft at a depth of 103 feet in the Hackensack River. In order to secure further information and confirm previous data, experiments were carried out in several other locations here and abroad, as above noted. The results obtained in these locations produced new evidence on the Aurora radiation at various altitudes. The data collected in Secaucus showed lower values than obtained in higher altitudes, which was naturally expected as the atmosphere in the mountains is much lighter. It was found that the atmospheric absorption coefficient for the Himalayan mountains is equivalent in absorbing power to about 19 feet of fresh water.

Penetrating Qualities of the Aurora Rays. In order to understand the penetration of these high frequency rays a few material substances are herewith mentioned which they are capable of piercing. Heretofore nothing was known or even realized regarding their existing power. The only previous known conditions about the Aurora was the visible streamers and the electro-magnetical disturbances set up in the atmosphere. These disturbances which we know about always cause interruptions in telephone, telegraph and power systems.

Several investigators in the past few years attempted to ascertain the principles of these rays but were misled by the various effects produced during polar storms. Evidence shows they even misjudged these powerful rays, of Cosmic origin. Their errors evidently were due to their using crude instruments which hampered the detection of these rays. To determine the qualities of these rays very sensitive instruments are essential and such have been used during recent investigations. Several well known investigators have approached the author to learn the characteristics of these specially designed instruments for their own benefit, but information has been withheld until the proper time.

It is known that substances which are transparent to some waves are opaque to others. What we call light is regarded as but a small part of a very long series

of electromagnetic waves in space. In order to measure the length of these waves the Angstrom unit is employed, whose length is one/one-hundred-millionth of a centimeter or, one/two-hundred-and-fifty-millionth of an inch. There are waves in space ranging from less than a thousandth of an Angstrom up to a length of many miles. The light waves are all included within a range of 3,900 to 7,600 Angstroms, or one/sixty-four-thousandth to one/thirty-three-thousandth of an inch. The longer of these waves makes the effect called red, and the shorter violet.

Glass is transparent to all of these waves. Ordinary glass is opaque to waves of less than about one/seventy-one-thousandth of an inch and more than one/eight-thousandth. Air becomes opaque to waves as short as one/one-hundred-forty-seven-thousandth of an inch, due to their ionizing effect upon it.

A thin sheet of ordinary metal will stop all the waves of the visible part of the spectrum, although a metal like pure gold may be made so thin that some of the light is transmitted. This shows that there is a certain degree of penetration of the light in the solid metal, so that it does not become altogether a perfect conductor to the rays. But there are in the quantum of electromagnetic radiation, waves other than those that appear as light, which are able to penetrate substances that to us seem opaque. Thus ebonite, an almost perfect insulator of electricity for ordinary purposes, though opaque to light waves, is transparent to all the longer waves beyond the red end of the spectrum. On the other side, waves shorter than light waves, such as the X-rays, readily pass through solids that are totally opaque to light. The recently discovered aurora rays coming upon us out of space are able to penetrate pure solid lead to greater depths with considerable ease. That only means that lead is transparent to them though opaque to light waves, and if we had eyes as sensitive to these aurora rays as they are to ordinary light, we could see through 20.8 feet of pure solid lead as through a window glass.

Here we have rays originating in the solar system, at least several hundred times more penetrating than X-rays. We can draw some fairly reliable conclusions as to the origin of these hard penetrating rays in the sun.

Observations and Measurements. Up to the present time, there has been in America only a general agreement in the measurements made on Aurora Rays by several physicists. For high altitudes up to 15,000 feet, Dr. Millikan claims he found a total discharge for an electroscope that was only one fourth of that calculated from the curves of Professors Kohlhorster and Hess for their previously assumed Cosmic Rays.

On Pike's Peak, Colorado, Millikan obtained a rate of production of ions seven times as large as that found by Dr. W. F. G. Swann on the same mountain. The variations are like those found, in the early determinations of e/m which showed fluctuations of about 100%. In our investigations of Aurora Rays in relation to altitude, direction, depth, geographical position and penetration in 1927 it was decided to develop more highly sensitive instruments. These new instruments have been used in all our latest experiments with satisfactory results and will be fully described in a separate paper in the future. However, eight sensitive electroscopes have been especially constructed for use under water at great depths. Their sensitiveness can be regulated by adjusting the atmospheric pressure within them. Furthermore their capacities can be determined with the greaterest of accuracy.

According to evidence obtained the penetrating qualities of Aurora Rays differ for different elevations. Another fact now established is that the Aurora

is always present and is the only possible source sending forth high frequency rays. When the Aurora Borealis is visible high readings are obtainable. On other days when the Aurora is invisible only normal readings are possible. These normal daily values have been mistaken by others for Cosmic Rays originating far beyond the Solar system.

In exploring different bodies of water, the rates of discharge of the electroscopes have been plotted against depth in equivalent feet of water beneath the top surface of the atmosphere. The readings fall upon a smooth ionization-depth curve which is being prepared for insertion in a future paper. This curve indicates a precison over a hundred times as great as that of Kohlhorster's and Millikan's instrument readings. Depth is reckoned in equivalent feet of water below the upper surface of the Earth's atmosphere.

The rate of production of ions diminishes as the electroscopes are lowered into the water. In previous experiments the readings ceased at a depth of 103 feet in the Hackensack river and 172 feet in Saranac lake. This means that our increased sensibility has proven the existence of considerably harder rays than we have previously observed. According to our latest measurements we have been furnished with reliable data that the Aurora Rays consist principally of at least three bands.

Experimental Locations and Results. In 1921 our first experiments were conducted in the Hackensack river and sounding balloons with special recording electrometers were sent up to an elevation of 15½ miles. The instruments testified to the correctness of the increasing discharge rate for all high altitudes, while the Aurora was semi-brilliant. In 1923, Kohlhorster from his experiments on the shielding power of the Alpine glaciers deduced an absorption coefficient of 0.25 per meter of water. It was finally concluded that rays of a powerful nature existed which must be more penetrating than those found by Kohlhorster. The results obtained in 1923 confirmed this and of course their existence appeared certain to be of Solar origin. The highest values of these rays were always observed during extreme intensities of the Aurora Borealis. This was verified by sinking sealed electroscopes in a concrete pipe shaft in the Hackensack river, Secaucus, N. J. and at Saranac lake, Adirondack mountains, N. Y., a distance of 350 miles at approximately the same time and dates. Telephone communications were arranged for between these two points during daily investigations However, we found different readings at both places. In the Hackensack river the ionization at the surface was 2.3 ions while at Saranac lake, altitude 5,000 feet we observed 12.7 ions per c.c. per sec. As the electroscopes were lowered into Saranac lake the number of ions diminished gradually to 2.3 ions at a depth of 172 feet. Below this level no further decrease was noted. The two sets of observations otherwise agreed in every respect. The additional 5,000 feet of air through which this radiation had to pass from the level of Saranac lake to the surface of the Hackensack river was in theory equivalent in absorbing power to 6.5 feet of fresh water. Here it was maintained that the rays in question had a stronger penetrating power at the higher altitude than at sea level. The evidence shows that the Aurora Rays varied in intensities at both places of observation. In 1927-28 and the first half of 1929 further experiments were carried out in Lake Ngantsi-Tso, elevation 15,745 feet and in Lake Kapur, elevation 22,230 feet, in the vicinity of Mt. Everest. The results found at both altitudes showed the extreme possibility of the production of a new type of ray of which nothing before was ever known. These same type of penetrating

rays appeared every day and night and reached their maximum values during the brilliant Aurora displays. In 1928, four additional highly sensitive lead sealed electroscopes were used at Mt. Everest, which were specially designed for this purpose. A total of 12 instruments were used and there was good agreement in the ionization results obtained. In our investigations in Lake Ngantsi-Tso the electroscopes reached a steady state of ionization when 78.1 feet below the water surface and all contined to indicate a reduction of ionization until a depth of 209 feet was attained. In considering the atmospheric absorption above the lakes as shown in the accompanying table, our latest experiments reveal powerful rays so penetrating as to pass through more than 20 feet of pure solid lead before being fully absorbed. This evidently shows that the absorption indicated the presence in radiation of wave lengths from 0.00057 to 0.000029 A.

These hard rays come in independently of ultra-violet radiation from the Sun which under the influence of the Earth's magnetic field are diverted to the polar regions and there, their energy is scattered to the atmosphere and by a natural process converted into Auroral light.

TABLE

Location	Altitude—Feet	Ions per C.C./Sec.	Depths in Feet
Hackensack River	Sea-Level	2.3.....1.3	3.5.....125.5
Saranac Lake	5,000	12.7.....2.3	3.5.....172.
Lake Ngantsi-Tso	15,745	24.3.....3.7	3.5.....209.
Lake Kapur	22,230	38.4.....3.1	3.5.....910.

Atmospheric Absorption Coefficient at Places Given			
Hackensack River 28.0 ft.	Saranac Lake 22.5 ft.	Lake Ngantsi-Tso 19.7 ft.	Lake Kapur 18.2 ft.

Visibility of Auroral Displays. The Aurora is clearly visible in the Northern and Southern hemispheres near the poles. A few facts that are known is that their brilliancy occurs in high latitudes. At the Equator none at all are ever seen. In California, lower Florida and at corresponding latitudes in Europe and lower Asia there is on the average only one Aurora display visible every 11 years. In Canada and the Northern American States they are one hundred and twenty-five times as frequent while in British Columbia, Norway, and on Mt. Everest they have their most frequent occurrence. They are more frequent and brilliant in some years than in others, occurring mostly in Spring and Autumn.

High Altitude Tests. The lakes chosen as quite suitable for under water observations were Lake Ngantsi-Tso and Lake Kapur situated about 200 and

110 miles from the summit of Mt. Everest. Lake Ngantsi-Tso is about 210 feet deep lying at an altitude of 15,745 feet. It is about 900 feet in width and 2,100 feet long. Lake Kapur is about 917 feet deep lying at an altitude of 22,230 feet. It is about 600 feet wide and 1,700 feet long, and is surrounded on all sides by mountains. Lake Ngantsi-Tso was fairly shielded by mountains from any possible rays generated in thunder-clouds. The zero reading of the first four electroscopes in Lake Ngantsi-Tso corresponded to depths of immersion of 209 feet, which were 26.1 for electroscope 1; 24.3 for electroscope 2; 24.7 for electroscope 3 and 24.2 for electroscope 4. In several other tests our first four electroscopes produced similar readings. In order to obtain precision of a higher degree on the first four electroscopes we used two of our later designed electroscopes 9 and 10, which are very sensitive and found an increase in reading of two per cent. This required six electroscopes to obtain a final reading for confirming our previous values as well as the recent with the first four electroscopes. In Lake Kapur, which is 6,485 feet higher in elevation than Lake Ngantsi-Tso, we observed higher readings as usual during visible Aurora displays and in daily normal ionization. Here we found the readings of six electroscopes corresponding to depths of immersion of more than 909 feet, which were 37.7 for electroscope 1; 38.2 for electroscope 2; 38.4 for electroscope 3; 38.7 for electroscope 4; 38.5 for electroscope 5; and 39.1 for electroscope 6. A similar check was made on our tests in Lake Kapur as in Lake Ngantsi-Tso which agreed in every respect during the strong Auroral displays. The scale of readings were observed to increase about 24 hours before the peak of the storm arrived. When the peak arrived which continued for periods of about 35 minutes to 90 minutes the instruments reached their maximum readings. After the peak, our instrument readings showed a gradual decline for a period of 29 hours, when the storm subsided. We, however, noted fluctuations in the instruments for several days after which the ionization reached a low steady value. These values ranged from 8.7 ions for Lake Ngantsi-Tso and 14.6 for Lake Kapur.

Ionization at Sea-Level. With all our latest investigations it has been confirmed that normal Aurora radiation is always present. Sea-level and deep valley observations taken during thunderstorms showed no influence upon the electroscopes. A specially designed radiometer, however, showed slight fluctuations due to p[illegible]ations from lightning discharges. The ionization found at sea-level under all weather conditions was 1.7 to 2.6 ions per c.c./sec. A series of readings were taken on board ship from New York City to Cherbourg. The mean of seven readings taken under uniform weather and the normal daily ionization conditions with two electroscopes was about five ions.

Influence of the Milky Way on Aurora Rays. Since strong evidence on this point would have the most important bearing upon the Auroral Rays, we selected a fairly deep ridge near Lake Ngantsi-Tso. This ridge which was screened by the surrounding mountains, avoided any possible influences from the Milky Way during a consecutively twelve day investigation. Here we obtained a value of 19.3 ions at the bottom of the ridge. This value which is less than that obtained at Lake Ngantsi-Tso was probably due to the lower altitude. The elevation at the base of the narrow ridge is about 1,418 feet below Lake Ngantsi-Tso. This reading was taken during an Auroral display while at the same time other experiments were under way at Lake Ngantsi-Tso. About four

days later our readings in the ridge were reduced from 19.3 to 7.6 ions. This reduction again showed that the Aurora is responsible for the higher values found at other places of observation. We also found no changes in our readings when the Milky Way was over head or out of sight. This is in agreement with our preceding measurements, and also with recent careful research at sea-level done subsequently to this by Drs. Hoffmann and Gockel. All past investigations were conducted under favorable conditions as to altitude and temperature constancy. The resultant data from our balloon surveys is not ready for full discussion at the present time, but will be presented in our next paper. Further experiments are now under way, in another lake on Mt. Everest, which is about 75 miles N. E. of Lake Kapur. This lake is situated at a higher altitude, and so far as known is the highest lake in the world. By exploring this lake, several advantages may be realized and new evidence revealed. Investigations are being made by pilot balloons, by aeroplane and by experiments in this lake.

Conclusions. We have found our latest readings in Europe for similar altitudes to agree very closely with observations in America. The readings taken at Mt. Everest show increased ionization due to the high altitudes. Our twelve electroscopes possessing different forms and material agreed in giving at sea-level an ionization value of 1.7 to 2.6 ions. On the Atlantic ocean our mean readings were five ions. A continual series of readings taken for twelve consecutive days in a deep valley failed to produce any difference between the Aurora radiation coming into the Earth when the Milky Way was overhead or when out of sight. Observations made during thunderstorms at sea-level showed no differences on the Aurora Ray readings. All our electroscopes showed a corresponding increase in their readings when the Aurora was visible, and very low values after the Aurora storm subsided. These low readings continued as normal on other days when the Aurora was not visible. The corresponding wave lengths were carefully determined according to Compton's and Dirac's equations and are 0.00057 to 0.000029 A.

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