Freiburg. (5) That portion of the radiation which comes from the earth is stronger in the warm season than in the cold. (6) The radiation coming from the atmosphere at a height over 2,200 meters shows an oscillation from day to day. Further observations on mountain tops are desirable in this connection.

It has been supposed—owing to the fact that at low elevations the production of ions is small while at great height the production is so large—that the sun is the direct source of the radiation. Against this theory is the lack of variation between day and night. It would be of interest to see how the radiation is affected during sun-spot periods and whether it is measurably influenced by the declination of the sun. On the Atlantic Ocean at a distance from the land a sensible local and temporary oscillation has been noticed to accord with that of the barometer. Lower pressure seems to favor an increase in the radiation. Again, upon approaching the land, a stronger radiation has been observed and there appears to be an oscillation corresponding daily with the periods during which the land and sea breezes prevail. These facts militate against the view that the sun is the immediate source of the penetrating radiation.—*E. O. W[alker]*.

CONCOMITANT CHANGES IN TERRESTRIAL MAGNETISM AND SOLAR RADIATION.[1]

By L. A. BAUER.

[Dated: Department of terrestrial magnetism, Washington, Nov. 17–Dec. 3, 1915.]

While good progress has been made by various investigators in establishing the relationship between fluctuations of the earth's magnetism and those of the sun's activity during the sun-spot cycle, there are still outstanding a number of important questions. The magnetic quantity hitherto generally used—as, for example, one of the magnetic elements (chiefly the magnetic declination) of the range of the diurnal variation (again chiefly of the magnetic declination)—has not admitted always of direct physical interpretation, nor has it furnished always a convenient measure of the magnetic changes. Accordingly the author in a preliminary examination of this relationship, made in 1909, introduced a quantity called the "local magnetic constant," designated by G, which, under certain assumptions, is proportional to the magnetic moment of the earth or to the intensity of magnetization.

Various recent investigations have shown that the quantity G provides an adequate measure of certain changes to which the earth's magnetism is continually subject. One interesting result of the 1909 investigation was that increased solar activity, as measured by sun-spot frequencies, was accompanied apparently by a decrease in the earth's magnetic constant. This is the general effect that accompanies any large magnetic disturbance. For example, during the magnetic storm of September 25, 1909, the earth's magnetic state was below normal for a period of about 3 months. Since magnetic storms in general increase in frequency, as well as in magnitude, with increased sun-spot activity, the general effect on the magnetic constant during the sun-spot cycle is as it was found to be.

In the present paper there are considered changes in the earth's magnetism of a considerably minor order of magnitude as compared with the magnetic perturbations just discussed; however, they are found to be not less important. The precise relationship between changes in solar radiation and possible changes in the earth's magnetism could be subjected to a definite examination only when values of the solar constant, of such accuracy as those of the Smithsonian Institution, became available. Fortunately we now have a series of determinations at Mount Wilson, of this constant by Abbot for a period of four to five months during the years 1905–1914, excepting 1907. The 1913 and 1914 data were kindly supplied by him in advance of publication, for special use in connection with the present investigation. There were likewise made available the magnetic data for the same years, recorded at the observatories of the Coast and Geodetic Survey, for which acknowledgment should be made to the superintendent of that survey.

In the Balfour-Schuster theory of the diurnal variation of the earth's magnetism, it was necessary to introduce an additional hypothesis to account for the great ionization required by the theory, and solar radiation suggested itself as a possible cause. "Hence," Schuster says, "we might expect an increased conducting power in summer and in daytime as compared with that found during winter and at night." If solar radiation plays the prominent part required in the Schuster analysis of the diurnal variation of the earth's magnetism, the question naturally arises: If, at any particular moment or period, the solar radiation falling upon the earth's atmosphere suffers from some cause an appreciable increase or decrease, is there a corresponding observable magnetic change? A diminution, for example, in the amount of solar radiation could be caused by the interposition of some screening body between the sun and the earth. The interposing body might be the moon, as during a total solar eclipse, or a cooling layer above the sun's photosphere. In the first case magnetic observations made during a total solar eclipse would shed some light, and in the second case a comparison of observed values of the solar constant with concomitant magnetic records would be of great interest. We have carried out both lines of inquiry.

It is not possible to enter here into the details of all tests applied and as to methods of computation employed. It must suffice to state the chief conclusions derived to date:

a. Changes in the earth's magnetism of appreciable amount are found associated with the changes in solar radiation as shown by values of the solar constant possessing the requisite accuracy. For the average daily change in the solar constant, which amounts to about 1.5 per cent of its value, the magnetic constant used as a measure of the prevailing magnetic state of the earth suffers a change of about 0.003 per cent, or about one digit in the fifth decimal C. G. S. units. The effect on the horizontal component of the earth's magnetic force would be about twice this.

b. Decreased solar constant appears to be accompanied by increased magnetic constant and decreased diurnal range of the earth's magnetism, in accordance with the following relations: 1 per cent change in the solar constant is accompanied by a change of about 0.002 per cent in the magnetic constant and by about 1 per cent in the magnetic diurnal range. Assuming for the present a linear relation between the solar constant and magnetic changes, a 10 per cent change in the solar constant, as occasionally occurs, may be accompanied by a change in the magnetic constant of about 0.002 per cent and by about 10 per cent in the magnetic diurnal range. The magnetic effects observed during total solar eclipses are about equivalent to those which might be expected from

[1] *Reprinted from* Proc., Natl. acad. sci., Washington, Jan. 1916, 2: 24–27.

about a 10 per cent change in the intensity of solar radiation.

c. Since the changes in solar radiation are aperiodic and occur more or less spontaneously, the effect on the earth's magnetism is generally of a threefold character: (1) An alteration in the diurnal range, (2) perturbations both of the world-wide and the local kinds, (3) an outstanding residual effect such as to alter the daily mean values of the magnetic elements by an amount 10 to 100 times that caused by the regularly-progressing secular variation. The magnitude of the effects may at times exceed the average ones described in (*a*) and (*b*), dependent upon peculiar local conditions (ionizations) of the upper atmospheric layers. Changes in solar radiation may thus furnish sufficient cause for the ever-present minor perturbations and elementary waves or pulsations of the earth's magnetism.

d. The daily noncyclic changes in the earth's magnetism, as found on magnetically quiet days by previous investigators, furnish an additional check on the foregoing results, their quantities harmonizing completely both as regards sign and magnitude with those given here. It is found that on consecutive quiet days the magnetic constant is, on the average, larger on the second day than on the first, the increase being equal to that which would be caused by an average daily change in the solar constant. Moreover, the reason why the magnetic constant, or the horizontal intensity, is larger, on the average, on the second quiet day is because, on the average, the solar constant is slightly smaller on the second day than on the first. The relation between solar change and magnetic change during consecutive quiet days is precisely of the same sign and amount as given in (*b*).

e. If the quiet-day magnetic effect were to persist throughout the year, it would cause a secular variation fully ten times that generally observed. However, the quiet days are in the minority, being exceeded three times and more by unquiet days on which the magnetic effect is of an opposite or compensating kind to that of the quiet day. Since these acyclic effects appear to be associated with solar changes, and since the latter are not periodic, but more or less sporadic, there is an outstanding effect at the end of the year which causes an irregularity in the regularly-progressing secular change. Accordingly, there should be found some correspondence between annual changes of the solar constant and annual magnetic changes. This is found to be the case. Since the solar-constant changes occur only approximately in accordance with sun-spot activity and since the magnetic changes are found to conform so closely to those in the solar constant, an explanation is obtained as to why the irregularities in the magnetic secular change do not always synchronize with changes in solar activity as measured by the sun-spot numbers nor correspond in magnitude to them.

THE RADIOACTIVE DEPOSIT FROM THE ATMOSPHERE ON AN UNCHARGED WIRE.

By S. J. M. ALLEN.

[Dated: University of Cincinnati, June, 1915.]

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In the Physical Review for 1908 appeared an article by the author on the "Radioactivity of the Atmosphere," which stated that a considerable amount of active deposit could be obtained from a smoky atmosphere on an uncharged wire. This deposit was the same in nature as that obtained when the wire was charged to a high negative potential, having decay curves varying between the same wide limits.

Mr. Wilson, at Manchester, England, published a paper [1] in which he stated that he could get no appreciable deposit on an uncharged wire, though he got an effect when the wire was negatively charged. This seemed strange, as one would expect a considerable effect at Manchester, which by report is as smoky as Cincinnati. Granting that the conditions are favorable at Manchester for obtaining the active deposit, Mr. Wilson's negative result may be explained in several ways. With a wire of only 50 feet he could not expect to obtain enough deposit to measure unless he used a very sensitive apparatus. The active deposit on an uncharged wire is in general small compared with that on a charged wire. Careful correction or elimination of the "natural leak" of the apparatus would be necessary. The author used 360 feet of wire and a very sensitive balance method in which the natural leak was eliminated.

Mr. Harvey, at Denver, Colo., states [2] that he could obtain a very small effect on an uncharged wire in an atmosphere which was very clear as far as smoke was concerned but contained a considerable amount of dust.

There does not seem to be much doubt that in an atmosphere containing small nuclei, such as dust, smoke, rain, and snow, one can collect a radioactive deposit without the aid of a strong electrical field. These nuclei act only as carriers and are drawn to the wire by diffusion, or wind. It is probably true that in case of smoke and dust particles the nuclei are sometimes charged. Negative nuclei would therefore be the most efficient as collectors of the radioactive matter, which is positively charged. Any wire insulated in the air would be subject to the effect of the natural potential gradient of the atmosphere which is normally negative with respect to earth. Except in rare cases this potential gradient would not be comparable with the high ones usually used by experimenters in different parts of the world.

The author could get an active deposit whether the wire was insulated from, or connected to, the earth, and even a small trace when it was positively charged.

The present paper gives an account of further observations made during the last 14 months under different atmospheric conditions. They are of considerable local interest, since for several years the Smoke Abatement League has labored to decrease the amount of smoke, and in the last year or two has been quite successful; so much so that to-day the average clearness of the atmosphere at Cincinnati is greatly improved over what it was a few years ago. It was therefore of interest to see if this was having any effect on the active deposit.

The experiments were carried out in exactly the same place and with the same apparatus as those in 1908. The wire was 360 feet long, running as an endless belt over pulleys. The active deposit was rubbed off onto a piece of cotton, or linen, and tested in the null reading "balanced" electrometer devised by the author. The electrometer was made very sensitive, and an uranium oxide standard used. Before each reading the "natural leak" was exactly balanced in the testing chamber and the standard, so that the only ionization measured was that of the active deposit.

By several preliminary experiments the conclusion was reached that nearly all the active deposit was removed from the wire by rubbing. At any rate only the outer layers of the deposit would be very active, since in a

[1] *Wilson*, Phil. Mag., 1909. [2] *Harvey*, Phys. Rev., 1909.