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PROCEEDINGS

OF THE

ROYAL SOCIETY OF LONDON.

*From May 1, 1879, to December 11, 1879.*

VOL. XXIX.



LONDON:  
HARRISON AND SONS, ST. MARTIN'S LANE,

Printers in Ordinary to Her Majesty.

MDCCCLXXIX.

- IV. "On the Relation between the Diurnal Range of Magnetic Declination and Horizontal Force, as observed at the Royal Observatory, Greenwich, during the years 1841 to 1877, and the Period of Solar Spot-Frequency." By WILLIAM ELLIS, F.R.A.S., Superintendent of the Magnetical and Meteorological Department, Royal Observatory, Greenwich. Communicated by Sir GEORGE AIRY, K.C.B., F.R.S., Astronomer Royal. Received April 23, 1879.

(Abstract.)

In this paper the author draws attention to the long series of magnetical observations which have been made at the Royal Observatory, under the direction of Sir George B. Airy, K.C.B., Astronomer Royal. Commencing in the year 1841, the observations for a few years consisted of eye readings of the various instruments, made every two hours; since the year 1848 the motions of the magnets have been registered by photography, according to a plan arranged by Mr. Charles Brooke.

Attention is briefly drawn to the question of magnetic variations, and to the circumstance that examination of the Greenwich records shows that, in addition to the ordinary diurnal and annual changes, there appears to exist, in the magnetic diurnal ranges, an inequality of marked character, and of longer period, resembling in its features the well-established eleven-year sun-spot period.

It is remarked that this is not, by any means, the first time that such relation has been discussed, it being, by some investigators, considered to be already sufficiently well proved. But it appeared to the author that the long series of Greenwich observations might be well applied as an independent test of the accuracy of the supposed relation. For (as regards the results actually employed) the observations have been throughout made on the same general plan, and with the same instruments. The conclusion arrived at should therefore be one worthy of some confidence.

The results for declination and horizontal force only are used, because, the vertical force instrument having been more than once changed, the strict continuity of the record by the latter instrument is somewhat broken.

The monthly mean diurnal range of declination, or of horizontal force, is taken to represent the magnetic energy of the month relatively to other months. Two series of numbers are thus formed, each series being treated independently. Days of unusual magnetic disturbance are omitted.

Before the numbers can be compared with sun-spot numbers, it is

necessary, in order to estimate progressive change, to treat them in some way that will eliminate the actual annual inequality. This is done, both for declination and horizontal force, by taking the mean of each twelve consecutive monthly values, and again the mean of each two consecutive values, giving a series of annual or smoothed means, the mean epochs of which differ by one month.

In the forty-third volume of the "Memoirs of the Royal Astronomical Society," Dr. Rudolf Wolf, of Zürich, gives a table of relative solar spot values, found by treating actual monthly numbers (for the purpose of removing accidental irregularities), exactly in the same way in which the monthly magnetic numbers were treated.

The magnetic numbers and Dr. Wolf's sun-spot numbers are thus strictly comparative, and from these numbers curves are drawn which show a remarkable similarity. Not only do the epochs of minimum and maximum accord, but smaller changes are also seen to appear in all three curves.

The epochs of minimum and maximum being tabulated, it is found that, on the average, the mean magnetic epoch follows the sun-spot epoch by 0.27 of a year. By another method of tabulation the difference becomes reduced to 0.10 of a year. Some other interesting details are here added.

The general circumstance that the diurnal ranges of magnetic elements are subject to an eleven-year period, similar to that of sun-spots, being considered to be satisfactorily established, it seemed desirable to ascertain whether the more fitful changes of the phenomena in any way also correspond. In order to make this comparison, the magnetic numbers, instead of being smoothed, as before described, were now cleared only of the *average* annual inequality, and compared with the *actual* monthly sun-spot numbers (not the smoothed numbers as before). Curves are given, founded on these numbers, and they show some very remarkable correspondences between the more rapid sun-spot and magnetic variations, especially between the years 1869 and 1873. It is remarked that the magnetic results appear to be sensibly improved since the instruments were placed (in the year 1864) in an underground apartment in which the diurnal range of temperature is less than 1°.

Further inquiry seems to point to a variation in the annual inequalities of magnetic diurnal range. This question is discussed in some detail, and the numbers and diagrams given appear to show that such variation really exists, the inequalities being increased at the time of a sun-spot maximum, and diminished at the time of a sun-spot minimum.

The following are the general conclusions supposed to be derived from the whole inquiry:

1. That the diurnal ranges of the magnetic elements of declination

and horizontal force are subject to a periodical variation, the duration of which is equal to that of the known eleven-year sun-spot period.

2. That the epochs of minimum and maximum of magnetic and sun-spot effect are nearly coincident; the magnetic epochs, on the whole, occurring somewhat later than the corresponding sun-spot epochs. The variations of duration in different periods appear to be similar for both phenomena.

3. That the occasional more sudden outbursts of magnetic and sun-spot energy, extending sometimes over periods of several months, appear to occur nearly simultaneously, and progress collaterally.

4. That it seems probable that the annual inequalities of magnetic diurnal range are subject also to periodical variation, being increased at the time of a sun-spot maximum, when the mean diurnal range is increased, and diminished at the time of a sun-spot minimum, when the mean diurnal range is diminished.

Conclusions Nos. 1, 2, and 3 appear to be sufficiently certain, but the evidence in favour of No. 4 is not so decisive.

May 15, 1879.

THE PRESIDENT in the Chair.

The Presents received were laid on the table and thanks ordered for them.

The following Papers were read:—

- I. "Note on a recent Communication by Messrs. Liveing and Dewar." By J. NORMAN LOCKYER, F.R.S. Received April 30, 1879.

In my paper of last December\* I called attention to the importance of discussing Young's observations of the chromospheric lines in connexion with the spectra of the metallic elements. In subsequent communications I have given preliminary results of this discussion so far as it has already proceeded.

Since my paper was read Messrs. Liveing and Dewar have, in a paper printed in the last number of the "Proceedings," given a table which professes to state the number of times various lines in certain metals were seen by Young in connexion with certain reversal phenomena observed by themselves.

The statements, however, made in this table with regard to the

\* "Proceedings," vol. xxviii, p. 172.