SHORT COMMUNICATIONS

SCINTILLATIONS OF RADIO SOURCES AND GEOMAGNETIC ACTIVITY*

By O. B. Slee†

The relationship between variations in the Earth's magnetic field and radio source scintillation has been somewhat obscure since the first observation by Little and Maxwell (1952) that, for sources observed through the Northern Auroral Zone, the scintillation rate, but not the amplitude, was closely correlated with the planetary *K* index. Since then a number of observers, mainly situated in high northern latitudes, also found no relation between the scintillation amplitude and geomagnetic activity. It is the purpose of the present communication to show that at southern temperate latitudes a relationship does exist between these quantities.

During the operation of the $85 \cdot 5$ Mc/s cross-type aerial at Fleurs near Sydney (latitude 33° 52′ S.) from 1955 to 1959 a nightly record was taken of the output of the east-west arm of the cross at sufficiently high sensitivity to detect radio sources within 45° of the zenith having flux densities of more than $50 \times 10^{-26}\ \mathrm{Wm^{-2}\,(c/s)^{-1}}$. The more intense sources outside the normal declination range of the array were also easily seen on the records. During the usual recording period of from about 1600 hr to 1000 hr local time, some 100 patterns followed each other in quick succession, as discrete sources over a large range of zenith angles made their transits through the narrow fan beam of the aerial. Consequently, an examination of each night's record allowed a reliable estimate to be made of both the severity of scintillation and its extent in the ionosphere.

Before the scintillation and geomagnetic data were compared it was found necessary to determine the nocturnal distribution of widespread scintillation activity. This was a relatively easy matter since the onset and cessation of scintillation for a particular disturbed night were often rather well defined. Figure 1 shows a histogram in which the number of occurrences of widespread scintillation is plotted against the local time of observation. It can be seen that the probability of occurrence of an extensive distribution of scattering or focusing irregularities is highest between 0 hr and 2 hr local time and is negligible near sunrise and sunset. There appeared to be no marked seasonal differences in the nocturnal distributions. As a result of this study, the geomagnetic data for each night were examined between 1900 hr and 0700 hr local time.

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† Division of Radiophysics, C.S.I.R.O., University Grounds, Chippendale, N.S.W.

The nightly geomagnetic activity was classified in three rather broad categories—low, if the planetary K index K_p, averaged over the local time interval 1900–0700 hr, lay in the range $0 < K_p \leqslant 3-$; medium, if $3_0 \leqslant K_p \leqslant 5-$; high, if $5_0 \leqslant K_p \leqslant 9$.

Scintillation activity was assessed in the same three general categories—low, if none of the radio sources showed detectable scintillation or alternatively its occurrence was isolated; medium, if the majority of the sources were noticeably affected for a time interval of several hours; high, when all sources exhibited intense scintillations for several hours during the night.

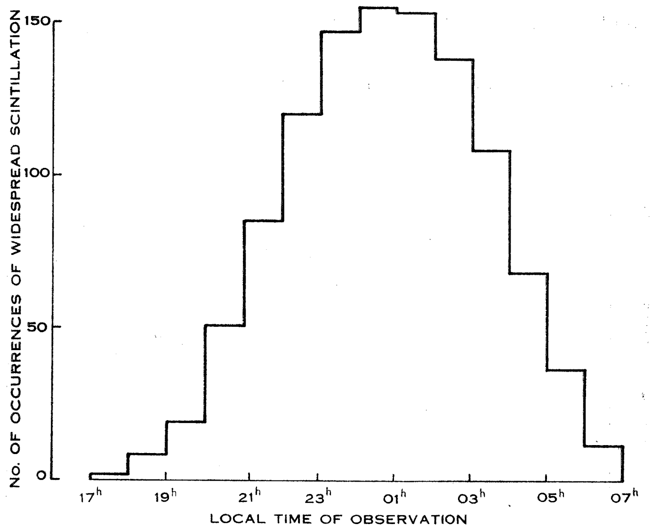

Fig. 1.—Histogram of the occurrence of widespread scintillation for hourly intervals of the local time of observation. The data were obtained from the records of 229 nights over the period 1955–1959 for which the onset and cessation of scintillation were well defined.

The correlation between the scintillation and geomagnetic indices on a nightly basis is shown in Table 1, which summarizes the results of 1127 observing nights. The numbers of chance coincidences are shown bracketed in the table. A χ^2 test of association between the two indices yielded a value for χ^2 of 44 which places their relationship beyond all reasonable doubt.

Scintillation and geomagnetic activity were also compared on a monthly basis by computing for each month the fraction of nights for which the indices were classed as medium or high. The resulting monthly indices are plotted in the correlation diagram of Figure 2, from which it is apparent that months of high geomagnetic activity are also those for which the scintillation activity is generally high. The computed correlation coefficient between the monthly indices is $+0 \cdot 37$ which is significant at the 1% level of confidence.

Up to now most of the observations relating to the influence of geomagnetic disturbances on radio source scintillations have been made from high northern latitudes, often for radiation passing through the auroral zone. The present results establish with a high degree of certainty that the ionospheric irregularities present in southern temperate latitudes are also related to variations in the Earth's field. It is apparent from the nature of the partial correlation that it is improbable that geomagnetic variation is a direct cause of widespread intense scintillation, indeed, Table 1 shows beyond doubt that the latter may occur frequently on magnetically quiet nights ; additional evidence against a causative relationship is the fact that geomagnetic activity does not show the marked nocturnal variation exhibited by scintillations in Figure 1. One conclusion which can be drawn from the observed significant partial correlation is that a scintillation mechanism already present is made more effective on magnetically

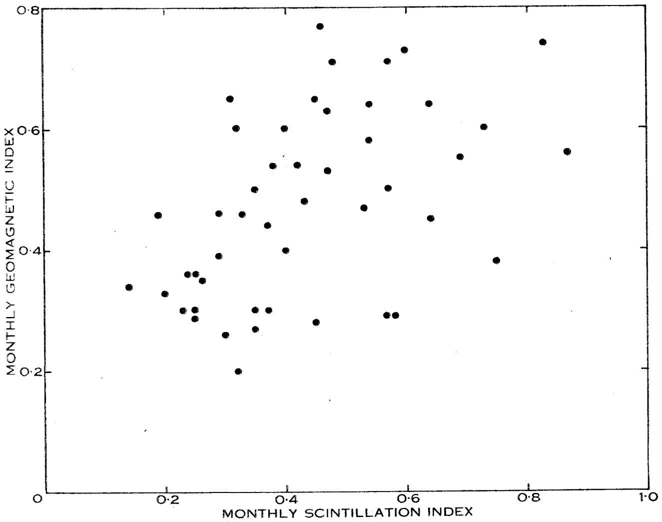

Fig. 2.—Correlation diagram in which the monthly geomagnetic index is plotted against the monthly scintillation index for 47 months during the years 1955–1959. See text for definition of the indices used.

disturbed nights, either directly by the magnetic disturbances or by some other effect related to the arrival of the solar corpuscular streams which are believed to be responsible for geomagnetic activity.

Some recent observations by Kidd *et al.* (1962) have suggested that during severe geomagnetic disturbances radio source scintillation is sometimes temporarily reduced. This is particularly the case for the longer metre wavelengths and for sources viewed in a direction close to that of the Earth's field. Such an effect, if present, would obviously tend to reduce the correlation between scintillation and geomagnetic activity.

In order to test whether the mechanism postulated by these authors to account for their results has affected the present conclusions, three intense discrete sources Hydra-A, Virgo-A, and Taurus-A, making angles of 5°·5, 19°·5, and 28°·5 respectively with the magnetic zenith were examined individually for correlation with the planetary K index. The results of this study showed that the scintillations from the source closest to the direction of the Earth's field were associated with the K index at the 1% level of confidence, while no such relationship was evident for the other two sources.

TABLE 1

CORRELATION BETWEEN SCINTILLATIONS AND GEOMAGNETIC ACTIVITY

Scintillation Index \ Geomagnetic Index	High	Medium	Low
High	15 nights (6)	37 nights (34)	42 nights (54)
Medium	32 nights (25)	167 nights (140)	184 nights (218)
Low	27 nights (43)	207 nights (237)	416 nights (371)

The narrow fan-beam aerial system used in these observations was not an ideal one for examining the scintillation behaviour of individual sources which were visible for only five minutes each night, so that the results are more likely to be influenced by sporadic scintillation activity which was neglected in the previous analysis. However, the study does demonstrate that proximity to the magnetic zenith is not a factor which will reduce the apparent association between scintillation and geomagnetic activity but rather have the opposite effect.

References

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