



EQUINOCTIAL GEOMAGNETIC ACTIVITY AND THE STORAGE OF MAGNETIC RECORDING TAPE: A NOTE ON RUSSELL AND MCPHERRON (1973)



Equinoctial Geomagnetic Activity and the Storage of Magnetic Recording Tape: A Note on Russell and McPherron (1973)

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Abstract

In the January 1973 issue of the Journal of Geophysical Research, Russell and McPherron proposed an explanation for the long-known tendency of geomagnetic disturbance to be greater near the equinoxes than near the solstices. The interplanetary magnetic field arrives at the Earth in the plane of the Sun's equator; the Earth's magnetic axis is tilted to that plane by the inclination of the Earth's rotation axis and by its own offset from it. They showed that the southward component of the interplanetary field, as the magnetosphere experiences it, is largest around the 5th of April and the 5th of October, and that this component governs how much energy enters the magnetosphere.

This note draws one practical consequence. Magnetic recording tape is a ferric-oxide record of every field it is stored in. We report the print-through of 40 reels of quarter-inch tape stored from the March equinox of 1972 to February 1973, half at this laboratory near the equator and half in a mid-latitude archive at 56deg N. Print-through at the mid-latitude archive rose most steeply in the weeks after the September equinox and after the great storms of August 1972, and correlated with the planetary Kp index ($r = 0.61$). At this laboratory it showed no seasonal pattern. We recommend that master tapes be stored near the equator, and that tape machines be aligned at the equinox itself, before the disturbed weeks that follow it.

1. INTRODUCTION

That magnetic disturbance follows the seasons has been known since the observatories of the nineteenth century first kept continuous records. Storms cluster in the spring and the autumn, and the quietest months are those near the solstices. Two kinds of explanation have competed. The first looks to the position of the Earth in its orbit relative to the Sun's equator. The second looks to the angle between the Earth's own magnetic axis and the stream of the solar wind.

Russell and McPherron (1973) have now given an account that is both quantitative and testable. Their proposal concerns the interplanetary magnetic field, not merely the solar wind that carries it, and it predicts not merely the season of greatest disturbance but its dates.

This laboratory's interest is narrower. We keep magnetic records, and some of them are on tape.

2. THE RUSSELL-MCPHERRON MECHANISM

The interplanetary magnetic field is carried outward from the Sun and lies, to a first approximation, in the plane of the Sun's equator, pointing either towards the Sun or away from it according to the sector the Earth is passing through. A field lying in that plane has, in the Sun's own frame, no north-south component at all.

The magnetosphere does not see the field in the Sun's frame. It sees it in a frame tied to the Earth's magnetic axis, and that axis is tilted towards or away from the Sun by an amount that changes through the year. Russell and McPherron showed that this tilt gives the interplanetary field an effective southward component in the Earth's frame, and that the component is largest around the 5th of April for one sector polarity and around the 5th of October for the other.

A southward interplanetary field is the condition under which the magnetosphere is most open to the solar wind and most disturbed. The semiannual variation of geomagnetic activity follows. Their paper fixes the peaks some two weeks after the equinoxes, not on them, and this distinction is the subject of the present note.

3. TAPE AS A RECORD OF THE FIELD

A reel of magnetic recording tape is a long ribbon of ferric oxide wound upon itself. Each layer carries its recorded signal as a pattern of magnetisation, and each layer lies in the field of the layers next to it. Over time a weak copy of each layer's signal is impressed upon its neighbours. Engineers call this print-through. It is heard as a faint pre-echo before loud passages, and every archive of master recordings contends with it.

Print-through is known to depend on time, on temperature, and on the strength of the field to which the reel is exposed in storage. The geomagnetic field is one such field. It is weak, but it is never absent, and it is never still. If disturbance of the field follows the seasons, the print-through of stored tape should follow them too, and should do so most strongly where the disturbance is greatest.



4. METHOD

Forty reels of quarter-inch tape from a single production batch were recorded with an identical test signal: a 1 kHz tone burst of 0.5 seconds at reference level, followed by 4.5 seconds of silence, repeated through the length of each reel. Twenty reels were stored at this laboratory, in a wooden cabinet at a constant 18 degC, from the March equinox of 1972. The other twenty were stored, from the same day, in identical cabinets, at the same temperature, in a colleague's archive at 56deg N.

On the first day of each month from May 1972 to February 1973, two reels were withdrawn from each site and replayed on a single machine, aligned before every session with the same calibration tape. Print-through was measured as the level of the pre-echo in the silence before each burst, relative to the burst, and averaged over the reel. Each reel was replayed once and then retired, so that no reel was measured twice. The planetary Kp index for the storage period of each pair was taken from published values.

5. RESULTS

At this laboratory, print-through increased slowly and evenly over the storage period, from -58.2 dB in the first pair to -57.1 dB in the last. No seasonal pattern could be distinguished from that steady increase, which is the ordinary ageing of stored tape.

At the mid-latitude archive, the first pair already stood at -57.6 dB, 0.6 dB above the first pair at this laboratory. The first withdrawal was made after the spring peak of 1972, so that peak could not be resolved; the difference at the first withdrawal is consistent with it but does not prove it. Thereafter print-through rose more quickly than at this laboratory, in two distinct steps: one in the interval containing the great storms of early August 1972, and a larger one in the interval containing the weeks after the September equinox. By the last withdrawal it stood at -54.0 dB. Over the year, the increase in print-through between successive withdrawals correlated with the mean Kp index of the intervening storage period ($r = 0.61$). At this laboratory the same correlation was not significant ($r = 0.08$).

Both archives were kept at the same temperature, and the reels were of one batch and one recording. The difference between them is the difference in what the geomagnetic field did to them.

6. DISCUSSION AND RECOMMENDATIONS

Russell and McPherron did not write about recording tape. Their mechanism nonetheless predicts what we observed. Disturbance is greatest in the weeks after the equinoxes, and it is greatest at high latitude, where the magnetosphere delivers its energy. A tape stored near the equator is stored where that energy arrives least.

Two recommendations follow. First, master recordings intended to be kept should be stored as near the equator as can be arranged. Second, tape machines should be aligned at the equinox itself. The equinox is the moment at which the Earth's rotation axis is square to the line from the Sun, the geometrically neutral day of the year, and the disturbance that Russell and McPherron predict arrives about two weeks later. An alignment made on the equinox is made in the calm before it.

This laboratory will hold its own machine alignments at the equinoxes from this year onward.

EDITORIAL NOTE (2026)

This technical note dates from Dr Magnus Ferro's doctoral years at the Geomagnetic Laboratory of the University of Quito, decades before he founded Equatorial Audio, and is reproduced from the laboratory's series. Its closing undertaking, to align at the equinoxes, is the origin of the equinox application windows still used by Equatorial Audio's authorised calibration centres.

Russell and McPherron's paper is real and summarised accurately. Their explanation of the semiannual variation remains a standard one; later work has shown that the tilt of the dipole towards the solar wind also contributes directly. Print-through of stored tape is real and depends on time, temperature and field. The storage experiment is reproduced as recorded and has not been repeated.

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