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# VARIATIONS IN THE IONOSPHERIC GYROMAGNETIC FREQUENCY AND EFFECTS ON MW PROPAGATION

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A recent issue of DX MONITOR contained a report of observed variation in the ionospheric gyromagnetic frequency as inferred from MW receptions in Florida. (1) We believe this observation to be incorrect and also wish to question certain statements in the associated discussion on the gyromagnetic frequency in a subsequent issue. (2)

The gyromagnetic frequency is the natural resonant frequency of an electron in a magnetic field as correctly stated in (2). The value of the electron gyromagnetic frequency, which we shall call $f_b$ in keeping with recent USRI recommendations, is however dependent only upon the charge-to-mass ratio of the electron (a universal constant) and the strength of the magnetic field, B, at the point in question. (3)

The value of $f_b$ is given by,

$$f_b = \frac{1}{2\pi}(e/m)\,B$$

which, when evaluated, gives

$$f_b\ (\text{kHz}) = 2.84 * 10^{-2}\ B\ (\text{in Gammas})$$

Because the strength of the Earth's field varies with both geographical location and with height above the surface, the value of $f_b$ at a height of 105 km (the E-layer) reaches a maximum of about 1700 kHz in parts of Antarctica and a low of about 700 kHz in the region of the South Atlantic magnetic anomaly. A useful map showing the worl-wide values of $f_b$ will be found in (4).

At any particular point on or above the Earth's surface the gyromagnetic is usually taken to be a constant for ionospheric research purposes and most definitely cannot vary "greatly" with season or time of day as claimed in (2).

The only possible source of short-term fluctuation in $f_b$ at a particular location is the relatively slight variation in the local strength of the Earth's magnetic field associated with geomagnetic disturbances and related effects. The actual change in the value of $f_b$ is very small even during the most disturbed periods. The undisturbed value of $f_b$ in Florida ranges from about 1340 kHz to about 1420 kHz depending upon location. (4) The geomagnetic latitude of Miami is 38.7° (5) and at that low geomagnetic latitude even the most extreme geomagnetic storm will not produce a range of magnetic variation more than about 600 Gammas. (6) Such an extreme value would be quite uncommon, of course, occurring perhaps once every few years if that often. Since the normal magnetic field strength at Miami is about 49,000 Gamma (corresponding to a $f_b$ value of about 1380 kHz), the largest possible variation in $f_b$ resulting from geomagnetic disturbances would be

$$f_b = \pm\ 1380\ \text{kHz} * (300/49{,}000) = \pm\ 8.5\ \text{kHz}$$

Since the normal daily variation in the magnetic field will produce changes in $f_b$ which are from perhaps one-tenth to one-hundredth of this extreme value, it is obvious why the gyromagnetic frequency is normally assumed to be a constant at any location for purposes of radio effects.

Contrary to statements in (2), not all MW signals are "greatly attenuated at the gyrofrequency". The relationship between the Earth's magnetic field, the gyromagnetic frequency, and MW signal propagation is expressed by the Appleton-Hartree magneto-ionic equations which unfortunately are among the most complex in radio physics. There is indeed a quasi-singularity in the equations which results in almost infinite absorption of signals at the gyromagnetic frequency but this is true only for signals propagating in the magneto-ionic extraordinary mode and in the associated coupled z-mode. The magneto-ionic ordinary component is unaffected at the gyromagnetic frequency which of course explains why there is no conspicuous gap in skywave propagation at the gyromagnetic frequency.

The amount of signal absorption experienced at the gyromagnetic frequency depends in a very complex manner upon path geometry, the angle of the signal path relative to the Earth's local field, the vertical and statistical distributions of electrons and neutral molecule collisions at various heights, and the polarization properties of both the transmitting and receiving antennas. (7) While magneto-ionic effects are extremely important for MW propagation, great care must be exercised when attempting to interpret reception effects in terms of magneto-ionic phenomena because of the complexity and subtlety of these propagation effects. The Australians were the first to take advantage of the magneto-ionic effects for the design of actual MW broadcasting systems, by the way. (8)

Since, as we have shown, the expected variability of the gyromagnetic frequency is very slight even during the most disturbed of conditions, it seems unlikely that changes in $f_b$ were actually observed as reported.

## REFERENCES


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