

Polarization: A Key Difference between Man-made and Natural Electromagnetic Fields, in regard

to Biological Activity

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In the present study we analyze the role of polarization in the biological activity of Electromagnetic Fields (EMFs)/Electromagnetic Radiation (EMR). All types of man-made EMFs/EMR - in contrast to natural EMFs/EMR - are polarized. Polarized EMFs/EMR can have increased biological activity, due to:

- 1) Ability to produce constructive interference effects and amplify their intensities at many locations.
- 2) Ability to force all charged/polar molecules and especially free ions within and around all living cells to oscillate on parallel planes and in phase with the applied polarized field. Such ionic forced oscillations exert additive electrostatic forces on the sensors of cell membrane electro-sensitive ion channels, resulting in their irregular gating and consequent disruption of the cell's electrochemical balance. These features render man-made EMFs/EMR more bioactive than natural non-ionizing EMFs/EMR. This explains the increasing number of biological effects discovered during the past few decades to be induced by man-made EMFs, in contrast to natural EMFs in the terrestrial environment which have always been present throughout evolution, although human exposure to the latter ones is normally of significantly higher intensities/energy and longer durations. Thus, polarization seems to be a trigger that significantly increases the probability for the initiation of biological/health effects.

Superposition of Coherent Polarized Waves/Fields of the same polarization. When two or more waves/fields of the same polarization and frequency are in addition coherent, in other words, when their phase difference at the location of superposition is:

$$\varphi = 0, \pm 2\pi, \pm 4\pi, \dots, \text{ (} n \text{ is an integer)}$$

the result is constructive interference, meaning that the resultant wave has an amplitude (intensity) equal to the sum of amplitudes of the single waves that interfere at the particular location.

When two waves of same polarization have opposite phases at another location, in other words, when their phase difference is:

$$\varphi = \pm \pi, \pm 3\pi, \pm 5\pi, \dots, \text{ (} n \text{ is an integer)}$$

then the result of their superposition is destructive interference, i.e. a wave of the same polarization but with diminished intensity.

The electrical components of two such waves (plane harmonic waves of the same polarization and frequency) reaching a certain location after having run different distances r_1 , and r_2 from their two coherent sources, are given by the equations:

$$E_1 = E_0 \sin(\omega t - k r_1) \quad E_2 = E_0 \sin(\omega t - k r_2)$$

$\omega = (-) \text{ } \text{EE kr t sin 12 w 2022}$

Again, the amplitude E_0 of the resultant electric field - E (electric component of the resultant electromagnetic wave), is:

$\varphi = ++ \text{ } \text{EEEEEE } 2\cos \frac{13}{001} \frac{2}{02} \frac{2}{01} \frac{02}{02}$ where $\varphi = (-) \pi \lambda r r \frac{2}{12}$ depending in this case only upon the difference in the distances run by the two waves, and not upon polarization.

At any location where: $\varphi = 2n\pi$, Eq. 13 gives: $=++(=+) \text{ } \text{EEEEEEE } 2 \frac{14}{001} \frac{2}{02} \frac{2}{01} \frac{02}{01} \frac{02}{02}$

At these locations we have constructive interference.

At any location where: $\varphi = (2n + 1)\pi$, Eq. 13 gives: $=+-(=-) \text{ } \text{EEEEEEE } 2 \frac{15}{001} \frac{2}{02} \frac{2}{01} \frac{02}{01} \frac{02}{02}$

At these locations we have destructive interference.

The intensity of the resultant wave at any location is: $=+ \text{ } \text{JJJ } 16 \frac{12}{12}$

The amplitude of the resultant wave intensity will be, correspondingly: $\varepsilon = (+) \text{ } \text{JcEE } 17 \frac{0001}{02} \frac{2}{2}$

www.nature.com/scientificreports/5 Scientific Reports | 5:14914 | DOI: 10.1038/srep14914 (at the locations of constructive interference), and $\varepsilon = (-) \text{ } \text{JcEE } 18 \frac{0001}{02} \frac{2}{2}$ (at the locations of destructive interference).

Thus, at the locations of constructive interference, the electric field vectors of the two waves/fields are parallel and in the same direction, and both the resultant field and the resultant wave intensity are maximum (Eqs. 14 and 17).

For two identical sources ($E_01 = E_02$): $E_0 = 2E_01$ and $\varepsilon = \text{JcEJ } 44 \frac{0001}{02} \frac{2}{01}$ For identical sources: $= \text{ } \text{ENE } 19 \frac{001}{02}$ and: $= \text{ } \text{JNJ } 20 \frac{0}{02} \frac{2}{01}$

This is why series of parallel RF/microwave antennas are often used to produce high-intensity beams in certain directions.

At the locations of destructive interference the electric field vectors of the two waves are anti-parallel, and thus, both the resultant field and the resultant wave intensity are minimum (Eqs. 15 and 18). For identical sources ($E_01 = E_02$): $E = 0, J = 0$.

Thus, for N number of polarized coherent electromagnetic sources of the same polarization, frequency, and different intensities, with electric components $E_1, E_2, \dots, E_N$, it comes that at the locations of constructive interference, the resultant electric field is the sum electric field from all the individual sources (e.g. antennas): $=+++...+ \text{ } \text{EEEE } E \frac{21}{N} \frac{123}{123}$

The bigger the number of coherent superimposed waves/fields (from the same or different sources), the higher and narrower the peaks¹⁸. That situation can create very sharp peaks of wave and field intensities at certain locations, not easily detectable by field meters, where any living organism may be exposed to peak electric and magnetic field intensities. Such locations of increased field/radiation intensity, also called "hot spots", were recently detected within urban areas, due to wave/field superposition from mobile telephony base towers²¹. Any location along the midperpendicular to the distance between two antennas is a location of constructive interference in the case of two identical antennas.

Thus, the difference between superposition of unpolarized and polarized electromagnetic waves/fields, is that while in the first case we have increased average wave intensity but zeroed net fields at any location, in the second case we have increased both wave intensity and fields at certain locations where constructive interference occurs. This difference is of

crucial importance for understanding the differences in biological activity between natural and man-made EMFs/non-ionizing EMR.