

# Comments on Pall's "Millimeter (MM) wave and microwave frequency radiation produce deeply penetrating effects: the biology and the physics"

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Pall (2021) [1] speaks of a "mechanism" by which Electromagnetic Fields (EMFs) exert forces on the channel sensors of voltage-gated ion channels on cell membranes causing "activation" of these channels, and claims this is his discovery! This is already published since 2000 in multiple publications by Panagopoulos et al, and it is widely known as "ion forced-oscillation mechanism" or "ion forced-vibration mechanism" [2-7, and more]. It describes in detail how polarized and coherent (man-made) EMFs force mobile ions in cells to oscillate on parallel lines and in phase with the applied oscillating EMF, and how the oscillating ions inside the channels exert Coulomb forces on the fixed charges of the S4 channel sensors of voltage-gated ion channels causing their irregular gating (dysfunction rather than "activation") [2-7].

Pall referred to these publications until 2015 to explain the calcium channel findings, and the "window" effects [8]. He had also made a public comment stating among other details: *"The whole basis of the heating/thermal/SAR paradigm of action of these fields is entirely based on the claim that there is no biophysically viable mechanism for the action of these weak non-thermal or micro-thermal fields, and that claim was shown by Panagopoulos to be wrong and the empirical evidence shows that Panagopoulos is right. This is THE best example I have seen of a clearly strongly supported paradigm shift within the last 50 years."* His comment was included in [7] with his consent.

Thus, Pall not only knows our mechanism, but he praised it until 2017, not claiming that it is his contribution. Then, he stopped referring to it, and now talks about a "VGCC

activation mechanism” as if it is his own discovery! This, of course, is untrue, and against any ethical and scientific principle.

He refers to Panagopoulos et al [4] for the effect of polarization, but not for the mechanism which he presents as his own. He speaks of “coherence of polarity” (a non-existing term) instead of polarization, and of “electronically generated EMFs” instead of man-made EMFs to differentiate from Panagopoulos et al [4], and “explains” how “coherent electronically generated EMFs” are more bioactive than natural EMFs as if this is another discovery his own! All these “new discoveries” are already thoroughly described and shown by equations in [3-4,7] where it is explained that man-made EMFs are produced by electric/electronic circuits and for this they are totally polarized and coherent.

In his effort to present our mechanism as his own under the new title “VGCC activation mechanism” he now claims that the irregular gating of the voltage channels occurs not by forces exerted by the oscillating ions on the sensors, but by direct forces from the applied EMFs which are “amplified” by the membranes [1]. A simple calculation shows this would require electric fields on the order of  $\sim 3 \times 10^6$  V/m (= 30mV/10nm), like when these channels are gated physiologically by changes of  $\sim 30$  mV in the voltage across the membrane ( $\sim 10$  nm width) [2-7]. But it has been shown experimentally by many studies, and theoretically in [2-7], that polarized (and coherent) electric fields down to  $\sim 10^{-4}$  V/m can induce biological effects. Moreover, incident fields cannot be “amplified” in living tissue as this is against basic laws of physics. If Pall thinks that his “direct” forces on the channel sensors make a new mechanism he should provide equations and numerical calculations on these forces, showing how they work.

The idea of irregular gating of voltage ion channels by forces exerted on their sensors was first introduced by Balcavage et al (1996) (see reference in 2-7), but no damping or restoration forces were considered, nor coordinated forces from several ions acting simultaneously on the channel sensor prevailing against the random forces due to thermal motion of these ions. These issues were solved in our studies [2-7, and more] which have more than 680 citations until now. This mechanism is verified by computer test in which other suggested mechanisms were found impossible in real damping conditions in cells [9]. Moreover, this mechanism has explained successfully the sensing of upcoming thunderstorms by sensitive individuals, and the sensing of upcoming earthquakes by animals, phenomena unexplained for centuries [5-6].

Apart from the major ethical issues, Pall's paper is misleading for many additional reasons: As shown in [2-7], the amplitude of oscillation of the ions, (computed to be  $A = \frac{E_o z q_e}{\beta \omega}$ , where  $E_o$  is the maximum strength of the applied field,  $z q_e$  the ion's charge,  $\beta$  the damping coefficient in the ion motion, and  $\omega = 2\pi\nu$ ,  $\nu$  the field's frequency), and the corresponding forces on the voltage sensors, decrease as the frequency of the field increases. Thus, only lower frequency EMFs, and the Extremely Low Frequency (ELF) (0-3000 Hz) components of pulsing, modulation etc of complex "microwave" EMFs can cause dysfunction (or "activation") of voltage-gated channels, not the high microwave frequencies (300 MHz - 300 GHz) [2-7]. Thus, the title and context of Pall's paper are misleading. If Pall thinks his "direct" forces are independent of the applied field's frequency he must again show this by equations.

He writes that microwaves produce "deeply penetrating" non-thermal effects in living tissues by their magnetic parts, while the electric parts are absorbed in the skin. But in high frequencies (radio-waves/microwaves/mm-waves) the electric and the magnetic parts of a wave are completely tied with each other, and if the electric part is absorbed the whole electromagnetic wave disappears. Only in the low frequencies the electric and magnetic components are not strongly interconnected and measured separately. This is basic in electromagnetism. Thus, any "deeply penetrating effects" are obviously not due to the high frequency carrier wave, but due to the coexisting ELF components which are very penetrating. These facts are again explained by the ion forced-oscillation mechanism [2-7].

In his attempt to show that his descriptions make a different "mechanism", Pall refers to several Russian studies, claiming that they report "non-thermal effects" of "non-pulsed mm-wave exposures". Two Russian reviews he refers to and can be found in English, are Pakhomov et al 1998 [10], and Betskii and Lebedeva 2004 (referenced in [1]). In several studies reviewed in [10] there were low frequency components of pulsing, or modulation, which Pall did not report. Whether he did that purposely or because he did not notice that, it shows that his descriptions of scientific studies are unreliable and misinforming. In the rest of the studies in [10], and in the Betskii and Lebedeva (2004) review, there is no information on possible existence of low frequencies. Thus, their presence is not excluded.

It is unlikely that any microwave generator does not contain on/off pulsations, even only for energy saving reasons as in radars. Even the onset and removal of an EMF exposure alone may produce the greatest effects (see E. Goodman et al 1995 referenced in [2-7]), as also

predicted by the solution of the equation in the ion forced-oscillation mechanism [2-7]. If there is any additional mechanism for purely microwave/mm-wave EMFs to produce non-thermal biological effects, it is to be discovered and verified.

The above major ethical and scientific issues and many more are the case in Pall [1]. We hope the Rev Environ Health journal will protect authorship and science by publishing these comments and retracting Pall's insulting, misinforming, and misleading paper.

## References

1. Pall ML, (2021): Millimeter (MM) wave and microwave frequency radiation produce deeply penetrating effects: the biology and the physics. *Rev Environ Health*. 2021 May 26. doi: 10.1515/reveh-2020-0165. Online ahead of print.
2. Panagopoulos DJ, Messini N, Karabarbounis A, Filippidis AL, and Margaritis LH, (2000): A Mechanism for Action of Oscillating Electric Fields on Cells, *Biochemical and Biophysical Research Communications*, 272(3), 634-640.
3. Panagopoulos DJ, Karabarbounis A, and Margaritis LH, (2002): Mechanism for Action of Electromagnetic Fields on Cells, *Biochemical and Biophysical Research Communications*, 298(1), 95-102.
4. Panagopoulos DJ, Johansson O, Carlo GL, (2015): "Polarization: A Key Difference between Man-Made and Natural Electromagnetic Fields, in regard to Biological Activity", *Scientific Reports*. 5, 14914; doi: 10.1038/srep14914.
5. Panagopoulos DJ, Balmori A, Chrousos GP, (2020): "On the Biophysical Mechanism of Sensing upcoming Earthquakes by Animals", *Sci Total Environ*. 717 (2020) 136989.
6. Panagopoulos DJ, and Balmori A, (2017): "On the Biophysical Mechanism of Sensing Atmospheric Discharges by Living Organisms", *Science of the Total Environment* 599–600 (2017), 2026–2034.
7. Panagopoulos DJ, (2017): "Mobile Telephony Radiation Effects on Insect Ovarian Cells. The Necessity for Real Exposures Bioactivity Assessment. The key role of Polarization, and the Ion Forced-Oscillation Mechanism", In CD Geddes (Ed.), "Microwave Effects on DNA and Proteins", Springer, Switzerland.
8. Pall ML, (2015): Scientific evidence contradicts findings and assumptions of Canadian safety panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action, *Rev Environ Health*, 30(2): 99–116.
9. Halgamuge MN, Abeyrathne CD, (2011), Behavior of Charged Particles in a Biological Cell Exposed to AC-DC Electromagnetic Fields, *Environmental Engineering Science*, 28(1), 1-10.
10. Pakhomov AG, Akyel Y, Pakhomova ON, Stuck BE, Murphy MR, (1998): Current state and implications of research on biological effects of millimeter waves: a review of the literature. *Bioelectromagnetics*, 19:393–413.