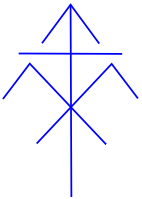
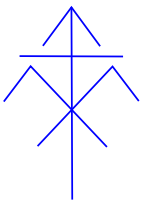


Environmental Current Pollution

*Current Pollution from our electrical systems is an invisible environmental pollutant.
I'll show how we can see it, how far it travels, and why it matters.*





Measureable from Public Land

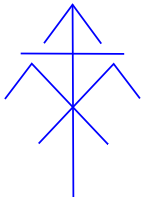
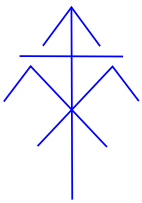
Power utility operators often resist cooperating in projects designed to measure and catalogue environmental current pollution.

All of the methodologies used in these studies have therefore been developed to allow full quantification of environmental current pollution based on measurements on public land.

Utilizing Biot-Savarts law, differential magnetometer measurements, phase/frequency-locked differential measurements and E-field mapping everything can be measured and documented from public land.



We don't need access to substations or transmission assets to document and measure the problem. A magnetometer is like a stethoscope for underground currents. It picks up the 50-Hz "heartbeat", even continents away.



Capacitive Leakage from Buried Transmission Cables

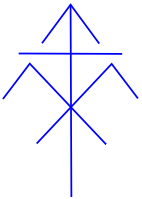
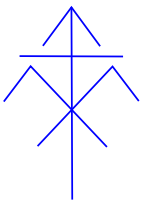
Capacitive leakage from cables is the unwanted flow of current through the insulation between a cable's conductors and ground, due to the cable's inherent capacitance. This occurs because insulation is not a perfect insulator and has both resistance and capacitance.

Causes of capacitive leakage

- Imperfect insulation: All cable insulation has some capacitance, meaning a small current can flow through it.
- Damaged or old insulation: Degradation of the insulation material increases its conductivity, allowing more current to leak.
- Cable length: Longer cables have higher capacitance, which increases the amount of leakage current.
- Moisture and foreign matter: Humidity or dirt on the cable can provide a path for current to bypass the intended insulation.
- Filters in electronic equipment: Electronic devices often have filters with capacitors that add to the overall capacitance of the wiring system and contribute to leakage current.



For a 20km 200kV cable, in healthy condition, this amounts to 181 A AC per phase.

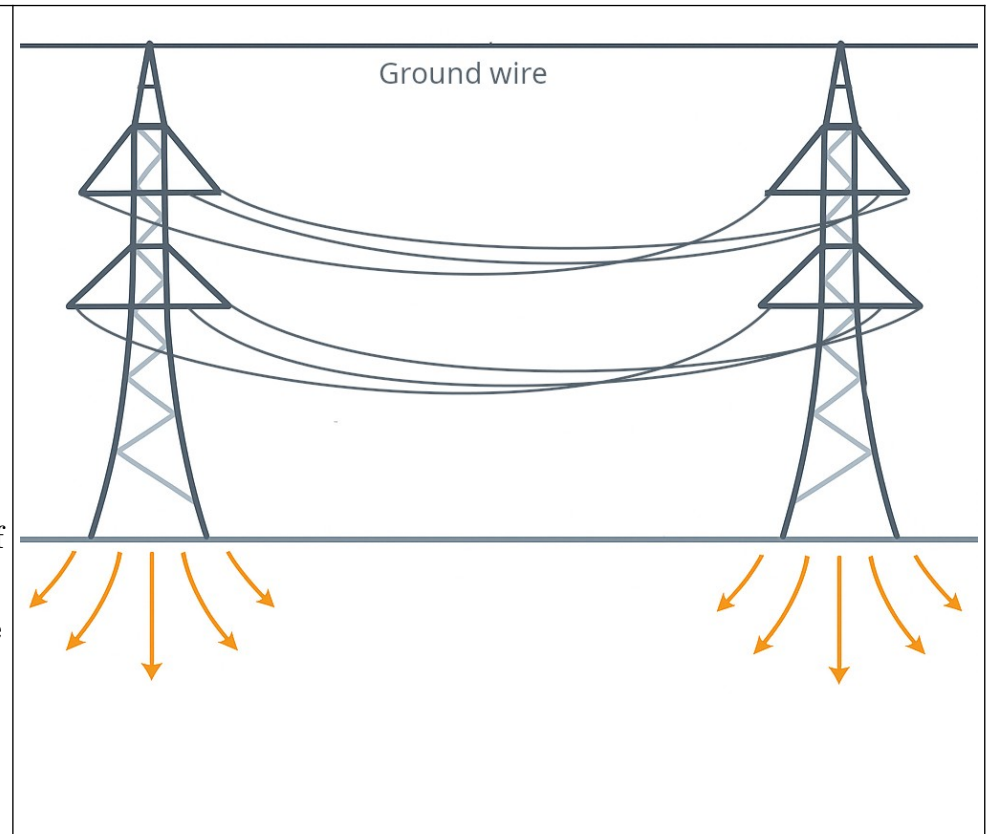


Mutual Inductance from Overhead Transmission Cables

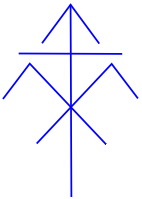
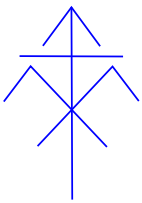
Mutual inductance is the phenomenon where a changing current in one conductor induces a voltage in a nearby second conductor through a shared magnetic field.

This will occur between the phase cables and the ground wire of a overhead electrical transmission system.

- Changing current creates a changing magnetic field: When an alternating current (AC) flows through the phase cables it generates a time-varying magnetic field.
- Magnetic field links with the top ground wire: This magnetic field passes through or "links" with the ground wire on top of the pylons.
- Induced voltage: According to Faraday's law, a change in the magnetic flux induces an electromotive force (EMF), or voltage.
- Result: The induced voltage in the ground wire drives a current into the ground.



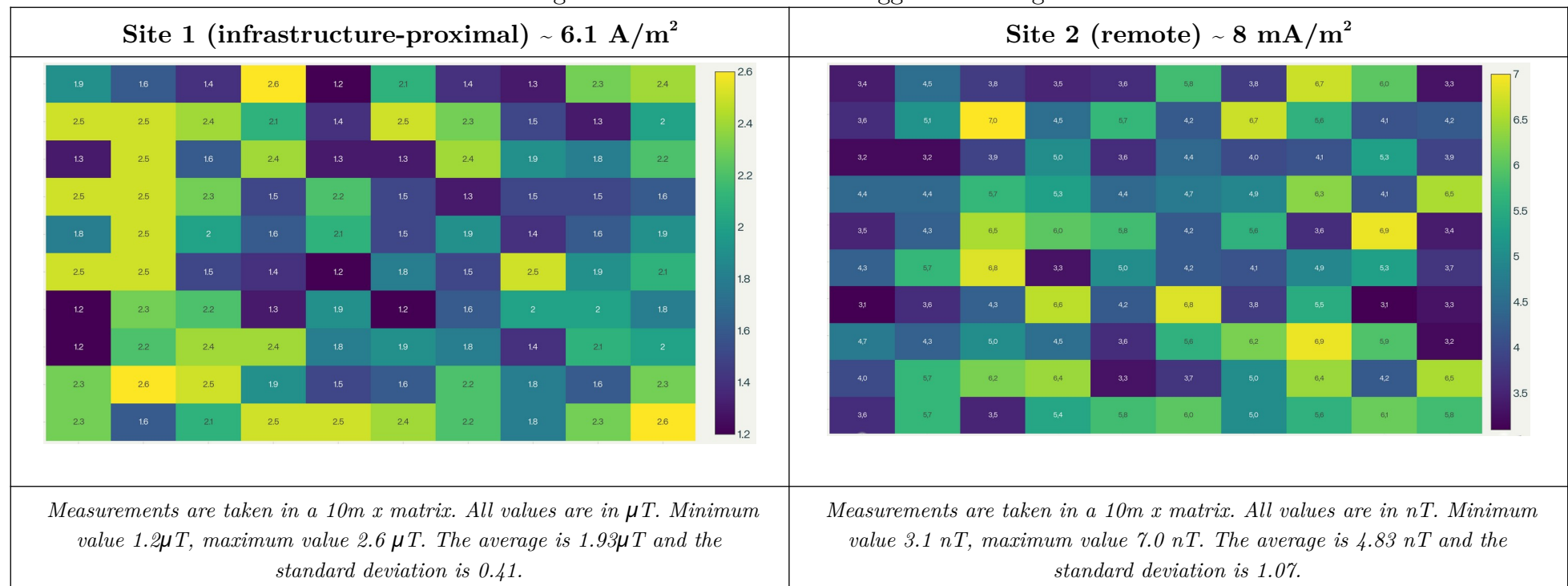
*Conservatively, this will drive 5 - 20 A AC into the ground for each pylon.
Much larger values has been measured.*



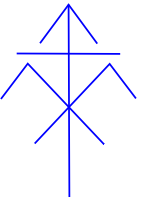
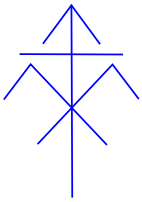
Systemwide Current Pollution

Calculated systemwide current pollution in Denmark estimates between 50 and 300kA driven into ground. Relative to Denmark's land area (~43,000 km²), this corresponds to an average areal current density on the order of a few amperes per km².

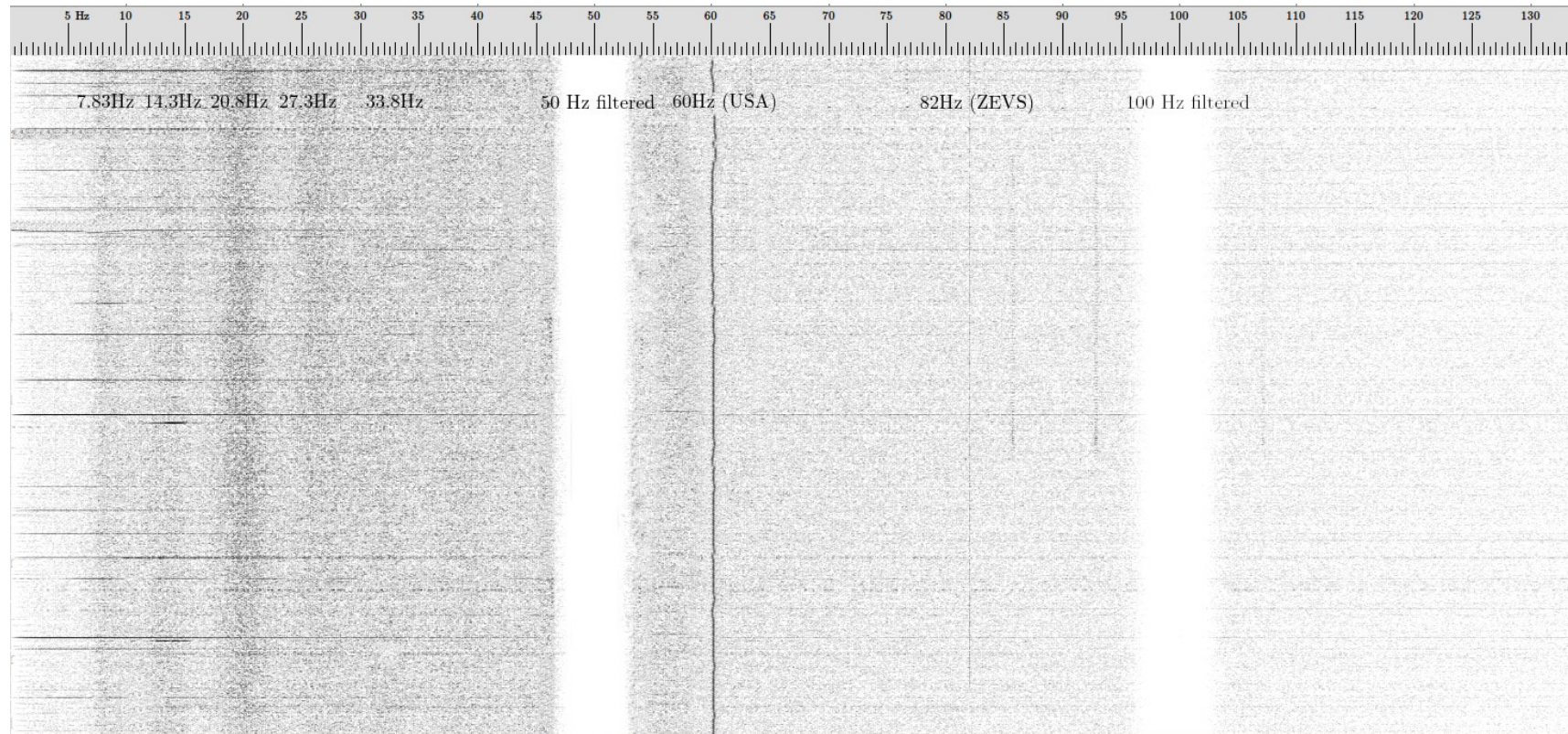
Actual magnetometer measurements suggest even larger values



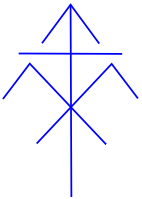
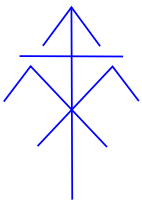
Estimates based on remote-site magnetometer surveys yield an aggregate environmental current pollution above 3 million amperes (relative to DK's land area), far higher than the calculated estimates.



Current Pollution Cross Continents



Current pollution travel astonishingly far—across entire continents. We can measure 60 Hz current pollution from the U.S. in Europe, and 50 Hz current pollution from Europe in the U.S.



Current Pollution from Decentralized Power Generation

Inverters, VFDs and similar electronics with fast rise-times contributes significantly to systemic current pollution.

Very fast rise times drive substantial displacement currents.

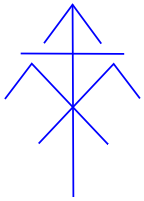
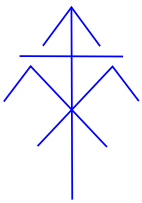
Two-level converters routinely hit 3–10 kV/ μ s edge rates, while SiC-based technologies can be yet higher. This can drive displacement currents up to 1000 A per edge.

RMS values can be calculated from switching frequency.
capacitance can be estimated from cabling and grounding geometry.

Estimations can be validated by magnetometer surveys outside the wind turbine or solar park inverter station.



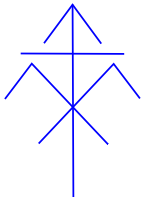
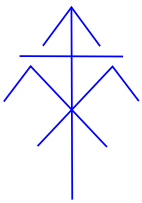
*Conservatively, this will drive 5 - 40 A AC into the ground for each wind turbine.
Values up to 200 A has been measured.*



Current Pollution from Faulty Infrastructure



Damaged 10 kV cable remained in service despite severe damage, likely from a lightning event. It was discovered during fiber-optic trenching ~0.5 m above the line. The grey mass is granite fused around the cable. No protection or fault indication was triggered. Aging/damaged cables are more prone to leakage than newer installations.

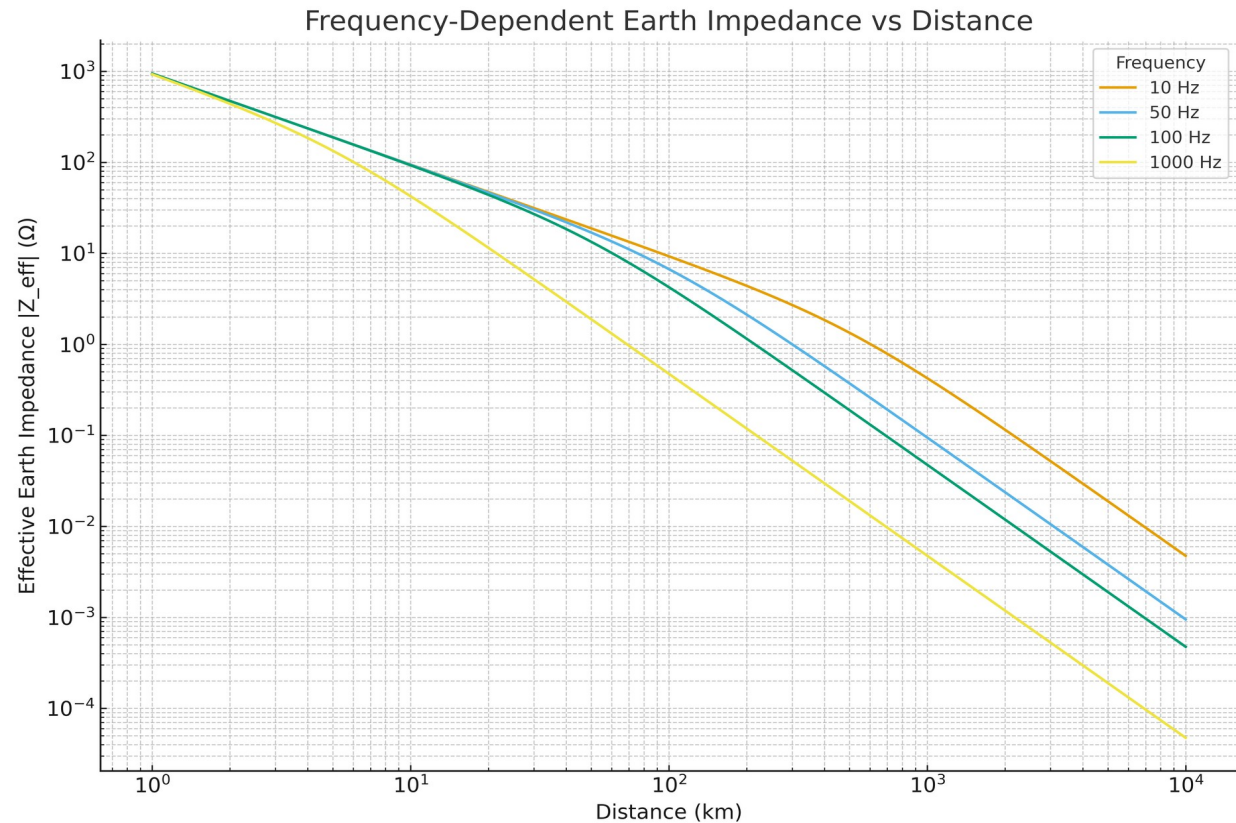


Propagation of Current Pollution

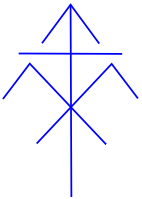
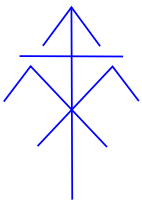
At short distances (1–10 km), impedance is dominated by resistive conduction, decreasing approximately as $1/D$.

Beyond hundreds of kilometers, the curve flattens, reflecting the increasing dominance of capacitive shunting via the Earth-ionosphere cavity.

The asymptotic flattening at long distances implies that current pollution can propagate efficiently over global scales without linear attenuation.



Current pollution, once injected into the ground, can effectively propagate nearly unattenuated for continental distances.



Biological Mechanisms I - Displacement Current

When a biological system is exposed to an external field, a displacement current can flow through the body's effective capacitance to its surroundings.

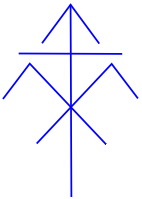
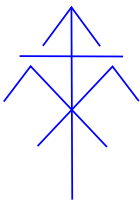
If the animal is electrically connected to ground (wet grass, moist soil, etc in natural settings, or reinforced concrete equipotentially bonded floor in farm settings), then the animal-ground path becomes resistive + capacitive, with effective impedances that can drop to tens of Ω to $k\Omega$ depending on hoof conductivity and moisture.

In practice, this means that μA to mA levels of 50 Hz (and harmonic) currents are possible. This is relevant both for animals in industrial-scale farms, and undomesticated animals living in natural environments.



Contact currents as low as $\sim 18 \mu A$ have been associated with increased cancer incidence.

Kavet, R., Zaffanella, LE., Daigle, JP. and Ebi, KL. 2000. The possible role of contact current in cancer risk associated with residential magnetic fields. Bioelectromagnetics, 21: 538-553.



Biological Mechanisms II - EMRE

Martin Blank and Reba Goodman, identified specific electromagnetic response elements (EMREs) in DNA that act as field-sensitive promoter elements—challenging the earlier assumption that DNA is electromagnetically inert at non-thermal field strengths.

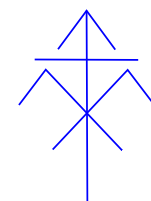
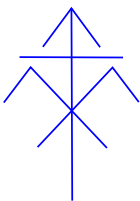
Blank and Goodman proposed that ELF fields perturb electron transfer within DNA: mobile electrons (notably those involved in hydrogen bonds between base pairs) are displaced by applied fields, producing transiently charged groups at nCTCTn sites. The resulting local destabilization can favor base-pair separation, facilitating initiation of transcription. Although electron and hydration dynamics occur at much higher intrinsic frequencies, ELF oscillations can act as quasi-static, pulse-like perturbations in this context.

Weak, non-thermal electromagnetic fields can influence gene expression.
DNA is a receptor (Fractal Antenna) for ELF.

George I, Geddis MS, Lill Z, Lin H, Gomez T, Blank M, Oz MC, Goodman R. Myocardial function improved by electromagnetic field induction of stress protein hsp70. J Cell Physiol. 2008 Sep;216(3):816-23

Lin H, Blank M, Rossol-Haseroth K, Goodman R. Regulating genes with electromagnetic response elements. J Cell Biochem. 2001;81(1):143-8.

Blank M, Goodman R. DNA is a fractal antenna in electromagnetic fields. Int J Radiat Biol. 2011 Apr;87(4):409-15.



Biological Mechanisms III - Wring Resonances

Whereas covalent bonds are too strong to be directly influenced by the environmental current pollution, most three-dimensional conformations of biological macromolecules (e.g., proteins) are stabilized by weaker interactions—van der Waals forces, London dispersion, hydrogen bonds, and related noncovalent effects—that can, in principle, be perturbed at much lower energy.

One such mechanism is the wring resonance, examined in a set of theoretical studies from 1997 that presented a detailed and rigorous mathematical model of how weak electromagnetic waves could influence macromolecular conformational stability via local resonance amplification. A few years later, the research group reported experimental validation consistent with the theoretical predictions.

Weak, non-thermal electromagnetic waves can influence macromolecular conformational stability via local resonance amplification.

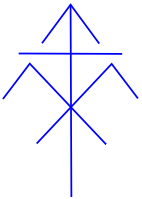
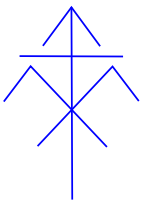
Bohr J, Bohr H. The implication of topology for protein structure and aggregation. Z. Physik D. 1997; 40:186-198.

Bohr J, Bohr H, Brunak S.. Protein folding and wring resonances. Biophysical Chemistry 1997; 63:97-105

Bohr H, Brunak S, Bohr J. Molecular Wring Resonances in Chain Molecules. Bioelectromagnetics 1997; 18:187-189

Bohr H, Bohr J. Microwave Enhanced Kinetics Observed in ORD Studies of a Protein. Bioelectromagnetics 2000; 21:68-72

Bohr H, Bohr J, Microwave-enhanced folding and denaturation of globular proteins. Physical Review, 2000;61(4);4310-4314



Biological Mechanisms IV - Schwan-Driven VGCC Gating

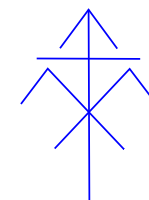
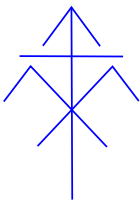
The idea that non-thermal electromagnetic fields can modulate voltage-gated calcium channels (VGCCs) was first articulated by Dimitris J. Panagopoulos and colleagues and subsequently experimentally verified a number of times.

Their original work is focused on ELF patterns in RF-based communication technologies, but by deriving a more general model for Schwan-driven VGCC-gating, this mechanism is explicitly relevant in relation to environmental current pollution and related electrical field intensities.

The proposed model is described in:

Horsevad, Kim, 2025 "Environmental Current Pollution and Possible Interaction Mechanisms for Biological Effects", Volume 14 Issue 10, October 2025, International Journal of Science and Research (IJSR), Pages: 410-421.

The derived model predicts that low-frequency electric fields, at levels commonly found near leaky transmission infrastructure and near electrically conductive underground strata, can induce transmembrane polarization on the order of a few hundred microvolts—well below classical electroporation thresholds ($\approx 0.2\text{--}1$ V), yet entirely sufficient to shift VGCC open probability by percent-level amounts.

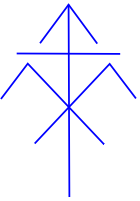
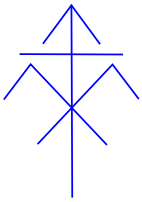


Implications for Biological Systems

Domain	Mechanism	Notes
Genome integrity	Wring Resonances, Bohr & Bohr	Primarily relevant for higher frequencies
Gene expression	EMRE, Blank and Goodman	EMF affects gene expression. DNA might function as a broadband fractal antenna.
Increased Reactive Oxygen Species	Irregular VGCC gating	Either via direct L-channel electrodynamics (Panagopoulos), which is primarily relevant for higher frequencies, or via Schwan-driven VGCC gating, which is primarily relevant for environmental current pollution
Navigation	Perturbed natural fields	Most migrating animals use local magnetic field variations and field topologies for navigation. Increased levels of environmental current pollution can easily swamp natural fields.
Electrodynamic effects	Displacement current	This mechanism is under-researched, measured levels are sufficient to affect nerve operation directly, and disturb any natural process depending on electrotaxis.

Typical levels of 50 Hz Current Pollution are ~100.000 times higher than natural levels.

The rapid electrification of all areas of our society might be a cure, which is worse than the disease.



References

This presentation is based upon these two papers:

- *Horsevad, Kim. 2025. "Development of Differential Magnetic Field Methodology for Estimating Quantity of Stray Current Carried Through Conductive Earth", International Journal of Science and Research (IJSR), Volume 14 Issue 5, May 2025, pp. 793-798..*
- *Horsevad, Kim, 2025 "Environmental Current Pollution and Possible Interaction Mechanisms for Biological Effects", Volume 14 Issue 10, October 2025, International Journal of Science and Research (IJSR), Pages: 410-421.*

These, and my other research, can be accessed at

<https://horsevad.net/publications.html>

This presentation can also be downloaded at the abovementioned website.