DEGASSING AS
THE BIOLOGICAL IMPACT OF
LOW ELECTROMAGNETIC FIELDS

Vladimir Shatalov
Professor of Biophysical Department,
Donetsk National University,
UKRAINE

E-mail: vladishat@gmail.com

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All known theoretical models of EMF bio-effects are controversial

- Effects of electric fields on cell surface structures and cell attachment
  - Polarization forces
  - Coulombic forces
  - Effects of induced charge on cells
  - Induced surface charge on cell matrix or substrate
- Cyclotron resonance and ion parametric resonance
  - Lednev’s model
  - Ion parametric resonance
- Biological electron transfer
- Effects on biogenic magnetite
- Magnetochemistry: Effects of magnetic fields on free-radical reactions
- Non-linear dynamics and application of stochastic resonance

*USA, NIH Publication No. 98-3981, 1998.*
*Bingi, Savin, 2003*
Any theory must answer the three main questions:

what is

1) the **primary target** of EMF?
2) the way of **accumulation** of EMF impact?
3) the cause of **biological effect**?

The presented model gives the answers!
1. The primary targets of EMF are nanobubbles of air dissolved in water or bio-liquid

- Its presence in liquids are non-controlled
- The density junction at the bubble border is the physical target for EMF forces
- These are macro-objects – no kT-problem!
- The EMF forces enlarge the bubbles
2. The energy of EMF impact is accumulated in the surface energy of extending bubbles

- The EMF perturbs the gas-liquid metastable equilibrium
- The gas phase growth means degassing of the liquid
- That is the reason for the dose-effect of EMF impact
- That is the reason for the observed various after-effects
3. The degassing of bio-liquids by EMF changes its properties that originates biological effects

- **pH increases** due to CO₂ output
- The **conductivity increases** due to release of the ions adsorbed on the bubble surfaces
- **Ca⁺⁺ activity increases** by the same way
- All the changes give some physical, chemical and **biological aftereffects**
Physics and Chemises
Laser beam via optical microscope (Bunkin et al, 2010)

Double distilled water

NaCl 0.8M
Figure 6. $\zeta$ potential of microbubbles in distilled water. Despite no addition of electrolyte or surfactant, aside from dissolved ambient CO$_2$, the gas–water interface was negatively charged and no appreciable variation in the potential was observed in correlation with bubble size.
Estimations of equilibrium size of nanobubbles

- Емец Б.Н. (1997) 180 nm
- Емец Б.Н. (2000) 20 nm
- Valle´e Ph. et al (2005) 300 nm
- Бункин Н.Ф. и др. (2009) 70 nm
- Шаталов В.М. и др. (2010) 200 nm

These tries are useless!
The factors which impact the spontaneous nucleation

- **Pressure and Temperature** – determine free energy barrier
- **Impurity ions** – counterforce Laplace pressure
- **Salinity and Acidity pH** – change air solubility in water
- **Surfactants** – decrease the surface tension and Laplace pressure
Surfactants adsorption instantly decrease the surface tension.

Diffusion time
\[ t_{\text{max}} = \frac{R^2}{D} \]

For \( R = 100 \text{ nm} \), \( D = 10^{-5} \text{cm}^2/\text{s} \),
\[ t_{\text{max}} = 10^{-5} \text{s} \]
Fluctuations of bubble surface energy sum in water and coming out

by Gudkov et al, 2011
Wavelets of the bubble surface energy fluctuations in water (down) and coming out (upp)

Wavelet number

<table>
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<th>100</th>
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<td>1200</td>
<td>1800</td>
<td>2400</td>
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A bubble is the primary target for EMF forces

- Polarization
  \[ d = \frac{\varepsilon_1 - \varepsilon_2}{\varepsilon_1 + 2\varepsilon_2} a^3 \varepsilon_0 E_0 \]

- Gradient force
  \[ F = -\text{grad}(dE_0) \]

- Field pressure add
  \[ \Delta P = \frac{dE_0}{\frac{4\pi}{3} a^3} \]

- Dipole-dipole force
  \[ F_r = \frac{3d^2}{4\pi\varepsilon_0 r^4} \left(1 - 3\cos^2 \theta\right) \]
The expected physical effects of EMF impact

- Pushing the bubbles out of the field aria – bubbles output - degassing
- Alternating adds to pressure – bubbles growth - degassing
- Dipole-dipole attraction – bubbles coalescence – degassing
- Adsorbed and counter-ions currents – local temperature growth – degassing and local magnetic momentum!
The expected chemical effects of degassing (?)

- **pH increases** due to CO$_2$ output changes $\zeta$-potential of ALL double layers in the liquid and by this way alters ALL surface stipulated reactions.

- **Ca$^{++}$ activity increases** due to its release from the surfaces of vanishing bubbles influences the Carbon Capture and Storage problem.
pH of pure water increases after EMF treatment

30-170MHz (Bessonova, Stas, 2008)
Conductivity of pure water increases after EMF treatment

30-170MHz (Bessonova, Stas, 2008)
Water pH increases after centrifugation and relaxes then by Zinchenko, Noga, Shatalov, 2009.
Biology

Some biological effects of degassing
Degassing of blood plasma probes after treating in 3000 cpm centrifuge

by Zinchenko, Shatalov, 2010
Degassing changes the glucose index and HbA1c in blood

by Zinchenko, Shatalov, 2010
Degassing changes the blood clotting times

Internal way

Degassing time, min

Internal clotting, min

Relaxation

Shaking (3000cpm), min

by Zinchenko, Shatalov, 2010
Degassing increases Ca^{++} activity in blood by Zinchenko, Shatalov, 2010

Clotting start concentration of CaCl$_2$, mM

Degassing time

Internal clotting, min

External clotting, min

0.5mM

0.1mM

0.5mM
Erythrocyte sedimentation rate tests after centrifugation

by Zinchenko, Noga, Shatalov, 2009
Resume: The mechanism of non-thermal EMF bio-effect

- EMF polarization induces bubble to bubble and bubble to border attraction.
- Degassing is a result of merge and emersion (coalescence) of synphase polarized nano-bubbles.
- The degassing changes hydrophobic interaction and increase activity of dissolved ions.
- That gives rise to biological effects.
New: Our theory answers the main questions

1) the primary target of EMF is a bubble as the liquid density discontinuity;
2) the way of accumulation of EMF impact is degassing of the treated liquid;
3) the biological effect is caused by changes of physical and chemical properties of liquids after degassing.
Adds: Resolved problems of the low EMF bio-effect

- **pH increase and IR-spectra changes** in irradiated water are caused by CO₂ output.
- **Paradox of water conductivity growth** connected to degassing under EMF.
- **Changes in transparency** of irradiated water are due to the bubble average size growth under EMF.
- **After-effect of EMF** is due to slow floating up of the integrated micro-bubbles.
- **Weather sensibility** may be caused by pressure effect on the equilibrium bubble size and floating up speed.
Epilogue: Things we’re seeking for may lay so close that become invisible when looking through!

Thank you for attention!

vladishat@gmail.com

Lake Manasarovar, Tibet