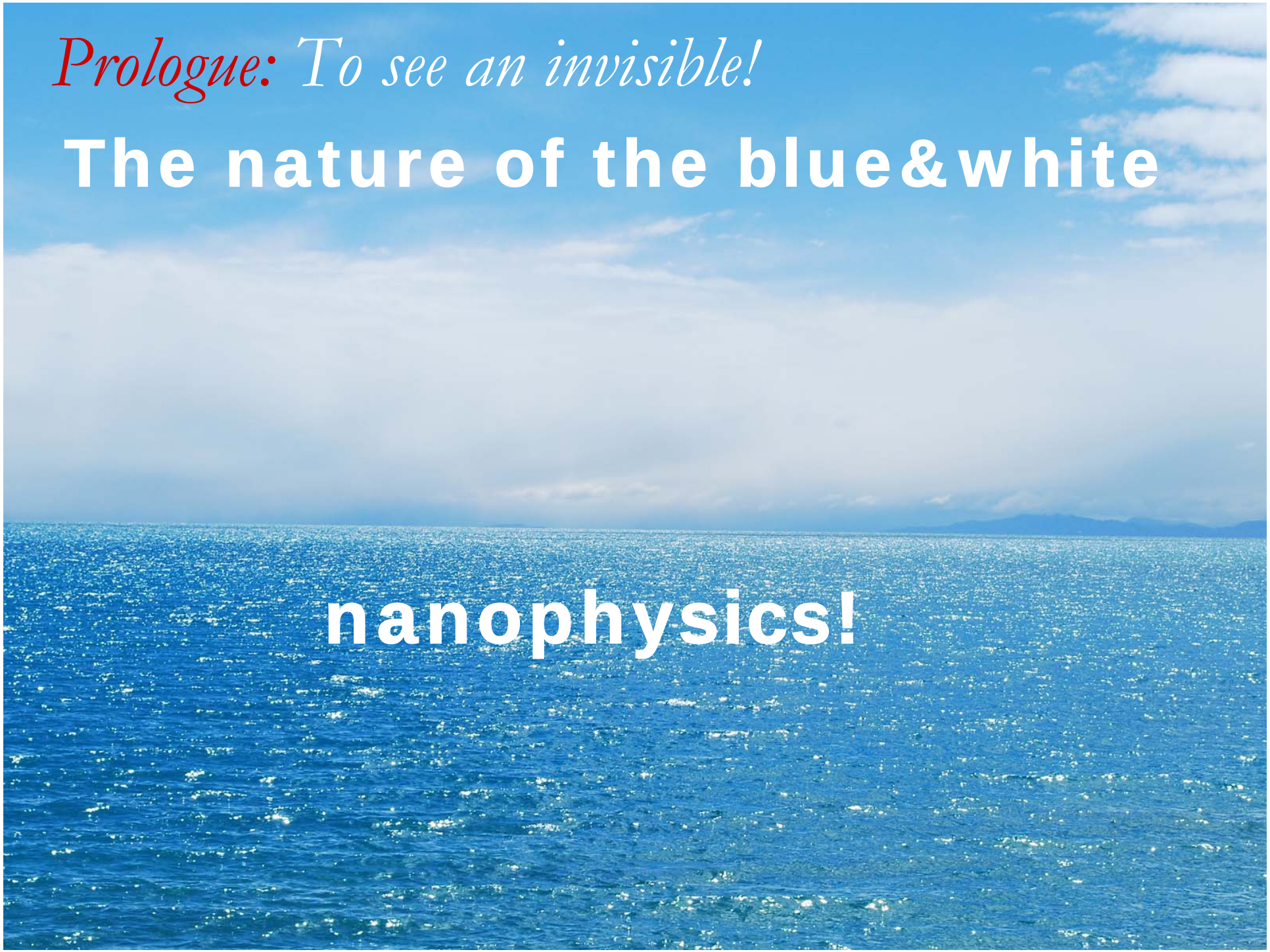
DEGASSING AS THE MECHANISM OF NON-THERMAL ELECTROMAGNETIC FIELDS EFFECT ON WATER AND BIOLIQUIDS

Vladimir Shatalov

Donetsk National University
Biophysical Department

Donetsk – 2009


Prologue: *To see an invisible!*
The nature of the blue&white
nanophysics!

Fact 1: The air solvated in water forms micro-bubbles

Gas	*Air* %	*Water* %
N_2	78.1	1.2
O_2	20.9	0.65
Ar	0.93	0.035
CO_2	0.031	0.028
Total	~100	**1.9**

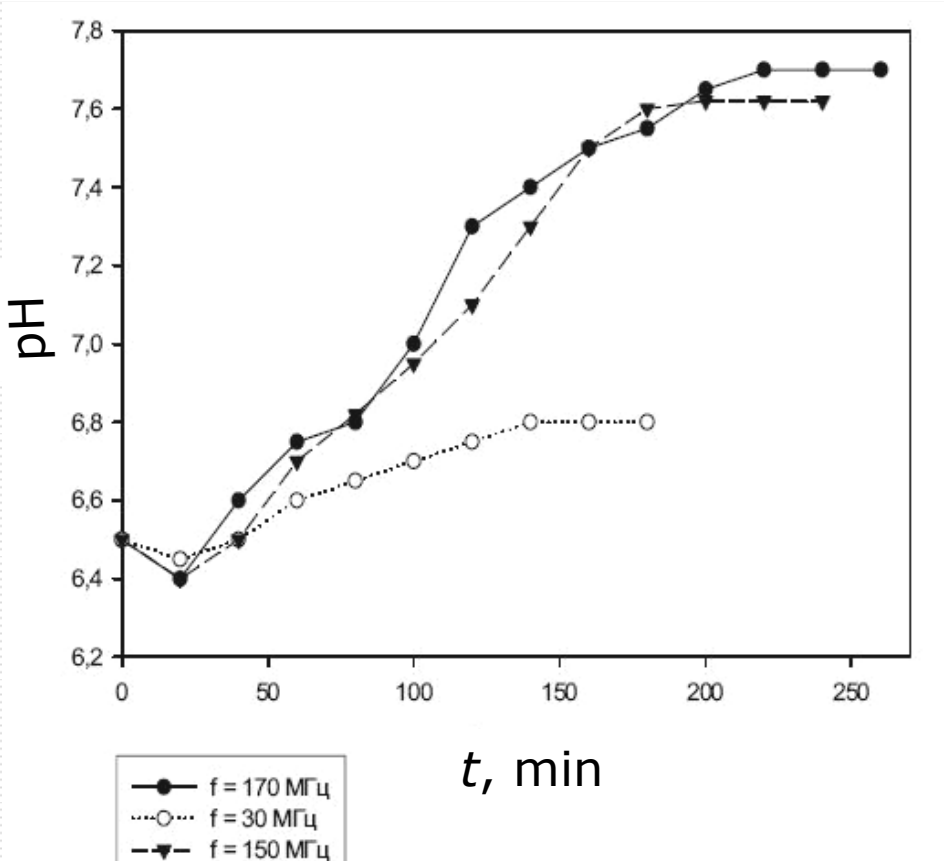
Fact 2: Waves accelerate the coalescence of bubbles

- An acoustic wave field pull oscillating bubbles together (and to boarders) by Bjerknes forces so speed up the coalescence (*Bjerknes V.*, 1891)
- Ponderomotoric effects of EMF and acoustic wave field are the same (*Lebedev P.N.*, 1897)
- Micro-waves and light decrease the volume of air in micro-bubbles without heating (*Emetz B.G.*, 1996, 2000).

Fact 3-4: Degassing reduces the acidity and electrical resistance

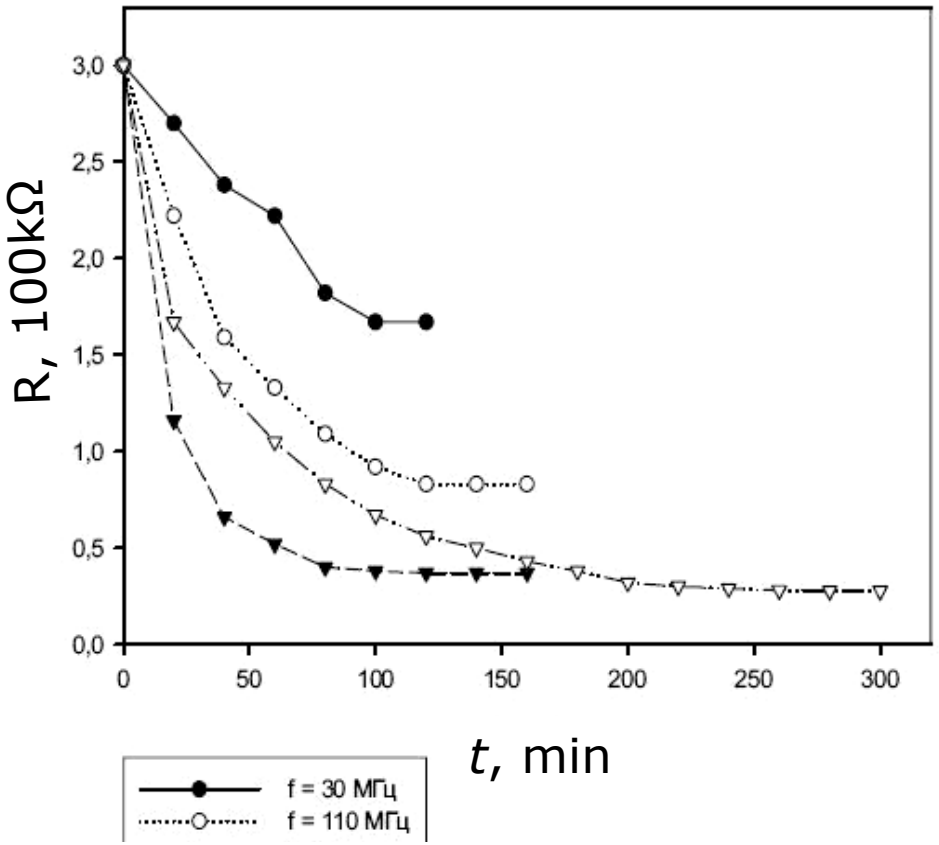
- The concentration [H^+] decreases (ΔpH~1 at 20°C) due to CO_2 output.
- Electrical resistance of degassed water is 0.8MΩ·cm (22°C) (*Pashley R.*, 2008) comparing to 18MΩ·cm (25°C) for ultra pure water (*Martin Chaplin's web-site*)

Fact 5: EMF exposure reduces the acidity of water



by *Stas I.E.*, 2008.

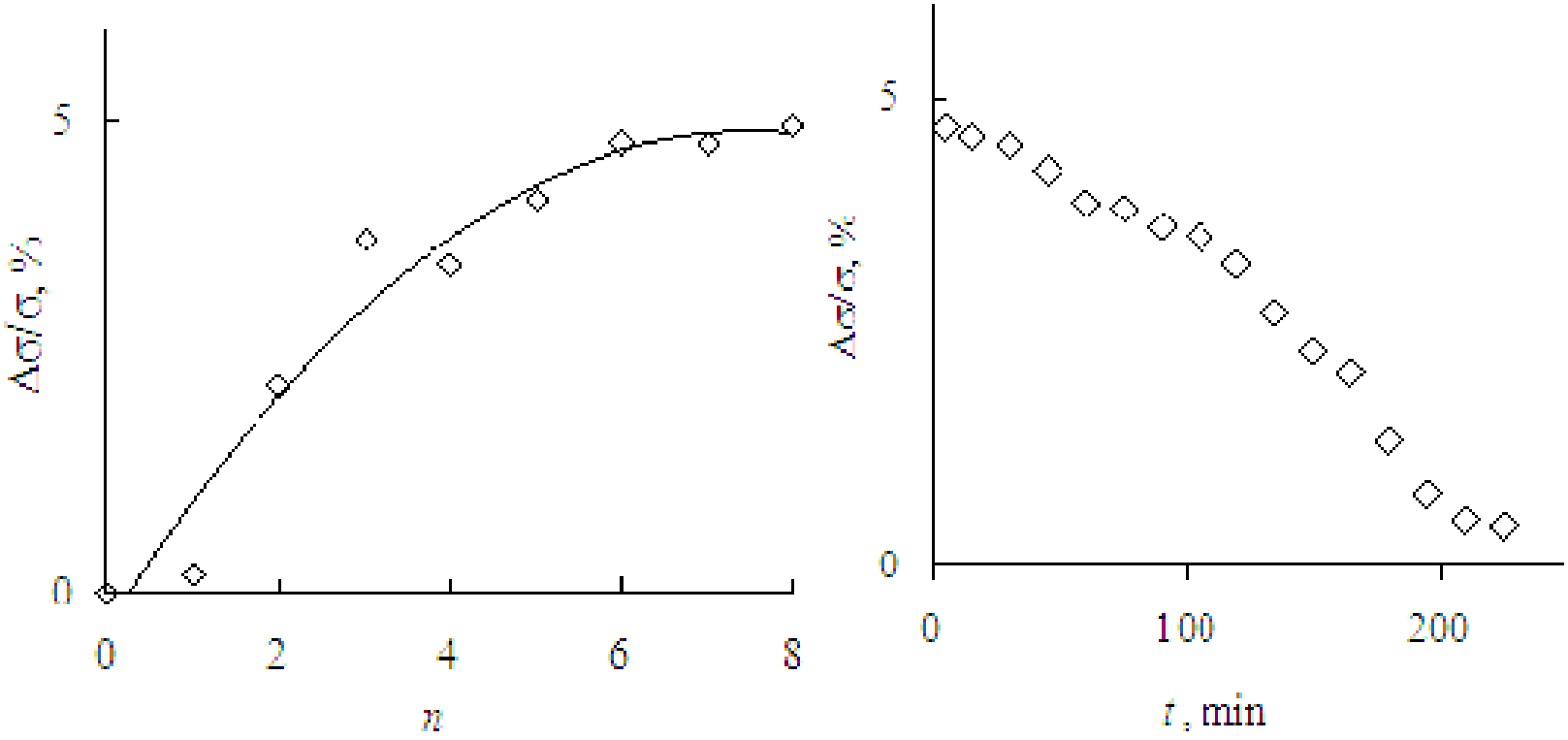
Fact 6: **EMF exposure reduces the resistance of water**



by *Stas I.E.,* 2008.

Fact 7: Degassing increases the hydrophobic effect

The surface tension of water

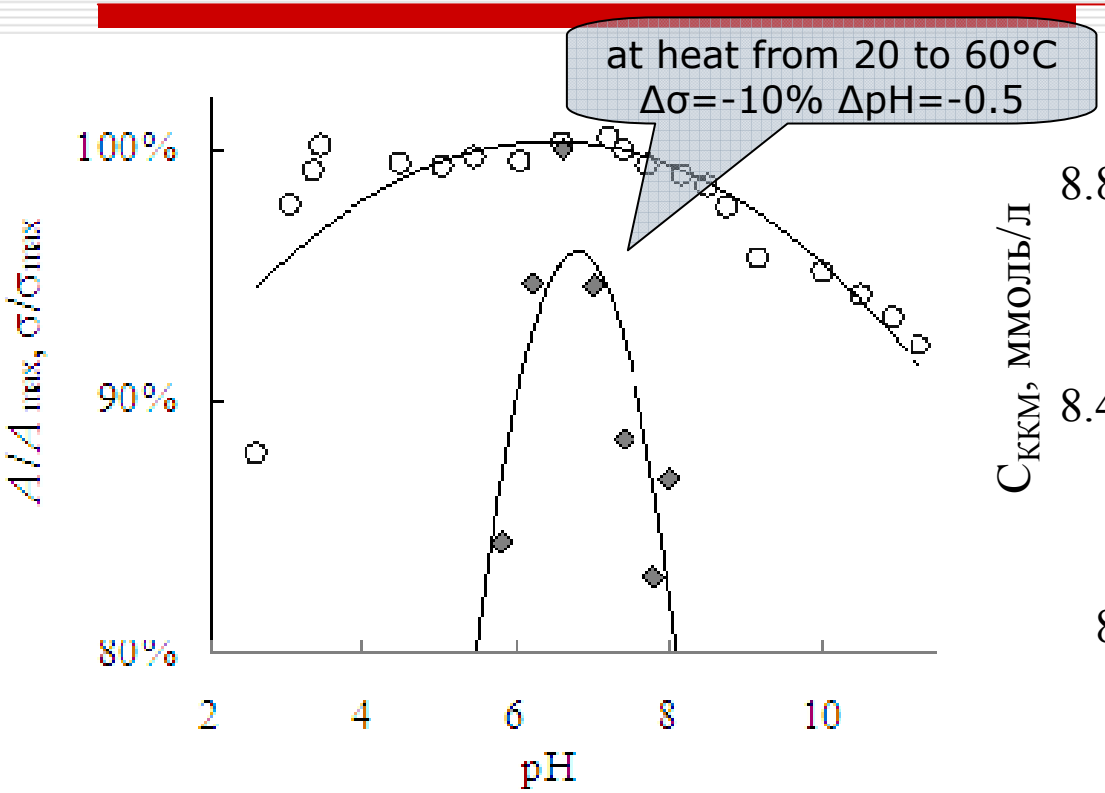


by *Koveza J.V., Noga I.V., Shatalov V.M.*, 2008.

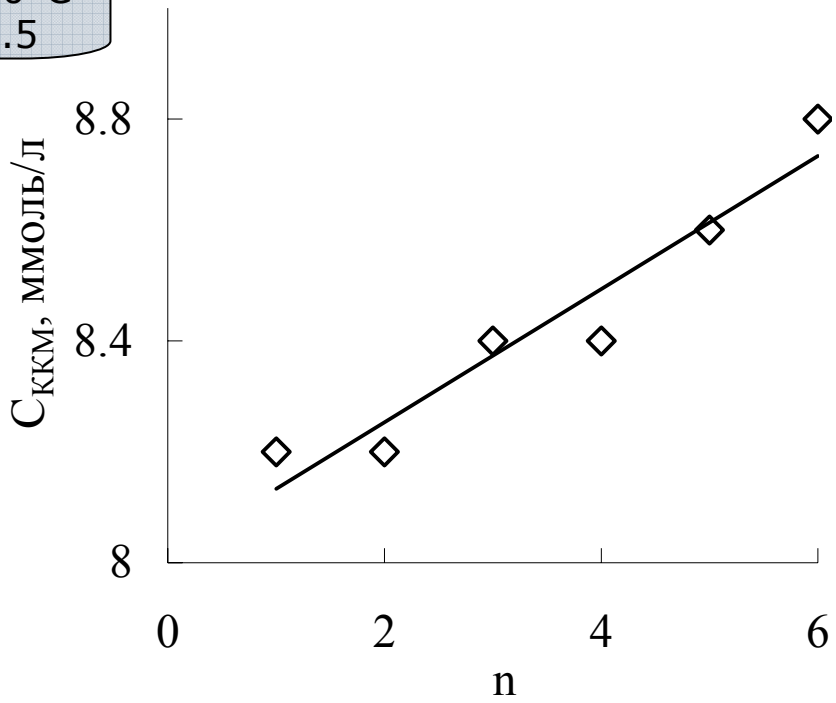
Fact 8: EMF increases the surface tension of water

- Electric ~1 MV/m (*Bateni A.*, 2004) or magnetic ~10 T (*Fujimura Y.*, 2008) fields increase surface tension of water in 2%
- Explanations – a stabilization of H-bonds or a dumping of surface waves
- *Degassing under EMF* – still never discussed

Fact 9: Hydrophobic forces control the protein activity



Catalase activity A and surface tention σ via pH of media
(*Koveza J.V., Noga I.V., Shatalov V.M.*, 2008)



Critical concentration of micelles via degassing degree n
(*Koveza J.V., Shatalov V.M.*, 2009)

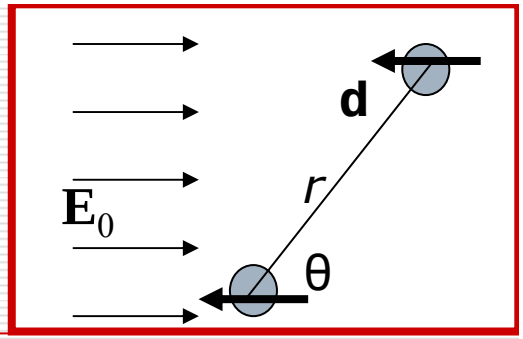
The new ideas following from the facts 1-9

- Nanobubbles in water (or bio-liquids) may be the primary target of EMF
- The EMF impact on the bubbles results in degassing of water (or bio-liquids)
- The degassing changes hydrophobic forces in bio-liquids that influences the protein activity

A version: Bubbles trap ions to get stability

- Trapping cross-section $$s_i = \pi a^2 \left(1 + 2\sqrt{\frac{e^2}{a m_i v_{i0}^2}} \right)$$
- Equilibrium equation $$P_{\text{атм}} + \frac{2\sigma}{a} = \frac{\nu k_B T}{\frac{4}{3}\pi a^3} + \frac{e^2}{4\pi\varepsilon\varepsilon_0 a^4}$$
- At minimal radius a=1.2nm the pressure is 1.2kbar
- In the range a from 5 to 500 nm neutral bubbles are not stabile $$a = 0.082\sqrt{N}$$
- At a ≥1μm bubble pressure is close to normal.
- The bubble of 10 μm in size has floating up speed 1.3cm/min.

The attractive interaction between bubbles



The induced dipole $\mathbf{d} = \dfrac{\varepsilon_1 - \varepsilon_2}{\varepsilon_1 + 2\varepsilon_2} a^3 \varepsilon_0 \mathbf{E}_0$ The bubble radius $a \sim 20\text{nm}$

Dipole-dipole interaction $\mathbf{F} = \left[F_r \mathbf{e}_r + F_t \mathbf{e}_t \right]$

Transversal force $F_t = \dfrac{3d^2}{4\pi\varepsilon_0 r^4} 2\cos\theta$ →0 in averaging

Radial force $F_r = \dfrac{3d^2}{4\pi\varepsilon_0 r^4}\left(1 - 3\cos^2\theta\right)$ = Stokes force $F_v = 6\pi\eta a v$

The bubbles are coming together with the speed $v \sim E_0^2$

Estimations of the coalescence time

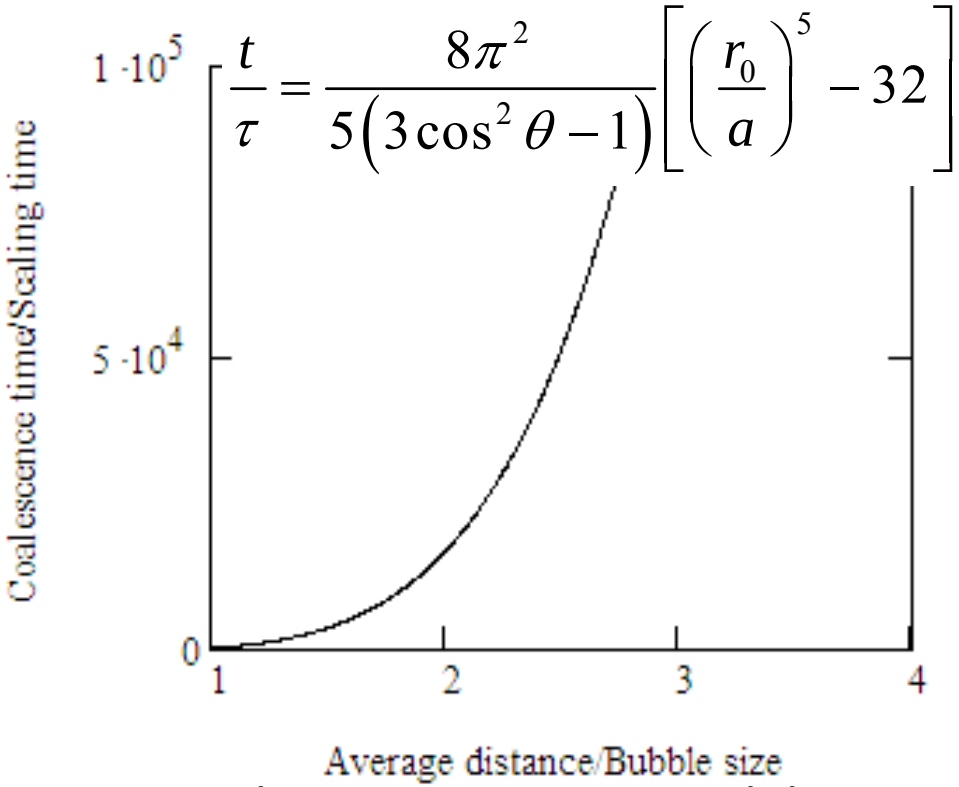


Fig. 1. Coalescence time via initial distance to bubble size parameter

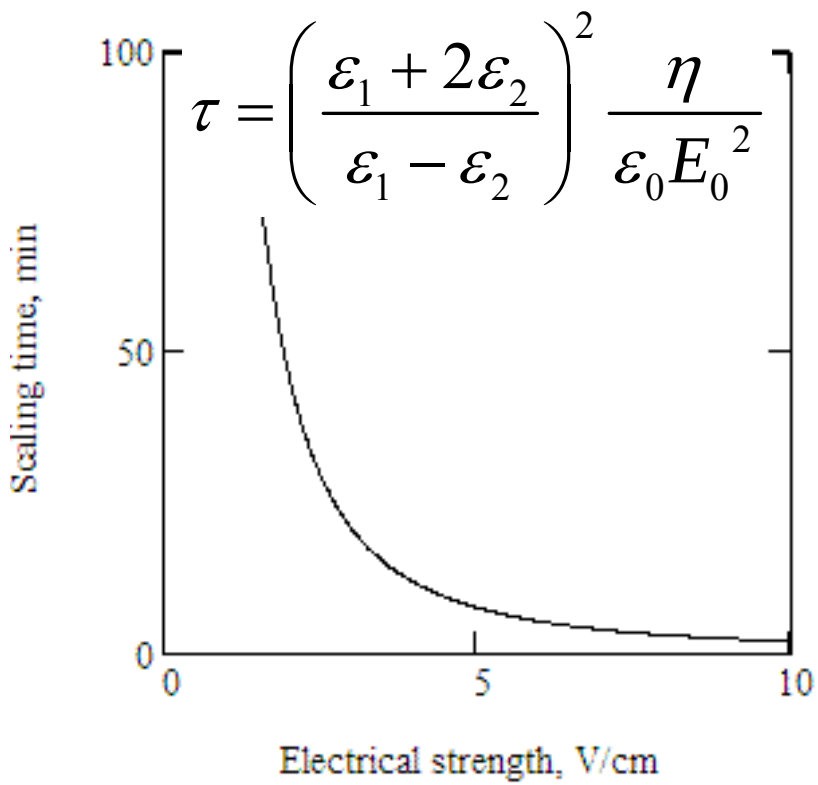


Fig. 2. Scaling time via electrical field strength in water

The frequency dependence as electro-acoustical resonance

Сила давления на пузырек $$\frac{P}{P_E} = \frac{3\left(1-3\cos^2\theta\right)}{2\pi^2}\left(\frac{\varepsilon_1-\varepsilon_2}{\varepsilon_1+2\varepsilon_2}\right)^2\left(\frac{a}{r}\right)^4$$

Объемная плотность энергии поля $$P_E = \tfrac{1}{2}\varepsilon_0 E_0^{\,2}$$

для E_0=1000V/m получаем $P \approx 2\cdot 10^{-8}$Pa

Условие резонанса $$\nu \approx \frac{c}{4a}$$ Для a=0.5μm получаем ν=166MHz

В радиочастотном диапазоне возможны резонансные явления, которые, по-видимому, являются причиной наблюдаемой частотной зависимости эффектов.

Resume: The mechanism of non-thermal EMF bio-effect

- EMF induces *bubble to bubble* and *bubble to border* attraction.
- Nanobubbles come together, integrate to macro sizes, then float up removing air from the water.
- That is the way of degassing under EMF.
- The degassing changes hydrophobic interaction that modify the structure and functionality of proteins

Adds: Resolved problems of the low EMF bio-effect

- **Primary target** of the low EMF biological effect.
- **pH increase and IR-spectra changes** in irradiated water are caused by CO_2 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: *A thing we're seeking for may lay so close and become invisible when looking through!*
Thanks for attention!
vladimir.shatalov@gmail.com
Simplicity is not always an occasion for doubts