Role of organized water in coherence of cellular electrodynamics

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We reexamine the possibility of existence of underdamped vibrations (oscillations) of biomolecular structures in living cell.
Important measure in this issue is the quality factor of the oscillator – Q factor. Q factor is a measure of how much energy can be stored in the oscillator. In other words, Q factor expresses how many periods of oscillations the oscillator undergoes before the amplitude of oscillation decreases the $1 / e^{2\pi}$ (or about 1/535) of the original amplitude. Further, the higher the Q factor the "sharper", narrower the frequency response of the oscillator.
Underdamped vibrations with Q>>1 enable accumulation of energy above the level of omnipresent thermal noise when energy is supplied to oscillator (molecule). This would have following consequences:

- change of reaction kinetics of the molecule
- enable resonant interaction of a molecular oscillator with external oscillating mechanical (acoustic) fields

Furthermore, if oscillating molecule (with Q>>1) is electrically polar it can:

- interact resonantly with electromagnetic field
- generate quasi coherent electromagnetic field, provided that the energy is supplied – coherence time depends on the Q factor

The role of the water in the damping of the molecular oscillations is crucial, for review see [1]. Usually, it is considered that the molecular oscillations are overdamped due to water viscosity. We argue here and review experimental evidence that water molecules which hydrate polar molecules undergo viscoelastic transition. Viscoelastic transition also occurs with increasing frequency of oscillation, approximately in the region of few GHz.

Further, based on the simple model we explain why Q factor of oscillations is higher in the case of low intensity (amplitude) external driving oscillation compared to the case of high intensity (amplitude) driving oscillation. We adopt simple damped forced oscillator model where the damping term is a decreasing function of oscillation amplitude. This function approximates a physical situation where neighbor layers of water molecules slide elastically along each other up to the certain threshold amplitude of displacement. Over this threshold amplitude the bonds between the neighbor layers start to tear apart and plastic (viscous) shear occurs whereby energy is dissipated.

References

[1] Pokorny, J., Vedruccio, C., Cifra, M., Kucera, O., Cancer physics: diagnostics based on damped cellular elastoelectrical vibrations in microtubules, European Biophysics Journal, 40, 747–759, 2011