Bioelectrodynamics and Biocommunication edited by Mae-Wan HO, Fritz-Albert Popp and Ulrich Warnke World Scientific Pubishing 1994. ($349) p 431 f (referencing Chapter 8 of the book) Google books
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bioelectromagnetism and biocommunication
notes

(what is ghosted varies over time)

Chapter 1: The History of Bioelectromagnetism Marco Bischof

Chapter 2: Electromagnetism and Living Systems

By Albert-Fritz Popp:

The physics of living systems is based on electrodynamics, thermodynamics, and quantum theory.
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Conventional understanding of bio systems is based largely on these. Biochemistry deals with charge interactions of valence electrons of organic molecules and concerns itself with heat production. Biochemistry also tacitly includes quantum theory because discrete electronic spectra cannot be described by classical potentials.

Models for ligand receptor binding or lock and key principle, so common in biochemical reactions, can be regarded as simplifications of the eigenstates of the Schrödinger equation.

The many-body Hamiltonian of the biochemical reaction is based on charge interactions of the valence electrons of organic molecules.

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Relaxation theory of Debye and Wager was deduced from a classical approach.

Electrical components such as resistors, caps, inductors, batteries, etc can be used to model certain aspects of bio systems.

However, as Frohlich pointed out, it is impossible to explain long-range order in living systems in terms of classical electrodynamics under the constraint of equilibrium thermodynamics. He introduced a chemical potential and showed that a Bose condensation like amplification of definite modes can occur. He took the cell membrane as an example where the supply of metabolic energy can amplify microwaves in a narrow frequency range so that they become the origin of coherent long range oscillations with stable phase relations. P. 37

The introduction of a chemical potential identifies the bio system as open rather than as one at thermodynamic equilibrium. Prigogene developed a topologically equivalent approach under the more general consideration of the non-linearity of reactions and far from equilibrium thermodynamic states. His "dissipative structures" describe, as does the Frohlich model, super molecular coherent pattern formations as transitions between disordered and ordered systems.
Thom's catastrophe theory, limit cycles, and chaos theory, which are based on non linear differential equations or iteration equations are logical extensions of Frohlich and Prigogine's approach, and do not require a quantum description.

Biological systems react specifically to molecular compounds, sometimes to single molecules. Such high sensitivity already requires a quantum description, because molecular structure cannot be understood in terms of classical physics alone.

Ordinary biochemistry is based only on charge interaction of valence electrons, while photobiology has to also include the interaction of biosystems with non classical light; ie single photons. One result of this is the formation of a new discipline of quantum optics.

Biochemistry and photochemistry are based on linear Hamiltonians, whereas the soliton concept depends on non-linear Hamiltonians. 38.

As Davydov and others have shown, the non-linearity of the Hamiltonian may induce "self-focusing" in matter in much the same way as the classical concept of non-linearity does. The difference between the Frohlich/Prigogine concept and Davydov's solotons is that "dissipative structures" need to be far from equilibrium to stabilize, while solitons may stabilize at equilibrium.

A more generalized concept is proposed which includes stability at both equilibrium as well as non-equilibrium conditions, based on the formation of coherent states in the most general sense; e.g. eigenstates of the annihilation operator. In this model organisms have the highest possible signal to noise ratio under permanent exposure to an external heat bath. 38.

Math quantity (not measurable) D, called displacement vector

Maxwell's first equation: Div D = $4\pi\rho$

Macroscopic “matter equation:

D= εE

where ε (>1) is called the dielectric constant and is introduced empirically.

ε describes the capacity of E to separate positive and negative charges in the given medium.

ε can be calculated only by quantum theory. (This seems to contradict the statement that ε is introduced empirically)

Popp’s treatment is consistent with the wiki doc: http://en.wikipedia.org/wiki/Maxwell%27s_equations , which helps to clarify what he is talking about.

D is the macroscopic electric displacement field , E is the microscopic electric field of electric field strength.

In bio systems, the dielectric constant is amazingly high at low frequencies (for an alternating E field).

Another matter equation defines the mobility of the charges under the influence of the external electric field:

J= σ E where J is the current density, and σ, the conductivity as a specific property of matter, is taken as a constant in the linear approach to the problem.

Based on fact that a magnetic force arises when a charged particle moves, he develops the general Ampere’s law as:

of the matter ($M = 0$ for vacuum). As the total effective current in matter is then $\vec{j}_{eff} = \vec{j} + \vec{j}_m$, we arrive at the general *Ampere's law*

$$\vec{\nabla} \cdot \vec{B} = \frac{4\pi}{c}\vec{j} + 4\pi\vec{\nabla} \times \vec{M}$$

In analogy to the displacement $\vec{D}(\vec{r})$ in case of an electric field, a vector field $\vec{H}(\vec{r})$ is introduced which is called magnetic field and defined by

$$\vec{H} = \vec{B} - 4\pi\vec{M}$$

This form of Amperes Law is not in the Wiki doc.

E and B are the physically measurable quantities, while D and H are purely mathematical terms.

By substitution, he arrives at a macroscopic form of Amperes Law which is in the Wiki doc.

The analog to D= εE is

H= 1/ μ B where μ is the permeability. Notes cases in which μ is GT or LT 1. For μ =1, we are desling with a vacuum.

The total force on a unit charge q is

$$\vec{K} = \vec{K}_{el} + \vec{K}_{magn} = q\vec{E} + q(\vec{v} \times \vec{B})$$

Which is called the Lorentz force.

Applying conservation of force (energy) in coordinate systems, he says that in a fixed coordinate system the change in velocity describes the time dependence of E and B, which mutually induce each other, he arrives at Faraday's law, which includes a 1/c term (1/speed of light) which is missing from the Wiki doc Faraday equation.

Points out that according to Coulomb's law, the sources of E (electric) fields are charges representing electric monopoles. It seems reasonable to look for corresponding magnetic monopoles as the sources of B fields. However, no one has found a trace of magnetic monopoles. The lack of sources of B fields is given by Gauss's law of magnetism,

Div B=0

He has developed all Maxwell's equations, which describe all the classical phenomena of electromagnetism. P. 42.

Notes that often it is convenient to work from potentials for E and B from which they can be derived:

E= -Del phi
B= Del X A

Where phi is a scalar potential and A is a vector potential.

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2.2.3 Basic Classical Understanding of Electric Properties of Living Tissue and Heat Loss p. 47

2.2.4 Non-thermal effects p. 50

2.3 Frohlich's model and related topics p. 61

2.4 Towards Quantum Biology p. 64
2.4.1 Extraordinary Polarizability of Biological Tissue
2.4.2 Extraordinary High Efficiency of Biological Activity
2.4.3 Stability of Wave Propagation
2.4.4 Extremely High Sensitivity of Biological Systems

2.5 Some Basic Problems and Open Questions p. 72
Two fundamental questions: the problem of the stability of bio systems, and the extraordinary properties of biological matter. The solution to both must involve thermodynamics and quantum theory

Chapter 3: The Biological Effects of Weak Electromagnetic Fields: Cyril W. Smith
The effects of man-made EMF on Biological Tissue

Chapter 4: Possible Mechanisms for Biological Effects of Weak ELF Electromagnetic Fields D. T. Edmonds.

Chapter 5: The Language of Cells- Molecular Processing of Electric Signals by Cell Membranes Tian Y. Tsong and Carol J. Gross

Chapter 6: Electromagnetic Fields and Biomembranes: Robert P. Liburdy

Chapter 7: Can Weak Magnetic Fields (or Potentials) Affect Pattern Formation?
Mae-Wan Ho, Adrian French et al

Chapter 8: Liquid Crystalline Mesophases in Living Organisms: Mae-Wan Ho and Peter T. Saunders

Ghosted:

Chapter 9: Dielectric and AC Electrodynamics

Chapter 10: Dynamic Cell Membrane Events

Chapter 11: On the Biological Nature of Biophotons Wei-Ping Mei
We all know what light is, but it is not easy to tell what it is not.

Chapter 12: Nonsubstantial Biocommunication

Chapter 13: Estimates of Brain Activity Using

Chapter 14: Log Normal Distribution of Psysio

Chapter 15: Biological

Chapter 16: Frolich's Theory of Coherent Excitations

Not ghosted:

Chapter 17: Energy and Electron Transport in
17.1 energy transfer along Alpha Helical Proteins
17.1.1 Solitons and Excitons in Protein Molecules

Chapter 18: Bioelectrodynamics and Biocommunication

18.2 Direct Measurements of Electrodynamical Activities – Noninvasive Technologies