# Quantum Biology: Unit Membrane Reduces Entropy Due To Wave Particle Duality

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**ABSTRACT**

For decades the conflict between the 2nd thermodynamic law and the evolution of life has been discussed in science. Entropy should increase continuously and this fact contradicts evolution of higher ordered biological states. The current paper presents a quantum biological approach which is based on ion currents of sodium or alike channels that is supposed to produce negative entropy. The concept of matter waves when passing through ion channels leads to highly structured interference signals which can be interpreted as an increase of order or negative entropy following the Boltzmann´s statistics. The concept is supported both by neurobiological data and recent observations of entanglement and coherence in unit membranes.

## Introduction

One enigma of life is that biology shouldn´t exist due to continuous increase of entropy in the universe, which is the logical consequence of the second thermodynamic law (Schneider, 1994; Taylor, 2014). Since the mid-1940ies this issue was discussed by physicists and biologists and is still debated nowadays (Schrödinger, 1944; Schneider *et al.,* 2005; Torday and Miller, 2016; Cronin and Walker, 2016). The present theoretical paper proposes an approach that the quantum mechanics applied to the unit membrane concept may offer an explanation in "negentropy", i. e. could biological phenomena paradoxically reduce entropy? This effect primarily concerns neuronal membranes with ionic influxes but the model could be transferred to any primitive unit membrane alike structure in early states of biological evolution.

## Biophysical background

We have to acknowledge that biological membranes (fluid mosaic model have crystal like structures with intercalated ion channels (Goni, 2014). Insofar, membranes may produce interference due to the lattice properties of the unit membrane. Electrons or even atoms or ions such as sodium or potassium ions, respectively, can behave as matter waves passing through crystals, similar to the effect of the double slit experiment (Meschede, 2010; Manning *et al.,* 2015; Münchner Internet Projekt, 2016). The following theoretical approach may be applied to biological membranes, although the unit membrane is for sure no static system.

We now look bit more in detail onto the aspect of probability and entropy according to famous Boltzmann equation (Meschede, 2010). The entropy – defined as dS = dQ/T - is statistically given by the Boltzmann equation S= k* ln P, where P is the probability and k corresponds to the Boltzmann constant. What does that mean in practice? We imagine a closed syringe in which a certain amount of gas with N particles is expanded from volume $V_1$ to volume $V_2$.

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The increase of entropy is

$$\Delta S = k * N * \ln\left(\frac{V2}{V1}\right).$$

We keep in mind: If the volume or area into which particles – e. g. sodium ions - distribute decreases on the one hand, entropy decreases on the other hand. The question arises, whether quantum mechanics effects can occur when sodium or potassium pass through the unit membrane via specific ion channels and generate entropy in contrast to the second thermodynamic law?

We now turn towards the effects of inference of particles in the double slit experiment or more general crystalloid structures behaving like matter waves according to de Broglie

$$\lambda_{de\ Broglie} = \frac{h}{m \cdot v},$$

λ corresponding to the wave length, h to Planck´s quantum of action, m to the mass and v to the velocity of the particle. Such experiments were done with electrons, neutrons or atoms and even molecules as well (Meschede, 2010). We send a matter wave through a crystal of an interferometer. Based on an even distribution of particles we find a characteristic distribution on the screen of the interferometer´s detector (envelope curve) behind the crystal given by the equation:

$$I_i = I_0 + I_0 \cdot \cos\Delta\Phi,$$

$I_i$ is the interference signal of the particle and $I_0$ the signal of the unaffected (initial) signal. $\Delta\Phi$ denotes the phase shift between the two matter waves of the interferometer. One should keep in mind that the envelope curve may be much more complicated (MIT study guide), but for the proof of principle the simple double slit equation may suffice.

What does this term mean with regard to Boltzmann statistics? First, we notice that the area into which the particles have distributed has changed and that the result of interference is an increase of order and probably a reduction of entropy. The schematic intensity versus phase shift of the interference signal is given in figure 1. For sure, the area or volume which is covered by the electrons, being evenly distributed when passing through the slit without interference, shows a characteristic interference pattern on the screen, i.e. Area$_{without\ interference}$ > Area$_{with}$

interference. Thus, the interference signal is much more ordered with maxima and minima on the detection screen. According to the Boltzmann equation, in terms of areas, we suppose a matter wave being x units (ΔΦ) wide (phase shift) and y units high (intensity). Without any interference effect the area filled in by the atomic beam – area of distribution - would be $Ai = xi * y_{max}$, i. e. the whole area is covered by the beam corresponds to the geometry of the slit. However, if we assume a interference matter wave distribution is still x units wide (exactly corresponding to Φ), but the matter beam sweep will only cover parts of the detector´s screen. With interference, we get a reduced area which is given as follows: $A_i = \int_0^x Io + Io(\cos\phi)d\phi$. This is just the area under a cosine curve and is given by A $Io * x + Io(\sin x)$.

We now get back to Boltzmann´s definition for entropy and calculate the decrease of entropy as follows:

$$\Delta S = k * \ln\frac{x * y_{max}}{\int_0^x (Io + Io(\cos\phi))d\phi}$$

In other words, the order of matter distribution has increased and therefore entropy has decrease because of a quantum biological effect in a biological membrane. The unit membrane can be therefore regarded as a potential source of an "entropy inverter" which reduces entropy and therefore allows life being in harmony with the second thermodynamic law.
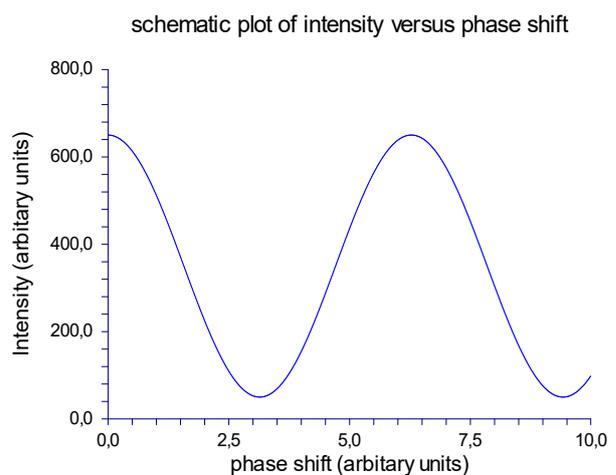
schematic plot of intensity versus phase shift

**F**i**gure:** Schematic plot of the screen of the interference signal. The interference signal corresponds to cosine curve which only a part of the detector screen (modified according to Meschede, 2010).

## Discussion of the hypothesis

Is this hypothesis a realistic scenario? The author thinks yes. The passage of sodium ions during the action potential is extremely rapid, i.e. approximately $10^6$ to $10^7$ or even $10^8$ sodium ions pass through the sodium channel in a second, i.e. a distance of about 10 nm and a diameter of 190 $10^{-9}$ m (Dudel, 1982; Summhammer and Bernroider, 2007; Richard *et al.,* 2013). Every hydrated ion loses its envelope to interact with amino acids of the channel for roughly $10^{-6}$ seconds. Recent calculations suppose coherent states that suffice to allow quantum effects in ion channels, particularly for sodium ions (Summhammer and Bernroider, 2007; Salari *et al.,* 2014). It is therefore not far to seek for the interpretation of sodium ions as probabilities as Max Born´s famous interpretation of the wave function $\psi$ (Bertlmann und Friis, 2008);

$$P(x,t) = |\psi(x,t)|^2 = |\psi 1(x,t) + \psi 2(x,t)|^2$$
$$= |\psi 1(x,t)|^2 + |\psi(x,t)|^2 + 2 * \psi 1(x,t) * \psi 2(x,t)$$

We therefore do not know where the sodium ions are, but only can make assumptions about the probability with regard to time and space. Sodium ions (Na+) show a rapid massive influx but the charge produced within 1 or 2 milliseconds is not homogenuously distributed. The result is a periodic distribution of electric charges $Q = n* Cn_{Na}$ on the inner site of the activated membrane segment and as $dV = dQ/C$ the resulting voltage is also distributed more ordered than charges before entering the ion channels according to the interference effect.

The proposed model of interference-like ordered charges following action potentials offers the chance of an intrinsic negentropy machine in neuronal unit membranes without inherent conflict of the 2nd law of thermodynamics. Life is therefore no surprise at all but the logical consequence of quantum biology.

## Abbreviations:

V = voltage, Q = charge, C = capacity, Cn = concentration, n = number of ions

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