

Some Solutions of Extensive Quantum Equations in Biology, Formation of DNA and Neurobiological Entanglement

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ABSTRACT

Based on the extensive quantum theory of biology and *NeuroQuantology*, the Schrödinger equation with the linear potential may become the Bessel equation. Its solutions are Bessel functions, and may form the double helical structure of DNA in three dimensional spaces. From this model we may predict the discrete bound energy spectrum of DNA. Moreover, we discuss some solutions of quantum mechanics and their meaning. Further, we research the entangled state of neurobiology by the extensive quantum method and the nonlinear theory. New experiments shown that the quantum entangled state should be a new fifth interaction, for its verification neuroscience will possibly take a very important role.

Key Words: biology, quantum mechanics, DNA, Schrödinger equation, Bessel function, entangled state, neuroscience

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1. Introduction

From the Titius-Bode law that describes the average distances between the Sun and various planets, we obtained a similar theory with the Bohr atom model and the extensive quantum theory whose formulations are the same with the quantum mechanics and only quantum constants h_i are different (Chang, 1993; 2002). Based on this theory we proposed the extensive quantum biology (Chang, 2012a), in which gene, cell, man and any live individual as the smallest live element in various levels are all different live quantum. Based on the inseparability and

correlativity of the biological systems, we discussed the nonlinear whole biology and four basic hypotheses. It may unify reductionism and holism, structuralism and functionalism (Chang, 2001; 2012b).

Neurobiology applies widely quantum mechanics, for example, the release of neurotransmitter is a quantum release, in which a vesicle is namely a quantum. These form a new word: *NeuroQuantology*. Tarlacı (2010a; 2015) proved we need quantum physics for cognitive neuroscience, and researched the probabilistic quantum thinking and obtained experimental results that are of basic significance in the fields of neuroscience and of psychology (Tarlacı, 2010c; 2014). Erol (2010a) researched basics and concise relations between Schrödinger wave equation and consciousness/mind. Vimal (2009a, b; 2010a, b) researched systematically the subjective experience aspect of consciousness as an integration of classical, quantum and

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subquantum concepts for emergence hypothesis, and discussed a theory of everything as introduction of consciousness in Schrödinger equation, standard model, and loop quantum gravity and string theory and unification of experiences with fundamental forces. Khrennikov et al. (2014) searched the quantum model for psychological measurements from the projection postulate to interference of mental observables represented as positive operator valued measures. Grandpierre et al. (2014) proposed the universal principle of biology: determinism, quantum physics and spontaneity. In this paper we discuss some equations and their solutions of the extensive quantum mechanics in biology, which may form DNA, and search neurobiological entangled state.

2. Extensive Quantum Theory of Biology

DNA is an important basis of molecular biology (Micklos et al., 2003). Benham et al. (2009) edited a book "Mathematics of DNA Structure, Function and Interactions". It is well-known that the model of DNA is a double helical structure. Its basic elements are A-T and G-C.

According to basic thinking of NeuroQuantology, we assumed that A-T and G-C are the basic quantum of DNA, or assume nucleic acid has five types of base quantum: A, T, G, C and U, but usual case A-T, G-C form double, therefore, we proposed the extensive quantum theory of DNA (Chang, 2014). For RNA the basic quantum elements are the corresponding A-U and G-C. The corresponding quantum theory and its many mathematical methods are applied to DNA and molecular biology. From this we discussed symmetry and super symmetry of DNA, and the quantum theory and equations of DNA. Further, we researched the string theory of DNA and general biological string. Some solutions and functions of these theories may describe probably DNA, biological things and their motions. Moreover, we proposed quantitatively a universal entropy theory on evolution of any natural and social systems (Chang, 2014).

A process of formulation of DNA should be: First, the quantum of DNA interact each other. Then they joint and form the double helical structure.

The basic equation of quantum mechanics is the Schrödinger equation:

$$i\hbar \frac{\partial \psi}{\partial t} = \left(-\frac{\hbar^2}{2m} \nabla^2 + U\right) \psi. \quad (1)$$

The time-independent Schrödinger equation ($\hbar = 1$) is:

$$\frac{d^2 \psi}{dr^2} + 2m(E - U)\psi = 0. \quad (2)$$

Assume that the potential U between the basic quantum of DNA is a simple linear potential $U=Fr$ (Brandt et al., 1994; Zeng, 2007), so the Schrödinger equation for DNA is:

$$\frac{d^2 \psi}{dr^2} + 2m(E - Fr)\psi = 0. \quad (3)$$

This potential may be the origin of gravity (Nesvizhevsky et al., 2002). Such Eq.(3) may become a Bessel equation:

$$\frac{d^2 \psi}{dz^2} + \frac{1}{z} \frac{d\psi}{dz} + \left(1 - \frac{\nu^2}{z^2}\right) \psi = 0. \quad (4)$$

Moreover, it may use various mechanisms of mathematical physical methods for reference, for example, the heat energy inputs for cylinder.

It is known that the general solution of Eq.(4) is:

$$\psi = AJ_\nu(z) + BN_\nu(z). \quad (5)$$

Here $J_\nu(z)$ are the Bessel functions (the cylinder functions) of the first kind (Figure 1) and $N_\nu(z)$ are the spherical Bessel functions of the third kind (also called the Hankel functions).

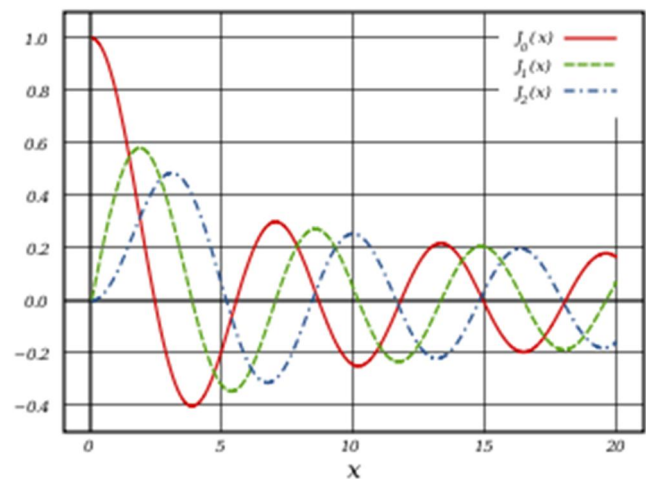


Figure 1. The Bessel functions.

If the bound condition is $\psi(0) = 0$, there will be

$$AJ_\nu(0) + BN_\nu(0) = 0. \quad (6)$$

For large z that corresponds possibly to the formulation of a long DNA link, the asymptotic solution becomes:

$$\psi \approx a \cos\left(z - \frac{\pi}{2} \nu - \frac{\pi}{4}\right) + b \sin\left(z - \frac{\pi}{2} \nu - \frac{\pi}{4}\right). \quad (7)$$

It corresponds to Figure 2.

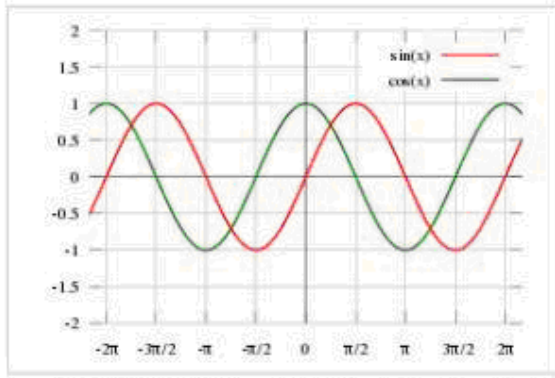


Figure 2. $2 \sin(x)$ and $\cos(x)$.

3. Some Solutions of Extensive Quantum Equations and Formation of DNA

If the solution (7) adds another equation $w=Ht$ in which H may be the magnetic field or other field, they will form the cylindrical helix in three dimensional space. The phase difference of $\cos(x)$ and $\sin(x)$ should correspond just to the double helical structure of DNA (Figure 3). Its interaction between A-T and G-C is the hydrogen bond, which is a special electro-magnetic force. When $a \neq b$, it is an ellipse. When $a=b=10A$, it is a radius of DNA, and $h=34A$ is a thread pitch of DNA.

Schematic diagram DNA

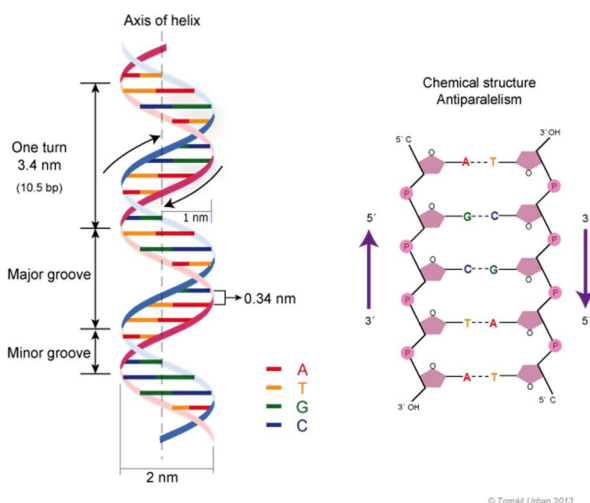


Figure 3. The double helical structure of DNA.

The absolute square of the wave function $\rho = |\psi|^2$ is identified with the probability density for observing the particle at position z . The asymptotic probability density of Eq.(7) is:

$$\rho \approx \frac{1}{2}(a^2 + b^2) + \frac{1}{2}[a^2 \cos(2z - \pi\nu - \frac{\pi}{2}) - b^2 \cos(2z - \pi\nu - \frac{\pi}{2})] + ab \sin(2z - \pi\nu - \frac{\pi}{2}). \quad (8)$$

For Eq.(8) with $a=b$, the density will be:

$$\rho \approx a^2[1 + \sin(2z - \pi\nu - \frac{\pi}{2})]. \quad (9)$$

From this model we may predict the discrete bound energy spectrum of DNA is:

$$E_n = \left(\frac{\hbar^2 F^2}{2m}\right)^{1/3} \lambda_n. \quad (10)$$

Let $\nu = 1/3$ in Eq.(4), $\lambda_1 = 2.338$, $\lambda_2 = 4.088$, $\lambda_3 = 5.521$, $\lambda_4 = 6.787, \dots$ (Zeng, 2007).

The Hamiltonian for a harmonic oscillator is (Ballentine, 1998):

$$H = \frac{P^2}{2m} + \frac{m\omega^2}{2} Q^2. \quad (11)$$

Its quantum equation is:

$$-\frac{\hbar^2}{2m} \frac{d^2\psi(x)}{dx^2} = \left(-\frac{m\omega^2}{2} x^2 + E\right)\psi(x). \quad (12)$$

The corresponding Heisenberg equation is:

$$\frac{dF(t)}{dt} = \frac{1}{i\hbar}[F(t), H]. \quad (13)$$

Its solution for $F(t)=x$ is:

$$x(t) = x_0 \cos \omega t + \frac{P_0}{m\omega} \sin \omega t. \quad (14)$$

Some potential and corresponding equations and their solutions all may derive the structural mode of DNA.

In neurobiology there is the universality of electrical signal (Nicholls *et al.*, 2001). The Schrödinger equation in the uniform magnetic field may also become the Bessel equation. If electromagnetic fields in biology are considered, we will introduce the extensive Pauli equation which may describe spin. In a magnetic field the Pauli equation is:

$$i\hbar \frac{\partial \psi}{\partial t} = -\frac{\hbar^2}{2m} \nabla^2 \psi + \frac{e\hbar}{2mc} (\sigma \cdot H) \psi. \quad (15)$$

Here the Pauli spin operators σ are three 2×2 matrices, and there is (Ballentine, 1998):



$$\hat{n} \cdot \sigma = \begin{pmatrix} \cos \theta & e^{-i\phi} \sin \theta \\ e^{i\phi} \sin \theta & -\cos \theta \end{pmatrix}. \quad (16)$$

They correspond possibly to the matrix $M_{DNA} = \begin{pmatrix} A & T \\ G & C \end{pmatrix}$ of DNA (Chang, 2014). Another form of quantum mechanics is namely the matrix mechanics.

Thomas-Fermi equation is:

$$\Delta \phi = \frac{8\sqrt{2}}{3\pi} \phi^{3/2}. \quad (17)$$

When the integral constants are zero, its solution is

$$\phi = \frac{81\pi}{8} x^{-4}. \quad (18)$$

For different potentials the solutions of equation are different. The formation of DNA is possibly the origin of the magnetic field. A charge moves along a helix in a constant uniform magnetic field (Landau *et al.*, 1975). Various nucleic acids all possess weak charge. Two coupled dipole oscillators may give the van der Waals force (Harrison, 2000), which is probably very important for keeping membrane in biology.

We should consider the rotation and oscillation in the extensive quantum biology, and research the extensive boson and fermion, and corresponding Bose-Einstein statistics and Fermi-Dirac statistics and possible the extensive Pauli Exclusion Principle in biology. The two basic quantum A-T and G-C of DNA are excluded each other, so both are similar with fermion, but A-T and G-C as whole is similar with Cooper pair, and corresponds to boson.

Further, there are the extensive Klein-Gordon equation and Dirac equation. If spin is any value, it will correspond to anion. We should investigate the extensive quantum electrodynamics (EQED) and the extensive quantum field theory (EQFT) in biology. The extensive quantum equations may possess spinor and twistor, etc.

4. Quantum Entanglement and Nonlinear Neurobiology

From the Einstein-Podolsky-Rosen paradox (1935) and Bell's inequality, new experiments shown the quantum nonlocality, the quantum entangled states and quantum teleportation

(Aspect *et al.*, 1982; Bennett *et al.*, 1993; Bouwmeester *et al.*, 1997; Zbiden *et al.*, 2001).

From *NeuroQuantology* Pratt (2003) searched consciousness, causality and quantum physics. Shan (2003) proposed a possible quantum basis of panpsychism. Bernroider (2003) discussed quantum neurodynamics and the relation to conscious experience. Tarlaci (2005) researched quantum brain dynamics, general quantum neurodynamics, quantum field theory and consciousness, and discussed a historical view of the relation between quantum mechanics and the brain, and assumed to be a quantum mechanical many-body system interacting with the macroscopic neuron system (Tarlaci, 2010b).

Erol (2010b) discussed quantum entanglement as fundamentals and relations with consciousness/mind. We researched the entangled state of neurobiology (Chang, 2013a). Ostovari *et al.* (2014) searched the entanglement between bio-photons and Tubulins in brain: implications for memory storage and information processing.

The entangled state of quantum may be described by following wave function:

$$|\psi^\pm\rangle_{12} = \frac{1}{\sqrt{2}} (|\leftrightarrow\rangle_1 |\uparrow\rangle_2 \pm |\downarrow\rangle_1 |\leftrightarrow\rangle_2). \quad (19)$$

Based on the Technique of Integration within an Ordered Product (IWOP) of Operator (Fan *et al.*, 1987) or Fan's method, Fan *et al.* (2003) proposed the representation of quantum entangled state:

$$|\eta\rangle = \exp\left(\frac{1}{2}|\eta|^2 + \eta a^+ + \eta^* b^+ - a^+ b^+\right) |00\rangle, \quad (20)$$

and discussed the coherent-entangled state in three-mode (Fan *et al.*, 2006):

$$|\beta, \gamma, \chi\rangle = \exp\left\{-\frac{1}{6}(2|\beta|^2 + 2|\gamma|^2 + \beta\gamma^* + \gamma\beta^*) - \frac{3}{4}\chi^2 + \left[\chi + \frac{1}{3}(2\beta + \gamma)\right]a_1^+ + \left[\chi + \frac{1}{3}(\gamma - \beta)\right]a_2^+ + \left[\chi - \frac{1}{3}(\beta + 2\gamma)\right]a_3^+ - \frac{1}{6}(a_1^+ + a_2^+ + a_3^+)^2\right\} |000\rangle. \quad (21)$$

Further, they searched the multi-partite entangled state representations via the IWOP technique (Fan *et al.*, 2007).



We discussed the fractal, chaos and soliton in nonlinear biology and neurobiology. They possess the soliton solutions, whose propagated waves and may keep the integrality and veracity of information in neural transfer (Chang, 2012a; 2013a, b). The Schrödinger equation, and Dirac equation, Klein-Gordon equation can be various nonlinear equations, therefore, the quantum mechanics of DNA may be developed. The nonlinear Schrödinger equation is:

$$i\hbar \frac{\partial \phi}{\partial t} = (\hbar\omega_0 - \frac{\hbar\omega_1^2}{2\omega_0})\phi - \frac{\hbar\omega_1^2}{4\omega_0} r_0^2 \frac{\partial^2 \phi}{\partial x^2} + a |\phi|^2 \phi = 0. \quad (22)$$

Its soliton solution is:

$$\phi(x, t) = \phi_0 \sec h[2\phi_0^2(x - x_0 - vt)] \exp\{i[\frac{\hbar v}{2Jr_0^2}(x - x_0) - \frac{Et}{\hbar}]\}. \quad (23)$$

Probably, this may describes the quantum teleportation of long-range (Tressoldi *et al.*, 2014).

New experiments shown that the quantum entangled state should be a new fifth interaction (Chang, 2008; 2013c). Its strength seems to be middle one. If its action distance is also middle-range, i.e., is neither infinite nor very short, the new interaction will be a special place (Figure 4).

We believe that neuroscience will take a very important role for the verification of new fifth interaction.

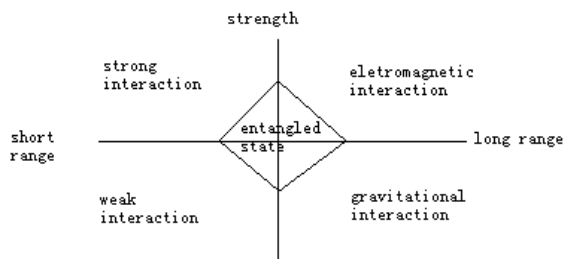


Figure 4. Relation among five interactions.

The wave solutions correspond to propagation of information. Different potentials correspond to different waves. The bifurcation corresponds to DNA replication and general catabolism, the soliton corresponds to information transcription, catastrophe corresponds to variation, the general chaos corresponds to cancer. For learning and memory the strong stimulation should correspond to nonlinear equation (Chang, 2012a).

In a word, our discussion should have inspired for investigations of quantum computer, of the cognitive neurosciences and the neural network (Gazzaniga, 1995).

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