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SYMMETRIES OF THE GENETIC CODE, WALSH FUNCTIONS AND THE THEORY OF GENETIC LOGICAL HOLOGRAPHY

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The result of studying symmetries in molecular systems of genetic coding and other genetic phenomena has led the author to the concept of systemic-resonance genetics [1-4] and to his ideas about the geno-logical code and the logical holography in genetics. This presentation is devoted to this research. People use oral speech and singing for communication due to an inherited ability to tune into resonances and to use resonances as carriers of information. Our vocal chords are an oscillatory system with many degrees of freedom. But according to principles of structural linguistics, our language did not come from nowhere, but overlays the oldest language - the genetic language. This is one of the reasons to study genetic informatics, and in particular genetic alphabets, from the standpoint of the mathematics of resonance and standing waves.

Moreover living organisms can be looked at as a huge chorus of coordinated oscillatory processes (mechanical, electrical, piezoelectrical, biochemical, *etc*.), which are

connected with their genetic inheritance along chains of generations. Since ancient times, it is the belief of chronomedicine that all diseases are the result of disturbances in the ordered set of oscillatory processes. From a formal point of view, a living organism is an oscillatory system with many degrees of freedom. The theory of oscillations uses the mathematics of symmetric matrices to study the resonant characteristics of oscillatory systems with many degrees of freedom. Symmetric and anti-symmetric matrices are used to study genetic phenomena. Results, obtained through "matrix genetics", have allowed us to recognize the key role of systems of resonance frequencies in genetics for modeling genetic structures in the language of these systems.

The concept of resonance plays a fundamental and interdisciplinary role in science. Quantum mechanics began in 1900 due to work by M. Planck, who analyzed a set of resonant oscillators inside of a cavity and, as a result, derived his famous law of electromagnetic radiation emitted by a black body in thermal equilibrium. Later, after more than 50 years of the development of quantum mechanics, E. Schrodinger expressed the fundamental meaning of resonance: "*The one thing which one has to accept and which is the inalienable consequence of the wave-equation as it is used in every problem, under the most various forms, is this: that the interaction between two microscopic physical systems is controlled by a peculiar law of resonance*» [5, p.115].

L. Pauling used ideas of resonance in quantum mechanical systems for his theory of resonance in structural chemistry. His book [6] about this theory is the most quoted among scientific books of the XX century. The theory was developed to explain the formation of hybrid bonds in molecules. The actual molecule, as Pauling proposed, is a kind of hybrid, a structure that resonates between two alternative extremes; and whenever there is a resonance between two forms, that structure is stabilized. His theory uses the principle of minimal energy since in resonant combining of parts into a single unit each member of the ensemble requires less energy than when working individually.

Genetic molecules are subordinate to quantum mechanics. The fundamentals of quantum mechanics are closely connected with the phenomena of resonance, knowledge about which are used to study structures of DNA and RNA alphabets. Each of nitrogenous bases is considered as a carrier of two resonant binary-oppositional traits "purine or pyrimidine" and "amino or keto". This approach leads to the idea about binary computers on resonances in biological organisms [3]. This allows also a representation of the genetic alphabets of 16 doublets and 64 triplets in a form of dyadic-shift matrices known in the technology of digital signal processing. The author

introduces the concept of dominant and recessive resonances to explain segregations within genetic alphabets. Structural regularities of genetic alphabets in these representations are analogous to Mendel's law of segregation of traits in organisms.

Some of our results concern standing waves, which are related to resonance and are used in many fields. For example, physical holography, which possesses the highest degree of noise-immunity, is based on standing waves superimposed of two coherent physical waves, optical and acoustical. But physical waves can be modeled digitally. Genetic encoding belongs to the field of discrete informatics, where complete orthogonal systems of Walsh functions (or Walsh waves) are used. Correspondingly noise-immunity and other properties of optical and acoustical holography can be modeled digitally using Walsh functions and logic operations based on dyadic groups of binary numbers. This can be represented by discrete electrical signals or other signals without any application of physical waves. We have shown that the genetic alphabets of DNA and RNA are related to logical modulo-2 addition, Walsh functions, and dyadic groups of binary numbers. Due to these results, the author has declared about the existence of the geno-logical code (or a algebraic-logical system of coding and information processing), which is manifested in structures of DNA-, RNA-alphabets and in features of the degeneration of the genetic code of amino acids. This geno-logical code is based on dyadic groups, systems of genetic Boolean functions and the spectral logic of these systems with using Walsh functions and Walsh-Hadamard spectra. In a relation with the statement about the geno-logical code, the theory of the «genetic logical holography» (GLH), which proposes a new mathematical approach to modeling some genetic structures and phenomena, is under developing now. The mathematical tools of this modeling approach are lattice functions, the notion about dyadic spaces, the dyadic convolution and the dyadic derivate, Walsh-Hadamard transformations. Examples from the new class of models in genetics are the following: 1) models of different kinds of repetitions of fragments in genetic sequences (complementary palindromes, simple palindromes, etc.) on the basis of the dyadic convolution of two vector-signals; 2) the model of the zipper reproduction of DNA molecules. We use the dyadic derivate for a comparative analysis of genetic sequences. In our opinion, appropriate mechanisms for the logic holography in biological organisms are created by means of resonance interactions of biological molecules and their ensembles. It should be mentioned that from the onset of physical holography, researchers have used its impressive phenomena to help understand and explain biological phenomena of functioning the brain such as associative memory [7]. By contrast, we utilize GLH theory to study more deep – genetic – level of biological organization.

There are many definitions of life proposed by renown scientists including Schroedinger, Bohr and Prigogine, one of whom stated that "*life is a partnership between genes and mathematics*" [8]. From the standpoint of our approach, the following new definition of life seems to be interesting: life is a complex system of genetic Boolean functions and their spectral logic with using Walsh-Hadamard spectra and genetic logical holograms.

In addition we employ Walsh functions to study oblique projection operators, which are related to genetic alphabets and represented by sparse square matrices where one column coincides with a Walsh function. Sum of such projectors are connected with complex and hypercomplex numbers, which we use in the model approach to study inherited biomechanical structures and algorithms ("genetic biomechanics") [9, 10].

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