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THE ASPECTS OF CONSCIOUSNESS IN THE VIEW OF PAULI'S EXCLUSION PRINCIPLE IN QUANTUM MECHANICS AND OF THE ENSLAVEMENT PRINCIPLE IN BRAIN STRUCTURES

Waldemar Ulmer

Max-Planck Institute of Physics, Goettingen, Germany

ABSTRACT: The problem of consciousness is a very old one of mankind. With beginning of enlightenment and the increasing importance of science the appearance of consciousness was shifted from philosophy to experimental methods in physics, chemistry, medicine, and to neurobiology, emerging the view that all perspectives of consciousness can be reduced and explained by the mentioned disciplines. This view is referred to as strong monism. Since the pure monism cannot explain consciousness and all related aspects of psychology and philosophy, the two-aspect monism turned out to incorporate a promising way to approach the problem. The present study considers the problem of memory and based on quantum mechanics. In particular, the role of the Pauli exclusion principle is analyzed, since from its viewpoint, elementary particles like electrons must exhibit a certain kind of memory with regard to occupied or unoccupied quantum states. Due to the enslavement principle this level of memory increases with increasing of complex molecules and structures. It is also very important with regard to long-range entangled states, which indicate to assume information functions in pyramidal cells.

KEYWORDS: Consciousness, Brain research, Mind, Memory, Entanglement, Exchange interactions, Enslavement.

1 INTRODUCTION

Consciousness of humans is a fundamental problem in psychology and philosophy. Based on increasing knowledge of specific functions of brain structures, brain research has adopted this problem in order to gain new insights. Since we have mind and feelings, the question arises, whether psychological aspects can be classified as a principal property of an additional dissociation of living systems, and whether only higher developed biological organizations should be attributed to these properties. Thus, we as humans are regarded as the highest species know about consciousness owing to our introspection, but it is rather an open question, insofar primates such as chimps or gorillas and even lower animals possess consciousness, although it is evident that they feel pain, but probably they do not reflect about suffering. The question of the existence of consciousness is rather an old problem and has been emerged in philosophy, but its origin may come from religion, where the soul plays a central role in the behavior of humans. Even in our common language this dissociation is always present, since we speak about feelings like happiness, joy, fear, pain, bad temper, hate and affection. An enhancement of the central association with soul occurs in various forms in religions such as Judaism, Christianism, Islam, Hinduism, and Buddhism. Since all expressions we make use in our daily language having lastly a religious origin, the dissociation between matter and mind is still present due to our introspection. Recent insights of brain research do not play a decisive role in our thinking and perception and are usually ignored. This dissociation between aspects of matter on the one side and processes of mind/psyche on the other hand is usually referred to as the dualistic view. Apart from religious aspects, Plato was the most important representant of dualistic philosophy in the Hellenic antiquity. According to Plato's view, the soul of humans is regarded as an immortal, immaterial 'thing', whereas the body is fleeting. In the era of enlightenment, philosophy received in increasing significance in the ideas of European scholars.

Descartes famous sentence **'Cogito ergo sum'** emphasizes the importance of dualistic thinking in the philosophy of the beginning of modern age. However, due to the progress in natural sciences, medicine, biology and psychology the dualistic view got doubts. In the time before Freud only animals got the attribute to act solely by drives, and all their motivations are steered by a libidinous behavior. If at all, consciousness was only attributed at the utmost to the primates being our nearest relatives of animals. Due to the development of psychoanalysis mainly originated by Freud the steering of human behavior by drives has been put forward. Based on this view, the conviction became of increasing importance, that all steering processes can be reduced to physicochemical mechanisms, which determine the behavior of all living systems (strong monism). The discovery of these mechanisms could be made available through the functional MRT (fMRT), PET-CT, PET-MRT, EEG, which provide the distinction between different functions of the corresponding areas and structures of the brain. However, we do not present details of experimental neurobiology and refer to significant literature comprising the present stage of this research [6, 33, 37, 38, 42, 53], which will bear further interesting data and insights.

2 Philosophical Aspects Of Consciousness And The View Of Experimental Neuroscience

The fundamental problem of consciousness exhibits two different ways of description, namely brain research and philosophical considerations based on feeling out the existential questions of humans. It is apparent that the philosophical way to reach an access to the consciousness problem is closely related to religion, and these both roots may have been mutually stimulated. I restrict myself to some essential views clarifying the method of the present communication. When we refer to well-known, famous philosophers, e.g. Descartes, Hume (the predecessor of Kant's philosophy), Leibniz, Kant, Schelling, Schopenhauer, Russell, Popper, then there exist – besides their original works – numerous secondary essays, which appear to have become rather unmanageable. Based on the progress of natural sciences, which has led to experimental observations and the mathematical description of the measurement data, a new era of philosophy became feasible. This development may be associated with Copernicus, Kepler, Galilei, Huygens, Leibniz, Newton, etc. The question of the intrinsic properties of matter became significant in philosophy, since the world view of the old Helens appeared to be indefensible. Leibniz, mathematician and nature philosopher, considered 'Monads' as the fundamental property of matter. Kant and Schopenhauer considered a similar question of the property of matter, namely '*what is the thing in itself*'. Although this formulation might appear to be antiquated, it may be associated with the rather actual problem of modern physics: What is the intrinsic property of the matter of elementary particles or electric charge. Fundamental aspects of Kant's philosophy are 'assessments a priori' and 'assessments posterior'. However, they are based on the knowledge of the nature in Kant's lifetime. Due to relativity theory and quantum mechanics these assessments cannot hold in the original way.

Schelling developed a philosophical scheme showing similarities to the views presented in recent considerations [28 – 30, 40, 41]. The main principles of this scheme are *identity philosophy* (a) and *natural philosophy* (b). With respect to the domain (a) Schelling developed ideas on the structure of consciousness as the fundamental basis of human pansophy representing the original mold in order to derive all secondary categories of philosophy and perception. In philosophy and nature science a supreme basic principle must exist, which Schelling denoted as the *'absolute'*, and all philosophical concepts and notions can be deduced from it. This absolute is located beyond objective provability (in mathematics this is called *axiom*). Schelling also introduced the distinction between the '*I and It'*, which also exhibits a relevance in modern physics, e. g. the complementarity developed by Bohr, considered in the following section. Schelling's further aim is to find the unity of knowledge, belief, and will. Nature is considered as an entity, the dissociation of this entity into natural science and humanities must be abolished. We should add a sidenote to the idea of the entity: The medical doctor Robert Mayer was impressed by this perception and philosophy leading to the impact that heat (produced in many physical and physicochemical processes) is a special kind of energy, and the total energy including heat energy is conserved. By that, the fundamental law of physics, namely the conservation of energy, was born. The natural philosophy (b) was the subject of the question, which Schelling intensively considered during his whole life-time. In the early period, Schelling used principles of transcendental philosophy as a starting point for the classification of nature phenomena. In contrast to Newton, Schelling considered nature as an organism (a similarity to the 'Monads' of Leibniz is obvious), which can be attributed by immanent dynamical processes, incorporating a living system of low order, and permanently reproducing and changing itself to gain structures of higher order. The different forces acting in nature represent a preliminary and instable equilibrium state incorporating the aspiration to create new formations. We can summarize: The dynamical process occurring in nature is linked to a development of forms and structure of higher order and complexity. In this connection, Schelling describes matter in nature by metaphors representing mechanism, chemism, living systems. The highest step in this evolution chain is obtained by humans, equipped with mind and consciousness. Schelling initiated the description of self-organization processes, which have assumed a central importance in modern molecular biology, and we refer to the enslavement and self-organization principle in biology [19]. Schelling considered finally incarnation as a fundamental evolution of the nature in direction to mind, spirit, and soul. By that, Schelling adopted the world-view of panpsychism, and Goethe was impressed by the view of panpsychism [1, 22, 44]. Goethe possessed the ability to formulate profound questions in an exalted way: The fundamental problem of matter arising in physics and existing until presence has found a wonderful formulation in Goethe's Faust, namely, to recognize 'what holds the world together in its inmost folds'. In modern particle physics one approaches this problem by elucidation of the quark structure properties. Goethe certainly could not know about these aspects of modern physics. However, the fundamental problem of the intrinsic property of matter are still present [28 – 30, 40, 41]; Goethe may be regarded as a predecessor having put forward this question. With the progress of science, in particular, biochemistry and medicine, the dualistic view of consciousness was shifted more and more to background. Only the neuroscientist Eccles [11, 12], supported by the philosopher Popper, have been the most prominent representants of it. In order to keep the idea of a soul, they introduced a so-called immaterial field, which should interact with biomolecules by psychons in analogy to massless photons mediating the interaction with charged particles [electrons, protons, and neutrons, if the quark structure is accounted for]. However, there are fundamental problems of this mental field and the psychons, e. g. the conservation of energy. It is impossible to detect this mental field and the interacting psychons by experimental methods. The analogy to photons does not hold, since photons exhibit a zero-rest mass, but due to the velocity of light they have a nonvanishing momentum mass, and interact with matter via electric or magnetic components. Since this view could not be accepted by neurobiologists and physicists, the idea of psychons has been rejected.

In the nineteenth century, there have been two milestones towards biochemistry/molecular biology: The synthesis of urea by Wöhler in 1828, and the discovery of nucleic acids by Miescher in 1869. However, the way from nucleic acids to understanding their function yielding finally DNA consumed about 100 years. The discovery of Wöhler confirmed the view that there is no difference between organic and inorganic chemistry. The progress in anatomy and biochemistry supported the assumption that living systems are characterized by biological functions. The imagination of the soul became obsolete. This is the *monism* view, according to which all biological functions can be reduced to physical and chemical mechanisms. It is also assumed that biology inclusive the mind with feeling and thinking will be explained by monism, and it would only be the necessary time to confirm monism by further data and insights. The present development of biotechnology based on the role of the molecular biology of DNA, proteins, brain functions seems to be right. It is not the purpose to draw a comprising image of the development of brain research. Everybody knows how *lysergic acid diethylamide molecules (LSD)* or *alcohol* (in higher doses) influence/change the *mind* and, by that, the complete personality structure of a human, which shows that even *psychic* processes are closely coupled to material processes. Another example may be lesions in brain after accidents or surgical operations, which may lead to reduced functions. By that, these examples make sure that the brain inclusive its very complex molecular structure is the center of all cognitive abilities (introspection, perception, long-time and actual memory, etc.). This fact speaks in favor of monism, but the hard problem of conscious and unconscious (Freud) remains unsolved. The present results in brain research are in flow, and appear to be preliminary. In this connection, we refer to three publications [15, 20, 24], which make apparent some principal differences between the human brain and those of the nearest primate relatives (e.g. chimps, gorillas, etc.). The human brain comprises a volume, being about 3 times bigger than that of the nearest primates. But this fact is not the only decisive feature, since above all the interconnectedness between the brain areas is significantly increased, and the pyramidal cells play the essential role.

The cortex of the human brain is equipped with pyramidal cells, which are able to provide connections with the hippocampus, the memory center of the brain. It is a recent finding [20] that via a single mutation of the gene ARHGAP11B localized in mitochondria is responsible for the activity of the stem cells to yield the increase of nervous cells in the cortex by a factor 3 correlating with the corresponding volume of the human cortex. A further finding [24] confirmed the exceptional architecture of the human brain by the activity pattern, and some genes are only active in the human cortex. What are the consequences of this special position? The communication [15] reports of measurements performed at the dendrites of nervous cells in the cortex. The authors [15] have studied the signals of single dendrites with the help of calcium-controlled action potentials. The result is that due to the narrow network of the synapses, the dendrites are already in the position to allocate the intensity of the signals. The pyramidal cells in some cortex areas exhibit the ability to perform 'computer power'. This fact is an exclusive feature of the human cortex; the human brain differs significantly from the other primates. The close interconnectedness of different human brain areas could also be demonstrated by exposing probands to different kinds of music with the help of fMRT. The primary auditory cortex as the receiver of acoustical signal transfers information induced by music to other brain regions, where dependent of the kind of music different feelings are evoked. Studies performed in connection with music therapy revealed that all brain areas are involved to produce these feelings. There is also a remarkable difference, if probands only use to listen music (passive case) or if they perform active music by the singing or by playing an instrument [2, 4, 26, 27, 39, 51]. The parallelism between psychological and organic processes could be shown in profound chronobiological studies [8, 43]. These studies revealed the following results: For probands with positive affect of the mood the circadian biorhythm was dominating, whereas for probands with negative affect of the mood the circaseptan biorhythm dominated. These results point out the close connection between the biorhythm of organ functions, the production of some hormones (e.g. hypothalamus and hypophysis), and the overall feeling characterized by the mood.

3 Aspects Of The Quantum Mechanics And The Role Of The Pauli Principle (PP) In The Foundation Of Consciousness

3.1 Overview Of The Basic Principles Of Quantum Mechanics And Molecular Mechanisms

It is noteworthy to refer to the statement [28], that the principles of quantum mechanics (abbreviation: ***QM)*** on the one side, and the genuine property of consciousness on the other hand have been declared as 'mysterious'; this statement refers to the duality between particle-like and wave-like properties of the quantum mechanical objects. It should be admitted that from the experiences and views by the macroscopic world, some aspects of QM may appear to be curious or contradictory. However, I cannot accept the view of mysterious aspects, since QM works well in many fields of applications such as solid-state physics [25], quantum chemistry [35, 47 - 49], nuclear and particle physics [13, 14, 46, 50], atomic physics, spectroscopy and quantum optics (laser and applications) [17, 18]. Feynman, who introduced the path integral method as a reformulation of QM, summarized this problem by: 'Physicists who assert to have understood QM do not understand it'. Feynman's statement occurred in a small circle of participants in a conference on quark theory. Based on *relativistic quantum theory*, Pauli [34] provided the proof that all particles with half-odd spin have to account for the exclusion principle. Since the exclusion principle plays a decisive role in the present study, it will be discussed in detail. The aspects of the simultaneousness of the rest systems of elementary particles has been analyzed in a profound study [46]. With regard to the present considerations, restricted to molecular biology, we have only account for spin-1/2 particles and, above all, for electrons. Particles with zero or integer spin have to obey Bose-Einstein statistics (e.g. photons: spin-1, π-mesons: spin-0). Elementary particles with spin-1/2 obey the exclusion principle, electrons, protons, neutrons and their antiparticles. Since the relative mass of atoms and molecules is determined by the protons and neutrons, properties like sound propagation or heath energy of a medium immediately result from them. The proton number of atoms agrees with the correspond electron number, which is the essential condition of the formation of complex molecules, necessary in chemistry and molecular biology. The total spin of molecules usually is zero (singlet state), true for almost all cases, the Bose-Einstein statistics is applicable with regard to molecular associations, if the internal structure of the molecules does not play a significant role, e.g., in gases without interactions between the constituents. An essential exception is the noble gas He (closed shell case), where the Bose-Einstein condensation provides the peculiar behavior at deep temperatures near the absolute zero point. A further interesting case is the triplet ground state of the O_2-molecule with two parallel spins (up, down, perpendicular), important in binding to hemoglobin coupling with relevance in its blood transport.

The question is now, what are the quantum mechanical principles ruling the behavior of many-electron systems in atoms and in the formation of molecules? It is clear that the motion of electrons in the attractive Coulomb field of nuclei and the repulsive electron-electron interaction are described by the Schrödinger equation. But this is not the whole story, since two additional principles have to be accounted for, namely (a) Pauli's exclusion principle and (b) the indistinguishability of identical particles belonging to the same kind, e.g. electrons:

1. The Pauli Exclusion Principle or more short Pauli principle (***PP)*** tells that each quantum state of the total system (atom or molecule) can only be occupied by one spin-1/2 electron. Pauli originally deduced this principle by studying the electron configuration of many electron atoms. The most prominent exception is the isolated H-atom and its role at the early quantum mechanics, since it is a one-electron-system, and spin-1/2 of the electron (and of the proton) only becomes feasible by the interaction with an external magnetic field. In physics, the exclusion principle has attained the importance comparable with the conservation of the total energy due to its universal applications, e.g. the quarks with spin-1/2 obey it, which determine the internal structure of baryons, e.g., protons and neutrons. The significance of the Pauli principle is, however, not yet exhausted, since in connection with the already mentioned case (b) the energy of a total system is remarkably modified.

2. According to a proved behavior that microparticles of the identical constituents cannot be distinguished, the many-electron-system remains unchanged by exchange of its constituents, and this property represents a further fundamental axiom in QM. This fact is in contrast to classical macroparticles, where all constituents can be distinguished leading to the Boltzmann statistics, i.e. they are labeled. Since electrons are indistinguishable with regard to their quantum states (a necessary property of microparticles), and the *PP* only permits the occupation of a quantum state by *one* single electron, we receive a completely new situation by the existence of *exchange interactions* due to their indistinguishability.

3. The physical foundation is explained by the simple reduction to an interacting 2-electron case, but the extension to a many-electron-system is rather straightforward. Assume the quantum state of the electron x_1 may be given by $\psi_1(x_1)$ and of electron x_2 this is $\psi_2(x_2)$, then the permutation of the identical electrons provides that $\psi_1(x_2)$ and $\psi_2(x_1)$ have to lead to

the same physical observation (the electrons cannot be labeled as usual in classical physics). Since on the one side the electrons are indistinguishable and permutations of the quantum states represent a necessary property of microparticles, and, on the other side, the *PP* only permits the occupation of a quantum state by one single microparticle, we receive a completely new situation, namely the existence of *exchange interactions* due to their permutability requirements.

The total wave-function satisfying the exclusion principle of the two-electron system for simplification can be written as an anti-symmetric product:

$$\psi(\mathbf{x_1},\mathbf{x_2}) \;=\; N\cdot[\psi_1(\mathbf{x_1})\cdot\psi_2(x_2)-\psi_1(\mathbf{x_2})\cdot\psi_2(\mathbf{x_1})].(1)$$

N is only a normalization factor of the wave-function, which is not of interest here. However, this formulation of the total wave-function (state of the two-electron system) is only valid, if there is no interaction between the both electrons. Thus, the above wave-function is too simple, since electrons interact by Coulomb repulsion (the corresponding Schrödinger equation will not be regarded here). Therefore, the total wave-function has to be extended by a correlation function ***K*** *(*$\mathbf{x_1}$ - $\mathbf{x_2}$*),* and a rather interesting correlation function is a two-point Gaussian function. By that, the modification of eq. (1) assumes the shape:

$$\left.\begin{array}{l}\psi(\mathbf{x_1},\mathbf{x_2}) \;=\; N\cdot[\psi_1(\mathbf{x_1})\cdot\psi_2(\mathbf{x_2})-\psi_1(\mathbf{x_2})\cdot\psi_2(\mathbf{x_1})]\cdot K(\mathbf{x_1}-\mathbf{x_2})\\ K(\mathbf{x_1},\mathbf{x_2})=\frac{1}{\sigma^3\cdot(\sqrt{2\pi})^3}\cdot e^{-\frac{(\mathbf{x_1}-\mathbf{x_2})^2}{2\sigma^2}}\end{array}\right\}.(2)$$

It should be noted that the correlation function **K** already satisfies the PP, therefore the restriction of the anti-symmetric product of the wave-function can be lowered. Rather important is the coherence length σ, since it determines the distance of a strong correlation in order to fulfill the *PP*. It should be noted that even long-range exchange interactions are controlled by the *PP*.

Thus, for long-range correlations the single Gaussian correlation function might be not enough sufficient, and a linear combination of two shifted Gaussians resulting from the substitutions $\mathbf{x_1} \rightarrow \mathbf{x_1} \pm \boldsymbol{\beta}$ and $\mathbf{x_2} \rightarrow \mathbf{x_2} \pm \boldsymbol{\beta}$ may be more adequate:

$$K(\mathbf{x_1},\mathbf{x_2},\sigma)=c_1\cdot K(\mathbf{x_1}\pm\beta,\mathbf{x_2},\sigma)+c_2\cdot K(\mathbf{x_1},\mathbf{x_2}\pm\beta,\sigma).\,(2a)$$

It makes sense to equate $c_1 = c_2 = 0.5$, but eq. (2a) can be generalized to more than two linear combinations, and the sum of the coefficients has to be ***1.*** It is obvious that with regard to a system containing various interacting electrons the correlation function according to eq. (2a) basically requires noteworthy extensions, but the underlying principle remains unchanged.

Examples of long-range couplings are: In superconductivity, we have to deal with two-electron correlations with opposite spin, which are coupled by a phonon (a state of quantized sound waves). The total spin is zero, and due to the long-range correlation these two electrons behave as a quasi-particle (Cooper pair) and a state of higher order is reached (a). As the ***PP*** connects correlated quantum states with rather long distances (the correlation length σ may even be beyond the usual microscopic distances), we have to deal with the so-called **'entangled states'**, which have received increasing attention during the last decade. The Cooper pairs in superconductivity (a) are examples of entangled states (b).

Exchange interactions are essential tools in the research of interacting quantum particles obeying the exclusion principle. Which information provide these interactions with regard to molecules and chemical bonds in many-electron system, if we have to deal with chain molecules?

- The total energy is lowered by the exchange interactions between the repulsive electrons, and the neglect of the ***PP*** may either lead to a smaller lowering effect of the binding energy or even chemical bond is instable.
- Noble gases exhibit a particularly high amount of energy lowering and form the stable noble gas configuration; the formation of chemical bonds between atoms is closely related to the noble gas configuration.
- Atoms aspire to reach states similar to noble configurations by forming molecules and the binding energy is lowered. Examples: The noble gas configuration of two electrons (He) can be reached by the chemical bond of two H-atoms to yield the H_2-molecule (prototype of covalent binding). On the other hand, when the atom (1) is missing one electron to reach noble gas configuration and the second atom (2) possesses one more electron, then by the ion binding the noble gas configuration is reached for both atoms. Atom (1) is the acceptor and (2) the donator by a charge transfer mechanism.

The ion-binding provides the formation of ion crystals, e.g. **NaCl**, but the dielectric constant of water molecules reduces the binding forces in a strong manner yielding $\mathbf{Na^+}$ and $\mathbf{Cl^-}$ by dissociation.

There arises the question of the specific importance of covalent bindings. In many actual situations, we obtain chemical bindings neither by covalent- or by ion-bonds, and it is only possible that one of special case characterized by the binding strength is predominant. With regard to molecular biology it should be mentioned that covalent bindings favor the ***formation of chain molecules.*** Because of the importance of carbon in biochemistry and molecular biology, we should consider detailed its electronic configuration by the view of the exclusion principle (for details of the chemical bonds and to the PP, textbooks of physics and chemistry should be consulted).

The electronic configuration of carbon permits two possible cases:

$$\left.\begin{array}{l} case\,1\,(two-valued\ carbon): 1s^2, 2s^2, 2p_1^{\ 1}, 2p_2^{\ 2} \\ case\,2\,(\,four-valued\ carbon): 1s^2, 2s^1, 2p_1^{\ 1}, 2p_2^{\ 1}, 2p_3^{\ 1} \end{array}\right\}.(3)$$

A prototype of case 1 is carbon-monoxide (C = O). In molecular biology, we have to deal with case 2 (sp_3-hybridization of the carbon configuration) yielding four-valued bonds, e.g. O = C = O (CO_2: carbon-dioxide). With regard to bonds between carbon atoms there are 3 possibilities forming preferably chains: **C – C** (single bond), **C = C** (double bond), and **C ≡ C** (threefold bond). The role of these 3 binding types in molecular chains based on carbons is essential in molecular biology, yielding the bases of the composition of very complex molecules. Single bonds occur e.g. in saturated lipids, whereas double and threefold bonds are a characteristic feature of unsaturated lipids having an important role in membrane functions, and, above all, in dendrites of nervous cells in brain by forming long-range carbon chains.

The role of exchange interactions will be made feasible by some examples: Fig. 1 shows the H-bonds between water molecules in the fluid state occurring by the negative oxygen $\mathbf{O^{2-}}$ (reaching noble gas configuration), and can also attract a proton of a neighboring water molecule by simultaneous reducing the binding strength of an already existing ***O-H bond***. By that, H_2O is formed again, but the released proton performs the same procedure by binding to the next reachable oxygen. Though the whole procedure represents an interplay of covalent- and ionic binding via exchange of protons and electrons from molecule to molecule. This interplay between water molecules in fluid state leads to essential mechanisms of the energy transfer in cells. Since water is an important constituent in cells in order to effectuate the dissociation of electrolytes necessary for the signal transport in nervous systems.

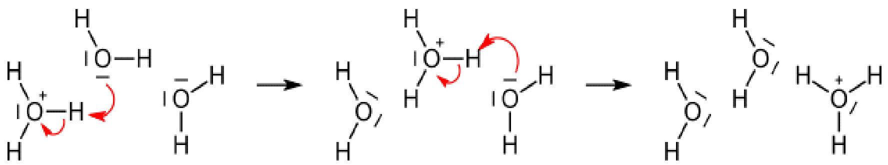

Fig. 1. Model of a H-bond chain in fluid water. The overall process resembles a wave propagation

A more complex mechanism of H-bonds plays a decisive role in many biological functions, and I only regard the double helix of DNA. Fig. 2 shows an example, where the protons swing with the help of the quantum mechanical tunneling effect between bases of nucleic acids, and the related electrons move in the same direction to change correspondingly the conformations of the bases.

The potential for the tunneling protons is presented in Fig. 3. We have also to verify a rather complex interplay, since the coupling of the base pairs along the helix induced by the long-range 3d electrons of the phosphoric acids makes the overall process rather nonlocal and happens within the complete DNA strands. However, this is not the only teamwork, because the protons magnetically interact with neighboring protons of the H-bonds due to spin-spin coupling and their electric currents inducing also a rather weak magnetic field. The protons forming the H-bonds of DNA carry out two kinds of interaction with the geomagnetic field, namely via electric charge (Lorentz force) and via spin. By the superposition of the different and coupled resonance frequencies resulting from the H-bonds *between* ***adenine - thymine***, and ***guanine - cytosine*** so-called '***beat-frequencies'*** along the DNA-chain will be produced [49]. These beat-frequencies represent the base of the chronobiological behavior of DNA, which exhibits wave-like properties, e.g. standing waves.

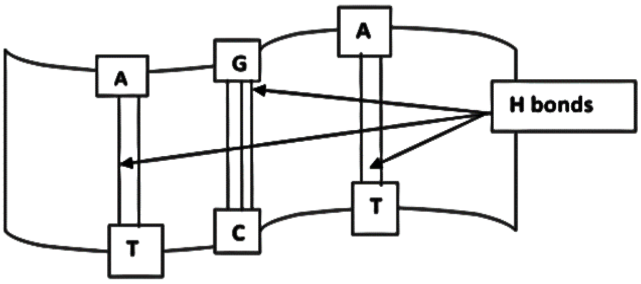

Fig. 2. Model of a DNA-chain with the H-bonds between the related base pairs A - T and G - C. The H-bonds are responsible of the conformations by keto – enol – tautomerism

Fig. 3 exhibits the essential importance of the quantum mechanical methods in order to comprise the mechanisms in molecular biology. Due to the asymmetry of the electronic configurations of the base pairs A – T and G – C, the model 1 only represents an approach and model 2 is certainly more adequate for the description of the proton motion between the base pairs.

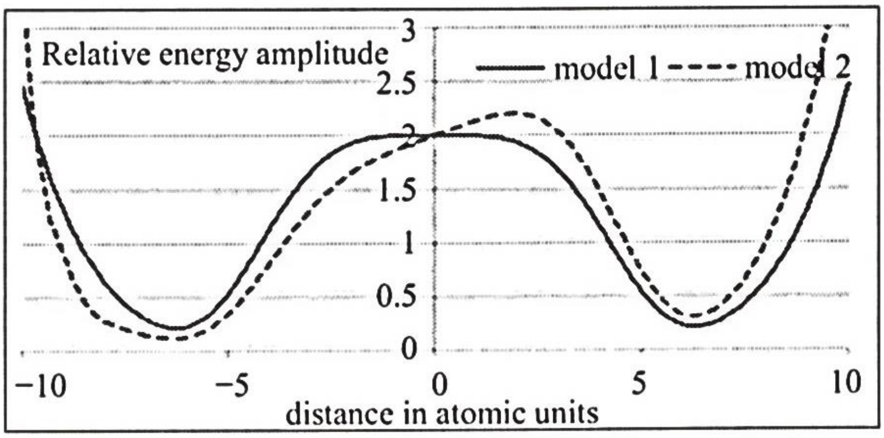

Fig. 3. Double minimum potential between the pairs A - T. Model 2: Dashed line with left-side minimum → keto-tautomer of A; at right side minimum → enol - tautomer of T. Model 1: Symmetric approximation between the base pair A – T

3.2 Some Information-Theoretical Aspects Of The Pauli Principle (PP) In QM

At the years between 1927 and 1930, a very intensive discussion started about the physical interpretation of QM, which is obviously not yet finished; the book of Heisenberg [21] gives detailed information on this stage, we particularly mention Heisenberg's discussions with N. Bohr, W. Pauli, A. Einstein, C. F. von Weizsäcker, and E. Schrödinger. A main part of these discussions dedicated to the measurement process in QM. According to Bohr we have to consider classical measurement apparats, which are only able to detect either processes of an entity of micro-particles in space-time or in the momentum-energetic level. This is in contrast to classical physics, where simultaneous measurements of space-time and momentum-energy are basically possible. Bohr denoted the natural philosophical conception of measurement processes in QM as complementarity; a rather familiar version of the complementarity is Heisenberg's uncertainty relation between position and momentum of a microparticle. A direct consequence of the Bohr's interpretation is the collapse of the wave-function due to a measurement. The meaning of this 'metaphor' is the following: Before the measurement the complete state of a quantum entity is given by a superposition of different states according to eq. (4); after measurement, *only* a specific state exists by reduction of the quantum states to one state with the probability P_k yielding the collapse of the original wave-function according to eq. (4a):

$$\psi(x,t)=\sum_{j=0}^{\infty}c_j\cdot\psi_j(x,t).(4)$$

$$P_k=\left|\psi_k\right|^2.(4a)$$

It must be pointed out that the collapse of wave-functions has been debated by physicists for a long time. Bohr's interpretation of the wave-function is not the only one, since arguments like a measurement process is always connected to interactions, which changes the original state, has been born by physicists, who (did not) do not accept Bohr's view. In Heisenberg's terminology the general wave-function represents a possibility, and the state reduction provides the fact (actual reality). With regard to the existence of consciousness the collapse of wave-functions according to eqs. (4) and (4a) has been accounted for [31, 36]. In particular, Penrose [36] connected these quantum states with entanglements, which imply the contradiction to combine the local collapse of the wave-function with an extremely nonlocal behavior. Therefore, the difficulty arose, in which way the collapse of wave-functions can provide insights in the appearance of consciousness, which Chalmers [7] denoted the '*hard problem of consciousness'.*

The detailed studies referring to the logic structure of QM in comparison to classical physics revealed that due to the dualism ***'particle – wave'*** there is no possibility for a statement such as '*true' or 'false*', since the interference between ***'true and false'*** prevents this fixation, necessary in classical logics. However, if we account for the indistinguishability of micro-particles of identical kind leading to exchange contributions for interacting micro-particles due to the PP, it appears to be possible to gain some noteworthy features. For this purpose, we have stated some important examples with potential importance in biochemistry and molecular biology. A rather interesting example leading to an entangled structure and having even importance in molecular biology and chronobiology is obtained by Fig. 2 referring to a model of a DNA description. This model can be founded by coupled electromagnetic resonators subjected to quantization [48, 49]. It implies an entangled structure due to the interplays of protons (H-bonds) and electrons creating permanently keto – enol – tautomerism. Einstein and coworkers very early have performed studies with regard to long-range scatter interactions between electrons and received the result that there exists a long-range correlation in the behavior of these particles. This study was the first one leading to entanglement in QM and is usually referred to as EPR-paradox, since Einstein intension was to show that due to the nonlocal character of QM this theory cannot be valid for the description of nature, since the causality in physics can be violated [52]. However, in connection with the ***PP*** the nonlocal property of QM is ensured. In the meantime, entangled states have found growing interest even in novel technical research in order to design the so-called '*quantum computer'* [3, 5, 16, 23, 52]. Until the present stage we have given some aspects, in which way the *PP* has to be accounted for in the formalism of QM, and what are the consequences of interacting many-particle problems (electrons) with spin-1/2. An essential question is the range of applicability of the ***PP***. If we assume that all interactions of electrons are mediated by the *instantaneous* Coulomb forces, then it is rather difficult to determine a limit range resulting from the interaction potential, which decreases proportional to the reciprocal distance **1/r**, and for long distances an extremely weak influence should even be present. Such a behavior would imply that entangled states are still present at extremely long distances. However, such 'entangled states' are difficult for measurements. Therefore, we have to account for that Coulomb forces are only valid for those distances, where their approximation within the relativity theory holds, because Coulomb interactions really are incorporated by photons, and the velocity of light determines the limitation of the validity of the simultaneousness. In relationship to this problem the question may arise, in which manner one electron gets the knowledge with regard to its behavior in order to fulfil the exclusion principle by exchanging information with electrons belonging also to the 'system', i.e. each electron has to know what is permitted (unoccupied: '*yes*') and what is forbidden (occupied: '*no*') and act correspondingly. This situation may provide some reasons for speculations:

One possible view might be to say that this behavior is an impressed feature of the nature, and it is the task of physics to describe this feature correctly. A second possible view being a little bit speculative might be that micro-particles like electrons exchange information about the quantum states with the help of a '*weak form of a memory' of each electron*, which is requested to obey the exclusion principle at least in a microscopic system. Since this exchange of information is closely connected to relativity theory, which requires some restrictions due to the velocity of light, the picture of the information exchange related to *memory properties of particles (electrons)* appears to be in agreement with the Pauli principle. It is evident that both view-points bear some truth, but in spite of possible speculations, Pauli's exclusion principle provides in contrast to the logic structure of QM a '*yes*' or '*no*' statement with regard to complex microscopic systems consisting of numerous electrons in order to provide information of either *'occupied'* or *'unoccupied'* of quantum states.

4 General Conclusions

The rather extensive discourse about QM inclusive PP was guided by the purpose to develop an acceptable base to provide an access to the *hard problem of matter* and to the *hard problem of consciousness*. It appears to be insufficient to mention the collapse of wave-functions as an explanation, in which way the mind may be able to attain the brain. At first, we shall return to Kant's philosophy, since Kant could not possess knowledges about physics of the 20th century. In Heisenberg's book [21] the discussions on Kant's assessment 'a priori' has been subjected to a profound analysis, since the assessment result from the role of perceptions assumed to be valid in the 18^{1h}; i.e. they are based on the scientific knowledges of that century, which are essentially related to Newtonian physics. The measurement process applied to micro-particles in QM has reached a significant higher level in abstraction compared to the world we can perceive by our senses. Thus, colors are the product of the brain. In physics, we have to deal with electromagnetic waves (photons). If the certain frequencies associated with visible light are reflected and scattered by a certain material (e.g. a yellow pullover), our perception in the brain tells us that the color of the object 'pullover' is yellow. If these waves pass through vacuum without scatter or reflection of photons, then we are not able to verify a specific color. Furthermore, the frequency spectrum producing colors is only a small part of all photon frequencies. Similar conclusions are valid with regard to sound waves, which are referred to as phonons, if sound waves are quantized. It is again the brain, which makes pressure oscillations in the air to '*note*'. Thus, various processes occurring under microscopic conditions cannot be perceived by our senses (the lists might be continued). Similar problems emerge with regard to space-time, of which the metric (general relativity theory) is determined by the mass distribution of the universe. The Euclidean geometry, as Kant assumed, is not *a priori* valid, although very practicable to solve problems in our daily routine on the globe. With regard to Kant's famous criticism of the pure rationality we summarize that Kant's axioms of perceptions have to be subjected to various extensions and modifications in order to be in coincidence with the results of modern physics. On the other side, Kant was right to suspect that all kinds of human perceptions cannot provide information on the 'thing in itself'. By that, the '*hard problem'* of matter still exists.

The present research in neuroscience, above all, the elucidation of the complex brain functions, appears to be continuously in flow, and the present state of art indicates that the research is far away from being closed or understood [6, 9, 10, 31 - 33, 36 - 38, 42, 45, 53]. This fact emphasizes the problem to simulate the complex brain function by neuronal networks with the help of elaborated technical means provided by informatics (artificial intelligence) and computer science. Although there exists a desirous interest to obtain useful applications and commercial benefits, these simulations remain to be in the dark due to still scarce (insufficient) basic knowledges delivered by brain research. The question arises, what is the progress in neuroscience, which renders the field of philosophical and psychological aspects. Thus, it is known that various neurological processes correlated with long- and short-term memory, emergence of feelings, visual and acoustical perceptions, decisions to perform actions or operations can be reduced to specific brain functions. This listing is certainly not complete, but it also includes the sensory motor-cortex and the important functions of the cerebellum. However, neuroscience cannot provide the reason on the creation of specific feelings, e.g. why a piece of music evokes pleasant feelings, which may be related to positive mood, whereas by other kinds of music mournful feelings are evoked.

Therefore, we summarize: On the one side, we have to take account of all aspects belonging to the field of matter either according to knowledges of classical physics or according to insights of modern physics (elementary particles and the laws of symmetries describing their behavior) can be classified as the '*hard problem of matter*'. On the other side, we have expounded the essential insights of brain function being coupled to very complex molecular processes studied in neurobiology and the existence of mind, feelings, etc., which are closely connected to these functions. Since we are the persons as human beings, who are able to think and able to create intellectual and artistical objects, all these aspects can be comprised by the existence of *consciousness*. Since all these processes are connected to brain functions, realized by complex structures and lastly formed by complex molecules, we can speak in agreement with references [28 - 30, 40, 41] of the *'hard problem of consciousness'*. There have been put forward many attempts to explain the appearance of consciousness. Thus, by the useful discovery of EEG, many brain functions could be observed by this technique, consisting of some specific wave-signals, and interesting studies [6, 9, 31 – 33, 53] have been dedicated to the *mind – body problem*. Koch and Crick [9] identified the Γ-waves with 40 Hz with consciousness. Yet this identification only provides a certain brain function (besides various other functions), but we are not able to attribute 'consciousness' to electromagnetic waves, and the *'hard problem of consciousness'* cannot find the resolution by this proposition.

However, the *'hard problem of consciousness'* is not only a principal item of actual research in neuroscience and natural philosophy, since scientists and philosophers like Hume, Leibnitz, Schelling, and Russell dedicated interesting conceptions to this item. In particular, Russell's considerations pursue the aim to receive a synthesis of the both hard problems (matter and consciousness) based on insights of modern science. The intentions of Russell's propositions are enhancements of Kant's '*thing in itself*'. Russel's conception is the so-called '*two-aspects-monism'*. The one aspect refers to matter governed by the law of physics, whereas the second aspect lies beyond physical experience. In an illustrative picture we could describe Russell's conception by one object, which provides a different image depending on the perspective. Russell's approach seems to be in congruence with studies [28 – 30, 40, 41], and, we particularly refer to advisements in [28], which gave a motivation of the present study. According to the chain of thoughts discussed by the mentioned author, the principles of physics with regard to matter are restricted to their behavior. Though in classical physics Newton's law describe the mutual attraction of earth-moon or earth–sun by the gravitation. In modern physics governed by elementary particles the attraction of electrons with nuclei and the motion of electrons in atoms or molecules are described by the laws of electrodynamics and quantum mechanics. By that, we may summarize all detailed advisements of Mørch, that physics principally describe the relations between physical objects, which, in the microscopic domain, are electrons and nuclei (protons and neutrons). This implies that physical descriptions only show, what the particles carry out according to physical laws, but not what the particles are in themselves, and physics represents the *software* related to the processes occurring in nature, but not the hardware, which is associated with the '*hard problem of matter'*.

This fact resembles Kant's 'thing in itself', and the considerations in [28] with regard to matter seem to be particularly influenced by Kant. However, already this view of physics requires some correction. It is a fundamental result of relativity theory and confirmed by numerous experiments that every kind of matter corresponds to a manifestation of the energy, and the famous Einstein formula $E = m \cdot c^2$ expresses this connection. It is interesting that the neurobiologist Roth [37] pointed out that the notion 'matter' has received a drastic transformation by modern physics, which results from the reason, that 'matter' is not a given magnitude and can be changed to appear in quite different states, e.g. the creation of γ-quanta via electron-positron interaction, which implies the annihilation of both particles. According to Mørch's reasoning the intrinsic properties of particles, equipped with matter, are not described by methods of physics. Therefore, in [28 – 30] it has been made use of the freedom to attribute elementary particles with some kind of consciousness. By that, the intrinsic properties of matter are characterized by two aspects, namely in which way they behave, when they get into contact with other particles (this is the domain of physics), and electrons as well as protons and neutrons at least know to which category they have to belong according to their 'consciousness'. This thesis is an interesting speculation and would be capable to solve the both hard problems in an elegant way. In spite of this interesting speculation there arise many unanswered questions:

It is ensured that animals are also equipped with consciousness, and it appears that the level of this consciousness increases with the evolution level. It is rather unclear, which kind (or level) of consciousness lifeless matter should possess. It is extremely unclear, why only electrons and perhaps protons and neutrons should be equipped with consciousness, since by sufficiently high collision energies these particles can be annihilated and further particles are created, having often lifetimes less than 10^{-16} sec before they have to undergo decay, and some high energy γ-quants may be the final result. In experimental high energy physics due to their electric charges, only protons and electrons can be accelerated to reach energies/velocities near the velocity of light. Thus, by the proton – proton or electron – proton collisions the symmetry principles of the created new particles are rather known, although further insights might still be discovered, e.g. the Higgs boson some years ago. The quarks, which represent the charge-coupled devices of hadrons (proton, neutrons, resonances induced by the excitation energies), belong to the symmetry group SU_3 in the charge space. In connection with the considerations and speculations of Mørch we mention, that these fundamental particles with spin-1/2 remain '*intact*', whereas the resonances may appear and disappear within extremely short time intervals. Free quarks cannot be knocked out via transfer of very high energy, since the binding forces (gluons) increase with increasing transfer energy. By that, it would be better to attribute the quarks besides the electrons to a certain kind of consciousness.

Kant's view of matter, which is mainly adopted in [28], should be compared with the insights of relativity theory and non-equilibrium thermodynamics. The supreme principle in physics is conservation of the energy, and matter seems only to be a specific manifestation of the energy. Due to the fundamental role of the energy, some further aspects go also beyond Kant's view of physics. What happens with the energies of the γ-quanta? These energies are downgraded by repeated scatter processes in order to yield finally only thermal energy by warming the medium and leading to a maximum of the entropy. In living systems, it is necessary to maintain a nonequilibrium of the energy distribution in order to enable fundamental processes such as self-organization, cellular renewal processes, and biorhythms. Since information theory revealed the connection between information and entropy on the one side, and energy distribution and entropy on the other side, it is basically the energy, which is responsible for the exchange of information in living systems. The so-called '*thermal equilibrium'* of a closed, very large system with the maximum of the entropy is usually be denoted by 'heat-death' of a system, and we should point out that the relationships between the four fundamental properties could not be foreseen by Kant, when he developed his philosophical construct of ideas. With regard to the complexity of living systems, above all, the organization of the brain, we are able to verify that the increasing complexity involves a hierarchy of necessary information processes governed by the PP, which is responsible for the information and energy exchange between the complex structures. However, this is not the philosophical starting-point. But there exists a parallelism of the physical view with respect to increasing information exchange and the increasing level of 'thinking' in the philosophical view. Mørch concluded in her papers that the so-called '*combination principle'* of the two-aspect monism is the only one with an attractive speculation, i.e. the level of consciousness goes parallel to the increasing of biological structure, in particular, to the human brain. This conclusion should be compared to Schelling's natural philosophy, since Schelling arrived at the same results in panpsychism, and he has already forestalled the principle of self-organization of living matter. A principial difference to Mørch is, that protons, electrons, etc. were completely unknown at the beginning of the 19th century.

The connection to the two-aspect monism by additional accounting for the combination principle shall finally be the comparison to the present results based on QM and, in particular, on the Pauli principle which can readily be extended by the enslavement principle in complex systems developed by Haken [19]. The dualistic behavior of electrons (and other micro-particles) with either wave-like or particle-like properties are their intrinsic features, which appear to be confusing by the macroscopic view of a human observer. Bohr's philosophical complementarity holds, since measurement processes occur at the macroscopic level. The Compton wavelength λ_c of the wave-like electron is given by:

$$\lambda_c = h/(mc) = 2.426 \cdot 10^{-14}\, cm \quad (5)$$

whereas with respect to its diameter d_e (extension of the point-particle electron) only the inequality $d_e < 10^{-16}$ cm is ensured (h is related to Planck's constant, m to the electron mass of, and c to the velocity of light). Therefore, it is mainly our human view to differ between wave and particle, whereby even in classical physics the particle is stylized up to a 'mass-point' bearing a macroscopic mass! The philosophical aspects of this dualism were pointed out in discussions between Bohr and Heisenberg [21]. Based on QM in connection with Pauli's exclusion principle it seems to be possible to see an access to the fundamental problem. The long-range exchange interaction between scattered electrons guided Einstein to the assumption of hidden parameters in the QM (EPR-paradox), since he could not accept the nonlocal character of QM, which may violate the causality principle, and he could not accept the probability in QM. A sloppy formulation is referred to as 'Einstein spook' [52], and the EPR-paradox is, in fact, the first entangled state observed in QM. However, this long-range (nonlocal) interaction yields an exchange of information between the states of the electrons, and the PP forbids the simultaneous existence of one state occupied by more than one electron. In the meantime, entangled systems have emerged an attractive interest, since not at last their possibilities are enormous with regard to the development of quantum computers, which might be an advanced tool of designing neurological processes [3, 5, 16, 23, 52]. We have already pointed out the phase transitions in superconductivity, realized by Cooper pairs. These 'quasi-particles' show entangled properties due to the PP. They are connected to long-range exchange interactions between electrons with different spin mediated by phonons and leading to lowering of the energy (energy gap), and even long-range tunneling processes through insulators could be confirmed (Josephson effects – Josephson received 1973 the Noble Prize in Physics for the discovery).

The cooperative long-range behavior between electrons and protons will be discussed by two examples, namely DNA and the role of unsaturated lipids in membranes of dendrites. DNA represents a very complex entangled system, since the couplings enfold the whole DNA. At first, we regard separately according to Fig. 2 the base pairs A – T and G – C, connected by H-bonds. The motion of protons is coupled to electron motions leading to tautomeric conformations. The electrons of each base pair have to fulfil the PP by molecular orbitals (MOs) as quantum states with distinct energy levels, and, together with the protons, the electrons of the uppermost MOs/energy levels are involved by exchange of information between the tautomeric conformations of the base pairs. Therefore, these electrons exhibit the uppermost position in the hierarchy of quantum information by instructing all electrons of the subordinated hierarchy with regard to their functions in creating entangled states by the base pairs mediated via H-bonds. We now regard the complete DNA consisting of numerous sub-entangled constituents, which create a new hierarchy of entanglement, and the uppermost state of the hierarchy is characterized by a maximum of quantum information combined with the ability to instruct the behavior of all subordinated entangled states. Thus, due to the PP the complex DNA stores an enormous magnitude of information, which is created by numerous 'yes' or 'no' decisions. If the DNA double helix interacts with surrounding proteins, RNA-molecules, electrolytes, and unsaturated fats, and other biomolecules, which may also be characterized by long-range states, then the whole complexity reaches an extended super-molecular state of entanglements, and the Pauli principle governs all allowed and forbidden processes by forming a memory structure. The resulting hierarchy of this complex system can be identified again by the enslavement principle of Haken [19].

A similar situation is received by nervous cells (in particular, human nervous cells in the cortex) and their dendrites, which are characterized by long-range activities and connect neighboring brain areas by synapses. The enormous 'yes' or 'no' possibilities of the electronic states due to the PP reach a high level of complexity of possible information in a system controlled by its order parameters. The membranes of the dendrites consisting of double layers, mainly formed by unsaturated lipids and proteins, imply in similar fashion, as already discussed, a hierarchic system of molecular chains, which exhibit a huge amount of possible quantum information and memory. The unsaturated lipids satisfy a further function, since they are able to transport electric signals induced by concentration gradients of electrolytes (saturated lipids are insulators and would be not suitable for these functions). Now we are finally able to summarize the investigations on the physical foundation of brain functions, the role of QM and PP in order to consider a juxtaposition with the philosophical conclusions.

1. Based on the physical background of the PP, we could verify the enormous magnitude of quantum information inclusive the corresponding memory and decision processes, since this principle connects different quantum states and controls all possible interactions even for long distances. The complexity of such a system is significantly increased by the introduction of additional coupling processes mediated by the synapses at the dendrites. We have also to be aware of the role of the enslavement principle [19], according to which the whole complex system resulting from coupling interactions between the subsystems and described by order parameters governs (or determines) the behavior of these subsystems; in other words: These complex and sub-entangled systems are able to create super-structures, since a composed system with exchanging information incorporates a higher level of order than the components. Therefore, we point out that a network of interacting quantum states, connected to subsystems, is governed by the Pauli principle, which enables to evaluate the receiving signals and information from our perception in order to serve the memory system by numerous sequences of decisions of allowed or forbidden possibilities. Which conclusions are possible by considering these results? Every microscopic system with more than one electron has to fulfill this principle due to the fundamental result of relativistic QM, according to which all spin-1/2 particles have to obey it [34]. The range of its validity with regard to complex structures is given by the relativity theory and nonlocal properties of QM, which determine the limitations of the principle of synchrony having particular importance for long-range entangled systems and probably violating the causality law.

2. The PP and exchange interaction between electrons of small molecules (e. g. H_2) do not provide comprehensive information on a fundamental memory property, since there are only a few 'yes' or 'no' possibilities. With increasing complexity of molecules (in particular chain molecules) the possible 'yes' or 'no' decisions increase correspondingly in order create a memory system for the storage of quantum information, which becomes useful for decisions and comparisons of alternatives. The increasing complexity of molecular structures immediately leads to a hierarchy of decision instances as expressed by the enslavement principle [19]. From a pure physical aspect with regard to exchange of information and transfer processes with lowering the energy or with the formation of entangled systems, it is the Pauli principle, which makes such a complex system '***thinking***'.

3. It seems justified to consider this principle from a philosophical view and point out its role in realizing a ***'thinking system'***. By passing to very complex molecular systems given in nervous cells and their contact interactions with neighboring cells via synapses, the Pauli principle assumes the function of a control system, which decides all allowed or forbidden processes based on the enslavement properties. This 'thinking system' can be characterized by some essential features with relevance in panpsychism, for instance the memory and storage of information, comparison of different kinds of information merging the human brain with other organs or resulting from our personal perception.

4. The physical aspects developed by the preceding 3 points deserve to be compared with the central assumption in [28], namely the combination principle in two-aspect monism of panpsychism, where the level of consciousness goes parallel to the increasing of complex biological structure, in particular, to the human brain. Therefore, small molecules can only exhibit rather an extremely small fractional amount of 'consciousness', and by passing exclusively to complex systems of higher order, it may play the decisive role. Therefore, both starting-points, the physical and the philosophical, exhibit the common feature that only very complex systems consisting of numerous atoms or electrons provide an access to fundamental problems of psychology such as recognition of structures, perception, and the motivation for some specific decisions. However, some essential aspects of consciousness (e.g. feelings, joy, positive or negative mood, etc.) appear to be too difficult to be founded by the physical principles, quantum mechanics and Pauli's exclusion principle, developed in this study.

According to the insights of this study the present author provided a support by arguments in favor of panpsychism, although the present stage of knowledge only permits the plausibility of these arguments, since we have only partially been able to comprise all aspects of consciousness. The plausibility cannot be considered as a rigorous proof of the validity of such speculations. If brain research will provide further insights in the processes, which organize the nervous functions and the information exchange between different brain areas, it may be possible to analyze long-range interactions, entangled systems and enslavement principle by a more profound level; it appears that the Pauli principle is able to provide significant contributions.

References

[1] Basfeld, M., "Goethe und die Naturwissenschaften", Spektrum der Wissenschaft 4. 122-124. April 1994.
[2] Beaty, R.E, "The neuroscience of musical improvisation", Neuroscience and Biobehavioral Reviews 51, 108 – 117. 2015.
[3] Bengtsson, I. and Zyczkowski, K, Geometry of quantum states – an introduction to quantum entanglement, Cambridge University Press, Cambridge, ISBN 0-521-81451-0. 2006.
[4] Blood, A.J. and Zatorre, R.J, "Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward motions", PNAS 98, 11818 – 11823. 2001.
[5] Bub, J, Quantum Entanglement and Information. In: Stanford Encyclopedia in Philosophy, Editor: Zalta, E. 2010.
[6] Bunge, M, The Mind-Body Problem, Pergamon Press, Oxford. 1980.
[7] Chalmers, D.J, The Conscious Mind – In Search of a Fundamental Theory, Oxford University Press, Oxford, New York. 1996.
[8] Cornelissen, G., Watson, D., Mitsutake, G., Fiser, B., Siegelova, J., Dusek, J., Vohlidalova, J., Svacinova, H. and Halberg, F, "Mapping of Circaseptan and Circadian Changes in Mood", Scripta Medica (Brno) 78 (2), 89 – 98. 2005.
[9] Crick, F. and Koch, C, "A framework for consciousness" Nature Neuroscience 6, 119 – 126. 2003.
[10] J. C. Eccles: The Physiology of Synapses. Springer, Berlin (1964).
[11] Eccles, J.C and Popper, K, The Self and its Brain, Springer, Berlin. 1977.
[12] Eccles, J.C, The Human Mystery - The Gifford Lectures 1977–78, Berlin, Springer. 1979.
[13] Feynman, R.P, Photon-Hadron Interaction, CRC Press, Taylor & Francis. 1972.
[14] Feynman, R.P, Quantum Electrodynamics, W.A. Benjamin, New York. 1962.
[15] Gidon, A., Zolnik, T.A., Fidzinski, P., Bolduan, F., Papoutsi, A., Poirazi, P., Holtkamp, M., I. Vida, I. and Larkum, M.E, "Dendritic action potentials and computation in human layer 2/3 cortical neurons", Science 3, 367, 6473, 83-87. 2020. DOI: 10.1126/science, aax. 6239.
[16] Gramich, J., A. Baumgartner, A. and Schönenberger, C, "Resonant and Inelastic Andreev Tunneling Observed on a Carbon Nanotube Quantum Dot", Phys. Rev. Letters 115, 216801. 2015.
[17] Griffith, D.J, Introduction to Quantum Mechanics. Prentice Hall, ISBN 0-13-111892-7. 2004.
[18] Haken, H. and Wolf, H.C, The Physics of Atoms and Quanta. Springer. 1980.
[19] Haken H, Information and Self-Organization; a macroscopic Approach to Complex Systems, Springer Series in Synergetic. 1988.
[20] Heide, M., Haffner, C., Murayama, A., Kurotaki, Y., Shinohara, H., Okano, H., Sasaki, E. and Huttner, W.B, "Human-specific ARHGAP11B increases size and folding of primate neocortex in the fetal marmoset", Science 31, 367, 6473, 83 – 87. 2020. DOI: 10.1126/Science, abb. 2401.
[21] Heisenberg, W, Physics and Beyond - Encounters and Conversations (in German: Der Teil und das Ganze), Ruth Nanda Nanshen, Editor. 1972.
[22] R. Hermann, R, Die Bedeutung der Bibel in Goethes Briefe an Zelter, Berlin. 1948.
[23] Horodecki, R., Horodecki, P., Horodecki, M. and Horodecki, K, Quantum Entanglement, Reviews of Modern Physics, 81, 865–942, 2009.
[24] Kanton, S., Boyle, M.J., He, Z., Santel, M., Weigert, A., Sanchis-Calleja, F., Guijarro, P., Sidow, L., Fleck, J.S., Han, D., Qian, Z., Heide, H., Huttner, W.B., Khaitovich, S., Pääbo, P., Treutlein, B. and Camp, J.G, "Organoid single-cell genomic atlas uncovers human-specific features of brain development", Nature, Doi: 10.1038/s41586-019-1654-9. Epub. Oct. 16. 2019.
[25] Kittel, C, Introduction to Solid State Physics, 8th Ed, John Wiley & Sons, Inc. ISBN 978-0-471-41526-8. 2005.
[26] Koelsch, S, Brain and Music Oxford, Wiley-Blackwell. 2012.
[27] Koelsch, S. and Skouras, S, "Functional centrality of amygdala, striatum and hypothalamus in a 'small-world' network underlaying joy: An fMRI study with music", Human Brain Mapping 35, 3485 – 3498, 2014.
[28] Mørch, H.H, "Is Matter Conscious? Why the central Problem in Neuroscience is mirrored in Physics", Nautilus, 6. April 2017.
[29] Mørch H.H, "Is Consciousness Intrinsic? A Problem for the Integrated Information theory", Journal of Consciousness Studies 26, 133-162. 2019. - ingentaconnect.com.
[30] Mørch, H.H, Panpsychism and Causation: A New Argument and a Solution to the Combination Problem, Doctoral Dissertation, Department of Philosophy, Classics, History of Art and Ideas, University of Oslo, Oslo. 2014.
[31] Okon, E. and Sebastian, M.A, "A consciousness-based quantum objective collapse model", Synthese, Springer. 2018.
[32] Owen, M, "Exploring Common Ground between Integrated Information Theory and Aristotelian Metaphysics", Journal of Consciousness Studies. 2019. – Ingentaconnect.

[33] Panksepp, J, Affective Neuroscience - The Foundation of Human and Animal Emotions, Oxford University Press, Oxford, New York. 1998.
[34] Pauli, W, "The connection between spin and statistics", Phys. Rev. 58, 15, 716 – 731. 1940.
[35] Pauling, L. and Wilson Jr, B, Introduction to Quantum Mechanics with Applications to Chemistry, Dover Books on Physics. 1985.
[36] Penrose, R, The Emperor's New Mind: Concerning Computers, Minds and The Laws of Physics, Oxford University Press. 1989.
[37] Roth, G. and Strüber, N, Wie das Gehirn die Seele macht Klett-Cotta. 2017.
[38] Roth, G., The long Evolution of Brains and Minds. Springer, Heidelberg. 2012.
[39] Sachs, M., Kaplan, J., Der Sarkissian, A. and Habibi, A., "Increased engagement of the cognitive control network associated with music training in children during an fMRI Stroop task", PLoS ONE, 12, e0187254. 2017. DOI: 10.1371/journal.pone.0187254.
[40] Seager, W, Panpsychist Infusion. In Panpsychism: Contemporary Readings, eds. G. Brüntrup and L. Jaskolla, Oxford University Press. 2016.
[41] W. Seager, W, The Routledge Handbook of Panpsychism, 1st Edition, New York. 2019. https://Doi.org/10.4324/9781315717708.
[42] Shepherd, G.M, Foundation of the Neuron Doctrine, Oxford University Press, Oxford. 1991.
[43] Shinagawa, M., Otsuka, K., Murakami, S., Kubo, Y., Cornelissen, G., Matsubayashi, K., Yano, S., Mitsutake, G., Ichiro Yasaka, K. and Halberg, F, "Seven-day (24-h) ambulatory blood pressure monitoring, self-reported depression and quality of life scores", Blood pressure monitoring 7, 69 – 76. 2002.
[44] Simmel, G, Philosophie der Mode. Kant und Goethe, Schopenhauer und Nietzsche, Frankfurt am Main. 1995.
[45] Singer, T., Critchley, H.D. and Preuschoff, K, "A common role of insula in feeling, empathy and uncertainty", Trends in Cognitive Sciences 13, 334 – 340. 2009.
[46] Ulmer, W. "Quantized De Sitter Space, the Connection to the Pauli Principle and an Application to Feynman's Relativistic Quark Theory II,", International Journal of Theoretical Physics, 8, 3, pp.199-209, 1973.
[47] Ulmer, W. and Hartmann, H, "On a geometric interpretation of Heisenberg's Uncertainty Relation and the Algebraic Structure of the Pauli Equation", Nuovo Cimento 47A, 59 -73. 1978.
[48] Ulmer, W, "On the Representation of Atoms and Molecules as Self-interacting Field with Internal Structure". Theoretica Chimica Acta 55, 179 – 201. 1980.
[49] W. Ulmer, W. and Cornelissen, G, "Coupled Electromagnetic Circuits and Their Connection to Quantum-Mechanical Resonance Interactions and Biorhythms", Open Journal of Biophysics 3, 253 – 274. 2013. http://ds, doi.org/10.4236/ojbiphy.2013.34031.
[50] Nonlinear Schrödinger Equation in Charge Space", Journal of Nuclear and Particle Physics 9 (2), 59 – 68. 2019. DOI: 10.5923/j.jnpp.20190902.03.
[51] Zamorano A.M., Cifre, I., Montoya, P., Riquelme, I. B. Kleber, B, "Insula-based networks in professional musicians: Evidence for increased functional connectivity during resting state fMRI", Human Brain Mapping 38, 4834 – 4849. 2017. DOI: 10.1002/hbm.23682.
[52] Zeilinger, A, Einsteins Spuk – Teleportation und weitere Mysterien der Quantenphysik, Goldmann, München. 2005.
[53] Zilles, K., Palomero Gallagher N. and Amunts, K, "Development of Cortical Folding during Evolution and Ontogenity", Trends in Cognitive Sciences 36, 275 – 284. 2013.