Synchronicity and the Unified View of Mind and Matter

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The concept of *synchronicity*, introduced by C.G. Jung and advocated by W. Pauli, is linked to the nonseparability of nature as seen in the correlations violating Bell's inequalities. Experiments on remote perception and experiments with the Random Event Generators (REG) performed over the last twenty years show a small but significant anomalous effect. Scientific explanation of such experiments involves the mind of an observer and is therefore very difficult. A plausible explanation of the results of such experiments, based on the concept of synchronicity or the EPR-type of correlations between parts of the brain and physical objects, is analyzed in this paper. No extensions to standard physics are required to understand these phenomena. The mind is treated as an emergent property of the brain and understanding the mind or consciousness also does not require any special "nonphysical" assumptions.

Motto: It would be most satisfactory if *physics* and *psyche* could be seen as complementary aspects of the same reality. (W. Pauli 1952)

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I. INTRODUCTION: ON MIND AND MATTER

Recent publication of the Pauli–Jung correspondence [1] leaves no doubt that Pauli devoted much thought to the concept of synchronicity, introduced by C.G. Jung [2] in a book that includes also Pauli's contribution. Despite many discussions on synchronicity that Pauli had with scientists working at the Advanced Study Institute in Princeton (where he did spend his war years and was later a frequent visitor) the idea was somehow forgotten and for many years did not appear in the scientific literature. This is not difficult to understand: the concept of "synchronicity" refers to the meaningful, although acasual, coincidence of some psychological state (dream, intention, thought) with an objective, external event that may be distant in time and space. Pauli himself was famous for creating troubles in laboratories he visited and apparently he regarded this "Pauli effect" as a manifestation of synchronicity. Since the concept of mind and psychological states is poorly defined in physical terms ideas such as synchronicity were too speculative to be considered seriously by physicists. The wish that Pauli expressed more than 40 years ago: "It would be most satisfactory if *physics* and *psyche* could be seen as complementary aspects of the same reality", may slowly become reality thanks to our deeper understanding of the foundations of quantum mechanics and developments of the cognitive sciences.

As individuals we are strongly hypnotized by our beliefs. Perceptual and cognitive processes are not passive but involve fitting the best models to the incoming input data, seeing through the glasses of our theories about nature rather than observing nature directly. As society our view of the world is based on scientific paradigms that are not easily replaced by others. One good reason for such conservative attitude is connected with the growing body of facts: each new paradigm shift should explain much more than the previous one. The difficulties of mathematical description of nature are progressively growing at each step: classical physics is able to solve the two body problem exactly, in the relativistic quantum mechanics exact solutions are obtained only for the one particle case, in quantum electrodynamics only the vacuum problem (zero particles) is exactly solvable while in quantum chromodynamics even the vacuum problem is too difficult to be exactly solvable. Future grand unified theories will not be easier to understand or to apply. Solution to the conceptual problems of physics and cognitive sciences and description of physical phenomena involving ordinary matter cannot lie in exotic physical theories. A unified view of mind and matter should be possible already within the present paradigms or we may not find it at all.

Since paradigms are so hard to change there is a natural tendency to dismiss all evidence that does not fit into an existing framework. Yet, if we know something about Nature it is because we have learned to ask specific questions and, if the results of experiments do not confirm our expectations, to revise our theories. In the last two decades a large number of interesting experiments involving human operators were performed giving data that

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seem to be hard to understand within the framework of present science [3,5]. The effects observed were analyzed in terms derived from parapsychology, such as psychokinesis, telepathy, precognition, and using such names as "anomalous data, remote viewing, remote perception" or "human operator effects". This data is largely ignored as "impossible", threatening our scientific world view. Many scientists hope that some simple systematic error explaining such data will be discovered. Nothing like that seems to be happening and more and more data pointing to the existence of such effects is accumulating. I will not review the data here since they are readily available in the literature [3,5]. It should be sufficient to mention just a few selected effects that should be explained.

1. Remote perception of objects and events in real time.
2. Perception of past and future objects and events.
3. Influence of intentional mind states on random events, including past and future events.

The last type of effects may be also called a "micropsychokinetic effects", although their existence, as I will show below, may be explained by synchronicity and thus does not really require any physical interactions. A large number of experimental data with the Random Event Generators (REGs) has been obtained in the Princeton Engineering Anomalies Research (PEAR) laboratory [3]. The portable equipment and the software for performing such experiments is now available from this laboratory to scientists interested in experimenting on their own. These effects represent reproducible synchronous events that Pauli called for in his letter to Fierz: "For me personally it would be much nicer to begin with 'acasual orderings' which are always reproducible (including those of quantum physics) and attempt to understand the psycho-physical connections as a special case of this general species" [6]. Perhaps the time is ripe for such an attempt.

Two reasons make the explanation of such experiments very difficult: involvement of human operators and mechanistic picture of reality that we still hold on to, despite the fact that more than half a century passed since quantum mechanics was invented. I will deal first with the mechanistic picture from the quantum mechanical point of view and then summarize very briefly a recently developed model of mind. Finally physical and mental points of view are combined to give a plausible explanation of the observed data as a special case of synchronicity. In contrast to many other explanations of anomalous phenomena no extensions to physics used in the description of matter, nor cognitive science used in the description of minds, is needed. What we end up with is a reasonable, unified view of mind and matter.

II. QUANTUM MECHANICS

Quantum mechanics is much simpler than most people assume. In essence it can be understood as an expression of the unity of nature. If we look at any object – human, tree, or an atom – we assume that this object is reducible to a small set of properties. Instead of a full, infinitely subtle, description of an object ("infinity in the grain of sand", as Blake puts it) we project onto reality our ideas about space, time, inertia. Thus the picture of a particle is reduced in our mind to a well defined point moving in three-dimensional space. A much better description of nature is obtained if we admit that each object is infinitely complex and thus should be represented by a vector $|O\rangle$ in infinitely dimensional space. To determine a property P of such an object we have to perform measurement, i.e. to interact with the object O by applying a certain operation $\hat{P}$ to the vector, $\hat{P}|O\rangle$. In return we get back a value of the measured property v and the same object. This procedure is summarized by the equation:

$$\hat{P}|O\rangle = v|O\rangle \tag{1}$$

This is the basic equation of quantum mechanics, so called eigenequation for the $\hat{P}$ operator corresponding to some observable property. This includes such properties as energy, position, momentum and time or duration. In case of time the proper operator is [7]:

$$\hat{t} = -\hbar\frac{\partial}{\partial E}; \qquad \hat{t}|O(p,E)\rangle = t|O(p,E)\rangle \tag{2}$$

Thus the change of time is related to the change of energy of the system. Such concept of time is closer to the physiological perception of time [8] than is the concept of time in classical physics. The result of the measurement may also change the object or change the internal state of the object, therefore in general:

$$\hat{P}|O\rangle = v|O'\rangle \tag{3}$$

All the rest, i.e. proper mathematical representation of these objects, is a technical matter. Thus quantum mechanics is an expression of the basic unity of objects that cannot be described by or reduced to a set of independent properties. Before a measurement is made nothing can be said about properties of quantum objects. The answer that one gets depends on the question that is posed to nature. Quite different "faces" of Nature are seen in different experiments. This is not a unique property of microobjects because many properties of people also depend very much on how do we approach them (arrange experiments) and what questions do we ask. Yet we are surprised because determining properties of macroscopic objects requires frequently no more than just looking at them. As long as these objects are large and interactions in the measurement process small this is quite true, but there is no reason to assume that it will be so in all situations. In particular, two particles that once interacted forming a quantum system should be described by one state vector, and even when they are separated at a large distance they are never quite independent (interaction with other particles may of course make it difficult to measure the non-trivial correlations between the particles). In fact this was Einstein's main objection to quantum mechanics. It was his formulation of an apparent paradox [9], known as the Einstein-Podolsky-Rosen (EPR) paradox, that brought to the attention of physicists the deep problem of a description of separated systems in quantum mechanics. Systems that are described by a single vector are called "entangled". How do we break the vector representing the whole group of objects in two or more parts, i.e. how can we disentangle the system?

To summarize the main point of this section: it is impossible. As Wolfgang Pauli once remarked "Was Gott vereint hat, soll der Mensch nicht trennen" (what God has united men should not separate). We cannot start with the two independent vectors describing the system without "playing God's role". This become evident in the past decade when very precise experiments measuring correlations between properties of pairs of particles separated at large distances were performed [10]. These correlations, in full agreement with predictions of quantum mechanics, even though particles may move very far away from each other, cannot be explained using the assumption that measurements are independent. Such nontrivial correlations, called nowadays the EPR correlations, or correlations violating Bell's inequality (this inequality sets the limit on the magnitude of correlations between measurements for independent particles) were predicted by quantum mechanics. The experimental verification of these predictions (cf. [10]) was a great success of physics in the 19080-s. Separation is ultimately just one of these illusions acquired in the childhood – "illusion" in the same sense as the independent existence of space and time is an illusion, although in both cases Newtonian concepts are useful approximations. The heated debates about these results show how hard it is to give up such deep convictions.

EPR correlations always persist, even if one of the measurements is performed at a different time. If the measurement on the first particle is performed after one second and on the other particle after one year the statistical correlation between the results may still be stronger than we could expect if the two measurements were really independent of each other. From another point of view such correlations may look like an influence of the present measurements on the future or past measurements, or like precognitive or retrocognitive results, although all that we really have are nontrivial correlations. Interactions among a larger number of particles may be too subtle to measure with the physical equipment that is suited to measure only simple correlations (for example, count photons) but is not sensitive to subtle changes in the correlated patterns. Is it possible that our brains are sensitive to such patterns? Are the remote viewing and the REG experiments simply another expression of this basic unity of nature?

The rest of this section will be more technical. To use quantum mechanics we have to define properties of the space to which our vectors symbolizing the objects belong (it should have a Hilbert space structure) and the nature of operators $\hat{P}$ representing the measurement processes. Quantum mechanics is a holistic theory and does not allow for a well-defined way of describing the separation of systems. This fact gave rise to alternative formulations of mathematical foundations of quantum mechanics [11,12]. Hilbert space of antisymmetric, many particle functions, describing the total system, can not be decomposed into separate subspaces.

Consider two systems, S_A and S_B, with N_A and N_B electrons, respectively. Each system is described by its own function, Ψ_A antisymmetric in N_A particles and Ψ_B in N_B. Assuming that both functions are normalized to unity it is easy to show that the product function $\Psi_{AB} = \Psi_A\Psi_B$ is always "far" from the antisymmetric function $\Psi = A\Psi_{AB}$, as measured by the overlap $\langle\Psi_{AB}|\Psi\rangle$ or the norm of the difference

$$2-\sqrt{2} \leq ||\Psi_{AB}-\Psi||^2 \leq 2 \tag{4}$$

The square of the norm does not exceed 2 because of Schwartz inequality. To prove the second inequality I'll proceed in small and detailed steps to save the reader the trouble of derivations. First, let's define the orthonormal basis for S_A and S_B:

$$\langle\phi_i^A|\phi_j^B\rangle = \delta_{ij}^{AB} \tag{5}$$

The unsymmetrized normalized product functions are:

$$\Phi_A(x_1,x_2,..x_{N_A}) = \Pi_{i=1}^{N_A}\phi_i^A(x_i); \qquad \Phi_B(x_1,x_2,..x_{N_B}) = \Pi_{i=1}^{N_B}\phi_i^B(x_i) \tag{6}$$

The idempotent antisymmetrizer does not give proper normalization, but

$$A_N = \frac{1}{\sqrt{N!}}\sum_P \varepsilon(P)\hat{P} \tag{7}$$

does. Therefore Ψ_A is obtained by:

$$\Psi_A(x_1,x_2,..x_{N_A}) = A_N\,\Phi_A(x_1,x_2,..x_{N_A}) = \frac{1}{\sqrt{N_A!}}\sum_P \varepsilon(P)\hat{P}\Phi_A(x_1,x_2,..x_{N_A}) \tag{8}$$

and the same for Ψ_B. Note that the antisymmetrizer A creating from the product function totally antisymmetric function $\Psi = A\Psi_{AB}$ is

$$A = \sqrt{N_A!N_B!/N!}\sum_{P_{AB}} \varepsilon(P_{AB})\hat{P}_{AB} \tag{9}$$

where $N = N_A + N_B$ and P_{AB} is either identity or it permutes particles of S_A with those of S_B. Since Ψ and Ψ_{AB} are normalized,

$$\begin{aligned} ||\Psi_{AB} - \Psi||^2 &= ||\Psi_{AB}||^2 + ||\Psi||^2 - 2\langle\Psi_{AB}|A\Psi_{AB}\rangle \\ &= 2 - 2\langle\Psi_{AB}|A\Psi_{AB}\rangle \geq 2 - \sqrt{2} \approx 0.59 \end{aligned} \tag{10}$$

because the overlap integral $\langle\Psi_{AB}|A\Psi_{AB}\rangle$ is non-zero only for $\hat{P}_{AB} = I$ when it is equal to $\sqrt{N_A!N_B!/N!} \leq \sqrt{2}/2$. The antisymmetric and the product wavefunction differ completly showing that there is no way in quantum mechanics to describe the separation of systems. In the textbook of Messiah (Chapter XIV, §8, [13]) it is proved that this nonseparability should not matter because probabilities of different states of a spatially isolated subsystem do not depend on the antysymmetrization of the function of this subsystem with functions of all other particles in the Universe. But how about the results of joint measurements? Consider two independent measurements on the systems S_A and S_B, of observables corresponding to the operators $\hat{A}$ and $\hat{B}$. These systems are in the following quantum states:

$$\begin{aligned} \Psi_A &= \sum_a C_a^A\Psi_a^A; \qquad \hat{A}\Psi_a^A = a\Psi_a^A \\ \Psi_B &= \sum_b C_b^B\Psi_b^B; \qquad \hat{B}\Psi_b^B = b\Psi_b^B \end{aligned} \tag{11}$$

Messiah [13] proves that taking the total function Ψ instead of the product functions $\Psi_A\Psi_B$ does not change the probabilities $|C_a^A|^2$. However, he does not look at the possible correlation of the joint measurements. Assuming that the two systems are separated the result of the joint measurement is:

$$\langle\Psi_A\Psi_B|\hat{A}\hat{B}|\Psi_A\Psi_B\rangle = \langle\hat{A}\rangle\langle\hat{B}\rangle \tag{12}$$

Define now a coefficient C_{AB} measuring a difference between this result and the result obtained without the assumption of separability, i.e. the results with the total wave function Ψ:

$$C_{AB} = \left(\langle\Psi_A\Psi_B|\hat{A}\hat{B}|\Psi_A\Psi_B\rangle - \langle\Psi|\hat{A}\hat{B}|\Psi\rangle\right)/\langle\hat{A}\rangle\langle\hat{B}\rangle = 1 - \frac{\langle\Psi|\hat{A}\hat{B}|\Psi\rangle}{\langle\hat{A}\rangle\langle\hat{B}\rangle} \tag{13}$$

If there is no difference between these two cases this coefficient should be zero. However,

$$\langle\Psi|\hat{A}\hat{B}|\Psi\rangle = \frac{N_A!N_B!}{N!}\sum_{P,Q}\varepsilon(P)\varepsilon(Q)\langle P(\Psi_A\Psi_B)|\hat{A}\hat{B}|Q(\Psi_A\Psi_B)\rangle = \frac{N_A!N_B!}{N!}\langle\hat{A}\rangle\langle\hat{B}\rangle \tag{14}$$

since all matrix elements for $(P,Q) \neq (I,I)$, by virtue of localization of the S_A and S_B subsystems, vanish. This leads to the following inequality for the correlation coefficient:

$$1 \geq C_{AB} \geq \frac{1}{2} \tag{15}$$

This is a huge difference. Of course one may disregard correlations with other systems useing local description of an isolated system, but than we will not learn anything about the correlations of this system with other systems, and precisely such correlations are at stake here. For further discussion of separability and the role of symmetry breaking see [14].

Consequences of nonseparability for perturbation theory of the weakly interacting systems are serious: “polarization approximation”, based on a product function that is not antisymmetrized in the exchange of electrons of the two subsystems, is a bad start for the perturbation theory leading to divergence even at quite large separations [15]. It is not clear how to apply a full quantum mechanical treatment to small systems in the neighborhood of a large system [16] (ex. solid state or biomolecules). Microscopic bodies cannot be isolated in quantum mechanical sense, they are always strongly coupled with their environment.

Quantum mechanics (QM) is thus unable to describe the separation of systems. Some experts came with alternative theories announcing that “quantum mechanics is dead” [11], presenting a theory of the quantum-logic type that allows for such a description [12]. Despite the results of EPR-type of experiments, delayed choice single photon experiments and all successes of quantum mechanics scientist keep projecting their own ideas on reality, trying to tell nature how to behave. How do we know that the separated subsystems are really independent? It is hard to measure correlations among more than a few bodies using the experimental hardware that we have today. Only very recently new exciting possibilities appeared allowing to make experiments with the entangled photons in multidimensional Hilbert spaces, measure EPR correlations between photons that have not been directly entangled, measure multiparticle correlations and experiment with “quantum teleportation” [17].

Different patterns of neural excitations may be modeled in quantum mechanical fashion as the eigenstates of some operators. Since we cannot have two different patterns at the same time these operators cannot commute. An analog of Bell’s theorem for such model should show a lower limit for correlations between two neural systems. Straightforward estimation of the correlation coefficient obtained here in Eq.15 gives very large minimal correlations. Why is it then so hard to measure such effects? Interaction with thermal degrees of freedom may wash them out completely. Detailed investigation of this point brought Khalfin and Tsirelson [18] to the conclusion that: “Under very careful, but undoubtedly feasible isolation of the collective degrees of freedom from the thermal ones, quantum correlations can arise and be conserved for long periods of time, even in the mechanical motion of macroscopic bodies”. Such quantum mechanical correlations between two separated crystals should be induced by mechanical movement and should persist for a long time.

Are our brains sensitive to such correlations? Is a reasonable picture of the mind possible at all?

III. BRAIN, MIND, CONSCIOUSNESS

In the synchronous events in general, and in the remote viewing and REG experiments in particular, conscious decisions and intentional states of mind are crucial. Consciousness is poorly understood and many physicists think of it as of some ill-defined force pervading the universe, something necessary to “collapse wavefunctions” and interfere directly in the measurement process. I will try to present here a “down-to-the-earth approach” (although it is not considered as standard by many physicists unaware of great progress in cognitive sciences) based on the most probable and natural assumption, i.e. that minds are emergent properties of very complex brains. Such an approach allows to understand thousands of detailed observations and results of experiments related to conscious behavior. Consciousness that physicist talk about in relation to the collapse of the wavefunction seems to have little to do with the concept of consciousness in cognitive science, related to the subjective experience of the world. The most natural solution to the measurement problem does not involve observers [19], just statistical description of the macroscopic apparatus. Great confusion arises when all wave phenomena, such as waves of neural excitation, described perfectly well at the classical physics level, are treated via quantum mechanical formalism. Descriptions appropriate at the microscopic scale of elementary particles are not useful for neurons or assemblies of billions of neurons, where statistical mechanics and dynamical systems theory is quite sufficient. Can we understand the cognitive mind and its relation to matter?

Cognitive sciences try to form detailed models of the mind. Many serious problems plague the foundations of cognitive sciences and of all the major scientific attempts to understand Nature the science of mind is the least developed. Mind-body problem has been called the most serious obstacle to the advancement of science [20]. The problem manifests itself in a number of ways. How can the non-material mind, or the B-world in terms of Popper [21], have an influence on the material body and vice versa? In more technical terms: “causally inert” mind states somehow influence the brain and the body. Mental representation is something cognitive agents have, but a cognitive agent definition requires mental representations – a vicious circle. Are AI systems capable of qualia – can they have genuine experiences, feel pain, have hopes or any autonomous purpose? “How can the meaning of the meaningless symbol tokens [...] be grounded in anything but other meaningless symbols?" [22].

All these problems are related and have a common solution [23] opening the way to artificial minds in contrast to mere artificial intelligence. Philosophers of mind rise sometimes objections against mathematical modeling in cognitive sciences. Mathematical modeling is more powerful than just linguistic description. Verbal descriptions are imprecise models of reality while mathematical models may have an arbitrary degree of precision. Everything that can be expressed in words can also be subject to mathematical modeling, therefore cognitive science, aiming at understanding how does the mind work, may also be based on mathematical language. The lack of a proper language to describe mind events is responsible for fundamental problems in cognitive sciences. The model of mind sketched below provides such a language.

A. Mind objects

The real objects of mind are not words or abstract symbols but rather "chunks of experience", involving bodily reactions. Mind objects are combinations of many features determined by the low-level processing of the brain circuits. As the objects of nature described by quantum mechanics, objects of mind are nondecomposable and multidimensional. Symbolic names are given to some of the objects of the mind. These names facilitate verbal communication, but symbols are only shadows on the wall. It is convenient to think about mind objects as embedded in some multidimensional space (Euclidean, Riemannian or even more complex), called further the "mind space", spanned by axes corresponding to features of internal representations. The Platonic world of abstract concepts is just a small subspace of the whole mind space filled with these multidimensional mind objects. Mind space serves as a stage for all mind events. Objects in the mind space are defined by "mind function" $M(X_i)$ for all relevant features X_i. Nonzero values of the mind function define these objects as a fuzzy regions in the mind space. Topographical relations of objects in this space are very difficult to imagine because of the large number of dimensions involved. Problems with understanding how the mind works are to a large degree connected with the difficulties in imagining relations in multidimensional spaces. The mind function, defined in the mind space, represents all objects that such system is able to recognize (i.e. correctly classify using partial description or distorted input). Cognitive system is able to modify the contents of the mind space by adding more objects (learning and remembering), modifying existing objects or learning new associations (changing topographical relations between existing objects).

Creation of mind objects is elucidated by developmental psychology [24]. Mind arises from the brain, *psyche* from *physics*, during interactions forming the inner representation of the world. Symbols, or abstract labels of the mind objects, have no meaning without the mind to interpret them. They are very useful for rapid activation of mind objects, since they are almost unique. Other features of mind objects – other dimensions of the mind space – such as preprocessed sensory features, are frequently more fuzzy and many of them are required for unique identification of the mind objects. There is no reason why using only symbolic names the whole complexity of a real mind space could be recreated. Artificial intelligence, based on the processing of symbols, does not lead to artificial minds based on the multidimensional mind objects. The meaning of the mind objects is grounded in the combination of all relevant features of their representation. Some of these features are related to analog sensory data while others to motoric behavior. Logic and reasoning are only approximations to the dynamics of activations of objects in the mind space. Expressions such as "to have in mind, to keep in mind, to put in mind, to make up one's mind" etc. refer directly to the mind space. Intuition is based on the topography of the mind space objects, i.e. their distance and shared features. Intuitive knowledge is identified with the quality of inner representations, formed in the process of unsupervised learning, of real objects and events in the environment in which the cognitive system develops.

At any given moment of time t some of the features of representation $X_i(t)$ have well defined values, pointing to certain region of the mind space. These features of representation $X_i(t), i = 1, 2...$, change with time. A collection of these features is called "mind state". An object corresponding to a given mind state is "activated" - the system recognizes this object and may respond to it. The process of activation of mind objects, or the evolution of mind states, has its dynamics. States in the regions of high $M(X_i)$ function values slow the rate of changes of the mind state, "trapping" these states for some period of time. It makes sense to talk about energy and momentum of this dynamics. Changing from one state of mind to another requires energy. The system receives this energy from the environment. The external stimuli are driving changes in the features of representation $X_i(t)$ leading to the recognition and learning processes. The internal dynamics leads to activations of the entrained mind objects (trains of thoughts or series of associations) and includes a stochastic component influencing the momentum of changes of mind states. The dynamics of the whole system is a mixture of this internal and external dynamics.

The probability of finding the system in a given mind state at a given time t depends on evolution of the mind state and on the value of mind function for that state. Some mind objects are more "attractive" than others, they hold the mind states for a longer time and are activated more frequently during the evolution of the mind state. Creation of new objects in the mind space requires time and energy. Objects are connected via their shared features (i.e. similar projections on some subspaces of the mind space), therefore an entrainment of objects occurs. Transition probability $p(A \rightarrow B)$ from the mind object A to the mind object B may be expressed in agreement with the conditional expectancy hypothesis of Sommerhoff [25]: "The brain's internal representations of the world consist of linked sets of conditional expectancies of the what-leads-to-what kind, which are in the main based on the past what-leads-to-what experiences of the world". The mathematical formalism useful for the description of actual dynamics resembles quantum-mechanical formalism, with $p(A \rightarrow B) = < M_A|\hat{P}|M_B >$ where M_A is a certain mathematical representation of the mind object A and $\hat{P}$ is the momentum of the mind state in a given moment of time. Simple recognition and learning processes activate only one object at a time. Once activated, an object is easily accessible due to the short-term memory. Therefore various objects in the mind space may be active at the same time in a certain time window, depending on the state of the input variables (sensory data and inputs from local internal processes). In this way complex objects, composed from many simpler ones, are analyzed in the recognition process and created in the learning process. The states of mind that lead to the strongest values of the mind function leave memory traces and are remembered as "an experience", enabling feedback (reflection). This experience is consciously perceived if it is sustained in a short-term memory for a sufficiently long time. Mind may react to this experience via associations and dynamics of the mind state.

It is natural to realize the mind function in a form of a modular neural network based on localized representation of the mind objects, each node processing a separate object. Neurobiological justification of such model is based on assemblies of neurons that specialize in recognition of certain mind objects. In the brain forward cortical projections are accompanied by prominent projections back to the original sites. The signals in neuroanatomical networks flow back and forth to sensory receptors and subcortical brain structures, making the activation of an object in the mind space by the internal dynamics of the brain almost indistinguishable from the external activation. Results of recent experiments on processing words and pseudowords [26] support the hypothesis that transcortical cell assemblies are involved in recognition of mind objects. These cell assemblies are large groups of neurons, with strongly reciprocal internal connections, binding parts of the cortex in which different sensory modalities are processed. Transcortical cell assemblies are sufficient to create objects of the mind space, i.e. to bind different sensory modalities in one experience, without any central place in the cortex where all information is gathered.

The model of the mind presented here is useful for discussions of evolution or development of minds through unsupervised and supervised learning in terms of the mind function and of the topography of the mind space, discussion of recognition, recollection, association, dynamics and many other mental processes. This language is based on purely abstract, mathematical constructs, and does not refer to anything physical. The view of the mind presented here is very different from conventional psychology or artificial intelligence models: mind is a dynamical system with evolution of the mind state leading to a series of activations of various mind objects. Symbols and language are of secondary importance and logic can at best be used to approximate evolution of the mind state in some circumstances. Such system is purely subjective and may reflect the nonalgorithmic nature of its environment. Mind is not just a product of neural machinery, mind is an enfolded environment, including detailed representation of the supporting body. Equipped with the abstract language allowing for the mathematical description of mind events we may solve the fundamental problems of cognitive science.

B. Mind-body and other problems

The mind function is operating in the mind space and it is created via the process of unsupervised learning and genetic evolution. The natural hardware realization of this function has the form of a neural network. Since mind objects are multidimensional, a thought or an abstract object of mind, such as an object representing a "low gas" observation on a car's gas gauge, leads to a physical, intentional action. If the mind is in the state represented by the "low gas" object, the next probable train of states is "the car will stop" and "look for a gas station". These objects were created in the learning process and once they are activated the motoric actions associated with these objects will follow.

The "mind over matter" mechanism is thus basically dependent on a proper understanding of the mind states. There is no "mind-body problem" because from the beginning there has been no mind-body separation. Mind is a reflection of a part of the Universe in the brain/body, mind space stores all chunks of sensory and bodily experiences and the dynamics governing changes of the mind states recalls them. A picture of a beloved person seen from a distance increases the heartbeat. Even abstract thinking can involve the body. In an important, experiential sense, mind, being reflection of Nature, has no boundaries. The spectrum of conscious states of mind has been analyzed by transpersonal psychologists in some details [27]. From the functionalist point of view mind is of primary importance. Realization of mind (the form of the brain) is secondary.

The symbol grounding problem [22] is solved in an straightforward way, together with the problem of qualia. An activation of a mind object is done using a subset of its features. Since it brings the state of mind into a specific region of the mind space other qualities associated with this object are immediately accessible, and the back-projection paths to the sensors activated. The experience is repeated, with vividity dependent on the strength of the back-coupling and the level of activation of the object. What do I mean by “sweet”? Something sweet! The brain/mind system points directly at the sensory experiences as the ultimate source of grounding the mind in reality. We do not ground symbols in experiences since experience comes before symbols, we label experiences. The label “sweet” corresponds to a projection of all sensations, all objects that we have associated with it. The existence of qualia has observable consequences: the probability of the next mind state obviously depends on them. From the sensation “sweet” memories of things sweet spring up.

The problem of the mental content is a particular form of the qualia problem connected with the mental objects. Thoughts must be about something since they are activations of mind objects containing reified experiences, are non-decomposable mixtures of many features of representation. Cognitive systems must have subjective states which results from their past experiences. A single sensory stimulus or a single word may put the state of mind into a region of the mind space where associations abound. Words, or abstracts symbols, are particularly effective in activation of mind objects because - in contrast with analog features of representation - they are more specific, they provide labels uniquely identifying the regions of the mind space where “chunks of our experiences” are stored.

C. Mind states and consciousness

Explanation of consciousness requires explanation of subjective experience and qualia. Mind is subjective, reflecting experiences of the system. The model of mind events requires dynamics and thus leads in a natural way to dreaming, day-dreaming and hallucinations in the altered states of mind. Mind events may be conscious or unconscious. Conscious mind events result from activation of mind objects connected with the large scale structure of neural excitations leaving memory traces (short-term or long-term memory mind objects) in the mind space. When a mind object is activated the system spends some time exploring different qualia or various dimensions associated with this mind object. Many computations in the brain (mind-supporting system) do not leave memory traces because they are done only locally or they activate the mind objects in a weak way. Except for such unconscious mind events there are also suppressed subconscious events. In quantum mechanical picture of reality actual events are also the “memory events”, recorded in the irreversible way, corresponding to the collapsed wave functions. Unconscious events in the mind space are similar to potential events in quantum mechanics. Scientific instruments are extensions of our senses and without memory they cannot bring potential to actual. Metaphorically speaking one may say that “Reality is the consciousness of Nature”, where “Reality” represents the observed, actualized, remembered events, and “Nature” contains all potential events.

The language of quantum mechanics of consciousness developed by Jahn and Dunne [28] may be useful to describe events in the mind space. Other problems, such as the problem of free will have also a natural solution in the mind space model (essentially the same as given in the postscript to the recent book of F. Crick [29]). I will not go further here into the description of the mind space model [23] since what was said above should be sufficient to talk about mind-body interactions in the context of anomalous experiments. The subject of consciousness and models of the mind are going to take a central place in science in the coming years. The mind model scetched here is quite natural and allows for an explanation of many facts related to cognition and are useful in creating computational models of cognitive systems. The concept of mind space is no more metaphorical (in the sense of being only an intellectual construct useful in description of reality) than the concept of space-time is in relation to what we experience as space and time. Physics started when a precise mathematical language was invented to talk about space, time and movement of objects. Yet these concepts are only metaphorical and should not be confused with reality itself. Looking at the emergent properties of neural networks and at the power of new neurofuzzy systems [30] it is hard to escape from a conclusion that further development along these lines should allow for creation of artificial minds. This will be the ultimate test of the cognitive science theories, such as the mind space theory. More complex theories will be needed only when this simple, pragmatic approach fails.

IV. ENTANGLEMENT, MIND AND SYNCHRONICITY.

Mind works predominantly by activating memory objects, constructing reality from known elements and constantly comparing the new with the old. Our picture of reality is composed predominantly of our own concepts and ideas about nature. We notice a few properties of real objects and replace these objects by idealized models composed of independent particles, forgetting that our representation of reality is not the reality itself. Nature does not have to conform to our preconceived ideas. The structure of mind and the structure of quantum mechanical description of nature is similar: in both cases we are dealing with nondecomposable multidimensional objects, and in both cases we would like to reduce them to a few properties that should tell us the whole story.

Explanation of synchronous events in the Jung sense is very difficult because it is hard to quantify them and thus determine if they are only due to a pure chance or if they involve some “acasual orderings”. To a large degree this problem of quantification is hunting the remote perception experiments [3,5]: even though the agreement between drawings and descriptions of target events is in some cases quite striking it is hard to express it in statistical terms. Still, these experiments, and the experiments with the Random Event Generators, are much closer to the reproducible experiments with synchronous events than the anecdotal events from our own experience. For experiments of this kind we may adopt two complementary points of view. Usually they are described in such terms as “micropsychokinesis, remote perception, precognitive perception”. On the other hand all that is demonstrated in such experiments is that there are synchronous events that do not seem to be causally connected. Before we compare two sets of data – human intentions and machine states, operator’s reports and actual events – we cannot say that they are unusual. There may be deviations of a distribution of random events from expected statistics but unless these deviations are correlated with some acasual factors in a longer series of experiments they may be just fluctuations. Drawings and descriptions produced during remote perception experiments become interesting only when acasual correlations with the real target events are observed. Synchronous correlations are quite sufficient to explain the anomalous experimental data [3,5], therefore we should explain how is it possible that objects and states of mind are correlated with specific objects and events in nature. As we have seen in the discussion of the EPR experiments and the nonseparability in quantum mechanics, nontrivial correlations of entangled systems are possible without any interactions between them! All that is necessary is two sets of measurements. What kind of measurements are made when we consciously perceive something?

When we look at a white wall for some time our visual system, having little input, is working on a threshold of a noise. Various mind objects are activated in an apparently random fashion and the internal dynamics of the mind state evolution prevails. One may describe this process as a measurement: the mind, which is a function of a large scale brain processes, is making measurements on the visual cortex. In the remote viewing experiments the mind makes measurements on parts of the visual cortex discovering different mind objects that appear to be correlated in a nontrivial way with events and objects of nature. Some results of these measurements have no correlation with later events or with target scene objects. That should be expected since only some results of the joint measurements are correlated in a non-trivial, synchronous way. This measurement process is independent of the time of the second measurement (event), although nontrivial correlations may have a tendency to wash out for longer times due to coupling of quantum collective and the thermal degrees of freedom. Experiments with Random Event Generators are also understandable from this point of view. In REG experiments intentional state of mind is generated and subconsciously sustained. An appropriate object of mind corresponding to the intention of obtaining positive or negative results is created in the mind space and periodically activated. Again, this activation or recognition may be described as the measurement process.

The remote perception experiences are primarily visual. In the mind space model recognition of the total object requires many features. If the visual inputs are small, not coming from the nerves connected to the eyes but rather are due to quantum correlations of patterns of neural excitations with some other patterns, only simple objects, single elements of the whole picture will be activeted strongly enough to be recognized. This process takes more time than the recognition of visual scenes when inputs are strong enough to quickly recognize many simple objects and hold the picture of the whole scene as one complex object. One should experience flashes, short activations of simple objects belonging to the remote scene or event. Dynamics of the low-level excitations in the visual system is almost chaotic in the absence of other stronger stimuli. In the terminology of the previous paragraph, mind objects are weakly and randomly activated. This activation may be correlated, via quantum entanglement, with many objects and events in nature. Our intention to think about a specific place, or a person in that place, or thinking about someone who will compare results of the remote perception experiment with our descriptions and drawings, creates experimental conditions making us more sensitive to objects or processes that are at that place. In such conditions certain mind objects are more often activated strongly enough to appear as flashes or short visions in our consciousness. What really happens can be described as a process in which the mind is performing measurements on certain parts of the brain, with patterns of neural excitations in this part of the brain correlated in the nontrivial ways via entanglement with some events and objects in nature.

The entanglement mechanism proposed here allows an explanation of the strange features of these experiments:

1. Effects will be small but statistically significant. Even the correlations between two entangled particles involving simple photon counts were hard to measure. Here correlations between complex patterns involving billions of particles are measured. Most of the correlations are of a trivial nature, i.e. accidental or explainable by causal thought processes. Thermal coupling can easily destroy all quantum coherence, therefore one should not expect consistent, large effects.

2. Effects have to be intentional: out of all possible correlations with objects of nature we have to focus on a particular place or on a piece of equipment. Intention is necessary to start selection of associations that begins with the known mind objects, representing equipment or people involved in the experiment. Some people may be more skilled or capable than others in forming such associations – correlation between such skills and general sensitivity of a person should exist.

3. No special assumptions about the entangled systems are necessary. Since all systems are entangled to a similar degree correlations should not depend on the type of noise sources in REG experiments or targets in the remote viewing experiments.

4. Since there is no exchange of energy, only correlations, statistical results should not significantly depend on the distance between the target and the operator involved or on the time delays between the two measurements.

5. Local probabilities are never affected by quantum entanglement, only the joint probabilities of measurements, therefore the local data should not look "unusual". Anomalous effects should be seen only when two sets of data are compared in a series of experiments.

6. During the experiments the brain should be active in a normal, walking consciousness, but not too distracted by external stimuli. Psychological effects of looking into water or gazing at a crystal should be favorable for remote viewing.

7. The brain of an operator should have a cue to get entangled with the hardware equipment or with the brains of other people involved in the experiment. Avoiding direct comparison of the two measurements may reduce the effect.

Most of these effects have been observed in the experiments quoted [3,5]. Synchronicity via quantum entanglement is the only mechanism I know of that can explain correlations of human intentions and mental events with the results of experiments that have been already performed [4] or that will be performed in the future.

It is very hard to use experimental physical techniques to discover correlations between more than a few particles. Consider a living cell, for example a brain cell. Many biochemical processes take place every second in a cell; many of them are controlled by photon emissions and absorption providing energy for reactions. There are indications that this ultraweak radiation is very coherent [31]. The pattern of these emissions and absorptions may be correlated in a very subtle way to many processes in nature, but we are not yet able to measure such subtle effects in physics laboratories. On the other hand, influences on the patterns of neural excitations in the brain should have noticeable effects on the activation of mind objects. Microtubules are good candidate structures for sensitive elements of cells on which measurement is made [32]. Superradiance and other collective quantum states should be possible in these cytoskeletal structures. Insinna [33] has already discussed synchronicity in connection with quantum coherence in microtubules. Although from the point of view presented here quantum effects are not necessary to understand the cognitive mind and consciousness it is hard to imagine synchronicity without quantum effects.

V. DISCUSSION

I have tried to present here a unified view of mind and nature, a view that is capable of elucidating strange remote perception and REG experiments. This was done without any extensions of standard scientific paradigms. Synchronicity requires two measurements and comparison of results. Other theoretical models attempting to accommodate results of anomalous experiments require non-linear versions of quantum mechanics or are based on rather peculiar interpretations of the quantum measurement process [34].

Two points are worth stressing: it is very difficult to give up deeply ingrained convictions, such as those related to separability of things, whether we think about the objects of nature as a collection of independent bodies or about ourselves as separated from Nature. In both cases separability, although sometimes a useful approximation, is ultimately just an illusion. Many people with deep insight into their own minds and their thinking process, including Erwin Schrödinger, already wrote on this subject not only from the point of view of physics, but also from their own personal point of view. Once we give up the idea of separability we do not have problems in accommodating the results of EPR experiments or with understanding of the relation of our minds and bodies (leading to the possibility of creation of artificial minds). We see also the possibility of explanation of the remote perception and REG experiments. It is very hard to give up the idea of separability since the mind is an active, rather than passive, system which models the incoming data by fitting the most coherent prototypes (mind objects) to the objects it perceives and most of everyday observations seem to confirm separability.

Although calculation of quantum probabilities for such complex system as the brain is not feasible, some suggestions and understanding of certain features of experiments involving human operators was possible. Quantum effects are not necessary to explain the cognitive mind but are indispensable to understand the subtle features of the mind manifested in synchronicity. A detailed theory of synchronicity should be based on the quantum mechanics of macroscopic bodies and their entanglements [18]. At present all that one can say is that there is no *a priori* reason why there should be no acasual correlations between the brain activity and events in nature. To prove that such correlations do not exist we would have to compute an analog of Bell's inequality for a very complex system, with wavefunctions for parts of the brain on one side and various natural objects on the other. Since it is impossible to separate wavefunctions of any physical systems, especially macroscopic bodies, and detailed calculations of multiparticle correlations are too difficult one has to resort to experiments. We cannot insist that nontrivial correlations should not exist without checking that experimentally. The results of such experiments indicate that a small but consistent effect exist. The simplest explanation consistent with all experimental data is based on the synchronicity due to the quantum mechanical nonseparability. Synchronicity effects described here are consistent with present theories in cognitive science and in physics, and do not require any extensions of our knowledge into unknown territories.

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