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ON DETERMINISM, RANDOMNESS, DEMONS AND ALL THAT

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"Part of the art and skill of the engineer
and the experimental physicist is to
create conditions in which certain events
are sure to occur"

E.Wigner

Abstract: The role of the Physics Knowing Beings (the PKBs) in nature in general, and on the energy flow in the large scale in particular, is discussed.

Wishing to pay due tribute to the memory of our dear friend and colleague Dr. Jovan Vujaklija, not only to the fine and keen physicist that he was, but also to the great and sincere humanitarian whose views were deeply inspiring to all of us who were lucky enough to have known him and equally unlucky to have lost him so early, we present this short essay as an attempt at defining the quintessence of the role of the Physics Knowing Beings (the PKBs) in nature.

In doing so we have been borrowing freely from the great body of the literature of physics, taking sides with the views and ideas which corroborate our own. The line of thought which we follow here is in different fragments elaborated in the literature cited at end of the paper. Compared to other many possibilities it leads, in our opinion, to the least muddled reasoning. In no way, however, do we claim that the views expressed here would conform to those of Dr. Jovan Vujaklija. It is much more likely that his reading of this manuscript on such a controversial an issue would have provoked many sparkling and fiery opposing argument of which we have for such a long time now been irrevocably deprived.

1. Experimenting with isolated systems we[1] got convinced that the behavior of all systems which we studied exhibit definite reproducible causal regularities. We have also succeeded in reducing all the cause-effect relations, at least in principle, to the actions of the four forces by which the constituent parts of the systems interact. It turned out that the states of the systems are characterized by more or less sharp distributions of the parameters which describe the states of those systems. As the final possible achievement we then sublime those regularities into the dynamic laws of the averages, the number of trials, or realizations, being bigger the laws of the averages being more closely observed. The point of paramount importance here is that the averages are fictions, which do not exist beyond mathematics. Crucial to such an interpretation is the identification of relative frequencies with probabilities in the limit of great numbers as well as is the assumption of ergodicity. Together, these two turn the averages into reality, and vice versa. Evolution of the states of the systems of specified composition from the states defined by given initial and boundary conditions into the new ones according to the dynamic laws of the averages we then identify with the deterministic behavior of nature. If the distributions are sharp we speak of the classical, and if they are not we speak of the statistical (classical or quantum) determinism[2]. Actual state of the Universe, including the possible local self-organization into the living matter, and eventually into the PKBs, thus results from such actions of the four forces. How then do the actions of the PKBs, which obviously produce states of the systems which would otherwise not appear on the scene, fit into this scheme? To close the circle and make it a vicious one we return to the very first word of this paragraph, to the word "experimenting" which already implies the activities of the PKBs which seemingly do not conform to the actions of the four forces only.

2. To answer this last question we have to deal in some detail with the definition of the isolated system, which is a key notion here. An isolated system in general, of whatever complex composition it might be, is such a system in which both the constituent parts and their interaction ability vanish beyond the boundary of the system (exempting the universal tendency of the systems to gravitate towards each other, the tendency being stronger the more of them already done so). Left to itself in an arbitrary initial state every isolated system of given composition, after appropriate mean time and following the dynamic law of the averages, comes to its timeless ground state and remains in it until eventually getting excited, or maybe even changed into

[1] By "we" we mean the local PKBs on Earth

[2] With the origin of the classical statistical determinism we deal in necessary detail below. The nature of quantum statistical determinism, which is due to the specific wave-like behavior of microscopic entities in the continuum-like vacuum is beyond our interests here.

another system, by some extraneous action. The new process governed by the dynamic laws of the averages then set in until the same, or another, ground state is again reached. Any system thus truly evolves only if its composition is changed by suitable interaction with another isolated system; otherwise it is either on its way towards the ground state, or waiting in it for something to happen. What will be the outcome of the interaction between the two systems depend firstly upon their composition and their relative motion and then on the average values of the parameters which describe their states.

Due to the detailed properties of the four forces, depending upon the average distances between the subsystems and their relative motion, there are two extreme types of isolated systems:

In the system of the *first kind* all its subsystems are confined to within the reach of the off the mass-shell interactions between them; the subsystems are continuously "stringed" together by the exchange of virtual particles and are at all times simultaneously aware of all the possibilities at their disposal within the system. They thus evolve according to the scheme of actual possibilities. If the subsystems are microscopic, the processes towards the ground state of the system are governed by the laws of the averages which fall under the notion of quantum statistical determinism (like, say, within the atom) or, as justified by the principle of correspondence, under the classical determinism, if the subsystems are macroscopic (like, for instance, within the solar system).

The system of the *second kind* is such a system whose subsystems are the systems of the first kind; the confinement into the boundaries of the system is by some extraneous interaction (like the vessel which contains a gas). The subsystems interact either by exchange of real particles or by "direct contact" only. Average distances between the subsystems are now comparatively great and, depending on relative velocities, the subsystems may on the average be most of the time even in their ground states. What is important here is that the interactions between the subsystems, which as we have seen are the only agents to lead to real evolution, are genuinely accidental. Between their discrete interactions the subsystems are "unguided"or move inertially, as we say[3]. This unavoidable element of chance, or true randomness of the interactions, makes such systems inherently stochastic and their behavior from the view of the PKBs is either classically statistically deterministic if the subsystems are microscopic (like, say, for a gas), or may be partly classically deterministic, if they are macroscopic (like, say, is the game of billiards)[4].

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[3] That we here do not emphasize the role of gravity may be justified by the view that motions under this force are actually inertial motions of the real world.

[4] The game of absolutely elastic billiards is the simplest system instructive in this respect. To the PKB observing the eternal motions of the balls every one possesses the precisely known future (if this is really so is a matter of no concern here) and the system looks utterly

3. The Universe itself, being composed of isolated systems of all possible levels of complexity both microscopic and macroscopic, is thus the most complex system of this second kind. The conclusion essential to our present purpose is that due to the properties of the four forces the evolution and the actual state of the Universe results largely from the accidental encounters of its component isolated subsystems[5].

Now, among the isolated systems of nature there exists a class of very complex systems which we call the live systems. They posses a remarkable feature of interacting non-accidentally with other isolated systems. By means of senses and their motoric ability and on the basis of something what we term instinct, experience and the ability to learn they behave very differently from the behavior governed by the four forces only. They do not follow the patterns of neither classical nor statistical determinism and the knowledge of usual set of initial and boundary conditions is not sufficient to the PKBs to predict their future states[6].

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deterministic. Due to the discreteness of the interactions, however, every ball heads towards a completely unknown destiny – its velocity will be changed at random and as the game goes on[4a] the system as a whole would eventually reach an equilibrated state with a given distribution of velocities and free paths. All the balls are exactly alike (their colors may convey some information to the PKBs but are irrelevant to the processes which go on) and their histories must ultimately equalize on the average, irrespective of the possible differences introduced at a certain stage by extraneous causes. Once the equilibrium is reached the instantaneous distribution over their ensemble should equal the time history of every ball from then on (although, strictly speaking, the system in equilibrium becomes timeless, equilibrium being the ground state of such systems). It thus turns out that the inertial motion between the interactions, which is equivalent to no motion at all, is most relevant, for it is this motion which introduces the essential element of chance. In the microscopic analog of such a system, a gas for instance, the PKBs do not have operational means to trace exact histories of individual particles and to know and influence their initial conditions and are thus necessarily left with the distributions and their parameters (averages and variances) only.

[4a]It also might be that the discreteness and randomness of the interactions, or the element of "novelty", as David Layzer puts it, has something to do with the existence of at least some of the arrows of time - the thermodynamic one (stemming from the irreversible decay of macroscopic order) and the electromagnetic one (due to the radiations, interacting on the mass-shell, never converging onto the systems which emitted them). The inevitable element of chance due to the discrete accidental interactions between the isolated subsystems makes the constituents forget the past states out of which the present one evolved, making the probability of exactly reverse sequence of states virtually null, except in equilibrium when past equals future (but only on the average) and time exists no more.

[5]The future of the Universe is thus only statistically determined (abstracting gravitation) though, being composed of such large number of isolated subsystems, probable relative deviations from its average evolution are negligibly small.

[6]Perhaps the most picturesque example of this is from Fred Hoyle's "Black Cloud". When, while hurtling towards the Sun, the Cloud did nor obey the laws of free fall and stopped upon reaching it, the physicists smelled life: "Bastard in Cloud", as Alexandrov laconically observed. Or, just compare the motions of the dead and alive bird in the atmosphere of the Earth!

4. The PKBs themselves go another step further. The outstanding features of their actions are obviously due to their knowledge of the dynamic laws of the averages and the ensuing power to predict the evolution of the systems of nature. But knowledge is not enough - these features are even more due to their ability to operationally realize the systems of almost any wanted composition which are otherwise improbable to appear under the accidental interactions in the world of the four forces, and to make the existing systems of nature to interact non-accidentally. Evolving by the dynamic laws of the four forces from such improbable states the average values of the parameters

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Through the phenomena of heredity and growth life also offers the ultimate example of the workings of both the quantum and classical statistical determinism and of the dynamic laws of the averages. (Self)organization of some 10^{27} atoms through countless elementary interactions into given positions according to the preconcived pattern transferred by only two initial cells into a final complex functional form which will eventually repeat the whole process, in principle in an endless succession, results from elementary processes which are essentially statistically deterministic only[6a]. Life may thus be viewed as the peculiar self-driven (through the interactions with the suitable environment) oscillatory process which would not have been possible if the averages were not very well defined indeed. And as the perfect reproducibility and identity of atoms suggest their quantal behavior the virtually error-free replication of life forms suggests the highly deterministic character of the processes involved ("bird is just an egg's way to make another egg"). Also the contemporary biological evolution on Earth, which is but another name for the deviations in replication verified by the interactions with the environment, is so slow because significant deviations, both random and induced, are comparatively improbable and rare[6b]. The low evolution rate thus indicates the high stability of the periodical processes of life and reflects the high level of determinism in the physical processes which govern it[6c]. Upon the deterministic and predictable birth of a new living system, however, a new quality is also being born - the system does not follow merely the simple patterns of physical systems any more and its behavior is not deterministic to the PKBs. New variables are needed to fully describe and predict its future states - the variables which would describe not only the states of the body (or the "hardware") but also the states of the mind (the"software"). Its feature to interact non-accidentally with other isolated systems, via "information interactions", states of mind and its motoric ability, demonstrates best that its full description is beyond physics as we know it. Further new qualities which may arise as the collective characteristics of the whole population of akin living systems are even more out of the reach of physics. (That the science of biometrics teaches us how to cope with the fact that the living systems, strictly speaking, are not ergodic and that the quantities describing their states are not stationary is not really helpful in this respect).

[6a]To appreciate the genesis of complex order out of probabilistic entities, or more rigid determinism out of the truly statistical one, compare the fuzzy (probabilistic) representation of atoms with the stick-and-ball models of molecules, which are both quite well founded and justified.

[6b]Genetical egineering which may enhance and direct evolution beyond the means of eugenics (or exosomatic evolution in general) is a striking yet most sophisticated manifestation and explicit "experimental" proof of the ability of matter for self-organization.

[6c]The possibility to clone a living system probably reveals better the underlying physics than biology.

describing the systems then exhibit histories which would otherwise never have occurred. In this the PKBs can not challenge the inevitability of the ultimate equilibrated (ground) state of the Universe of minimum free energy and maximum entropy[7]; it is the route towards this end which the PKBs can locally change at will against the accidental though on the average most probable ("natural") sequence of states which would otherwise develop under the workings of the four forces[8].

5. If the demons are beings capable of violating the natural[9], the activities of the PKBs which make the river of nature flow along an improbable riverbed can rightly be termed as demonic (the other historical demons, like these of Laplace or Maxwell, which base their activities on the (mis)uses of classical determinism only, remaining just the gedanken ones). The demonic actions of the PKBs are reducible to the existence and workings of the very peculiar and complicated something by means of what they interact with matter to their own ends and this set of operations of ever increasing complexity may as well, and not only for brevity, be called the fifth force[10]. What is then the crux of the demonic activities of the fifth force?

6. Those actions are perhaps best described by Freeman Dyson as the actions against different hangups in the flow of free energy in the Universe which at given instances arise due to certain quantitative features in the world of the four forces[11]. The “hangups” lead to states of matter which the PKBs would

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[7] We do not deal here (except occasionally) neither with the possible final fate of the Universe nor with the flows of energy and entropy in the Universe as a whole and thus not with the possible role of the PKBs on the cosmic scale. Answers to those questions would depend on whether the Universe is finite or infinite, closed or open, upon the initial conditions, and so on. Much more observational evidence and theoretical insight is needed to eventually shift those questions from metaphysics to the realm of physics proper. We discuss mostly the role of the PKBs on a smaller scale where flows of matter, energy and entropy are, hopefully, understood well enough already.

[8] Compare the meaning of the adjective "natural" as resulting from the actions of the four forces, vs. that of "artificial" as resulting from the actions of the PKBs (or of the "fifth force", see below).

[9] Webster identifies a demon with a "daemon", which is "in Greek mythology any of the secondary divinities ranking between gods and men".

[10] To justify the use of the term "force" more fully one may think of the four forces and their macroscopic manifestations (perhaps above all the faculty to move the systems mechanically against the inanimate working of the four forces) as representing the components of the fifth one.

[11] Dyson defines four main hangups: 1. The size hangup (the distances between substantial lumps of matter in the Universe are so great that interaction between them is very unlikely). 2. The spin hangup (centrifugal barrier effects prevent lumps of matter to collapse except very slowly due to dissipative processes). 3. The thermonuclear hangup (gravitationally condensed matter has to pass the long-lasting era of hydrogen burning before collapsing further). 4. The weak-interaction hangup (the non-existence of the di-proton necessarily involves the slow weak interaction transformation of the proton into neutron whilst sythesizing hydrogen into

generally classify as “fuels”. The fifth force seems the only agent able to overcome at least those hangups which may be released by realizing the systems of specific and otherwise improbable composition and the adequate improbable initial conditions, and thus change the rate of flow of energy in the Universe beyond that determined by the accidental actions of the four forces only (Fig.1). It is the only force able to exhaust completely the free energy

Fig.1. Explosion of the fission-fusion bomb. Probably the best yet known to us proof of the demonic actions of the PKBs – not due to its destructivity, as the uninitiated non-PKBs would think, but due to practically zero probability to occur within the world of the four forces. The particular lump of matter which partly accomplished here the state of ultimate nuclear stability and thus almost completely exhausted its free energy content, would never have reached this state without the workings of the PKBs. Evolving through the sequence of the most probable states, and into the PKBs, nature is in for a surprise – the improbable states start to take part in its further evolution. But, is it a surprise or is this done with the purpose to complement itself and achieve what could not possibly be achieved otherwise?

contents of the Universe and this might represent the ultimate mission of the PKBs in nature. In an open and infinite Universe, which contains an infinite amount of “fuels”, the evolution into the PKBs is possibly the only way for nature to defy its own heat death indefinitely. This may also be the ultimate among the paradoxes of infinity.

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helium). On the larger scale the PKBs might even break through the two major hagups – the size and the spin ones – and trigger the nuclear processes which the masses brought together by their (mechanical) actions would hardly ever experience otherwise. (Nuclear processes lead to the most stable and least reversible states of matter and at the same time most important ones not only for the practicing PKBs but also from the view of natural philosophy. If one is inclined to think it big, life in general, and PKBs in particular, may become the main regulator of the nuclear (read elemental) evolution of matter in the Universe).

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