THE PHYSICS OF THE BOOLEAN OBSERVER

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Abstract

Interaction of human beings, as well as of other entities in the biosphere and of most modern artifacts, with the environment, is performed through organs (sensors or actuators) made of bistable devices, hence is based on Boolean algebra, i.e. on the game of "yes or no."

However, in addition to this "analytic mode" of behavior, human beings seem also to possess a less understood but very powerful "synthetic mode," not based on distinguishability and verbalization (in other words not on numbers and words) but on a sort of union with the Chaos. From this back door of our mind seem to come artistic inspirations, as well as scientific intuitions or other unconventional modes of "information transfer under sensory shielding'; such as telepathy and precognition.

A mathematical expression of the wave function of quantum physics with complex exponent, containing a pair of quantities representing "information" and "action" respectively, allows us to grasp an understanding of the real and the imaginary world of the observer.

Resumo

A interacção dos seres humanos, bem como de outras entidades da biosfera e dos artefactos mais modernos, com o seu meio ambiente é efectivada mediante orgáos (sensores ou agentes) formados segundo dispositivos de quadro duplo, uma vez que se baseia na algebra booleana, i.e. no jogo de "sim ou não"

No entanto, adicionalmente a este "modo analítico" de comportamento, os seres humanos parecem possuir um "modo sintético", menos compreendido mas muito potente, que se baseia não na diferenciabilidade e na verbalização (noutros termos, não em números e palavras) mas sim numa como que unido com o Caos. Por esta porta trazeira do nosso espírito parecem chegar as inspirações artisticas, assim como as intuições científicas ou outros modos não convencionais de "transferência de informação sob cobertura sensível", tais a telepatia e a pré-cognição.

Uma expressão matemática da função ondulatória da fisica quãntica com expoente complexo, contendo um par de grandezas que representem respectivamente "informação" e "acçao'; permite-nos akançar uma compreensão das mundos reql e imaginário do observador.

1. Introduction

There are two doors through which we acquire knowledge: one is from the outer world; the other is from the inner world. This latter door, however, is harder to penetrate and requires particular attitude as well as long training, which we seldom do, to listen to the "inner voices."

The door towards the outside world is made of our (five) senses: therefore it works on distinguishability, i.e. on whether a bistable device in any of our senses is either excited or at rest. Think, for instance, to the retinal molecule in the human eye, that switches from its "11-cis" to the "trans" configuration, when it is hit by a photon. In other words, the acquisition of knowledge through the door of senses rests on the pillars of Boolean algebra, i.e. on the game of "yes or no" devices, not too different from those used in many types of digital machines that human beings have devised to be helped in their daily activities.

The acquisition of knowledge through this outside door proceeds as follows (see left side of fig. 1, lower five levels): signals received from the outer world are "perceived," i.e. they induce change of state in some sensing device and this change is amplified up to a level suitable to excite a pattern of neurons in the brain. Important factors of this *perception* process, are "attention" and "verbalization," where "verbalization" is the assignment of a category to the perceived pattern, stemming from the "a-priori knowledge" of the observer, i.e. from his/her past learning of "words," mostly done during infancy and adolescence, whereas "attention" is the assignment of a suitable memory space, the size of which depends on the depth or accuracy with which we want that observation to be made.

Subsequent to verbalized perception is the construction of *experience,* which requires some extraction of repetitive patterns from several perceived events, to be utilized for prediction of future events of similar nature.

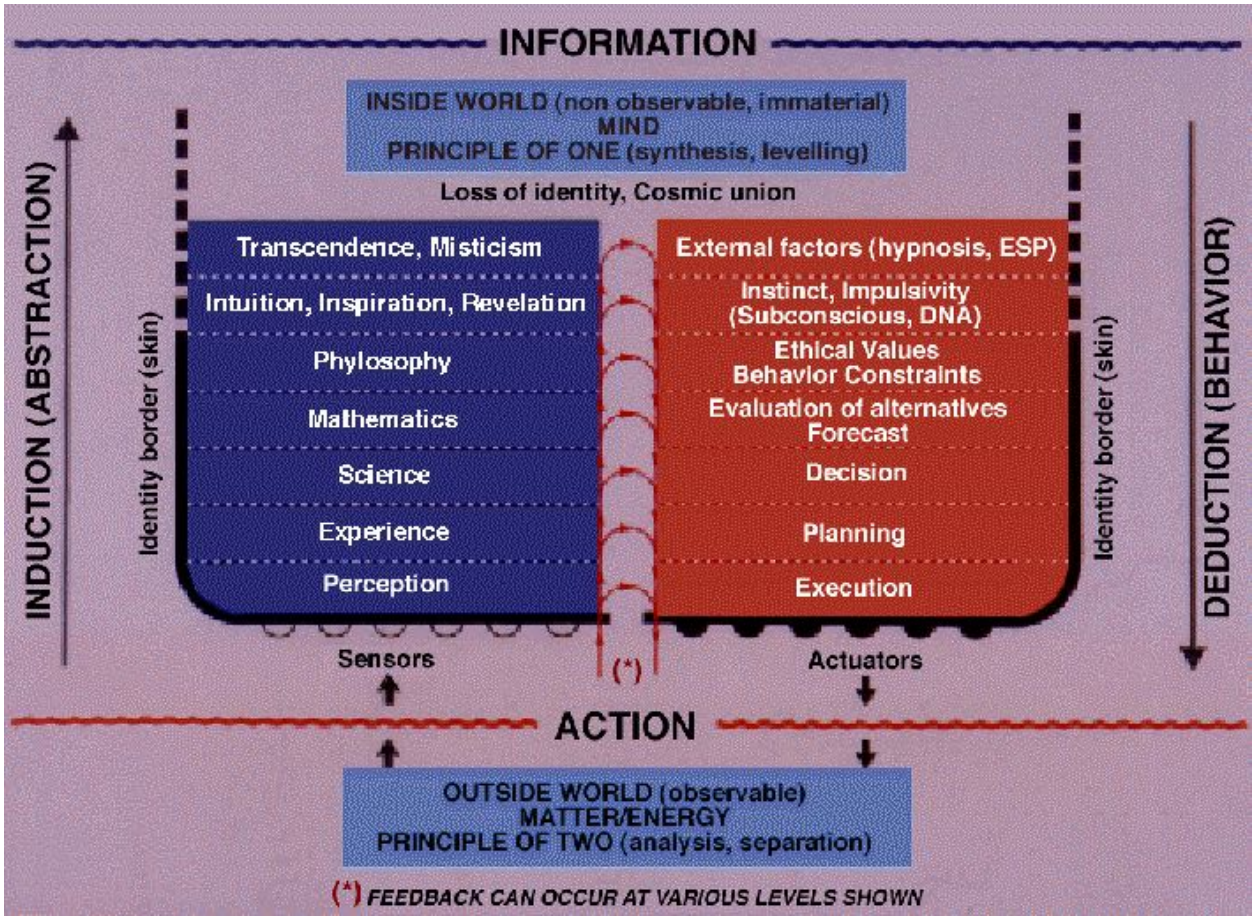

Fig. 1 - A Model of Mind-Matter Interaction

One step further to experience is the construction of *science* which, apart from a higher level of generalization (i.e. of extraction of common patterns from a wider class of events), aims at creating models as independent of observers as possible, as well as at extending their validity possibly to the whole space-time domain.

Verbal communication among human beings appears to be increasingly decisive along the three steps considered above. However, the language of *mathematics* lends itself, better than the language of words, to express general models of science in a more compact and more universal form. As the Pythagorean scientist Phylolaos (as well as, much later on, Lord Kelvin) maintained, there is no "true" knowledge if it cannot be expressed with numbers, thus implying that knowledge only expressible in words is just the beginning of knowledge, not yet "true" knowledge.

This view is, however, to be taken with some caution, mainly because *philosophy,* in the quest of that unique principle, if any -- which is believed to govern all events in the visible universe, and therefore to stay atop of all sciences and physical laws -- usually utilizes again the language of words, though trying to obey to precise logic patterns and rules of reasoning as those accompanying the mathematical expressions of science. On the other hand, according to more recent scientific findings, anything which is expressible in words can be dealt with by knowledge processing machines, therefore again can be represented by streams of ones and zeroes, i.e. by binary numbers.

The whole process described above -- from perception to philosophy -- of acquisition and construction of ever higher ranks of knowledge can be termed as "induction" (from Latin "inductio" which means "taking in") and leads from mere perception and experience of everyday life to ever more abstract but powerful models, where details become blurred, as when we look at the surface of earth from a higher and higher elevation. We may then say that the constructions of mind lead from the analytic mode of the process of observation, based on Boolean distinguishability, namely on the "principle of two," to the synthetic mode of the holistic conception of the universe, i.e. to what we may call the "principle of one."

Conversely (see the lower five levels at the right side of fig. 1), the active behavior of human

beings towards the outside world follows the opposite path, that of deduction[1] (from Latin "de-ductio" which means "taking out"), which transforms general principles, as those of ethics or behavioral constraints, of philosophical nature, into actions performed with Boolean actuators (muscles), through successive steps such as *simulation* and *evaluation of alternatives* (implying prediction of their effects), *decision* on which alternative to implement, and finally *planning* and *execution* of actions, to induce observable changes in the outside world. Thus, this process can be deemed as one converting abstract principles (high-rank knowledge, or information) into physical actions. However, feedback from the induction to the deduction process (and vice versa) can occur at any level shown, whereby actions/events are converted into information and therefrom information is converted back into actions/events. Of course, the capability to effectively interact with the environment is as great as greater is the knowledge acquired in the past, therefore, it generally increases with age and education, apart from innate qualities, which we will touch upon in the following.

It is also to be remarked that especially superior animals (e.g. mammals), but also, in various degrees, all entities in the biosphere, possess at least one or two of the lower levels shown in fig. 1. The same can be said of some artifacts.

In fact, modern AI (Artificial Intelligence) techniques such as neural networks, auto-learning, person / machine communication with natural language, problem solving and robotics (which perhaps will utilize most of other AI techniques) aim to conferring to artifacts all five induction / deduction levels shown in the lower part of fig. 1 (perhaps with the exception of philosophy) and this will be progressively achieved as long as the logic path which takes from the outside world to superior ranks of knowledge / behavior will be more and more clearly understood. One decisive step in this direction will be the achievement of full self learning capability, through which a "baby machine" may become a full-fledged "experienced machine" capable of successfully challenging the rational behavior of the most "expert" human being. The conceptual jump in the design of such super intelligent artifacts will be that of switching from today's "stored algorithms" mode of operation to that of "stored paradigms" i.e. to the storage of scopes and constraints, leaving the execution of steps to strategies permitted by the built-in structure (e.g. neural networks) and by the subsequent machine learning process.

2. The Boolean and the ecstatic observer

Despite the marvels of the above-sketched rational behavior (which has been attributed by many scholars to the left hemisphere of the human brain), we concur with Albert Einstein that "there is no logic path that takes from observation of the outside world to the discovery of fundamental laws of nature." Einstein maintained (but anyone of us could easily agree with him) that his greatest ideas came from intuition, vague at first, then progressively refined with logic reasoning and with confrontation with experience. Therefore the growth of a bright idea is certainly indebted to the rational behavior, but the birth of it has to be attributed to a sort of uncontrolled emergence from the ocean of the uncertainty, hence to irrational behavior; according to the aforesaid scholars, this is the domain of our brain's right hemisphere, which works on a *synthetic* instead of an *analytic* mode, and whose acquisition of knowledge is generally accompanied by that sentiment which we call "emotion." This is the "back door" which we were speaking of at the beginning of this paper.

To better understand this "synthetic mode" of acquiring knowledge, think to a summer sunset, as observed by either a "Boolean observer" (100% rational) or an "ecstatic observer" (100% emotional). The former may behave like a sophisticated robot, measuring the intensity and wavelength of light from all directions, the chemical composition, temperature and velocity of the surrounding air, the various patterns of objects in the visual field, all acoustic sound patterns and their probable sources, and so on. The final result will be myriads of bits, though well organized, classified and properly labeled. The Boolean observer, with its 100% analytic mode, will break the reality in an infinite number of bits and pieces, as deep as deeper (i.e. more detailed) knowledge acquisition is demanded.

As for the ecstatic observer, he/she must first forget his/her own identity and become mentally part of the observed scene, trying not to distinguish (even not the self from the environment), not to

[1] In this context, the term "deduction" is used in a somewhat broader sense, with respect to that adopted e. g. in AI or in psychology.

"reason," not to analyze, but to *live* that experience as a whole. Strangely enough, he/she has not to shut down his/her senses; on the contrary, these should be all fully alert to receive all sensations from the environment[2]: colors, shapes, perfumes, breezes, sounds, etc., though possibly in a non-verbalized perception mode, aiming to sense more the harmony of all those sensations, as constituents of a unified experience. Yoga and Zen techniques, as well as any form of transcendence or mysticism, lead to that "ecstatic" ("ekstasis," in Greek, means "union") or synthetic mode of acquiring knowledge (but perhaps "knowledge" may not be the best word to use here) and, as known, they cannot be "taught" (it would require to know the "science" of a nonscientific behavior) but must be lived or experienced through intense and long-lasting exercises, though with the aid of a senior experimenter.

Of course, human behavior follows from a mixture of the two modes outlined above, also because the two brain's hemispheres are connected through a (not too high) number of fibers of the "corpus callosum."

A first understanding of the human limits to follow either mode of behavior may be gained through a review of the Heisenberg's uncertainty principle.

3. The Boolean observer and the uncertainty principle

The uncertainty principle is usually stated in terms of the limit to the product of accuracies attainable on simultaneous measurements of two "conjugate" quantities, such as energy and time or momentum and position.

However, it can also be formulated in terms of "action" (a physical quantity given by the product of the two aforesaid conjugated quantities), which has the advantage of being a relativistic invariant, i.e. independent of the observer. In this case, the uncertainty principle says "any event, involving an action "A" less than $\hbar$ cannot be observed"[3]. This means that any stimulus with duration t_s and energy E_s such that $A=E_s\ t_s < \hbar$, is not able to fire a bistable device, i.e. to induce an elementary change of state, which would correspond to the acquisition of one bit of information by a Boolean observer. Thus, the maximum information I which can be gained by said observer, whenever an action $A > \hbar$ is involved, is:

$$I = A/\hbar \qquad (1)$$

or, the minimum action A required to acquire I bits of information is:

$$A = \hbar I \qquad (2)$$

Relation (1) says that, in the ideal case of maximum (Boolean) observation efficiency, *the number of action quanta equals the number of information bits.*

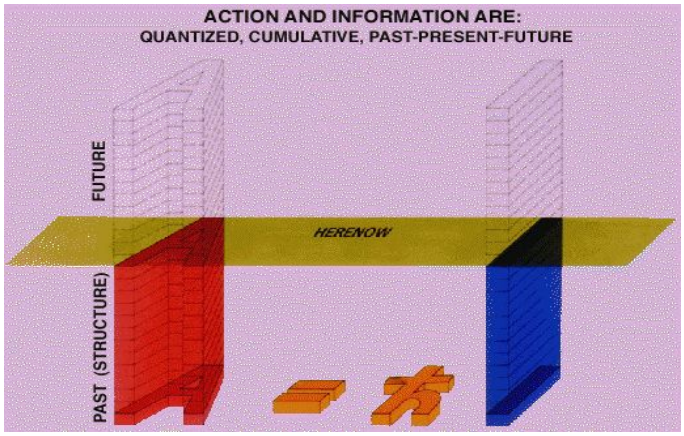

Fig. 2 How Action Quanta and Information Bits Add Up

This can be visualized as in fig. 2, where the construction of knowledge by a Boolean observer is shown as a pile of information bits, corresponding, one-to-one, to the number of action quanta

[2] The reader may recall the "ganzfeld" conditions requested in some experiments of parapsychology, as also performed by the Nobel Prize on Physics, R. P. Feynman.

[3] $\hbar$ is given by the Planck's constant h, divided by 2π. Moreover, the above statement is to be taken statistically, as known.

received by his/her/its sensors. Of course, knowledge is given by events happened in the "past" of the observer and the "here-now" sensation is that coming from any new (additional) event, superimposed to those already interiorized in the memory structure of the observer.

The construction of higher ranks of knowledge, then, proceeds from all elementary perceptions along the scheme outlined in fig. 1, with a continuous interaction with past (or a-priori) knowledge and with an increasing degree of abstraction, which latter, somehow, destroys the actual event perceived, by substituting, in its place, a sort of convolution of present sensations with past experiences of the individual observer. Communication between many observers, then, tries to construct a sort of "objective truth" as the "invariant" component drawn from the varied experiences of the individuals.

The same as certainty is constructed with the unit of information called "bit," uncertainty may be deemed as being constructed with units of doubt, which may be called "ambiguity" or "negative bit," in that it represents the elementary uncertainty between two equiprobable states. To better understand this unit of doubt, the reader may refer to any of the three examples shown in fig. 3, by verifying that the observer's mind is incapable of deciding which one of two categories (names) to assign to the perceived visual patterns.

More precisely (the reader can experiment by staring at each figure for, at least, 10 seconds), the observer's mind "switches" from one to the other of two "meanings" every few seconds, so that, at the end, the answer to the (Boolean) question: "**A** *or* **B**?" is "**A** *and* **B**," because the observed pattern contains *both* **A** and **B**. This suggests a more pleasurable interpretation of uncertainty in that it appears to possess more "plenitude" that certainty, also because certainty implies "choice," i.e. destruction of all other alternatives, whereas uncertainty leaves all the alternatives "alive," i.e. with equal chance of existence.

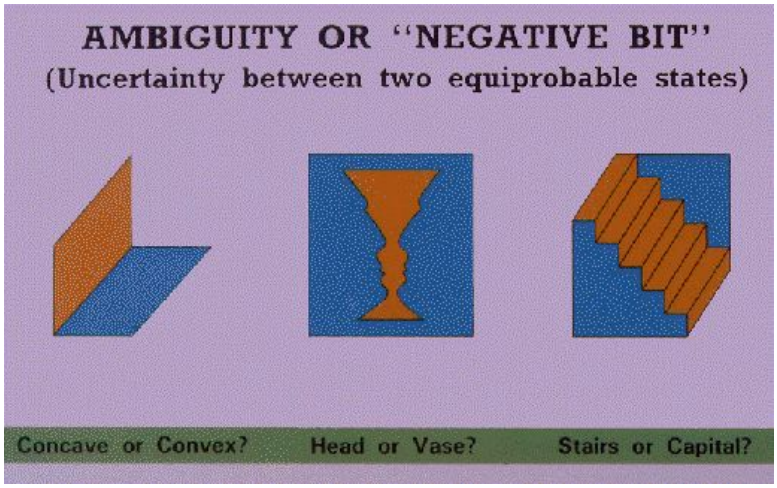

Fig. 3 Ambiguous images or the "Negative Bit"

Therefore, the construction of large ensembles of information, as well as that of large ensembles of doubt, may be deemed as stemming from binary ladders made of either type of building blocks (fig. 4), which lead to either a choice or a non-choice (i.e. a "plenitude") of one among N equiprobable states. This can be expressed, in logarithmic form, by the quantity M, given by:

$$M = \log_2 N, \qquad (3)$$

representing either (binary) information I or (informational) entropy S, given by the number of either (binary) choices or non-choices needed to arrive at one member of the whole roster of alternatives N considered[4]. The above justifies the name of "neg-entropy" given by L. Brillouin to information, as well as the name of "neg-information" which may be given, conversely, to entropy.

It should be pointed out that certainty or uncertainty about objects or events -- hence their measures: information or entropy -- are quantitatively related to the amount of knowledge obtainable

[4] *M* also represents the memory size, i.e. the number of physical bistable devices, needed to store all *N* alternatives, in that it can assume $N=2^M$ possible configurations.

on them by a human observer. Therefore, when we say, e.g., that a mole of nitrogen has 10^{28} bits of entropy, it means that we lack 10^{28} bits of information *to know* all the states of that volume of gas. On the other hand, when we say that we have 10^{10} bits of information on certain object or event (e.g. a DNA molecule), it means that *we know* all 10^{10} binary microstates that describe that object or event.

Fig.4 also suggests that, beyond the Heisenberg's barrier to the acquisition of (analytic) knowledge by both human mind and artifacts, the huge ocean of Chaos extends with about the same structure of Order, if it were not for the "and" glue that holds together the bits of Chaos, instead of the "or" acid that breaks the bits of Order apart from Chaos.

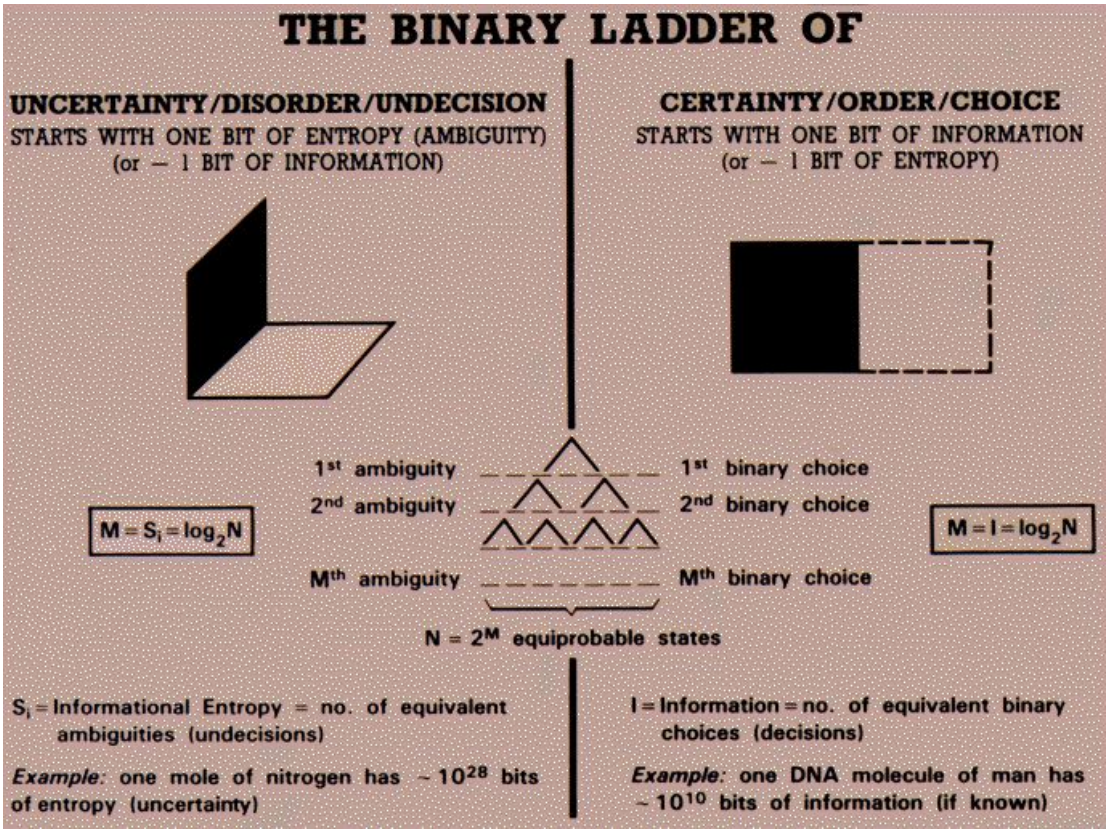

Fig. 4 The Binary Ladders of Doubt and Certainty

4. Real and Imaginary World

From what precedes, it appears that the process of observation -- more generally, the process of interaction of the observer with the outside world -- results in the construction of an inner, progressively immaterial world, made of "subjectivized" or "interiorized" records coming from the abstraction[5] of words, sounds, visual patterns, signs, physical events, etc. perceived in the past: the older they are, (i.e. the lower they are located in the pile of fig. 2), the less easily distinguishable (recallable) they become at "present," as if they had rejoined the ocean of chaos and uncertainty.

To an alert mind, the outside world, perceived through senses, represents the "real world," that where actions are performed and events (i.e. observable changes) happen; it also represents the "future," as the observer clearly sees the possibility of physically getting in touch with the objects perceived, even if the information received about those objects refers on how they were in the near or far past, depending on their spatial distance from the observer and on the nature of the information-carrying messengers. Again, more distant objects become less easily distinguishable, up to the complete black-out when they are located at approx. 15 billion light-years distance, corresponding to the emersion of the universe from the Chaos (Big Bang).

[5] The word "abstraction" (from Latin "abs-tractio," meaning "drawing from") not only has the usual meaning of rendering "abstract" (i.e. intangible) what is physically perceived, but also of extracting what is fundamental to that perception, i.e. what may be common (or "invariant") to a wider class of similar observations.

Therefore, far past and far future events seem to merge into the ocean of Chaos, being therefore precluded to the analytic mode of observation by the human mind.

Around the "here-now," the near past and the near future seem to touch in a sort of a moving borderline; that of the observer's conscious life, which acts as a two-way transformer of either past into future (actions) or future into past (observations/ information).

Quantum physics allows us to grasp an understanding of such processes (fig. 5). In fact, either any observation or any performed action implies the occurrence of a *change* of state of some entity. This is described in mathematical terms by the change of the entity's wave function $\overline{\psi}$ from its initial state $\overline{\psi}_{in}$ into its final state $\overline{\psi}_{out}$ related one to the other by:

$$\overline{\psi}_{out} = e^{-j\frac{Ht}{h/2\pi}} \cdot \overline{\psi}_{in} \qquad (4)$$

whereby the change of $\overline{\psi}_{in}$ into $\overline{\psi}_{out}$ is attributed to a *cause* (stimulus), expressed by the so-called Hamiltonian *H*, which represents the energy of the stimulus, or, better, by the Hamiltonian action *Ht* performed by the Hamiltonian, applied along the time interval *t*. The effect of the applied stimulus on $\overline{\psi}_{in}$ is, as shown by (4), only to change *the phase* of $\overline{\psi}_{in}$, not its magnitude; more precisely, the number of radians of the induced phase shift on $\overline{\psi}_{in}$, equals the number of action quanta ($Ht/\hbar$) of the applied stimulus. Therefore, the magnitude of $\overline{\psi}_{out}$ equals the magnitude of $\overline{\psi}_{in}$

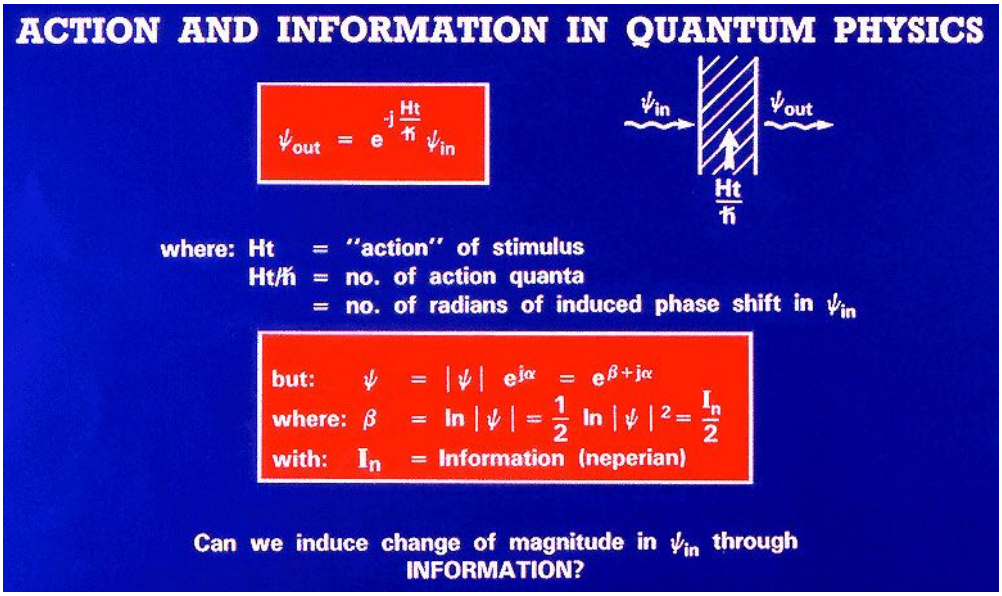

Fig. 5. Action and Information in Quantum Physics.

It is known from quantum physics that the square ψ^2 of the magnitude ψ of any wave function, represents a (scalar) probability. Therefore, if we write the wave function in a full exponential form, i.e.:

$$\overline{\psi} = \psi \cdot e^{j\alpha} = e^{\beta + j\alpha} \qquad (5)$$

we may see that the real part β of the complex argument of $\overline{\psi}$ represents a (negative) information quantity, since:

$$\beta = \ln\psi = \frac{1}{2}\ln\psi^2 = -\frac{I_n}{2} \qquad (6)$$

given the fact that information is defined as the negative logarithm of probability. As the logarithm is with base "e," the information *I* shown in (6) is *Neperian information*, and is therefore measured in *nats*, instead of *bits*, the two measures differing merely by a constant of proportionality (ln 2).

In conclusion, we see from (5), that, in force of (6), the description of "reality" in quantum physics rests on two basic (real) quantities β and α, the former representing *information*, the latter representing *action*, and that these two quantities seem to pertain to two somewhat separated and independent worlds, though both codetermining the observed "reality." In fact, it is a firm result of quantum mechanics that the description of entities and events in the microcosm cannot be obtained without using complex quantities, such as the wave function $\overline{\psi}$ or its complex argument $\beta + j\alpha$, as in (5). Any dissection of this "complex" reality (made of a "real" and an "imaginary" part) would lead to a monocular understanding of nature, whereas complex numbers -- as was pointed out by Leibnitz since year 1690 -- possess the "amphibian property" of taking into account the influence of both the "real" and the "imaginary," whatever meaning is attributed to these two adjectives, apart from the strictly mathematical one.

However, as it was shown in the foregoing, the world of "pure" information is that inside the observer, that of "pure" action is outside the observer. One is immaterial (the world of mind), the other one is material (the world of energy/matter) and this latter is the so-called physical world, in which observable changes either happen or are intentionally caused to happen by observers.

We have learned, along the evolution of the biosphere, how to induce such changes in the physical world, through physical actions, as by relation (4). Will we learn how to manipulate pure information (i.e. to use the "force of mind") to also induce changes in the physical world, e.g. by changing the *magnitude*, instead of the *phase*, of $\overline{\psi}$? Or, by utilizing the intrinsic capabilities of entities to transform information into action, by taking control of their inner world through entering their "back door" through our mind, as done, e. g., with hypnosis?

Answers to these questions are being increasingly sought, along the last few decades, by several prestigious researchers in various Universities. Enough scientific evidence has been acquired on telepathic and precognitive phenomena (technically labeled as "information transfer under sensory shielding") as well as on "low-level psychokinesis" and "out-of-the-body" experiences, none of them being explicable through any known (subluminal) information, or action, or carrying messenger.

It is a firm belief of the writer that future progress in this direction could be better achieved if we become fully aware of the existence of the aforesaid two worlds and if we will succeed in taking control of the innermost "imaginary" world of entities in the universe.

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