Endophysics — Physics from Within
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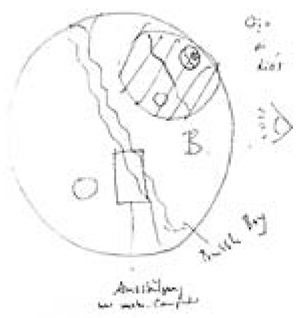

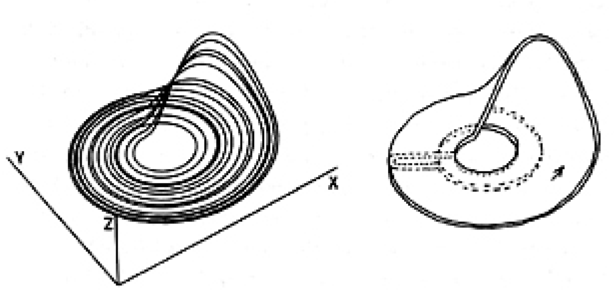

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Der Rössler Attraktor

A new science, Endophysics, is introduced. Only if one is outside of a nontrivial universe is a complete description of the latter possible — as when you have it in your computer, for example. The laws that apply when you are an inside part are in general different (endophysics is different from exophysics). Gödel's proof is the first example, in mathematics. In physics, it is desirable to have explicit observers included in the model world. Brain models are a case in point. Macroscopic brain models, however, are non-explicit in general. Therefore, an explicit microscopic universe is introduced in terms of a formally one-dimensional Hamiltonian, in which "formal brains" can arise as explicit dissipative structures in the sense of Prigogine. The pertinent endophysics is still largely unknown. As a first step, the implications of having the observer contain indistinguishable particles (Gibbs symmetry) are considered. Campbell's postulate — a microvacillation of time's axis — is an implication, with Nelson's postulate and hence the Schrödinger equation following as corollaries. Thus a "nonlocal" internal interface is implied by a local theory. Microscopic observer properties can "percolate up" to affect the macroscopic spatio-temporal appearance of the model world. Physics becomes dependent on brain theory.

Endophysics has so far been largely confined to science fiction. The best example to date is probably Simulocron Three by Galouye [1], which for some reason was not included in Hofstadter and Dennet's anthology on computer-cognition relevant fiction [2]. Galouye lets a whole world be simulated in a computer. The operator is able to look at this world through the eyes of the "ID units" — the poor inhabitants of the world. One inhabitant, code numbered ZNO (Zeno), unfortunately has to be unprogrammed because he gets suspicious and is about to infect the rest of the community. Only later does the evidence accumulate, to his creator, that he, too — but perhaps you wish to read the story for yourself. (Eventually, the two lovers, from different levels, come to live happily ever after, since, after all, there is no basic difference between two subroutines that formally belong to two different levels of nesting.)

Shortly after Gödel [3] had given his famous proof about the incompleteness (from the inside) of arithmetic, his close friend von Neumann [4] began to ponder the question of whether or not quantum mechanics might represent an analogous limitation — within a physical rather than mathematical context. Fortunately, von Neumann was able to prove that if quantum mechanics is accepted as the most basic physical theory, which contains all possible others as special cases, then there is no need to worry. The structure of quantum mechanics happens to be such that "the state of information of the observer regarding his own state" cancels out from the formalism [5]. That such a type of result is particularly likely to kindle suspicion in certain vulnerable individuals did not occur to von Neumann, since he could not possibly have read Galouye.

About half a century before, a similar physical nightmare had already haunted Maxwell [5] (and apparently Lohschmidt before him, according to Boltzmann [6]). Maxwell conjectured that there might in general exist two types of physical law. An example of the first kind would be Newton's law when applied to celestial bodies — it would make no difference whether or not you sat on one of the bodies. An example of the second kind would be Newton's (or Hamilton's) law again, but applied to the many microscopic bodies whose mechanical interactions supposedly underlie thermo-dynamics. Being confined to the same world here could make a significant difference. Unexpectedly, this point of Maxwell's, which was made implicitly, went unnoticed. The two famous proofs [7,8] that the demon cannot work (opening and shutting a little trapdoor of near-zero mass at the right moments), both do no more than show that the demon, if it is a sub-system, cannot do its job with a net gain, in case it has to go about hunting for information. The fact that a much simpler mechanism suffices (an asymmetric trapdoor of near-zero mass needs only to be cooled regularly -i.e. an infinitesimal amount of kinetic energy must be removed — to generate the same effect automatically [9]) was overlooked. This oversight is nevertheless minor since operating a near-perfect cooling machine, for a single particle, presumably requires the same investment of free energy once more, from a subsystem. But what is the situation for a non-subsystem? Indeed, when sitting at the keyboard of a higher-level computer in which a Hamiltonian universe is being simulated, doing either magic trick (adjusting the tenth digit of a particular particle's position at strategic points in time, or keeping a particular particle cool automatically) will prove equally feasible.

Thus, the second law is endophysical in nature. Maxwell was right with his suspicion. So was Smoluchowski [10] some time later with his debugged version of the demon. He proposed that you try being a demon yourself: just buy one of those modern infrared-sensitive night glasses. In addition you need a bowl of water, a dark room, an ordinary spoon, and two thermos bottles, one red and one blue. Then just wait and sample, with the spoon. Since your eventual success will be the first anyhow, you need not worry about the magnitude of the effect. Any consistent effect that you are able to produce without a fancy lab (10^{-10} degree) will be fine. Smoluchowski realized that if you are sure that this tamed (macroscopic) version of the demon will be censored too, you as a corollary have to believe in the existence of (from the macroscopic point of view) counter intuitive nonlocal macroscopic correlations. As he died the same year he made his proposal, he was not able to tell which outcome he would abhor more. This story (even if slightly dramatized) is exceedingly hard to tell since everyone tends to get the punch line wrong. Again, you need Galouye to point out clearly where you think the answer lies.

Next comes Ehrenfest's demon — Einstein. In a letter [11], Ehrenfest compared Einstein — in his indefatigable attempts to find a loophole in the consistency of quantum mechanics (in his exchanges with Bohr in the Ehrenfests' home) to a little Jack-in-the-box who wants to play Maxwell's demon against the quantum law. Indeed, in more recent times the quantum nonlocality [12] has taken on a similar status to Smoluchowski's earlier proposal.

Two further important names in the history of endophysics are Popper [13] and Finkelstein [14]. Popper talked Einstein into accepting his proof [13] that complete self-observation is impossible in (continuous) physics, and into believing with him that one should try to find a Gödel-type formulation of quantum mechanics [13]. Finkelstein [14] set up a program for a "holistic physics" in the spirit of the late Bohr, but discrete. He hypothetically attributed both the quantum limit and the relativistic limit to the fact that the whole is not available to us. Later, he gave an explicit example of a finite-state machine (computer) whose internally evaluated state is different from that existing objectively [15]. Still later he endorsed the two notions "physics from without" and "physics from within" [16] by coining the technical terms [17] used in this chapter. The name "endophysics" is his creation.

In the same year, Fredkin [18] described the first explicit, computer calculable model universe as a reversible-type cellular automation. (Earlier cellular-automata "worlds" like Conway's game life [119] had all been irreversible.) This universe consists solely of information. Once you assume it exists, implemented in whatever kind of hardware you may think of, its properties are fixed. It starts producing "material" properties of its own inside — like assemblies of black pixels that mutually attract each other with a definitive force law like Coulomb's. The hope is that, eventually, all laws of nature as we know them might come out as an implication. You only have to hit — by happenstance — upon the right reversible local rule. The number of such laws to be checked empirically is unknown. Possible counter arguments invoking the existence of nonlocal phenomena in quantum mechanics are answered with the argument that nonlocal correlations over large distances have been abundantly observed in real-time computer runs [18]. The dichotomy between exophysics and endophysics is hereby invoked. The only major problem with this explicit model world is that, so far, no dissipative macroscopic processes can be simulated since even a single "elementary particle" uses up hundreds of variables. Irreversible "observers" cannot yet be included. This computer world therefore still belongs to the first or "general" phase of endophysics. Here, general limitations that invariably show up from the inside are sought. Gödel provided the paradigm and Maxwell the first potential physical example. In contrast, the second or "special" phase of endophysics will be brain theoretical. Assumptions that are not completely general and that enter into the properties of explicit observers ("brains") arising in the explicit model world will be admitted into consideration. This makes the connection to Galouye's (and Lem's [2]) science fiction even closer. Interestingly, the first potentially conscious computer program was developed by Kosslyn and Shwartz [20] (cf. also ref. 21 for a related but more complete blueprint). Like its forerunners — of fiction status presumably — it is non-reversible. All such models have yet to be embedded into a more minimal (reversible) universe. On the other hand, a concrete example of a microscopically specified world that "goes all the way up" to include macroscopically subsystems such as observers has so far been lacking. A specific world of this type is considered in the following.

Discussion

Endophysics is still in its infancy. A single explicit model universe that reaches through all levels from the microscopic to the macroscopic is available so far. A general endophysical question worth considering in detail is the second law with all its ramifications. Other questions of the same standing have yet to be identified. In the realm of special endophysics (including brains), most questions have also yet to be formulated. There may be other "general" special axioms to consider besides that of observer-internal particle indistinguishability.

Even though indistinguishability may turn out to be but a minor determinant of an observer-centered future endophysics, focusing on it at the beginning may turn out to have been a lucky accident. It helped show that simply putting a reversible universe into a computer and running it exophysically is not sufficient to uncover its endophysics. In addition, hints at the possible existence of endophysical properties even where there are no exophysical correlates, are needed. The Gibbs symmetry simply does not exist exophysically. In a similar vein, both quasi periodization and microvacillation could easily have been overlooked were it not for certain counter intuitive theoretical proposals already present in the literature.

Particle indistinguishability has the further asset that it is a "maximally simple" property. Symmetries and reduced representations are staples of any physical theory. Trajectorial multiuniqueness, nevertheless, is fairly nontrivial conceptually. To the present author, for example, it is still not clear to what extent one may trust a symmetry argument. For more on the history of this problem, one can go right back to Leibniz.

A more general endophysical problem worth discussing is the consistency question. Can any endophysics be consistent? To what extent is "internal consistency" assured for its inhabitants? Specifically, can internal interfaces be consistent? How far can their consistency go, maximally? Are only single measurements covered (direct consistency), or are derived general laws included (indirect consistency)? What about "metaconsistency": a meta-consistent world would be one in which it is impossible even to embark on an endophysical program.

These questions may all be studied explicitly using the present model universe (with the r.t plane forming the main tool). It is also possible to study the question of "consistent interaction" between two observers -with a single observer who relies on his own earlier notes forming the simplest case. The nontrivial nature of the latter problem was first seen, in real physics, by Bell. The central endophysical idea of metaunmaskability goes back to Descartes. He introduced the fairness question (in French). Can a "mauvaise plaisanterie" (a bad joke) be excluded, from the inside? Both Einstein and Bohr concurred with him that a physics whose consistency was not great enough to permit at least a glimpse at the reasons for our own limitations would be a "bad dream".

In the present context, Cartesian fairness assumes a different ring. Simulating a Hamiltonian world in a computer having finite precision is bound to destroy many "subtle" conservation laws. Subtle conservation laws would be those that preserve the consistency of internal interfaces. The second law, for example, is subtle since it can be violated by "late digits" (cf. ref. 9). Even more subtle would be a macroscopically consistent world that nevertheless is nonlocal microscopically. Two mutally incompatible macroscopic worlds could then coexist, in harmony, in the same microscopic world (exophysics). Only if such a level of accuracy is guaranteed can the inhabitants embark on an endophysical path.

Therefore, a reversible integration routine will be required in the long run. Its use will amount to putting a discrete "lowest-level universe" underneath the present one. Like Fredkin's universe [18], the latter ought to be "embeddable" again into a continuous Hamiltonian.

To conclude, endophysics is the study of demons. Maxwell's demons do not work — they are each blocked by a censor. Further demons and their corresponding censors will have to be uncovered. Understanding incompleteness is worth more than completeness — almost.

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