Beyond the ‘theory of everything’ paradigm: synergetic patterns and the order of the natural world

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Jun. 12, 2021

ABSTRACT

David Bohm suggested that some kind of implicate order underlies the manifest order observed in physical systems, while others have suggested that some kind of mind-like process underlies this order. In the following a more explicit picture is proposed, based on the existence of parallels between spontaneously fluctuating equilibrium states and life processes. Focus on the processes of natural language suggests a picture involving an evolving ensemble of experts, each with its own goals but nevertheless acting in harmony with each other. The details of how such an ensemble might function and evolve can translate into aspects of the world of fundamental physics such as symmetry and symmetry breaking, and can be expected to be the source of explicit models. This picture differs from that of regular physics in that goal-directedness has an important role to play, contrasting with that of the conventional view which implies a meaningless universe.

INTRODUCTION

Stephen Hawking said in 2000 ‘I think the next century will be the century of complexity’. Why he said this is unclear, but it is likely that he found the subject of complexity of interest, and thought it had much potential. The following argues that complexity is important in physics in a way unlikely to have been envisaged by Hawking, where we argue that the conventional ‘theory of everything’ approach is likely to be superseded by one where the logic of complex systems plays a central role, aspects of reality involving complex systems underlying the familiar laws of physics in the same way that descriptions involving atoms and molecules underlie the kinds of behaviour associated with macroscopic accounts of behaviour such as that of hydrodynamics. Rather than the laws of physics being fixed in time, they emerge progressively in ways related to their effectiveness at achieving particular goals implying, in contrast to conventional physics, the involvement at a fundamental level of *meaning* and *purpose*.

In the following, the subject of coordination dynamics(1) plays a key role. It has been suggested in this context, on the basis of experimental evidence, that living systems manage complexity on the basis of an organisation involving *synergies*, a reference to groups of entities interacting with each other in such a way as to act as functional units, such functionality emerging as a result of internal interactions being modified in response to feedback, a form of learning process. What is less clear is how local ordering of this kind can result in a global construct that is very effective despite its complexity. It will be argued, on the basis of examination of the phenomenon of natural language, that what is involved here is an *evolving collection of experts working in harmony with each other*.

In this connection, the issue of the flexibility of behaviour turns out to be crucial, since inflexible systems can achieve little, but such flexibility or variability must not be excessive, since reliable behaviour demands a degree of predictability. The experts involved therefore have to achieve a reconciliation between variability and inflexibility, a key aspect of design in general. For example, as I type this document it is necessary that the characters appearing in the document should be the same as those that I type on my keyboard (inflexibility), while on the other hand the characters I that I enter are not all the same (variability). The need to achieve a fusion of these complementary aspects strongly constrains what system modifications over time may be possible. These considerations indicate an essentially mathematical aspect of design, more relevant in the context of physics than in that of biology, since uniformity in variable situations is a central characteristic of mathematics.

Linking such accounts of biological systems with fundamental physics is achieved on the basis of instructive parallels between *living systems* and *systems in equilibrium*, which share the feature of persisting over time in one way or another. The phenomenon of crystallisation makes the parallels clearer: a unit cell can be viewed as a collection (synergy), whose expertise consists in being able to organise the movements of other atoms in such a way that copies of the original are the outcome. What we envisage is a more complicated version of the same, with a range of experts working in harmony with each other as discussed. These matters will now be addresssed in more detail.

EQUILIBRIUM, EXPERTISE AND HARMONY

As already noted, equilibrium states share with life the feature of persisting over time. This persistence is not automatic, involving a complicated collection of mechanisms in the case of life. The key factor is that sustaining a given condition can involve what might be called expertise, or more generally the activity of collections of experts, each with its own speciality. Coordination dynamics, as noted, postulates organisation involving the functional units known as *synergies*, which it has been argued emerge through self-organisation processes involving feedback from the behaviour of a unit to the interactions between components.

A number of details as to how this works in practice have emerged in the field. For example, the concept of attractor is important, since the attractors of a system have fewer degrees of freedom than does the system as a whole, and it is this factor that makes the system act as a unit rather than just a collection of components behaving more randomly. But the situation is complicated in that external influences can modify the behaviour associated with the attractor, for example switching it from one type of behaviour to another, a situation known as multistability. Such behaviour has modelled mathematically in terms of an equation known as the Haken-Kelso-Bunz (HKB) equation, illustrating the point that mathematical relationships can be of considerable relevance in the context of life. Such switching modifications constitute part of the effective functioning of the system as a whole, as will be discussed in the context of natural language, by providing a mechanism for adaptability (again exemplifying the reconciliation of variability and inflexibility, since it involves a single system with the ability to function in more than one way).

There is a similarity between the organisation discussed in coordination dynamics and that of computer software, in that both involve collections of functional units working in harmony with each other. But in the case of computer software, the programmer's investigations are the source of the software. Can the organisation of life be explained in the same way? To address this issue we turn to the phenomenon of language, a system that is both effective and complicated, as well as being readily available for detailed study.

THE PHENOMENON OF LANGUAGE

The concept of a collection of experts working in harmony was inspired by study of a computer simulation of language understanding due to Winograd[2] . The software runs in a simulated 'blocks world', and has the ability to respond appropriately to quite complicated sentences, such as the question 'is there anything which is bigger than every pyramid but is not as wide as the thing that supports it?'. It was created using a functional approach to the structure of language, an approach based on consideration of the question of what it is that is accomplished by specific features of language (as opposed to the more conventional approach which just focusses on the structure of language as such). The program was designed to simulate such functionality by replicating the activity of the individual processes concerned, including the linkages between them. It might be characterised as a collection of experts (the individual functions defined in the software) working in harmony with each other, in that each expert is able to achieve its specified goals without disrupting the performances of the other experts.

It was not the purpose of Winograd's program to address the question of the development of language, but its structure and organisation gives insights into how this is likely to have happened. It is relevant at this point to introduce the ideas of Charles Sanders Peirce[(3)], who studied the concept of sign systems generally. His key idea is that such systems have a triadic character, involving a third system mediating the interactions of two others, facilitating their cooperation. In his semiotics he studied in detail various specific ways in which this process occurs, which in the present terminology might be referred to as the manifestation of *varieties of expertise*.

We suppose now that use of a language by individuals involves, as suggested by the computer simulation, the collective activity of organised collections of experts, each expert specialising in its own aspect of language. At any given time such collections are able to ensure effective communication between individuals in a way that requires the ability of the individual experts to work together (the inter-expert harmony referred to), a strong constraint. The question is then how the system is able to move from one effective collection to another. A feature of the program, with an affinity to multistability, appears to be the solution to the dilemma, in that the functioning of the program involved the systematic use of *alternatives*, each involving a default in a given situation, in conjunction with an alternative that is used if that default is ineffective. Since such an alternative is immediately available, this strategy takes up less time than would a wider search. But from the present perspective, though this was not included in the functioning of the program, the strategy additionally facilitates the evolution of the whole system, in that the availability of alternatives permits *experimentation*, the search for novelty giving rise to alternatives that, if sufficiently successful, can become the default.

This picture, based on multistability, provides an explanation of how it can be possible to have a system that is highly effective despite its complexity, since it allows for progressive evolution, moving from a relatively stable situation, involving one complicated effective mechanism, to another one based upon a modified equally effective one, with an intermediate exploratory mode for which the standards demanded are less high.

FUNDAMENTAL PHYSICS AND CIRCULAR THEORY

The question now arises as to how the above picture can be adapted to produce one where, as with Wheeler's 'observer-participancy' concept[(4)], laws of nature emerge over time rather than being absolute as in the conventional picture. Guha Majumdar[(5)] has proposed as their origin the presence of a background 'fundamental unified field', a kind of equilibrium state preexisting any universe where specific physical laws apply. Similarly Yardley[(6)] has posited a system 'pi' that 'produces stability and reliability for reality, which, in and of itself, is, markedly, unstable and unreliable'. This Yardley links to Peirce's sign theory, implying that it has the ability to respond to signs or patterns present in an appropriate manner. Such a system in the background would, like language, have the potential to evolve so as to become highly effective as an organising mechanism.

In her writings Yardley discusses a number of specifics as to the various roles that her 'pi' could play, in effect extending the analyses of Peirce. In particular she emphasises the role of bifurcations, paralleling discussions of the role played by this process in coordination dynamics. One system can become two that at the same time work together and maintain their separateness, a situation referred to as oppositional dynamics. Furthermore, when two such systems merge they can separate in ways that can be parameterised by a phase variable, the so called line-circle relationship mediated by the background 'pi', something mathematically equivalent to the pseudospins of Anderson's model of superconductivity. Yardley's writings are in essence a collection of posited pictures of the activity of natural systems, as opposed to a logical analysis, similar perhaps to the pictures in term of which biologists characterise their discoveries, but well may merit detailed attention in view of the way that they may facilitate development of the kind of proposals made here.

An intriguing phenomenon that has some parallels with the above is the observation(7) that liquid water responds selectively to auditory signals, generating a range of patterns, suggesting that water itself has states to some extent organised in ways similar to those discussed here in terms of the specificity of their responses to perturbations.

WHAT IMPLICATIONS?

Modelling consistent with these ideas should be possible in ways similar to current modelling of brain processes and neural networks, but that is for the future. However, even at this time some insights are possible. These relate in particular to symmetry and related concepts. Symmetry arises on account of the fact that if something is invariant in response to a particular set of transformations, what is learnt in one situation may be applicable in related situations if the relevant transformations are applied. It is this fact that makes it possible to be expert in a wide variety of situations, it being possible on occasion to produce this invariance by adjusting some parameter. An expert in a skill is someone who by sampling a sufficient number of instances of the skill has been able to set parameters correctly in this way. Simple invariance can in some cases be extended to invariance under the operations of a symmetry group, as can be achieved simply by achieving invariance under a set of operators that can generate the group.

The concept of manifold comes in naturally in this connection, since groups can be associated with operations upon points in a manifold embedded in a space associated with available degrees of freedom of some particular system. We can accordingly expect manifolds and symmetries to enter naturally in the present context. Symmetry breaking is also relevant because once symmetry has been achieved symmetry breaking provides additional degrees of freedom that can be explored to evolve the whole system.

CONCLUSIONS

The above has demonstrated the possibility of a radically different picture of fundamental reality to that of current orthodoxy, derived simply by adapting the kind of organisation present in life to equilibrium situations. It circumvents the usual difficulties arising in connection with the attempt to create a theory combining gravitation with the other forces by asserting that there is no unification of the conventional kind: gravity is very different from the other forces and arises from very different mechanisms, any apparent unity deriving from the presence of the postulated unifying field, which is not governed by any specific equation as demanded by the 'theory of everything' approach.

Nevertheless, some aspects of the current picture may remain valid, as for example the symmetry aspects discussed above. For example, the strings of string theory may be related to the synergetic units of the proposed alternative, and there may well be other aspects of the conventional view that can similarly be grounded in the alternative perspective presented here. On the other hand, this new perspective differs from the usual one in that in this picture we do not live in a meaningless universe, but in one where purpose has a major role, and this may have profound implications. It is hoped that future explorations, possibly involving computer simulations, will clarify such issues.

ACKNOWLEDGEMENTS

I would like to thank Dr. Mrittunjoy Guha Majumdar for discussions that acted to a considerable extent as the starting point for the ideas presented here, including those of the fundamental equilibrium state and the role played by degrees of freedom. I am indebted also to Scott Kelso and Ilexa Yardley for informative discussions.

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