A STRUCTURAL THEORY OF EVERYTHING

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ABSTRACT

In this paper it is argued that Barad's *Agential Realism*, an approach to quantum mechanics originating in the philosophy of Niels Bohr, can be the basis of a 'theory of everything' consistent with a proposal of Wheeler that 'observer-participancy is the foundation of everything'. On the one hand, agential realism can be grounded in models of self-organisation such as the hypercycles of Eigen, while on the other agential realism, by virtue of the 'discursive practices' that constitute one aspect of the theory, implies the possibility of the generation of physical phenomena through acts of specification originating at a more fundamental level. This kind of order stems from the association of persisting structures with special mechanisms for sustaining such structures. Included in phenomena that may be generated by these mechanisms are the origin and evolution of life, and human capacities such as mathematical and musical intuition.

INTRODUCTION

The quest for a 'theory of everything' may be said to have begun with Newtonian mechanics, followed by Maxwell's electromagnetic theory, then basic quantum mechanics, later quantum electrodynamics, then ultimately the 'Standard Model', which provides a unified description of the strong, weak and electromagnetic forces, and fits the experimental data well. But the task of including gravitation in the 'theory of everything' has not turned out so well, the outcome being theories that are mathematically elegant, but where there is little or no contact with experiment. Other questions also arise in connection with the idea of a theory of everything, such as whether quantum mechanics as such is applicable to biology (1), and whether or not it provides an adequate account of observation.

The difficulties cited above may be of little interest to the working physicist, but they could have a similar status to that of the 'small clouds on the horizon' that beset classical physics at one time, ultimately leading to it being superseded by quantum theory. Those difficulties accordingly merit closer attention. The approach that seems most promising in this context is the realist point of view characterising the 'agential realism' of Karen Barad (2), and the 'reality of possibility' concept of Ruth Kastner (3). The realist position differs from the usual one adopted in quantum mechanics in that it attempts to describe what actually happens in the case of *individual events*, rather than simply computing averages. The difference is apparent in the case of a typical high-energy physics experiment in which large numbers of individual events are observed. Quantum theory addresses only statistical averages, whereas one can imagine instead a theory that can describe what happens individual events. In confining oneself to statistics as is the norm, one may be missing crucial information, as would indeed happen in sciences such as astronomy. This would clearly be the case in astronomy, where for example a statistical approach to meteor showers would fail to note the occasional peaks in intensity.

The present paper attempts to go beyond the formulations of Barad and Kastner in two ways. First of all, a close affinity will be demonstrated between agential realism and certain classical models of self-organisation, such as Eigen's hypercycle model, with the conclusion that the characteristic features of the quantum domain may merely involve some possibility within the classical domain, characterised by a particular kind of order. Quantum mechanics would still remain an important area of study, but would no longer be regarded as fundamental, and study of this specific type of order would then replace particle physics as currently practiced as the premier field of study in physics. Further, in this connection it will be shown how a particular aspect of agentive realism, namely the evolution of discursive practices, can account for the emergence of specific physical phenomena, in rather the same way that discourse within a technical community leads to technical advances on the human plane. Such a picture would explain physical reality in a way totally different from the conventional one where some specific calculation would account for the details of phenomena.

INDETERMINACY

Barad's agential realism, an attempt to make sense of the quantum domain in realist terms, is a development of ideas due to Niels Bohr, where a central role is played by the concept of indeterminacy. Bohr argued that details of the quantum domain are in general not merely *uncertain*, relating to mere ignorance of the details, but *indefinite* or *indeterminate*, in the sense that treating values of variables as definite would be contradictory. For example, when a beam of light is split into two by a beam splitter and combined in such a way as to produce an observable interference pattern, we may be inclined, considering photons as particles, to ask which path was taken by an individual detected photon. But if a one of the two paths had definitely been taken by a photon, there would be no interference pattern. This contradiction implies that the question of which path a particular photon took has no acceptable answer. Bohr infers from this that one should not presume that a given assertion about a system is necessarily meaningful; rather, what can be stated meaningfully is a function of the context. Quantum particles are not like classical particles, where attributes can be presumed regardless of the context.

AGENTIAL REALISM

Barad considers it a defect of Bohr's philosophy as stated above that he gives too much priority to the situation of the physics experiment, thereby introducing an artificial distinction between experiments and the rest of nature. Furthermore, he ignores the question of *what is the case* (ontology), considering only *what can be known* (epistemology). To address these deficiencies, Barad argues that what is real is the *phenomenon*, for example an action of measurement. An aspect of such a phenomenon is the *agential cut*, referring to a separation following measurement between a measuring apparatus registering the outcome of a measurement (an *agent*), and something playing the role of an *object* of measurement. This split is something that can happen in the context of a measurement, but the process described is hypothesised to be a more general possibility, producing in effect a subject-object split.

Furthermore, as noted by Bohr, we would be wrong to treat measurement as being a measurement of some abstract entity such as position; rather the physical apparatus related to the abstraction is primary, and only as a limiting case does the measurement that the apparatus delivers correspond exactly to a concept that we may have such as position or momentum. In the case of scientific measurements, the design of the measuring instrument is guided the intent to measure some existing parameter, but this need not be the case in general; rather, a concept associated with an agent emerges over time as the agent evolves.

We can, if we wish, view the situation in the following terms. A quantum particle is not like a classical particle, but more like a swarm of insects or birds, where while we can be definite that the entity exists, ascribing to the entity concerned it a definite position or velocity is not permissible. Further, there can at times be a phenomenon analogous to a cut, involving the appearance of a further distinguishable entity, or in general a structure of some kind.

Structures that emerge in this way, are structures within the total phenomenon and contingent upon it, and cannot be viewed in isolation just as, in the same way, quasi-particles in a medium, and their interactions, are features of that medium and cannot be understood in isolation. Dependence on the background applies equally to *relationships* between structures.

THE PRIORITY OF RELATIONSHIPS

According to Barad, *relationships precede relata:* relationships are prior to things that are related. This may seem mysterious at first sight, but becomes less so if we recognise that relationships depend on specific schema. Just as entities emerge under which entities tend to sustain themselves, there are contexts in which particular schemes of interaction assist entities in sustaining themselves. One might characterise this state of affairs by saying that in them the advantages of particular design principles are being manifested.

DISCURSIVE PRACTICE

The analysis can now be taken one step further, taking into account the fact that the activity of one structure may systematically influence others. This introduces the idea of a distinction between *information* and the *influence* of that information. Such a distinction involves a kind of symmetry breaking, where one entity starts to exert control over others, so it becomes a supplier of information to other systems. A further subtlety is Barad's concept of *discursive practice*. For information transfer to be able to be effective at achieving some outcome, information must be processed in accord with enduring specific rules, and it is the behaviour associated with the application of such rules that Barad terms discursive practice.

We now consider discursive practice and its evolution in more detail. For communication between two entities to be effective, they must share a language or discursive system, an integrated entity that may involve and evolve many components, some of which involve discursive activity itself, whilst others relate this discursive activity to the context of its use, in other words to non-discursive practices. Discursive activity is a form of measurement process, with discourse relating to what control may be possible. Thus evolution of discursive practice is related to the emergence of new mechanisms for control.

Discursive practices are closely linked with *concepts*. Earlier we noted Bohr's comment that while position, for example, appears to be a well-defined concept, a word such as position has meaning only to the extent that we are able to say what the position of something is with some appropriate apparatus. The same applies to relationships, which are similarly entities that can be characterised with suitable apparatus or perceptual equipment. Discourse adds precision to this state of affairs, as for example by the way it permits the formulation of rules and to define relationships and processes. In the case of human society, discursive practices have reached a very high level of development, and our discussion of the emergence of physical laws will invoke the possibility of similar evolutionary development in the quantum domain.

THE ACTIVE ASPECT OF MATTER

Barad views matter as something active, configuring its surroundings so as to continue to function effectively ('concerning itself with what matters'). Activity as such is by no means an unorthodox presumption, since omnipresent activity is familiar both in classical physics, in the context of molecular motion at finite temperatures, and in the case of quantum-mechanical zero-point motion. And in the biological context, matter configuring its surroundings appropriately is equally familiar. What is new here is simply the idea that the quantum domain involves similar configuration processes.

Eigen's discussions of biological self-organisation (4) are relevant in this context. The question he addresses is how the complicated molecular systems found in biology can sustain themselves and also evolve. He concludes that a structure known as a hypercycle plays a crucial role, being able for example to utilise small selective advantages and to be able to evolve quickly on the basis of the selective advantages that favour self-sustaining systems.. Hypercycles, involving a closed cycle of information carriers coding for functional systems that generate the information carrier next in the cycle, can also develop branches exhibiting various functionalities, with a common element allowing the branches to coexist. Computer simulations have demonstrated the validity of such conclusions.

Eigen's models involve molecules, but the principles involved could be equally relevant in the context of agential realism, provided that structures with corresponding features exist. There seem to be no fundamental reasons why this should not be the case, especially in a system close to an instability, where non-linearity would be conducive to structure formation.

Hankey (5) has arrived at conclusions somewhat similar to those of Eigen, along the following lines. A system that performs a sequence of changes can develop an instability if some end product is similar to the starting situation, thereby allowing the cycle to be repeated. The existence of such cycles can be probed by a general increase in the effective gain, and when such cycles emerge changes can be made to enhance the extent to which they are self-sustaining. Such self-sustaining cycles are then readily available for use in other situations. Learning in general is known to involve similar cyclic processes (i.e. the repetition that typically forms an integral part of the learning process).

THE SELF-MAINTENANCE PRINCIPLE

Implicit in the above discussion is the principle of *self-maintenance*, namely that what is present in a situation is in part determined by what can maintain itself. From this it can be anticipated that entities exhibiting effective principles of self-maintenance will also be found, and that these principles may well involve the way such entities interact with other entities. This proposition is, clearly, relevant to biology, and the principles of agential realism can equally be viewed in this light. For example, the agential cut can be seen as a strategy where differentiation into subsystems has a value in that two cooperating systems, relating to each other and developing in accord with particular schemes, may be able to achieve more than can a single system.

RELATIONSHIP TO THE POSSIBILIST INTERPRETATION OF QUANTUM MECHANICS

In Kastner's 'possibilist interpretation' of quantum mechanics (3), the collapse of the wave function associated with observation is interpreted as the outcome of a *transaction* with a *possibility*, which outcome makes something definite, in the same way as in the present analysis. Possibilities are things that can be considered real, but are not necessarily *actualised*, which state of affairs Kastner equates with existing 'within the observable spacetime theater'. The theory developed here can accommodate possibilities but in a different way, namely as *aspects of discourse* rather than something real. In this way, Kastner's transactions with possibilities translate into discourse involving possibilities, of which some may subsequently be realised.

EVOLUTIONARY AGENTIAL REALISM

John Archibald Wheeler, in his article ‘Law without Law’ (6), explored the hypothesis that the ‘observer-participancy’ of quantum mechanics (equivalent to the measurement process discussed in the above) could be the basis of a new science that could replace the existing ‘imposing structure of science’. The above considerations leave us in a position to understand how this might be achieved. The new picture involves agents evolving more and more advanced concepts over time, instantiated by evolving discursive practices along the same lines as those involved with cultural evolution. The basic mechanics of evolution would be the same, only the context in which that evolution would take place being different. With cultural evolution, we start with regular physics and chemistry, and with nervous systems already preprogrammed with mechanisms for developing along particular lines. Here we start with a system that knows essentially nothing, but which can explore and learn, provided the initial physics supports the kinds of structures and relationships that are required.

As to details, what we know about how children come to make sense of the world is arguably relevant, since they also start knowing almost nothing. Piaget (7) made systematic studies of the incremental changes that occur during development, each of which can be identified with the coming into operation, and utilisation, of a new module. An example is the development of the object concept: at a certain stage in a child’s development an object that is covered up so it is no longer visible is treated as if it no longer exists: for example it will stop trying to reach it if it had been trying to reach it previously, but later new resources become available and actions directed towards the object continue even when it cannot be seen. There is a clear logic to the sequence of the incremental changes (8), as a consequence of the way existing skills need to be operational before new ones can be acquired. The computer model of Osborne (9) exemplifies such an incremental process.

As regards the actual mechanics, what has been discussed so far suggests the following picture. From an initial hypercycle the developments envisaged by Eigen and Hankey can occur, with new concepts being established through the mechanisms envisaged by Bohr and Barad, whereby some apparatus becomes more and more representative of particular concepts over time. The fact that this process involves the use of the mechanisms corresponding to a concept implies in effect that it is the most useful concepts that get developed in this way. Familiar examples in childhood development are those of an object, and number, which get clearly defined though apparatus that deals with reality in such terms.

As regards space, we recall that geometry developed originally through the study of manipulations involving actual movements in space, and we can imagine the agents of agential realism acquiring spatial concepts in the same way. Barad considers space not as ‘a collection of preexisting points set out in a fixed geometry, a container … for matter to inhabit’, but rather as the concomitant of a collection of interactions within a system (referred to by her as *intra*-actions), referred to as a topology. How this topological structure is related to ordinary geometry is not discussed, but given the relevance that symmetry groups have in geometry, one possibility would be that concepts of transformation and invariance play a role, in conjunction with group properties defined in terms of transformations, which together can serve to delineate a geometry. Our subtle agents are presumed to be able to work on the basis of such concepts to shape a geometry to fit particular specifications. Barad notes that relationships develop prior to space, justifying the possibility of relationships existing irrespective of spatial relationships, as happens with the EPR paradox.

Ultimately, discourse evolving in the manner described can come to cover techniques for creating particular kinds of universe, and particular kinds of life in such universes. Such partly directed behaviour could have relevance to questions such as the origin and evolution of life where, perhaps as a consequence of the influence of Monod’s writings (10), it has traditionally been assumed that there is no preferred direction or meaning in the universe.

LINKS TO HUMAN CAPACITIES

This picture may in addition be able to account for human skills such as mathematical and musical intuition, which are hard to explain on conventional grounds there being little to account for the selectivity of aesthetic judgements in music (11), or similar ability to discern mathematical truth, on evolutionary grounds. These may reflect functional mechanisms at a deeper level, to which human mentality has access.

CONCLUSIONS

The conventional picture is that cognitive processes derive from biology, which itself derives from physics and chemistry, which again derive from some deeper physics such as string theory that has minimal contact with experiment. Quantum mechanics is assumed rather than derived. In the present approach the idea of a self-sustaining system is primary, manifesting itself in universal basic forms that can combine together in complex ways. Specific principles related to systems being self-sustaining then come into play, including differentiation into units, and protocols relevant to relationships between units. These include the use of discourse, with its ability relate to reality in ways that can readily generalise. Physical laws then emerge as concomitants to prescriptive discourse, in the manner discussed above.

There are some parallels between the present situation and that which prevailed at the time when the atomic theory was being developed. The latter postulated a deeper reality capable of accounting in simple terms for a number of phenomena (such as the specific heat and thermal conductivity of gases) that were, at that time, characterised in purely mathematical terms with no underlying model. Taking the hypothesised deeper reality seriously led to considerable advances in science, and the same may apply to the present proposals. While this the view presented here is very different to the usual one, there is nothing irrational about it; it merely contradicts ideas that are commonly held, which ideas would be irrational themselves if held as dogma. Clearly, the synthesis described here is far from complete, and it must be for the future to examine the proposals in detail to assess their relevance and validity.

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