How is emergence possible[1] ?

The impact of quantum physics on a philosophical concept

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Abstract : *At the beginning of the twentieth century, "emergence" appeared as a philosophical concept aimed at taking a middle way between reductionism and vitalism. But since the "basis" of any emergent process is supposed to be physical, the evolution of physics proves highly relevant to our conception of what emergence consists of. In this paper, I first review some recent attempts at rescuing the idea of emergence by relying on quantum mechanics. I then show that a proper reading of quantum mechanics forces us to change deeply our view of what emergence is, in order to allow it at all.*

Introduction

Are there truly *new* high level *properties* arising from nothing else than a large number of interacting low level components none of which possess these high level properties when taken in isolation?

In this question, the problem is formulated in somehow metaphysical terms. Those who raise it want to know whether there truly *exist* such emergent large-scale properties ; they want to know whether these large-scale properties *are* more than just epiphenomena. This ontological formulation of the

[1] A former version of this paper was intended as part of my contribution to the Mind & Life meeting in Dharamsala (India) in october 2002 with H.H. the Dalai-Lama. More developed versions of the same line of argument can be found in M. Bitbol, "Ontology, matter and emergence", *Phenomenology and the Cognitive Science*, 6, 293-307, 2007 ; M. Bitbol, "Downward causation without foundations", *Synthese,* 185, 233-255, 2012

problem of emergence is not surprising in view of its historical motivation. After all, the concept of emergence was invented in order to find a satisfactory compromise between two extreme ontologies. The first of these two ontologies is monist and materialist: it says that there exist nothing else than material elements and their properties. The second ontology is dualist: it says there are two substances or two realms of being: mind and matter, or life and inanimate matter. Emergentism aims at finding an ontological "middle course" (Lloyd Morgan, 1923) between the monist materialist and the dualist ontologies. But being a middle path does not preclude showing a little bend towards one or the other of the two extremes. Emergentism thus comes closer to dualism when it tries to endow the emergent properties with some sort ontological consistence, and with causal powers of their own.

Obviously, it is the latter strong version of emergence that is interesting. But as we shall see, its exceedingly high ambition is also its major weakness. No convincing proof of there being genuinely, ontologically, emergent *properties* can be given. Even less so when one believes that the basic constituents of the world are little things (say the elementary particles) endowed with intrinsic properties. My conclusion will be that if there is a viable middle path, then it is definitely non-ontological; it presupposes a thorough criticism of ontological claims *at every single level of knowledge*. I will support it by arguments drawn from quantum mechanics.

Let me first examine how other authors (Silberstein and McGeever, 1999 ; Humphreys, 1997 ; Kronz and Tiehen, 2002) have tackled the problem of emergence in the framework of Quantum Mechanics. They did so because, in the face of a series of negative arguments against "ontological emergence", they concluded that

the only plausible candidate for true emergence occurs as a typically quantum configuration, namely *non-separability*.

In the same way as, in classical physics, *non-additivity* yields emergence of (apparent or real) new features on a permanent ground of elementary parts, in quantum physics *non-factorizability* yields emergence of (allegedly real) new features wherein the initial elements are so to speak resorbed. This quantum situation, in which the state of the whole seems to determine the state of the parts rather than the other way around, utterly contrasts with the usual assumption of "supervenience" according to which the state of the parts determine the state of the whole. With this idea of Quantum Mechanics in mind, a stimulating view of "ontological" emergence was formulated. Assuming a hierarchy of levels of properties, P. Humphreys suggested that properties at the higher level can arise from the "fusion" of two or more properties at the lower level (Humphreys, 1997). Here "fusion" is taken literally, since it means "disappearance" of what is fused within a new entity. This being granted, the lower level properties can have *no causal effect of their own,* because they no longer exist after the fusion. The only properties that have a *direct* mutual causal connection are the fused properties of high level. If some causal connection between two lower level properties nevertheless occurs, it does so through the mediation of a complex process involving the upper level, followed by the *splitting* of the upper level properties into a plurality of lower level properties.

Within this frame of thought, the only genuine causal process is the one that takes place at the higher level of organization. The *splitting* of the upper level properties into lower level properties then generates a mere *appearance* of causality at the lower level. Here, the distribution of the qualifyers "apparent" and "real" is turned upside down: the emergent process is *real*,

whereas the process involving "basic" elements is only *apparent* since it is mediated by the upper level. This means ontological emergence in the strongest sense of the word: the only real process is the high level one. But of course, some difficulties arise at this point. Let me develop two of them.

To begin with, no quantum formalism (neither Quantum Mechanics nor Quantum Field Theory) substantiates the idea of a complete *disappearance* of the many parts within the whole. In standard Quantum Mechanics, the parts still play a role as a set of labeled subsystems mutually correlated by the rules of symmetrization (Bosons) or antisymmetrization (Fermions). And in Quantum Field Theory, the observable "Number" takes on values which are usually greater than one. An order of multiplicity persists in spite of the holistic feature of non-separability. Yet, on the other hand, the parts are usually indistinguishable. They have an identical function within the overall system, and they cannot thus be identified individually with some element which existed *prior* to the compound system. To sum up, in the quantum paradigm, there is a mutual relation of co-arising between the whole and its parts. The many parts are still taken as constitutive of the whole, but at the same time the whole is irretrievably involved in the definition of the parts since no independent characterization of each sub-system can be given. This remark on the quantum theory of wholes and parts gave rise to a conception called "dynamical emergence" (Kronz and Tiehen, 2002). It represents a compromise between "radical emergence" (the fusion view) and prototypical emergence (the usual view of pre-existing parts).

The second difficulty concerns the concept of *property* which, in a quantum theoretical framework, is either inappropriate or completely redefined with respect to its classical and everyday counterpart. Instead of features that can properly be ascribed to

objects themselves, quantum mechanics manipulates interactional observables. The widespread use of the word "property" without qualification by the philosophers of emergence is then utterly misleading, and this challenges virtually every step of their thought process about quantum emergence.

Now, in the absence of true intrinsic properties at the high level of holistic correlation observables, and at the low level of individual observables as well, it is plainly wrong to assert that Quantum Mechanics displays "ontological" emergence. What emerges is only a radically new mode of possible *cognitive relation* between the microscopic environment and the available range of experimental devices. Here again, the concept of ontological emergence cannot be sustained. But this apparently disappointing dismissal of intrinsic emergence is pushing us toward a very positive conclusion after all.

For, although one can lend no credit to the idea of "ontological" emergence, including in Quantum Mechanics, this does not mean at all that the reductionists are right to declare that only the elementary constituents and their low-level properties do *exist*. Deconstructing the formal concepts of substance and of property in Quantum Mechanics proves precisely as challenging for the reductionist as it is for the supporter of "true" emergence of high level intrinsic properties. Indeed, the physical process may have no substantial roof of emergent properties, it has no substantial ground of elementary properties either, according to the most straightforward reading of Quantum Mechanics. Features *at every level* are interactional observables, *not intrinsic properties*, and this ensures a perfect equivalence between elementary features and global emergent features.

A more detailed way of entering this new trend of thought, which combines emergentism with non-substantialism, consists in criticizing a very widespread distinction between "emergent" and

"basic" features instituted on the ground that emergent features are essentially *relational* whereas basic properties are allegedly *monadic*. T.W. Deacon, for instance, makes an extensive use of this hypothetical difference. When he asks "What emerges?", his "(...) answer is not some 'thing' but rather something like a *form* or *pattern* or *function*" (Deacon, 2003). The features that "really" emerge are collective "topologies" or "configurations" according to Deacon. This enables him both to endow emerging features with some sort of autonomy at the purely topological or relational level, and to retain the "fundamental" status of the basic constituants of the world and their "substrate properties".

But what if the so-called "substrate properties" happen to be just as much configurational as the high level features? In this case, here again, any asymmetry between the components and the resulting emergent features would vanish.

This argument was developed by some philosophers who have a good grasp of the situation in contemporary physics. Thus, Bickhard and Campbell, (2000) pointed out that "According to our best science, there are no elementary 'particles' or basic particulars at all (...) What have seemed to be 'particles' are now conceptualized as particle-like processes and interactions resulting from the quantization of field processes and interactions". Instead of substantial individuals, Quantum Field Theory deals with *types of patterns* similar to the familiar vibration modes on violin strings.

Therefore, even from the standpoint of a difference between properties and configurations, there is no essential difference between the alleged "basic" level and the emergent levels. Every level of organization which falls within the domain of study of physics is thoroughly relational. And no level can claim for itself the privilege of being *for sure* the ultimate one; ultimate *and* monadic. Several arguments and

reflections thus converge towards the conclusion that *the world of physical phenomena is groundless throughout*. Nowhere can one locate in it an ultimate level of absolute being.

Along with these remarks, it becomes clear that the difficulties and paradoxes of emergence arise from a desperate attempt at taking a wrong conception of the low level as a model for the high level. If the low level is allegedly made of substantial particles endowed with intrinsic properties, then in order to raise the high level to the same standard of dignity as the low level, one unavoidably asks for true emergent intrinsic properties. But if indeed the whole process is *groundless throughout,* then there may be emergence without emergent properties. Not asymmetric emergence of high-level properties out of basic properties, but *symmetrical co-emergence* of microscopic low-level features and high level behavior. Not emergence of large scale absolute properties out of small scale absolute properties, but *co-relative* emergence of phenomena. These phenomena, in turn, are to be construed as relative to a certain experimental context, with no possibility of separating them from this context. The notion of emergence thus gains credibility at the very same time as it loses ontological content.

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