Essay

Quantum Entanglement & the Implicate Order

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Abstract

In this essay, we debate, from conceptual point of view, the relationship between quantum entanglement and the implicate order theorized by David Bohm.

Keywords: Quantum entanglement, implicate order, David Bohm.

1 Quantum Entanglement and the Implicate Order

Before to introduce the possible link between QE and the IO, we need to analyze the concept of IO. Historically Bohm proposed originally in 1951 (Bohm, 1951) the ontological interpretation of QM based on an interpretation of quantum theory and later developed especially in cooperation with his long-time colleague Hiley (Bohm,Hiley 1993).

Bohm[2]felt that the ontological interpretation can do two things to make the IO more specific: firstly, to show how the explicate order arises out of the IO, and secondly, to provide a more specific idea about how mind and matter are related. According Pylkkänen (Pylkkänen,2007):

> To see how the explicate order arises out of the IO, it is useful to consider the "field theory", that is, the ontological interpretation of the electromagnetic field. Roughly, one thinks of the electromagnetic field being in an IO (as we indeed mentioned above when saying that the movement of light waves in, for example, every region of the

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[2]Buckley-Peat (Buckley, Peat 1996) Bohm explain to connection between QM and the notion of observer: This idea of implicate and explicate order obviously involves wholeness, because, in the IO, everything has its origin in the totality, it is folded into the totality. Moreover, the separation of the observer and the observed is no longer basic in this view. **The observer is essentially an IO, and so is the observed**. Everything that is observed is really the intersection of two streams of energy: one stream which belongs to the thing observed, the other which belongs to the observer. The 'phenomena' are the result of the intersection of these two streams. Both streams come ultimately from the same total reality. It suggests a structure in which mind and matter are not very different. Anyone can see that our thought has this character, that a large part of it is implicit or folded up. When one part is explicit, a tremendous amount is implicit. This IO is common to mind and to matter, so it means that we have much of a parallelism between the two sides. The things which are well defined and explicate have to be seen as special features of the IO. The underlying reality is the IO, and the explicate order is a very special case of the IO.

> room enfolds information about the whole room). When one applies the ontological interpretation of quantum theory to this field, one then sees how the explicate order arises. The explicate order here is the famous "quantum", that is, a bullet of light, which in Bohm's theory has to be seen as a momentary, particle-like manifestation, rather than as a continuously existing particle. This, of course, is very much in the spirit of what we have said above about the IO.

Bohm in his paper (Bohm,1990)[3] developed in detail the notion of IO. His essential idea is that the whole Universe is in some way enfolded in everything, and that each thing is enfolded in the whole. According Bohm, everything enfolds or implicates everything. In his words:

> The basic proposal is then that this enfoldment[4] In this sense, the whole universe is enfolded in everything, and everything is enfolded everywhere in the whole universe. The IO thus prevails as the most fundamental order of the universe currently known to us relationship is not merely passive or superficial. Rather, it is active and essential to what each thing is. The external relationships are then displayed in the unfolded or explicate order in which each thing is seen, as has already indeed been indicated, as relatively separate and extended, and related only externally to other things. The explicate order, which dominates ordinary experience as well as classical (Newtonian) physics, thus appears to stand by itself. But actually, **it cannot be understood properly apart from its ground in the primary reality of the IO**. Because the IO is not static but basically dynamic in nature in a constant process of change and development, I called its most general form the holomovement. All things found in the unfolded, explicate order emerge from the **holomovement**[5] in which they are enfolded as potentialities and ultimately they fall back into it. [.....] It takes only a little reflection to see that a similar sort of description will apply even more directly and obviously to mind. The general implicate process of ordering is **common both to mind and to matter**[6]. This means that ultimately mind and matter are at least closely analogous. Therefore, it seems reasonable to go further and suggest that the IO may serve as a means of expressing consistently the actual relationship between mind and matter without introducing something like the Cartesian duality between them.

[3]In that article Bohm to provide a basis for a non-dualistic theory of the relationship of mind and matter.

[4]This idea of "enfoldment" of the whole universe in each part, resonates with Leibniz's idea of monads. According Bohm the enfoldment is taking place in a wide range of domains, each region or "part" of the universe enfolds information about the whole universe.

[5]Accordin Pylkkänen the IO is not static but rather basically dynamic in nature, in a constant process of change and development. This is why he called its most general form the holomovement. Bohm's ontology takes movement as fundamental, and here he connects with the tradition of "process philosophers" from Heraclitus to Whitehead. Bohm's IO ontology contrasts with the ontology that has been prevalent in Western philosophy and science. This is **the atomistic ontology,** which assumes that everything consists of some fundamental elements (i.e. particles and/or fields) that are only externally related to each other. Atomistic ontology dominates much of contemporary science and philosophy. Bohm claims that physics strongly suggests that the atomistic ontology does not fit with the experimental facts of relativity and quantum theory. If he is correct, we need a new more fundamental ontology or theory of reality, and this is indeed what he tried to develop. He also thought that the IO framework can be extended to the domain of biological and psychological phenomena, making it into a proposal about the general architecture of existence as a whole, instead of just about physical existence.

[6]Bohm was led to propose that the general implicate process of ordering is common to both mind and matter.

Accoding Bohm the Non-locality (Bell's Inequality violation) lead us to new notion of quantum wholeness which implies that the world cannot be analyzed into independently and separately existent parts. **Quantum wholeness is what is primary.** In particular, such wholeness means that in an observation carried out to a quantum theoretical level of accuracy, the observing apparatus and the observed system cannot be regarding as separate. Rather, each participates in the other to such an extent that it is not possible to attribute the observed result of their interaction unambiguously to the observed system alone.

With Bohr, he shared the view that quantum theory emphasizes undivided wholeness, as well as the more philosophical idea that it is important to carefully consider the role of language and communication in physics. According Bohm, Bohr treats the entire process of observation as a single phenomenon which is a whole that is not further analyzable. For Bohr, this implies that the mathematics of the Quantum Theory is not capable of providing an unambiguous (i.e., precisely definable) description of an individual quantum process. But rather, it is only an algorithm yielding statistical predictions concerning the possible results of an ensemble of experiments. Bohr further supposes that no new concepts are possible that could unambiguously describe the reality of the individual quantum process. Therefore, there is no way intuitively or otherwise to understand what is happening in such processes. Only in the Newtonian limit can we obtain an approximate picture of what is happening. And this will have to be in terms of the concepts of Newtonian physics. Bohr's approach has the merit of giving a consistent account of the meaning of the Quantum Theory. Moreover, it focuses on something that is new in physics (i.e., the wholeness of the observing instrument and what is observed). The question is clearly also of key importance in discussing the relationship of mind and matter. But Bohr's insistence that this wholeness cannot be understood through any concepts whatsoever – however new they may be – implies that further progress in this field depends mainly on the development of new sets of mathematical equations without any real intuitive or physical insight as to what they mean apart from the experimental results that they may predict. It seems very important to question Bohr's assumption that no conception of the individual quantum process is possible.

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