Non-quantitative hidden variables

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Abstract

I report some excerpts from the book on Quantum Mechanics by David Bohm, where he describes the entanglement. In particular, I notice how Bohm point out the implicit assumptions usually accepted when the hidden variables are discussed. In a footnote Bohm mentions the implicit assumption that the hidden variables are supposed to be *quantitative*. The goal of the present notes is to show how the idea of non-quantitative hidden variables matches well with the recent suggestion of Faggin ad D'Ariano about the quantum nature of consciousness. (version: 2025-08-04 01:25)

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> "Quality and quantity are fairly generally regarded as complementary terms, although the profound reason for their complementarism is often far from being understood [...]" [Gue45]
>
> Rene Guenon - Le Règne de la Quantité et les Signes des Temps

1 Entanglement - the premise

EPR The first reference to the *problem of entanglement* (although not called with this name) was risen by Einstein Podolsky and Rosen [EPR35]. It was mentioned as a demonstration that Quantum Theory was not complete. In the EPR paper, the idea of *hidden variables* was suggested as a solution to the "quantum oddity". (For a clear discussion of the entanglement I suggest [WM08, §13.1, p. 247-248])

Bell In '64 John Bell managed [Bel64] to express the problem in a way which was *experimentally testable*. Indeed, EPR had formulated the problem in a conceptual way. On one hand there was the *hidden variable theory* of which EPR had suggested the existence; on the other hand, the Quantum Theory was presented as an alternative description, the conceptual difference being the probabilistic or deterministic description of reality. The contribution of Bell was to find a *point of contact* between the two descriptions, *i.e.* a specific quantity, which can be formulated using the two different descriptions, but which has a different, unreconcilable value in the models. Moreover, this quantity can be experimentally measured, and in general a result will be compatible with only one of the two models.

One important remark is that the theorem discriminates between Quantum Theory (QT) and a *Local* Hidden Variables Theory (LHVT). This means that a Non-Local Hidden Variable Theory is compatible with the description of QT.

2 Information theory

The reductionist epistemic paradigm can not conceive the existence and/or the reality of consciousness. It is considered as an *epiphenomenon*. In the reductionist paradigm, the idea that can be discussed, and that goes as close as possible to the idea of consciousness is the idea of *information*. Information theory has been devised by Shannon [Sha48] and has been further developed to describe quantum systems [NC01, Gra15]. Faggin gives a detailed discussion on the difference between information and consciousness [Fag24].

3 Excerpts from Bohm

[Boh51]
Chapter 22, "Quantum theory of the measurement process"

3.1 The enunciate of the paradox

[Boh51, pag. 612]
Section 15: "The Paradox of Einstein, Rosen, and Podolsky." [EPR35]

"[...] It seemed to them that a necessary requirement for a complete physical theory was the following:

1. Every element of physical reality must have a counterpart in a complete physical theory. As to what actually constituted the correct elements in terms: of which physical theory should be expressed, they felt that this question can be decided finally only by recourse to experiments and observations. They nevertheless suggested the following criterion for recognizing an element of reality, which seemed to them a sufficient criterion:

2. If, without in any way disturbing the system, we can predict with certainty (i.e., with probability equal to unity) the value of a physical quantity, then there exists an element of reality corresponding to this physical quantity. The authors agreed that elements of physical reality might well be recognized in other ways also, but they intended to show that even if one restricted oneself to elements that could be recognized by means of this criterion alone, quantum theory as now interpreted led to contradictory results. The use of the above explicit criteria rests, however, on certain implicit assumptions, which are an integral part of the treatment given by the authors, but which are never explicitly stated. These assumptions are:

3. The world can correctly be analyzed in terms of distinct and separately existing 'elements of reality,'

4. Every one of these elements must be a counterpart of a **precisely defined mathematical quantity** appearing in a complete theory (see footnote)."

The footnote reads:
« In Sec. 18, we shall make the alternative assumption that elements of reality exist in a roughly defined form and **do not necessarily have to be counterparts of precisely defined mathematical quantities** appearing in a complete theory. Thus, we shall give up the implicit assumptions (3) and (4).»

3.2 The assumptions

[Boh51, pag. 619]

«These assumptions, which are at the root of all classical theory, might perhaps be called the hypothesis that reality is built upon a mathematical plan, for it is required that every element appearing in the real world shall correspond precisely to some term appearing in a. complete set of mathematical equations. Although such a hypothesis seems quite natural to us at this time, it is by no means inescapable (see footnote). »
The footnote reads:
«Historically speaking, it is a comparatively **new idea**, having arisen in connection with the great success of mathematical analysis in mechanics and electrodynamics during the period between the sixteenth and early twentieth centuries.»

3.3 Bell

Bell published articles formalizing the ideas of EPR, using the simplification of Bohm, and proving that if the Bell inequality holds, no hidden variables can exist [Bel64]. However, the hidden variables formalized by Bell, although not characterized in any way, and being *unknown* by physical description of reality, are used as argument of integrals. Therefore, there is the implicit assumption that they are quantitative.

4 My contribution

I advance the hypothesis that a good candidate for "non quantitative hidden variables" are the *qualia* described in cognitive science , which can be briefly defined as "the elements that we perceive within our consciousness" [Cha95, Fag24].
It is relevant the following excerpt from [Fag24]:
"Our consciousness is the inner semantic space where the signals coming from the physical world, both inside and outside the body, are "processed" by the brain and take the form of feelings, sensations, and meanings, i.e., of qualia."

4.1 Literature on consciousness

4.1.1 Consciousness, qualia

[Lew29, Cha95, Dam99]

4.1.2 Qualia as pure states of Quantum Mechanics

[DF22]

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