SOME NOTES ON THE DIFFERENCE BETWEEN INTERACTION AND MEASUREMENT [DRAFT]

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ABSTRACT. In this paper I present some reasons to adopt an holistic point of view, eliminating a boundary subject/object in the measurement. I review shortly Everett’s and Cramer’s positions, casting light on their flaws, to introduce a logical motivation to thinking to an experiment as a totality in which everything is entangled.

1. Everett

The idea to consider as starting point a totality is not new, neither in the field of Quantum Physics. I could make the name of Bohr, but after him, it was supported by Everett and Cramer. For many reasons, however, they failed to appreciate their own intuitions. For example, Everett introduces a relativistic theory to eliminate the concept of external reality:

\[
\text{...every system that is subject to external observation can be regarded as part of a larger isolated system.}\]

But in such a larger isolated system,

\[
\text{there is nothing outside the system to observe it. There is no place to stand outside the system to observe it. There is nothing outside it to produce transitions from one state to another.}\]

This way, Everett denies the existence of a boundary (shifty or not) between observer and observable. There is a system (a totality) in which everything happens. There is no action from an observer (subject) towards an observed system (object).

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\[\text{[III57, p. 455]. The embolding is mine. In this context it is useful remember John von Neumann which distinguishes two type of operations \{Eingriffen\} on Quantum Systems or on manifolds of Quantum Systems: Wir haben also zwei grundverschiedene Arten von Eingriffen, die an einem System S oder einer Gesamtheit \{S_1, \ldots , S_N\} vorgenommen werden können. Erstens die willkürlich Veränderungen durch Messungen (…) Zweitens die automatische Veränderungen durch den Zeitablauf (…) [vN32, p. 186]. We therefore have two fundamentally different types of interventions which can occur in a system S or in an ensemble \{S_1, \ldots , S_N\}. First, the arbitrary changes by measurements (…) Second, the automatic changes which occur with passage of time [WZ83, p. 553]. The effort of Everett is to subsume the first type of intervention in the second time, avoiding the problematic concept of something external to the observed system.}\]

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\[\text{[III57, Iv]. The embolding is mine. In this passage, Everett is questioning the necessity of an external observation to collapse a wave-function. Given a system S, Cramer confounds the necessity to have another system S’ with which S interact, with the problem of the observer-measurer. The wave-function collapses with a simple interaction. [Oza03, p. 117]. On the contrary, the measurement is in a meta-level as regards the interaction. See my [Bon10c]. The observer cannot collapse directly the wave-function, by only arranging the experiment in which such collapse happens.}\]
There is an interaction. Inside it and only inside it we can speak of observer and observable. In this sense, the interaction is prior at least ontologically to the disarray between subjective and objective side.

We are in perfect agreement with Everett on this point. But, some pages after, he ruins his theory, contradicting himself. There is no boundary in our world (in the phenomenon of our world) but between our world and others worlds. With the collapsing, the system is in an eigen-state, say, $|\varphi_i\rangle$; but the original wave-function was a sum of more states. What about them? With the collapse, our world splits itself in many worlds, one for every possible eigen-state belonging to the primitive wave-function. In our world, the observable is in an eigen-state $|\varphi_i\rangle$, in other worlds, is in an eigen-state $|\varphi_j\rangle$, in another $|\varphi_k\rangle$, etc. The wave-collapse is so at the origin of a branching, every branch standing for an alternative world:

\[ (... ) \text{ there is no single unique state of the observer } (... ) \text{ there is a representation in terms of a superposition, each element of which contains a definite observer state and a corresponding system state. Thus with each succeeding observation (or interaction), the observer state “branches” into a number of different states. Each branch represents a different outcome of the measurement and the corresponding eigenstate for the object-system state. All branches exists simultaneously in the superposition after any given sequence of observation.} \]

So, according to Everett, the superposition of states in the wave-function has as a consequence a superposition of eigen-states, each living in its world. And any inhabitant of a world is unaware of the existence of the other worlds:

\[ (... ) \text{ no observer will ever be aware of any “splitting” process.} \]

This means that Everett’s effort to eliminate the boundary and the presence of an external reality fails. There is no more a boundary in a single world, but there are many boundaries between the many worlds belonging to the different branches. Yet, it is difficult to grasp the meaning of something external to the subject, now it is required to think to something external to an entire world. I think that Everett simply moves the boundary observer/observable from one place to another.

Despite, his interesting starting point, Everett’s theory ends to re-introduce the concept of external reality in another place of the theory.

2. Cramer

John G. Cramer starts willing to vindicate the Copenhagen Interpretation referring to Everett’s theory of many worlds. In Cramer’s theory, we have an emitter and an absorber. The first send a wave to the absorber; this answers with an echo-wave. From the matching of retarded waves (from the emitter) and advanced waves (from the absorber) it arises the quantum event. The event has its source in the interplay of emitter and absorber. Therefore, we cannot say that the transaction starts from the emitter to arrive at the absorber. But it is transaction to define its point of departure and the its point of arrival. No causal arrow.

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3[III57, p. 459]. The italic is Everett’s.
4[III57, p. 460].
5Cramer doesn’t approve the branching originating the wave-collapse of Everett’s theory, but he is a supporter of a relational way aiming, as in Everett, at to renounce to the reference to something external to the subject.
Nevertheless, Cramer in a way or another is compelled to explain the direction of the transaction. He affirms that it is arrow-less, but then, how describing the flow of a process? There is no causal arrow, but a time-arrow.\footnote{This facet is very puzzling, as Cramer denies a direction of the time.}

(...) in the transaction model the emitter is given a privileged role because it is the echo received by the emitter, rather than that received by the absorber, which precipitates the transaction. Thus the past [where the emitter lays] determines the future [where the absorber lays] (...) rather than the future determining the past.\footnote{\cite[p. 669]{Cra86}}

In other words, first we have subject (emitter) and object (absorber), then the relation (the transaction) between them. Cramer like Everett, ends to contradict the core of his theory. The theory was born to eliminate a division in the experiment in two contiguous sides, but at the end it restablishes this boundary under a diverse fashion. In fact, Cramer could make another step and assign to the transaction a founding role. On the contrary, in Cramer transaction and difference emitter/absorber live side by side, without deducing this difference from the totality of the transaction. This cannot, perhaps, be accomplished with purely physical tools, but it is possible in philosophical terms.

It is the accuse which Hegel move to the address of Schelling. For Schelling we have an absolute on one side, an a multitude on the other side. How can this molteplicity be deduced from the absolute? In Schelling there is no deduction at all. It is almost a postulate. But, then, how can his absolute be a real ab-solute?\footnote{Absolute derives from the Latin ab-solutus (ab-solveo), free-from. Now, how can be an absolute in this sense be limited from something external to it?}

For Hegel, the molteplicity of the reality must be deduced from the absolute, from its internal articulation. There is nothing beyond it.

The fact that we, empirical observer, make experience only of a splitted world doesn’t conflict with a primitive holistic reality. In fact, it is the event, founding us as observers, which introduces an arrow from the subject to the object. But prior to the event, there is nothing apart a situation in which all is entangled.

3. Model Theory

This state of affairs, according to which, we are entangled in a totality defining our rôle is not so strange at it can appears at first sight. I think to Model Theory, for example. Let use state a formula, say,

\[(1) \quad <x, y> \in R\]

is true or false? A priori, neither true nor false. We must know what this formula means. For example, it exists a model \(\mathcal{M}\) in which \(x\) refers to Alice, \(y\) to Bob, \(R\) to the set \(\{<x, y> \mid x\ loves\ y\}\) and in \(\mathcal{M}\) it is true that Alice loves Bob. I.e.

\[(2) \quad \mathcal{M} \models <a, b> \in L\]

Where \(a\) refers to Alice, \(b\) to Bob and \(L\) to the relation loving. Well, now we can exhibit another model \(\mathcal{M}'\) such that in \(\mathcal{M}'\) \(x\) is mapped to 1, \(y\) to 3, and \(R\) to the relation \(\geq\); so, we have:

\[(3) \quad \mathcal{M}' \not\models <1, 3> \in \geq\]
In other words, our formula (1) is true in the first model $\mathfrak{M}$ and false in the second $\mathfrak{M}'$. Why? Because, it is the model to establish the meanings of $x$, $y$ and $R$. In any model there is a function-interpretation which maps variables and constants in the domain of the model. But this means that the validity of a formula depends from the structure of the model in which is interpreted. I.e. a formula has no meaning in itself, but only in a totality which interprets its constituents.

Pay attention to this fact. In our fist case, the model assign a particular meaning to the relation $R$: the relation of loving. But making this, it introduces also an arrow from Alice to Bob. It is in the nature of the relation having a relate and a correlate. It is the relation to define which ordered couple belongs to it and which not. And in the essence of relation ‘loving’ there is the request that one is a lover and one a loved. In our fist model, the interpretation of $R$ is such that the role of lover is assigned to Bob and the role of loved to Alice. But this amounts to say that it is the relation loving to establish an arrow from the relate to the correlate. Outside the relation loving Alice could be a correlate and Bob a relate. Or it could happens that there is no arrow between them.

Furthermore, we have seen that only in a relation we can speak of arrow, and of roles. But what defines the meaning of the relation? The model. In fact, in the first case the model has established as meaning of $R$ the relation loving; in the second case the model has established as meaning of $R$, the relation being greater or equal to. So we can speak of truth, falsity and meaning in general only inside a model, which represent in a mathematical fashion the concept of context, event, situation, etc.

For this reason, it is not absurd to put the totality as the background, the apriori which found the elements belonging to it. In the case of Model Theory it is this just the case. Obviously, in reality we have no a unique situation or event. Exactly, as we have not only one model, but many.

4. Quantum Events

For this reason, I have used a model-theoretic symbolism to illustrate a wave-collapse in my [Bon10c]. For two reasons: first, the collapse can occur only inside an event, a larger structure, an experiment which constitutes its a-priori, which found it. Second, the value of an observable refers always to an eigen-state, a sort of model-structure in which an observable has a meaning. Perhaps, it would be not too absurd to describe an eigen-state this way:

$$|\varphi_i\rangle = \langle R, m_i >$$

I.e. $|\varphi_i\rangle$ is seen as the ordered couple built up from a domain (the real numbers) and a function interpretation $m_i$ which assign a meaning to the observables (the hermitian operators associated to them).

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9This is not at all correct. Many theories are cathegoric. They have only one model up to isomorphism. But also in this case, we have that it is a totality to generate the semantics for a theory.
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