# Quantum Mechanics: Observer and von Neumann Chain

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Abstract

In this brief paper, we argue about the conceptual relationship between the role of observer in quantum mechanics and the von Neumann Chain.

## 1 Introduction

The introduction of Stapp's book (Stapp, 2003) put in evidence the fundamental problems in QM in relation to Mind/Matter problem.According Stapp, the basic problem in the interpretation of QM is to reconcile the quantum features of the mathematics with the fact that our perceptual experiences

[1]Mind, Matter and Quantum Mechanics, 2003

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are described in the language of classical physics. Observed physical objects appear to us to occupy definite locations, and we use the concepts of everyday life, refined by the ideas of nineteenth-century physics, to describe both our procedures for obtaining information about the systems we are studying, and also the data that we then receive, such as the reading of the position of a pointer on a dial. Yet our instruments, and our physical bodies and brains, are in some sense conglomerates of atoms. The individual atoms appear to obey the laws of QM, and these laws include rules for combining systems of atomic constituents into larger systems. Insofar as experiments have been able to determine, and these experiments examine systems containing tens of billions of electrons, there is no apparent breakdown of the quantum rules. Yet if we assume that these laws hold all the way up to visible objects such as pointers, then difficulties arise. The state of the pointer would, according to the theory, often have parts associated with the pointer's being located in visibly different places. If we continue to apply the laws right up to, and into, our brains, then our brains, as represented in QM, would have parts corresponding to our seeing the pointer in several visibly different locations. Inclusion of the effects of the environment does not remove any of these parts, although it does make it effectively impossible to empirically confirm the simultaneous presence of these different parts. The orthodox solution to this problem is simply to postulate, as a basic precept of the theory, that our observations are classically describable. This postulate is incorporated into the theory by asserting that any conscious observation will be accompanied by a "collapse of the wave function" or "reduction of the wave packet" that will simply exclude from the prior physically described state all parts that are incompatible with the conscious experience. This prescription works beautifully. When combined with the rule that the probability that this perception will occur is the ratio of the quantum mechanical weighting of the reduced state to the quantum mechanical weighting of the prior state, one gets predictions never known to fail. This ad hoc injection, in association with "consciousness", of "classical" concepts into a theory that is mathematically incompatible with those concepts, is the origin of the mysteriousness of QM. There is mounting evidence from neuroscience that our conscious thoughts are associated with synchronous oscillations in well-separated sites in the brain. This opens the door to a natural way of understanding, simultaneously, both the mind-brain and quantum-classical linkages. Oscillatory motions play a fundamental role in QM, and they embody an extremely tight quantum-classical connection. This connection allows the quantum-classical and mind-brain connections to be understood together in a relatively simple and direct way.

## 2 Observer and von Neumann chain

Bondoni (Bondoni,2010) analyze the possible relationship between two fundamental elements, the measurement process and the von Neumann chain[2]. We introduce briefly his pathway.

Bondoni start his analysis from the problem nested in Ozawa's effort to block von Neumann's chains and in his attributing the wave-collapse to a interaction between systems. Ozawa's analysis suggests to distinguish (sharply) the mathematical world from the phenomenological one. In Ozawa's own words:

> The orthodox view (of the wave-collapse) confuses the time at which the outcome of measurement is obtained and the time at which the object is left in the state determined by the outcome. (. . . ) it confuses the time just after the reading of the outcome and the time just after the interaction between the object and the apparatus. There is no causality relation between the outcome and the state just after measurement.

[2] We recall that von Neumann's quantum theory is a a formulation in which the entire physical universe, including the bodies and brains of the conscious human participant/observers, is represented by the basic quantum state. The dynamics involves three processes. Process 1 is the choice on the part of the experimenter about how he will act. This choice is sometimes called the "Heisenberg choice", because Heisenberg emphasized strongly its crucial role in quantum dynamics. At the pragmatic level it is a "free choice", because it is controlled, at least at the practical level, by the conscious intentions of the experimenter/participant: neither the Copenhagen nor von Neumann formulations specify the causal origins of this choice, apart from the conscious intentions of the human agent.Process 2 is the quantum analog of the equations of motion of classical physics, and like its classical counterpart is local (i.e., via contact between neighbors) and deterministic. This process is constructed from the classical one by a certain quantization procedure, and is reduced back to the classical process by taking the classical approximation. It normally has the effect of expanding the microscopic uncertainties demanded by the Heisenberg uncertainty principle into the macroscopic domain: the centers of large objects are smeared out over large regions of space. This conflict with conscious experience is resolved by invoking Processes 1 and 3. Process 3 is sometimes call the "Dirac choice". Dirac called it a "choice on the part of Nature". It can be regarded as Nature's answer to a question effectively posed by the Process 1 choice made by the experimenter. This posed question is: will the intended consequences of the action that the agent chooses to perform actually be experienced? (e.g.,will the Geiger counter be observed to be placed in the intended place? And, if so, will the specified action of that device be observed to occur?) Processes 1 and 3 act on the variables that specify the body/brain of the agent. According Stapp, the "Yes" answer actualizes the neural correlates of the intended action or associated feedback.

This analysis according Bondoni is correct, otherwise, he argue, we would have a regress at infinity , a sort of hegelian *odd* infinity as von Neumann points out:

> we must always divide the world in two parts, the one being the observed system, the other the observer. (...) That this boundary (i.e. between the observed system and the observer) can be pushed *at will* deeply in the interior of the body of the real observer is the content of the principle of the psycho-physical parallelism.

Bondoni, retain that surely the word used "at will" is the source of such problem. This way, the counsciousness can enter in the description of a measurement. On the other hand, we must distinguish the *measurement* and the *reading* of this measurement; i.e. the entanglement of the object with the observer and the reading of this interaction by the experimenter. In this way, we can no longer assert that the mind causes the collapse, as the given collapse is occurred earlier.
Moreover Ozawa demonstrates that the wave-collapse occurs in a time interval $t + \Delta t$, while the perception of this collapse is at $t + \Delta t + \tau$, interval in which the two systems (object and observer) can no longer be in a relation.
On the other hand, we can observe that exists only that is perceivable in a *phenomenon*. A measurement which is not perceived (by a reading) is not a real measurement. It is a logically possible interaction which doesn't belong to the reality. From the difference between the above mentioned intervalsOzawa infers a difference between measurement and perceiving of this measurement. But it is a logical inference. How can someone experience a measurement without interact with it (with a reading)?[3] And if this collapse is not experienceable, then we are making *meta*-physics (we are going *beyond* physics). Therefore, is not usefull putting aside a non physical entity as the mind to leave room for something more abstract, as a measurement without reading, also if this *something* has a definite grade of mathematical reality. Moreover, Ozawa doesn't answer the main question.

[3] One can interacts with an object *without* knowing the result of this interaction. For example, an observer can know that he is interacting with an object, without knowing the eigenstate in which the object jumped. The observer knows that surely by *this* interaction the system-object jumped in an eigenstate $|\phi_i\rangle$ and that an observable $\mathcal{O}$ must have in $|\phi_i\rangle$ an eigen-value $\lambda_i$. But the observer cannot, without a reading, know in *which* eigenstate the system is. Obviously, knowing the wave-function of the system, he knows too the amplitudes of the probabilities associated to its vectors, but this is only a mathematical (statistic) forecasting, not a perception. In this sense, the fact that at $t + \Delta t$ the system-object is in an eigenstate is only an *inference*.

The reading of a measurement is invoked to explain the collapse; now, if this cannot be more the cause of the collapse, what is the real cause? Apparently, the interaction between subject and object, but we have no direct experience of it. It is a *perceived* measurement in a given context to determinate the wave-collapse. Von Neumann *seems* adhering to this position, stating:

> experience only permits statements of this type: an observer has made a certain (subjective) observation; and never any like this: a physical quantity has a certain value.

Obviously it is higly questionable the *subjective* character of our perception. Our perception is on the contrary *objective* in a phenomenological point of view. What is more objective than the fact that we have in front of us a *given and no other* experimental set-up, built in a *given* way, with *given* pointers?
Using Bohr's own words:

> (...) in actual experiments all evidence pertains to observations obtained under reproducible conditions and is expressed by unambiguous statements referring to the *registration* of the point at which an atomic particle arrive on a photographic plate (...).

And:

> (...) the problem of explanation that is embodied in the notion of complementarity suggests itself in our position as conscious beings and recalls forcefully the teaching of ancient thinkers that, in the search for a harmonious attitute towards life, it must never be forgotten that we ourselves are both actors and spectators in the drama of existence.

Obviously, it is one thing asserting that reality must be confined to the realm of experience and one other asserting that the cause of the wave-collapse, which oughts to belong to our experience, must coincide with the act of registration of a measure. Ozawa successfully shows that this act cannot cause the collapse. But, where is, then, the real cause of this collapse? If this is the measurement, where is, ontologically speaking, this measurement?

Quoting Planck:

> it is impossible (...) that the development of the knowledge in Physics until now aimed at a fundamental and radical division between the processes in the external nature and the processes in the human world of feelings.

Being no clear distinction between subject and object, it is best adopting an *holistic* view and consider as fundamental the perceived phenomenon. I.e. there are not in reality subject and object as two clear distinct entities, but a relation which *founds* it. Subject and object are only in a relation, in a totally entangled *Gestalt*. The measurement seen as interaction is such a Gestalt. But not meaning that observer and object *enter* in relation, but that the relation *founds* relate and correlate.
What it is this relation in the measurement? The totality of the experimental arrangement which permits speaking of measurement. A totality which lives in our perception and is made of perceiving devices and tools of measurement. This is the *kantian* position of Bohr which sees in the experiment the real cause of any result: the *a-priori*, a sort of *category* which makes possible speaking of measurements, particles, collapses and so on. A frame in which the observer arranges his experiences. Planck observes:

> what we can measure, that it exists.

The act of measuring, the registration of measurement, not the measurement without observer. What a measurement could be without observer, Bondoni add: I don't dare to say.
Bondoni, concludes his paper, with two distinct questions:

1. the reading of a measurement cannot be the cause of the wave-collapse

2. attributing the wave-collapse to the interaction observer-object *before* the reading of the measurement stops von Neumann's chain

According Bondoni, Ozawa successfully demonstrates 1. Bondoni, is not sure that stating 1 rules out completely the problem hidden in 2. That is, the rôle of the subject in the act of knowing. In particular, it is not clear the *phenomenological* correlate of the measurement. In absence of a precise phenomenological correlate of a measurement, we can infer that this process amounts to an *observation without observer*. We disagree with this conclusion, the universality of QM is not a problem but a resource, to us the real question is: where we can stop the von Neumann chain?

References

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