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From quantum measurement to biology via retrocausality

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ABSTRACT

A reaction cycle in general or a metabolic cycle in particular owes its evolutionary emergence to the covering reaction environment acting as a measurement apparatus of a natural origin. The quantum measurement of the environmental origin underlying the molecular processes observed in the biological realm is operative cohesively between the measuring and the measured. The measuring part comes to pull in a quantum as an indivisible lump available from an arbitrary material body to be measured. The inevitable difference between the impinging quantum upon the receiving end on the part of the environment and the actual quantum pulled into the receiving end comes to effectively be nullified through the retrocausative propagation of the corresponding wave function proceeding backwards in time. The retrocausal regulation applied to the interface between the measuring and the measured is to function as the organizational agency supporting biology, and is sought in the act for the present in the immediate future within the realm of quantum phenomena. Molecular dynamics in biology owes both the evolutionary buildup and maintenance of its organization to the retrocausal operation of the unitary transformation applied to quantum phenomena proceeding backwards in time. Quantum measurement provides the cohesive agency that is pivotal for implementing the retrocausal regulation. In particular, the physical origin of Darwinian natural selection can be seen in the retrocausal regulation applied to the unitary transformation of a quantum origin.

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1. Introduction

The molecular world in the biosphere on the Earth is full of repeated measurements, since detecting the reacting partner is everywhere. That sounds experiential in admitting both the distinguishability and the inseparability between detection and reaction in process when viewed from the Eastern perspective. Detection inducing a reaction is not specific enough in itself before its actual implementation. Although the reaction to follow is intimately cohesive to the preceding detection, both are neither taken to be strictly concurrent nor coextensive. There is no likelihood such that both the detection and reaction may be completed at the same moment in a synchronized manner. The preceding reaction

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constantly precipitates something to subsequently be detected by its surrounding in that perspective. The Eastern tradition is thus unique in living with those inevitable incompatibles between the detection and reaction at the present moment.

Here measurements are understood as instances of transferring material resources of whatever sort between an arbitrary pair of two bodies referred to as the measured and the measuring. What is measured can be identified by the agent of measurement to the extent of referring directly to the material resources to be transferred between the two. This obvious fact is good enough for pointing to the relevance of quantum mechanics in the biological world because of its inclusion of the measurement process as the principal and inevitable ingredient in quantum phenomena. Quantum measurement is a scheme of cohesively furnishing the quantum correlation between what is to be measured and to be measuring (Hobson, 2017).

Chemical reactions in biology are in fact full of measurements mediated by the transfer of the quantum resources when viewed from the Western perspective legitimately grounded upon the material basis. Henceforth, chemical reactions in biology would turn out to be the meeting ground of both the Western and the Eastern traditions. Nonetheless, the Western tradition can go into such an extreme that the analytical theory of measurement may be conceivable even in quantum mechanics in terms of Hermitian observables operating on Hilbert spaces. In contrast, the Eastern counterpart could be receptive enough to live with the experiential aspect of measurement that is equivalent to tolerating incompatibles and inconsistencies originating from within at the moment of Now (Matsuno, 2015). Although the Western side of the quantum measurement may look a source of troublesome enigma (Bell, 1990), the Eastern side might suggest a likely loophole to escape from such a stressful malaise.

What is special to the moment of Now is its agential capacity of distinguishing different tenses, say, between the past, present and future, as addressing the issue of what time is all about. None of the past, present and future tense can change its own tense by itself alone. In contrast, there is no room of agential Now that could be saved for tenseless-time, which has been long appreciated in the practice of the standard physics of the Western origin.

2. Quantum measurement; revisited

In the present article, quantum mechanics we shall follow is taken to allow for the standard scheme of separating the material world into the two parts; one comprises the superimposable linear states developing as being subject to the deterministic equation of motion, and the remaining other houses the agency of identification or measurement being responsible and competent enough for substantiating such a separation in the first place. At issue will be how the directly measurable quantum properties develop in time, rather than relating the effect of measurement, whatever it may be, indirectly to probabilities generated from a quantum wave function.

In fact, any synthetic chemical reaction is a process of measurement par excellence since the synthetic reaction is the process of transferring part of a participating atom or molecule latent in the preceding reactant to the succeeding product. Receiving a quantum particle, whether an atom or a molecule, is nothing other than a form of measurement proceeding at the receiving end. Once synthetic chemical reactions happen to be ubiquitous, the repetition of the underlying measurements may be taken to be as a matter of course.

Needless to say, once the repeated measurements proceeding in chemical reactions is grasped within the scope of equilibrium thermodynamics, there would be no necessity of referring directly to the quantum process of measurement in an explicit manner thanks to the ubiquity of the principle of detailed balance applicable there. The principle has already assumed the establishment of the balancing between the forward process and its reversed one of any reaction without being bothered by further figuring out how each measurement participating there may proceed in practice. Moreover, measurement is intrinsically anti-symmetric in time since it cannot tell what will be measured prior to the actual event of measurement, in contrast to the time-symmetric operation of the underlying unitary transformation of quantum origin whether forwards or backwards in its movement.

On the other hand, however, once the reaction environment happens to persistently stay away from meeting the condition of fulfilling thermodynamic equilibrium as in the case of the neighborhood of hydrothermal vents whether on both the primitive and contemporary Earth, or elsewhere, it would be required to pay direct attention to the occurrence of the measurement of quantum origin. In fact, the contrast between an arbitrary material body and its environment is already implicit in admitting the act of measurement for relating the body to the environment. The environment is concrete enough by itself as allowing for no abstraction. It goes beyond something already abstracted like the exogenous conditions framed in the form of a nonnegotiable premise to be adopted in the standard practice of theoretical sciences. Both the capacities of measuring and being measured are latent in the environment. The relational activity between a pair of any two parties of material origin is made feasible if a material particle or a quantum in short is transferred from one party to the other.

One possible vehicle for coping with the quantum process of measurement latent in chemical reactions may be the formalism in terms of the density operator in general or the density matrix in particular after John von Neumann. Although the density operator formalism may further analytically be brushed up to the scheme of the positive operator-valued measure (POVM) in a more transparent manner (Barnett, 2009), we shall stay here with the original density matrix formalism for the sake of its intuitive clarity.

At issue must be how the quantum mechanical character of synthetic chemical reactions leading to the origins of life could practically be saved without easily being entrapped and terminated by a shortcut to chemical reactions in thermodynamic equilibrium. It has already been the established fact that the quantum states of those chemical reactants conceivable in the ensemble chemical kinetics in thermodynamic equilibrium are the incoherently mixed ones rather than the pure ones. Accordingly, the pressing concern for us at this point should be upon how the pure quantum states could be saved and under what sort of the reaction environments could they become likely.

The possible likelihood of the reaction environments harboring the origins of life could be envisioned in the perspective such that “the probability of life is approximately equal to the probability of the physical-chemical conditions under which it arose” (de Duve, 2005, p. 158). In essence, once the reaction environments could happen to precipitate those molecular aggregates that may be able to have the capacity of identifying the conditions for their own making, it may be likely that such aggregates could become durable even proto-biologically through their replication via constant exchange of the component elements (Matsuno, 2014). One likely condition for enhancing prebiotic synthetic reactions may have resort to hydrothermal micro-environments facilitating the faster transport of activated reactants to the possible reaction sites before undergoing the inevitable dissipation due to thermal diffusion (Mast et al., 2013; Priye et al., 2017).

We shall first examine in the next section how could the pure quantum states survive through the process of repeated measurements. Its philosophical implications will briefly be mentioned in

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