Reality as Information?

Michele Caponigro

ISHTAR, Bergamo University

Abstract

Can information be taken as fundamental level of quantum reality?

We argue about two different positions: Rovelli and Zeilinger.

author e-mail: michele.caponigro@unibg.it

1 Reality as Information?

Probability has played an important role in the foundations of QM from the beginning and continues to play an important role today. The choice of an interpretation of probability affect the interpretation of QM. Recent developments in Quantum information theory has led to new way to look at the foundations of QM, including a greater emphasis on possible role of subjective probability in QM. Several works claims that the QM can be view as information theory. According these works ,the description of physical systems in terms of information and information processing, is the only way to describe physical system. For instance, according Bub's words (Bub, 2008): *I argue that QM is fundamentally a theory about the representation and manipulation of information, not a theory about the mechanics of nonclassical waves or particles. The notion of quantum information is to be understood as a new physical primitive.* The author give at the information an ontic statute, in this context it is possible, for instance, deduce the physical laws and the matter from the information. We note others extreme positions on this topic, for instance, Zeilinger (Zeilinger,2005), where he claims that: *"The discovery that individual events are irreducibly random is probably one of the most significant findings of the twentieth century, even for single particles, it is not always possible to assign definite measurement outcomes independently of and prior to the selection of specific measurement apparatus in the specific experiment. For this reason, the distinction between reality and our knowledge of reality, between reality and information, cannot be made.*[1] The same position is the following statements of von Baeyer (von Baeyer, 2005) : Information as physical reality: *in 1905 Einstein proposed that the world is not what it seems. He suggested that is not continuous but atomistic, not absolute but relative, not classical but quantized. In the ensuing century his euristic hypothesis were confirmed as facts. They define what might be called the " atomic world view" Today we stand on the threshold of a new era: the information age. Far from replacing the atomic view of the world, the concept of information can be enlisted to build upon our current understanding of nature, and fill in remaining gaps.* We think that the possible relationship between reality and information is

[1] According Zeilinger this simple principle play a role in QM similar to that of the Principle of Relativity in Special Relativity, or to the Principle of Equivalence in General Relativity. In particular, he suggests this principle provides an explanation for the irreducible randomness in quantum measurement and for the phenomenon of entanglement. A form of phenomenalism to physical object (they objects are taken not to exist in and of themselves, but to be mere constructs relating sense impressions) and a form of instrumentalism about the quantum state.

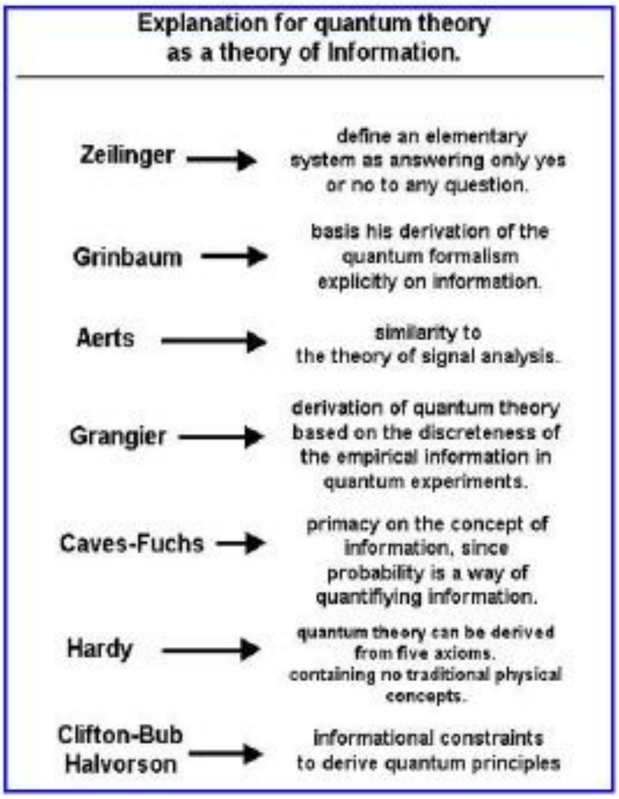

Figure 1: QM as Quantum Information?

very delicate problem and it seem quite approximate to say that information is the reality. This conclusion simply contradicts the everyday belief that physics is concerned with the physical structure of objects and that is the laws which govern the physical structure.

2 Reality as particles?

According Blood (Blood, 2008), it is remarkable that the particle-like properties which have led physicists to postulate the existence of particles mass, energy, momentum, spin, charge, the photoelectric and Compton effects, localized perception, particle-like trajectories (in bubble chambers, and atomic discreteness can all be explained by QM alone (wave function/state vector alone). This means there is no need to postulate the existence of particles (because QM can account for all the evidence). The net result is that there is no evidence for particles. Wave-particle duality arises because the state vector alone has both classical wave-like and classical particle-like properties. If only the state vector exists, then some of results of the Bell-Aspect and Wheeler delayed-choice experiments are easily and naturally understood.

According Blood, the relative ease of interpretation of the Bell-Aspect and Wheeler delayed-choice experiments, and the severe difficulties encountered in constructing viable theories of particles underlying QM, strongly suggest that the physical world

consists solely of wave functions/state vectors. Seeing that the wave-particle conundrum can be resolved within QM is a step towards demystifying the theory. But we still do not know why our perceptions correspond to the characteristics of a particular quantum version of reality, and we still do not know the origin of the probability law.
For these reason, Blood do not interpret subatomic reality in terms of particles. To conclude this section we cite Wilczek (nobel prize 2004) about the notion of particle:

> Particle physics is not really about particles anymore, but about the mathematica relationship, in particular, symmetries, aspects of nature that remain invariant under different circumstances; the world of elementary particles is an intercative world whose constituents derive their identities and properties from one another in endless negotiations.

3 Relational Realism:Rovelli's Interpretation

Rovelli (Rovelli, 1996) departs radically from such strict Einstein realism, the physical reality is taken to be formed by the individual quantum events through which interacting systems (objects) affect one another. Quantum events exist only in interactions and the reality of each quantum event is only relative to the system involved in the interaction. In Relational QM, the preferred observer is abandoned. Indeed, it is a fundamental assumption of this approach that nothing distinguishes, a priori, systems and observers: any physical system provides a potential observer, and physics concerns what can be said about nature on the basis of the information that any physical system can, in principle, have. Different observers can of course exchange information, but we must not forget that such information exchange is itself a quantum mechanical interaction. An exchange of information is therefore a quantum measurement performed by one observing system A upon another observing system B. The physical theory is concerned with relations between physical systems. In particular, it is concerned with the description that observers give about observed systems. Following this hypothesis, all systems are equivalent. Nothing a priori distinguishes observer systems from quantum systems. If the observer O can give a description of the system S, then it is also legitimate for an observer O' to give a quantum description of the system formed by the observer O. It is rejected any fundamental or metaphysical distinctions as: system/observer, QS/classical system, physical system/consciousness. Rovelli (Rovelli, 1996) assume the existence of an ensemble of systems, each of which can be equivalently considered as an observing system or as an observed system. A system (observing system) may have information about another system (observed system). Information is exchanged via physical interactions. Rovelli's position, lead us to consider the following epistemological implications:

- rejection of the individual object
- rejection of individual intrinsic property

For these reasons, the consequences are: (a) it is not possible to give a definition of the individual object in a spatio-temporal location; (b) it is not possible to characterize the properties of the objects, in order to distinguish from the other ones. In other words, if we adopt the interaction like basic level of the physical reality, we accept the philosophy of the relations.

References:

(Bub, 2008) Quantum Mechanics is About Quantum Information." Foundationsof Physics 35, no. 4: 541-560

(Blood, 2008) No Evidence for Particles 2008, arXiv:0807.3930v1 [quant-ph]

(Caponigro, 2008) Interpretations of Quantum Mechanics: A Critical Survey, arXiv:0811.3877v1

(von Baeyer, 2005) Information as physical reality: A new fundamental principleproposed by Zeilinger, 2005

(Rovelli, 1996) Relational Quantum Mechanics in in arXiv:quant-ph/9609002v2

(Zeilinger , 2005) Concept The message of the quantum in Nature 438, 743 (8 December 2005)