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Toward a Reconciliation of Copenhagen and Everett**

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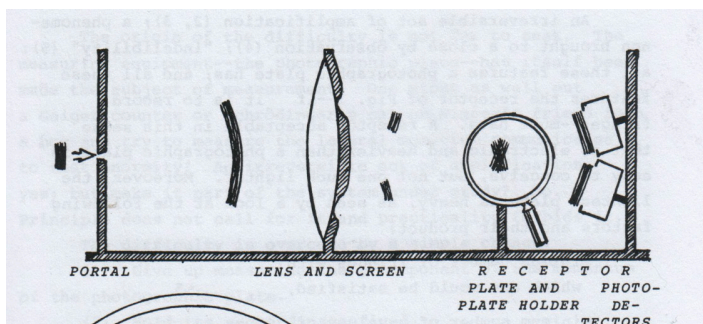
Beyond the Measurement Problem: Toward a Reconciliation of Copenhagen and Everett

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One hundred years after Heisenberg's discovery of quantum mechanics, there is still no consensus over even basic facts about its interpretation. One reason for this impasse can be traced to a disagreement in the first place about the role of the observer in quantum physics. Since the development of the Copenhagen interpretation by Bohr in 1927, observers and measurements have been central elements in orthodox presentations of quantum mechanics. And yet in the philosophy of physics, there is a persistent narrative that such interpretations face a "measurement problem," that references to observers or measurements should not be included in presentations of our fundamental physical theories, but rather should be regarded as emergent from more fundamental ontologies described by the quantum wave function or other parameters. Is there a way of reconciling this disagreement? To do so, one might find inspiration in the reaction of Wheeler, over several decades, to the interpretation of his doctoral student, Everett, and his theory of the universal wave function, which later became the many worlds interpretation.

Everett's central idea was that a quantum system need not interact with an external observer or measuring device in order for there to be definite facts about its reality. Even in situations in which a system's quantum state is correctly described as being in a superposition with respect to an observable, one can consistently assign definite values to it. It is just that in such a situation, there will not be just one definite value of the observable, but several. Wheeler was initially enthusiastic about Everett's proposal, not least because it allowed for the possibility of a quantum theory of the whole universe, a quantum theory of spacetime. He presented Everett's idea to Bohr and his group in Copenhagen, however, they rejected it. For a time, Wheeler tried to convince Bohr, and Everett too, that their two interpretations of quantum mechanics could be made compatible. But neither was receptive to the idea. And eventually Wheeler too moved on.



From: Wheeler, John Archibald. 1978a. The "Past" and the "Delayed Choice" Double-Slit Experiment. In *Mathematical Foundations of Quantum Theory*. New York: Academic Press, 9-48

It is interesting to ask what made Wheeler reject Everett's proposal, indeed whether he ever fully rejected it; a study of his notebooks and unpublished lectures suggests a unified framework linking Copenhagen and Everett was an idea he often returned to. But by the late 1970s, Wheeler was most of the time promoting his own variation on the Copenha-

gen interpretation which he called 'participatory realism.' Its central idea was that quantum mechanics showed us that reality was created out of acts of what he called 'observer-participancy.' These are situations in which an observer probes a system with a question. Later, as participatory realism evolved into Wheeler's idea of "it-from-bit", the idea came to be that the observer-participants probe systems with yes/no questions, always receiving "yes" or "no" binary answers. Thus, the resulting reality (the "it") is binary or bit-like. The central argument that Wheeler used to motivate participatory realism was based in his idea of the delayed choice experiment, which had several possible implementations (interferometer, double slit) and was subsequently successfully realized.

Participatory realism has been extremely influential across the fields of quantum information and quantum optics. In the past fifty years, Wheeler's participatory realism has evolved in interesting ways into the frameworks of QBism, the information-theoretic approaches of Brukner and Zeilinger, the algorithmic idealism of Müller, even the relational quantum mechanics of Rovelli. These are all Copenhagen-ish frameworks, to use a phrase from Leifer, in the sense of all privileging the role of the observer or subject in the determination of reality.

One can recognize important insights in the work of these physicists that motivate privileging the role of observations in the securing of definite realities. But arguably, there are important insights as well in the work of Everett and his followers, particularly regarding the fact that observers are built up out of more fundamental components that must also be described quantum mechanically. How can one develop an approach that recognizes both lines of reasoning?

An inspiring idea was presented in the Enrico Fermi Lectures Wheeler gave in Varenna in 1977. These lectures were published under the title *Frontiers of Time*. In these lectures, Wheeler presents his idea of the participatory universe, but also raises a question for it. Could it really be correct that nothing we fail to observe is real? What about all of these photons in our universe that nobody will ever observe?

What about the unbelievably more numerous photons that escape our telescope? Surely you do not deny their "reality"? Of course not: but their "reality" is of a paler and more theoretic hue. The vision of the universe that is so vivid in our minds is framed by a few iron posts of true observation – themselves also resting on theory for their meaning – but most of the walls and towers in the vision are of papier-maché, plastered in between by an immense labor of imagination and theory. (Frontiers of Time, p. 27)

Here Wheeler is contrasting two conceptions of reality. The first, "the iron post" reality, is what is given in acts of observer-participancy. This is the reality that we see and touch, that we make predictions about and see confirmed. The second is the "papier-maché" reality which he claims to have a "pal-

er and more theoretic hue.” This is no less in the world than the other, but it is not what is “vivid” in our minds. It is what we never interact with and escapes our observations.

Wheeler’s two conceptions of reality provide a way of unifying Copenhagen and Everett. Yes, we might say, the Copenhagen interpretation provides the correct way to understand the predictions of quantum mechanics, what they describe, and the sense of reality that matters for the everyday. But at the same time, there is more to our world than this reality that we see. This falls out of quantum mechanics once we

realize that observers aren’t basic. A full description of this fuller (though more “theoretic” because unobserved) reality comes from following out the Everett interpretation and its description of many worlds. In Everett’s time there was not a complete understanding of why we do not see these other universes, why we can’t see them. This had to wait the later work of Zurek and others on decoherence in the 1990s. But once this explanation is available, we can see how it allows the two interpretations, Copenhagen and Everett, to fit together and provided a unified picture of a quantum world.
