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Quantum Measurements: from a philosophical dilemma to a technological resource

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Abstract

In 1913 Niels Bohr postulated that electrons undergo quantum jumps when atoms emit light. In quantum mechanics, introduced by Heisenberg and Schrdinger in 1926-1926, time evolution (and light emission) is continuous, but now a different kind of jumps occurs when quantum states are randomly projected by measurements. While troubled by the discontinuous jumps in his early theory of the atom, Bohr was able to reconcile the measurement-induced jumps with his Copenhagen interpretation of quantum theory. This was an interpretation, however, that was strongly disliked by Schrdinger, Albert Einstein and by many great scientists until this day.

After a brief review of the Bohr-Einstein debates, I will present the underlying idea and simple examples of a modern, stochastic formalism that describes quantum systems, subject to measurement. I will discuss how the unpredictable character of measurements in quantum theory can be used as a resource to drive quantum systems into states for which we have no other means of preparation, e.g., non-classical states of light and entangled states of remote particles, and how it may also significantly boost our ability to perform high precision sensing with quantum systems.

Einstein was famously worried by a God playing dice and by spooky action-at-a-distance in quantum measurements. In the end of the talk, I shall show some practical results of the theory of measurements, that might have worried him even more.