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THE UNIVERSITY of WISCONSIN MADISON

PHYSICS COLLOQUIUM

Quantum Measurements

From a Philosophical Dilemma to a Technological Resource

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Abstract: The famous discussions between Niels Bohr and Albert Einstein on the interpretation of quantum mechanics did not resolve their main issue which concerned the indeterminacy of measurements on individual quantum systems, and even today there is no, commonly agreed upon, understanding of the quantum measurement problem. The experimental situation and hence the subjects of theoretical investigations have, however, been considerably refined since the early days of quantum mechanics. Without claiming a solution to the more philosophical questions we now have an effective formalism that describes quantum systems that are made subject to measurements. After a brief review of the development of this formalism, we will turn to its use and consequences. We will discuss how, e.g., an atomic quantum system is not only driven by the fields that we shine on the atoms but also by the measurements that we perform on the fields that they emit. This has far reaching applications for our means to control quantum systems, and a few key examples will be presented of schemes for the preparation of specific quantum states, generation of entanglement, and transfer and processing of quantum information that rely on measurements and perform with much higher success probability than if they were based on the time evolution under a given Hamiltonian. We conclude with a discussion of the prospects of applying conditional feedback to continuously observed quantum systems.

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