Max-Planck-Institut für Struktur und Dynamik der Materie

Max Planck Institute for the Structure and Dynamics of Matter

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CFEL, Bldg. 99, Seminar Room IV

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A Heuristic Approach to the Quantum Measurement Problem: How to Distinguish Measuring Devices from Ordinary Objects

Quantum mechanics (QM provides an extremely accurate description of the microscopic world as well as of numerous properties of matter that arise from the collective behavior of its constituents. Its predictions have been confirmed in countless high-precision experiments and its development has enabled groundbreaking inventions such as the laser and the transistor. Yet, in spite of its enormous success, the measurement problem, that is, the question of the interaction of an elementary particle with a measuring device, still remains as a nagging and unresolved mystery, embodied in the meaning of states such as the Schrödinger's cat, which are allowed by QM but contradict classical realism. Following a period of reduced attention on fundamental issues, important advances in the understanding of quantum entanglement coupled with unparalleled progress in the manipulation of atomic-size objects and, more recently, the emergence of quantum information science, have brought renewed interest in the subject.

Most of this talk is devoted to an informal review (at the senior undergraduate level) of the Copenhagen and hidden-variables interpretations, as well as the many-worlds and decoherence formulations, which give distinct answers to the measurement puzzle. We also discuss an alternative, poor man's approach based on the observation that quantum measuring devices differ significantly from ordinary objects. We argue that there are only two basic classes of particle detectors for which a measurement conduces either to a phase transformation (e. g., the bubble chamber) or a macroscopic transfer of charge (e. g., the Geiger counter). For both types, the state prior to a measurement is thermodynamically metastable and the particle being measured induces an irreversible transition into a stable state. Using these facts, we show that there is a multiplicity of Hamiltonians associated with different pointer states of a detector, which precludes the realization of quantum superpositions of the Schrödinger-cat type.

Host: Andrea Cavalleri

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