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Foundations of Quantum Mechanics

Written homework due Wednesday December 6, 2017

Exercise 22: Essay question. Describe the measurement problem of quantum mechanics. (Use formulas where appropriate.)

Exercise 23: Exponential distribution
Find the variance of the exponential distribution with parameter λ.

Exercise 24: GRW theory
Consider the GRW theory with the constant σ much smaller than the value 10^{-7} m suggested by GRW; say, $\sigma = 10^{-12}$ m. Explain why Heisenberg's uncertainty relation implies that a free electron, after being hit by a GRW collapse, would move very fast. Use the uncertainty relation to compute the order of magnitude of how fast it can be (assuming it was more or less at rest before the collapse); the mass of an electron is about 10^{-30} kg and $\hbar \approx 10^{-34}$ kg m^2 s^{-1}.

Exercise 25: Expectation value
Derive from the general Born rule (8.45) and the spectral theorem 8.8 that the expectation value $\mathbb{E}Z$ of the random outcome Z of a quantum measurement of the observable with operator A on a system with wave function ψ ($\|\psi\| = 1$) is given by

$$\mathbb{E}Z = \langle \psi | A | \psi \rangle \,.$$

For simplicity, assume that the eigenvalues of A are discrete, i.e., that A possesses an orthonormal basis (rather than a generalized ONB) of eigenvectors.

Exercise 26: (optional)
Argue that GRWf and GRWm are empirically equivalent, i.e., make the same predictions.

Reading assignment due Friday December 8, 2017: A. Einstein, *Reply to Criticisms*, pages 665–688 in P. Schilpp (editor): *Albert Einstein, Philosopher–Scientist* (1949). Read pages 665–672 and the first quarter of 673.