Introduction to the Kirkwood-Dirac Distribution: Quantum Thermodynamics and Nonclassicality

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This is the second pedagogical introduction to the Kirkwood-Dirac (KD) distribution. I explain why the KD distribution is used to quantize fluctuation theorems—seminal results in classical nonequilibrium thermodynamics-and how the KD distribution signals nonclassicality. Work, heat, and entropy production are often treated as average quantities. Studying the fluctuations around these averages leads to insights in classical systems. No-go theorems reveal a surprise: In quantum systems, such fluctuations cannot be described by probability distributions that simultaneously satisfy a set of intuitive requirements. KD distributions can characterize the fluctuations while satisfying the requirements. The fact that KD distributions can take negative or nonreal values is a strength: Such values indicate fluctuations that are nonclassical in the sense of generalized contextuality. I detail the KD distribution's relationship with generalized contextuality in a way applicable outside of quantum thermodynamics.

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