An Information-Theoretic Description of Quantum Mechanics*

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Abstract

It is well known that various probability distributions can be obtained as maximum-entropy distributions subject to constraints: for example, the normal distribution is the maximum-entropy distribution for a given mean and standard deviation. The Wigner quasi-probability distribution (Wigner 1932) describes all observable behavior in a quantum-mechanical system, but unlike standard probability distributions it may also take negative values. We show that the Wigner distribution is a stationary point of the entropy of a complex-valued probability distribution, subject to satisfaction of the entropic uncertainty principle (Everett 1957, Hirschman 1957, Beckner 1975). (To do so, we extend Shannon's 1948 axiomatization of entropy to the complex case.) This result shows how quantum mechanics can arise from purely information-theoretic considerations.