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Entropic Dynamics: an Inference Approach to Time and Quantum Theory

There is considerable evidence suggesting a deep connection between the fundamental laws of physics and information. Our goal here is to discuss quantum theory as an application of entropic methods of inference. The entropic dynamics (ED) approach allows us to see familiar notions such as time, the phase of the wave function, and Hilbert spaces from an unfamiliarly fresh perspective. Here are some examples: In an inference approach uncertainty and probabilities are the norm: indeterminism demands no explanation. What requires an explanation — but this is much easier to achieve — is the determinism that characterizes the classical limit. Time is a book-keeping device introduced to keep track of change and, although quantum mechanics is time reversible, time itself is not. An arrow of time emerges naturally. The magnitude of the wave function receives the standard interpretation according to the standard Born rule. This is not surprising. What might be surprising is that the phase of the wave function also receives a statistical interpretation — in terms of an entropy. The quantum measurement problem is resolved. Once quantum theory is seen as a theory of inference the dichotomy between two distinct modes of wave function evolution is erased. Continuous unitary evolution and discontinuous wave function collapse correspond to two modes of processing information, namely entropic updating in infinitesimal steps and Bayesian updating in discrete finite steps. These two updating rules are not intrinsically different; they are special cases within a broader scheme of entropic inference. In ED, unlike the standard interpretation of quantum mechanics, configuration space variables play a privileged role. For example, the positions of particles have definite values just as they would in classical physics. Therefore the old problem of how can a measurement ever yield a definite outcome does not arise. There are no inconsistencies because in ED position is the only observable. More explicitly: other “observables” such as momentum, energy, angular momentum and so on are not attributes of the physical particles but of the probability distributions. This opens the door to interpreting all other “observables” in purely informational terms.

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