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Quantum information and the arrow of time

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Quantum physics, despite its intrinsically probabilistic nature, lacks a definition of entropy fully accounting for the randomness of a quantum state. For example, von Neumann entropy quantifies only the incomplete specification of a quantum state and does not quantify the probabilistic distribution of its observables; it trivially vanishes for pure quantum states. We have proposed quantum entropy that quantifies the randomness of a pure quantum state via a conjugate pair of observables/operators forming the quantum phase space. The entropy is dimensionless, it is a relativistic scalar, it is invariant under canonical transformations and under CPT transformations, and its minimum has been established by the entropic uncertainty principle. This entropy is the inverse of the information content of a state.

The entropy is monotonically increasing during a time evolution of coherent states under a Dirac Hamiltonian, i.e., information is lost. However, in a mathematical scenario, when two fermions come closer to each other, each evolving as a coherent state, the total system's entropy oscillates due to the increasing spatial entanglement. We hypothesize an information law governing physical systems whereby the information of a closed system cannot increase, implying a time arrow for particle physics.

We then explore the possibility that as the oscillations of the information must by the law be barred in quantum physics, potential information oscillations trigger annihilation and creation of particles.

Biography

Davi Geiger has completed his PhD in Physics at MIT, has received an NSF young careeer award, and is an associate professor at the Courant Institute of Mathematical Sciences. This work is in collaboration with Professor Zvi Kedem also at at the Courant Institute of Mathematical Sciences.