

The arrow of time

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I discuss origins of the “arrow of time” on a number of examples of physical phenomena exhibiting irreversible behavior. After an introductory discussion of (relative) entropy, I present derivations of the Second Law of Thermodynamics in the formulations of Clausius and Carnot from quantum statistical mechanics, using properties of relative entropy. I then present a model of a quantum particle interacting with a heat bath whose motion turns out to be diffusive (quantum Brownian motion). The remarkable feature of the model is that the diffusive nature of the motion of the particle can be derived mathematically from unitary quantum dynamics. The next phenomenon to be discussed is friction – a paradigmatic example of irreversible behavior. I present a model of (infinite-dimensional) Hamiltonian mechanics describing a particle coupled to a harmonic wave medium whose motion exhibits deceleration/friction resulting from emission of Cherenkov radiation. I conclude with a sketch of the fundamental irreversibility of the quantum-mechanical time-evolution of physical systems featuring events.

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