Physics and Reality

Arrows of time – topic list

**Week 5: Concepts of time**

* **Worldviews:** linear vs. cyclic time
* **Ontologies w.r.t. time:** relationism (or reductionism) vs. absolutism (or substantivalism)
* **Being and becoming:** presentism, possibilism, and eternalism
* **Relativity:** causality
* **Emergent spacetime:** discrete spacetime and causal set theory

**Week 6: Reversibility and irreversibility**

* **Time-reversal invariance:** Newton’s second law, Maxwell’s eqs., the Schrödinger eq.
* **Feynman–Stueckelberg interpretation:** particles and antiparticles
* **The CPT theorem:** invariance under charge conjugation, parity, time reversal
* **Macroscopic irreversibility:** the second law of thermodynamics, Boltzmann’s H theorem
* **Objections and resolutions:** Loschmidt, Zermelo, the past hypothesis, Machian philosophy

**Week 7: Information**

* **Maxwell’s demon:** apparent violations of the second law
* **Szilard engine:** measurement as restoration of the second law
* **Landauer’s principle:** memory erasure as restoration of the second law (via Bennett)
* **Information theory:** Shannon information, Jaynes’ maximum entropy, objective vs. subjective probabilities
* **Stochastic thermodynamics:** thermodynamics of small systems,fluctuation theorems, Kullback–Leibler divergence

**Week 8: Scale dependence**

* **Reductionism:** methodological and theory reductionism
* **Constructionism:** Anderson’s “reductionism constructionism”
* **Emergence:** things can be more than the sum of their parts
* **Complexity:** simple laws can lead to complex dynamics for certain systems
* **Renormalization:** divergences in quantum field theory, renormalization group flows, effective field theories, fixed/critical points, the *c*- and *a*-theorems