The Arrow of Time

The laws of physics are symmetrical for time reversal, but the Universe apparently is not

$$F = m\frac{d^2R}{dt^2} = m\frac{d^2R}{d(-t)^2} \qquad \Lambda_{\text{time reversal}} = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

CPT symmetry

History

1800s Boltzmann saw asymmetry put into 2nd law of thermodynamics "by hand"

Current Efforts

Information theory

Holographic principle

My Efforts

$$F = \left(\frac{d}{dt}, c\vec{\nabla}\right)\left(E^2/c^4 - P^2/c^2, 2E\vec{P}/c^3\right)\left(\frac{d}{dt}, c\vec{\nabla}\right)(ct, \vec{R}) = m\frac{d^2R}{dt^2} + \delta$$

Classically, delta is super tiny, but adds up with 10^{23} particles, so laws are not space-time symmetric.

Maxwell equations are invariant under time reversal:

starts from B^2-E^2

Poynting vector ExB flips sign under time reversal