

# The Arrow of Time

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

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

## History

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

## Current Efforts

Information theory

Holographic principle

## My Effort

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

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

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