

DETERMINISM IN PHYSICS

CLASSICAL & QUANTUM

AGENDA

Classical physics

Entropy

The uncertainty principle

Deterministic evolution, probabilistic measurements

Quantum and biology

Rescuing determinism:

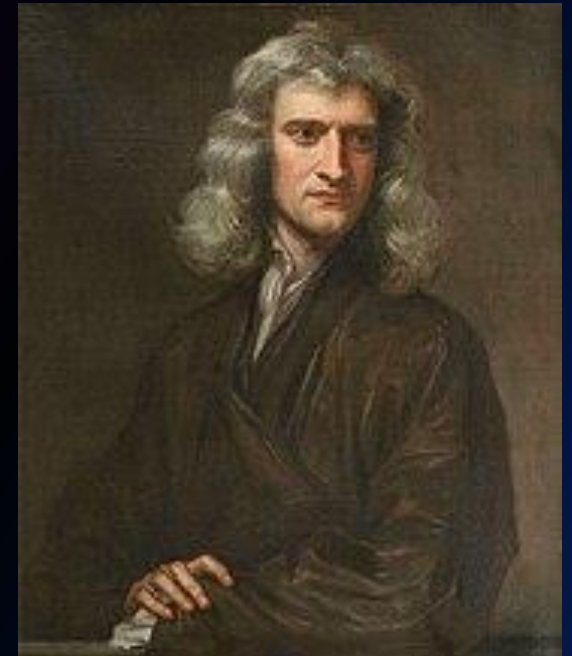
- Hidden variables and Many worlds

Quantum games

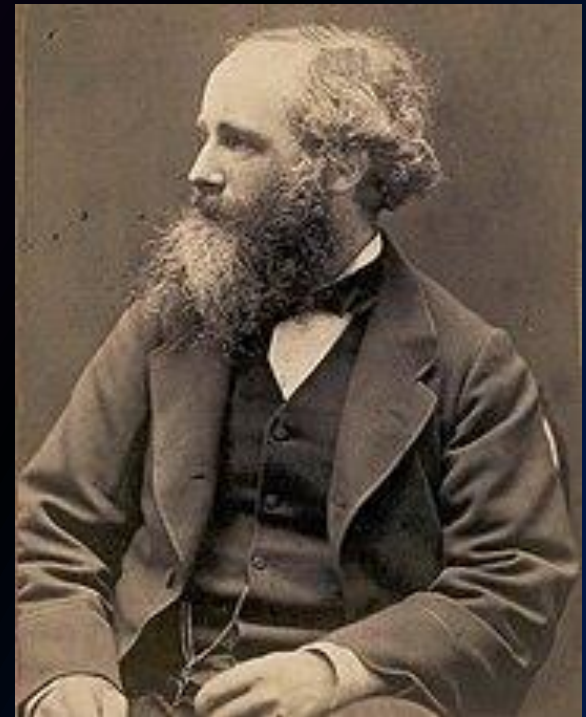
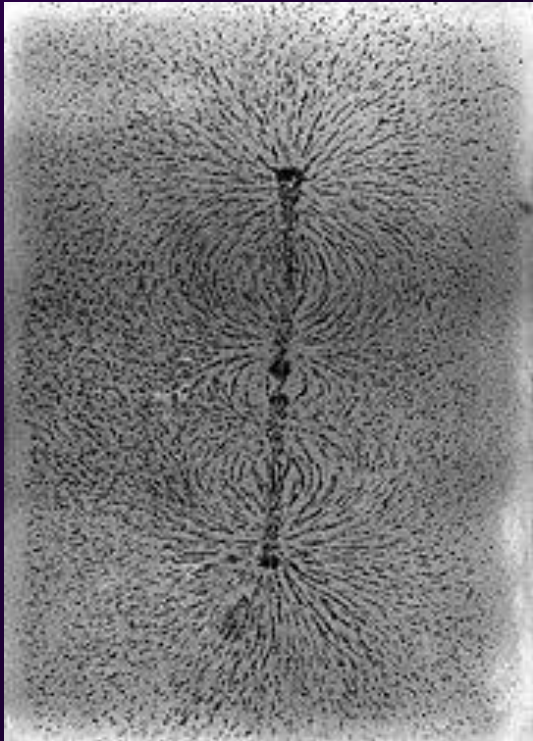
A lesson from History

CLASSICAL MECHANICS

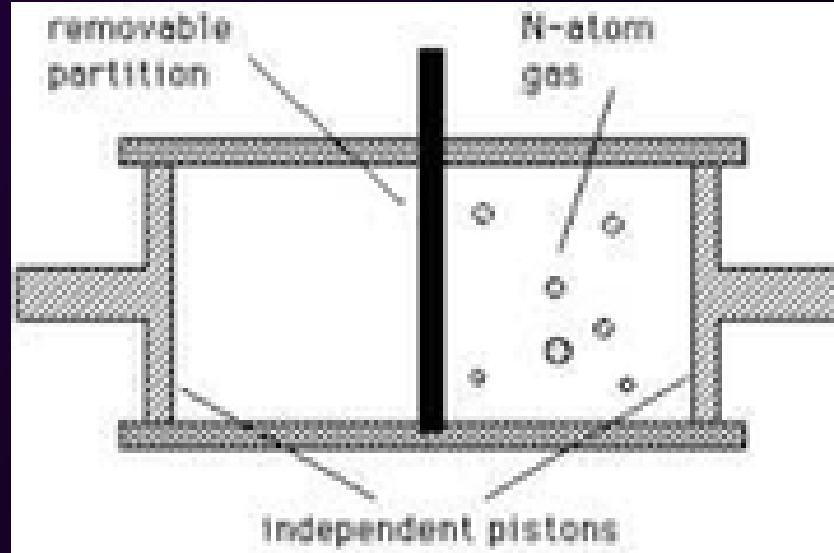
DETERMINISTIC IN PRINCIPLE
NOT IN PRACTICE



CLASSICAL ELECTRODYNAMICS DETERMINISTIC, PLAGUED BY INFINITIES

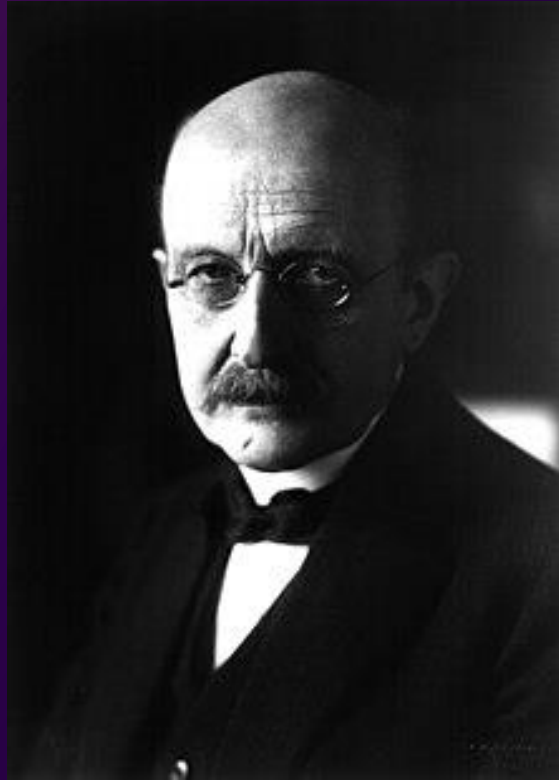


ENTROPY IGNORANCE DOMINATES



QUANTUM MECHANICS

PLANCK CONSTANT AND UNCERTAINTY PRINCIPLE



Mysterious fundamental system of units

c : bounds speed

h : bound what can be known

G : bounds the unknown physics

$$\Delta P \Delta X > h$$

Planck area: $\frac{hG}{c^3}$

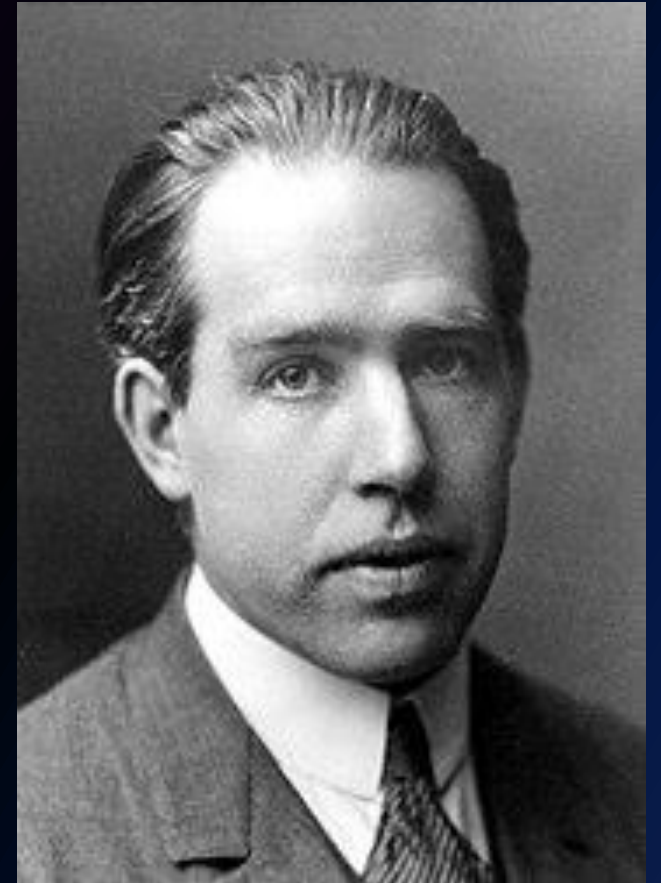


COPPENHAGEN

Ψ = QUANTUM INFORMATION

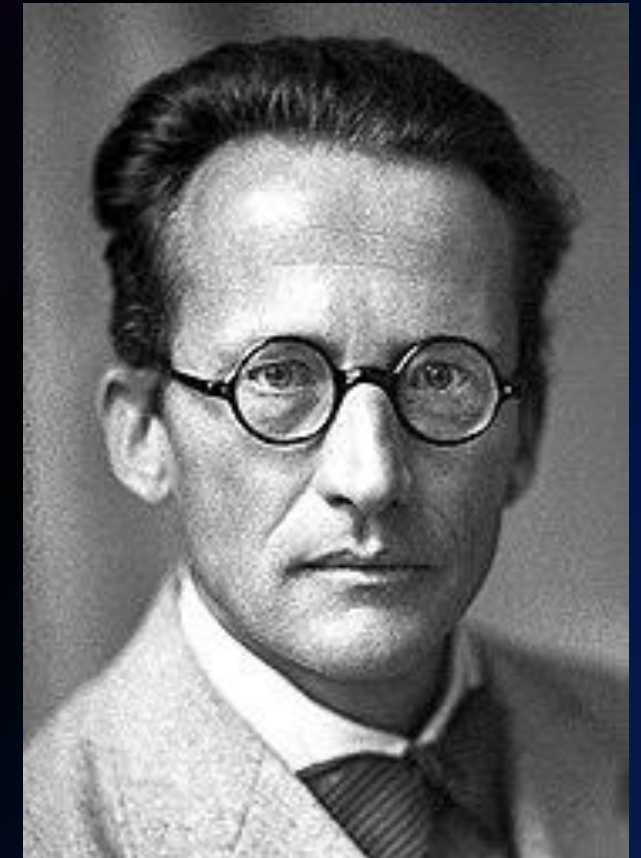
Ψ determines what is possible,
not what there is

It is wrong to think that the task
of physics is to find how Nature is.
Physics is concerns what we can
say about Nature



QUANTUM MECHANICS

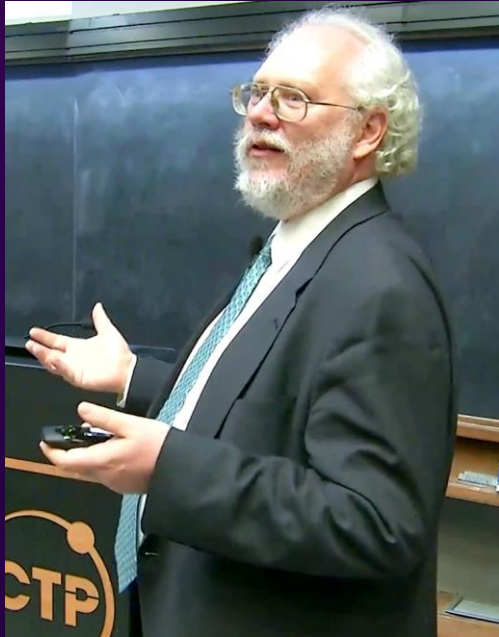
DETERMINISTIC AND REVERSIBLE BETWEEN MEASUREMENTS
MEASUREMENT FIXES UNIQUE REALITY



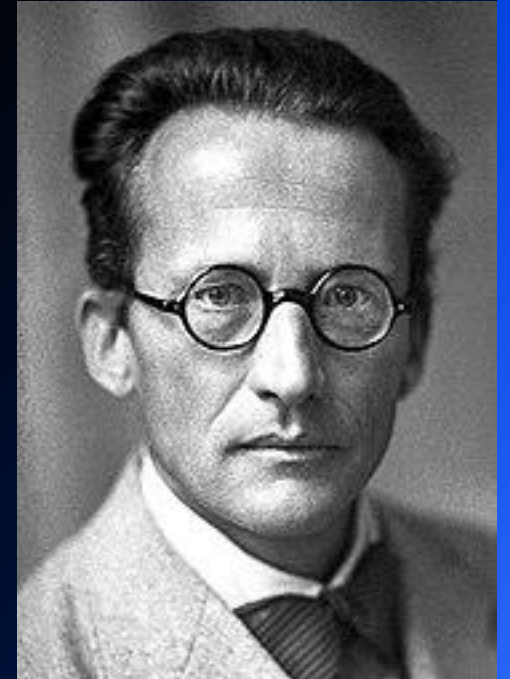
Nothing exists until it is measured

QUANTUM MECHANICS & BIOLOGY

NEW LAWS TO BE EXPECTED IN AN ORGANISM



- Noise in Quantum computers & biology
- Error correction



A QUANTUM GAME

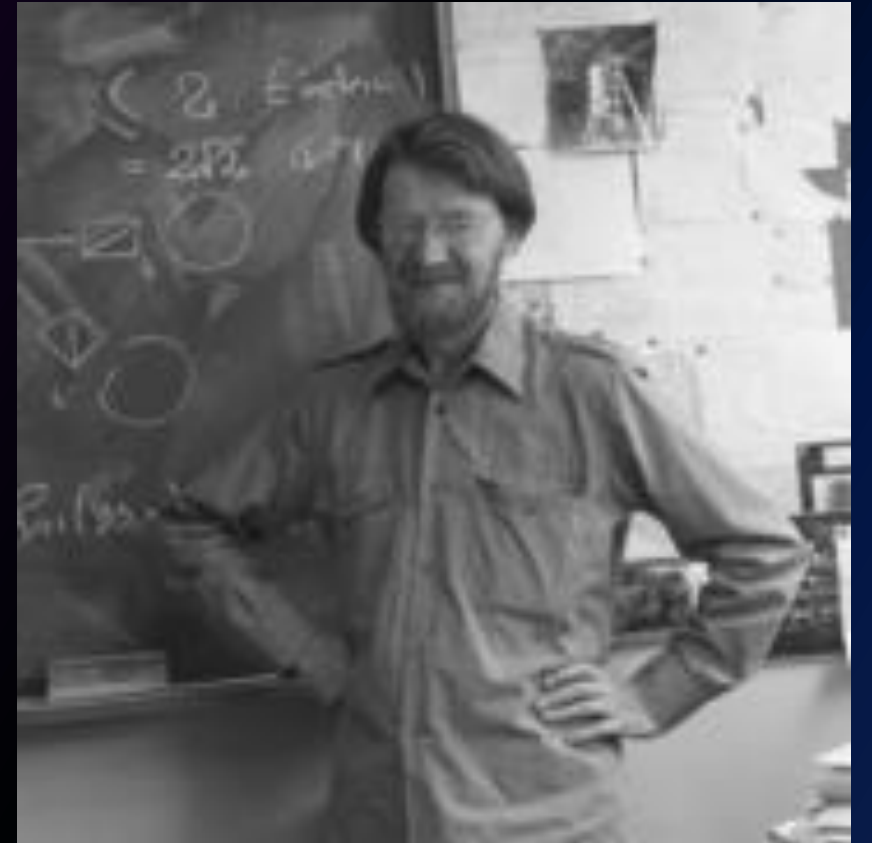
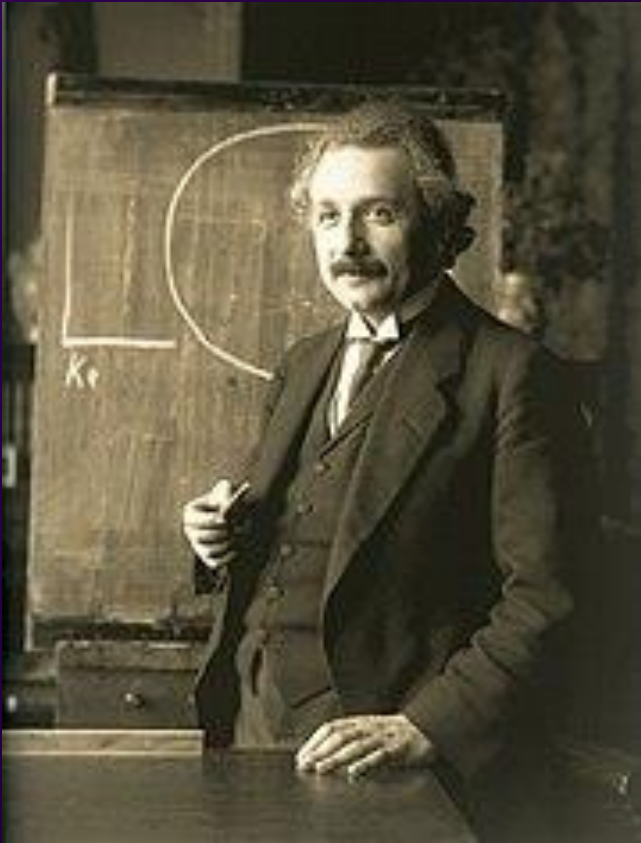
THE UNREASONABLE POWER OF QUANTUM RANDOMNESS

Alice	Bob	Charlie	win
X	X	X	1
X	Y	Y	-1
Y	X	Y	-1
Y	Y	X	-1
1	1	1	

Classically: Win with probability $\frac{3}{4}$

Quantumly: Always win

HIDDEN VARIABLES ATTEMPT TO RESCUE DETERMINISM



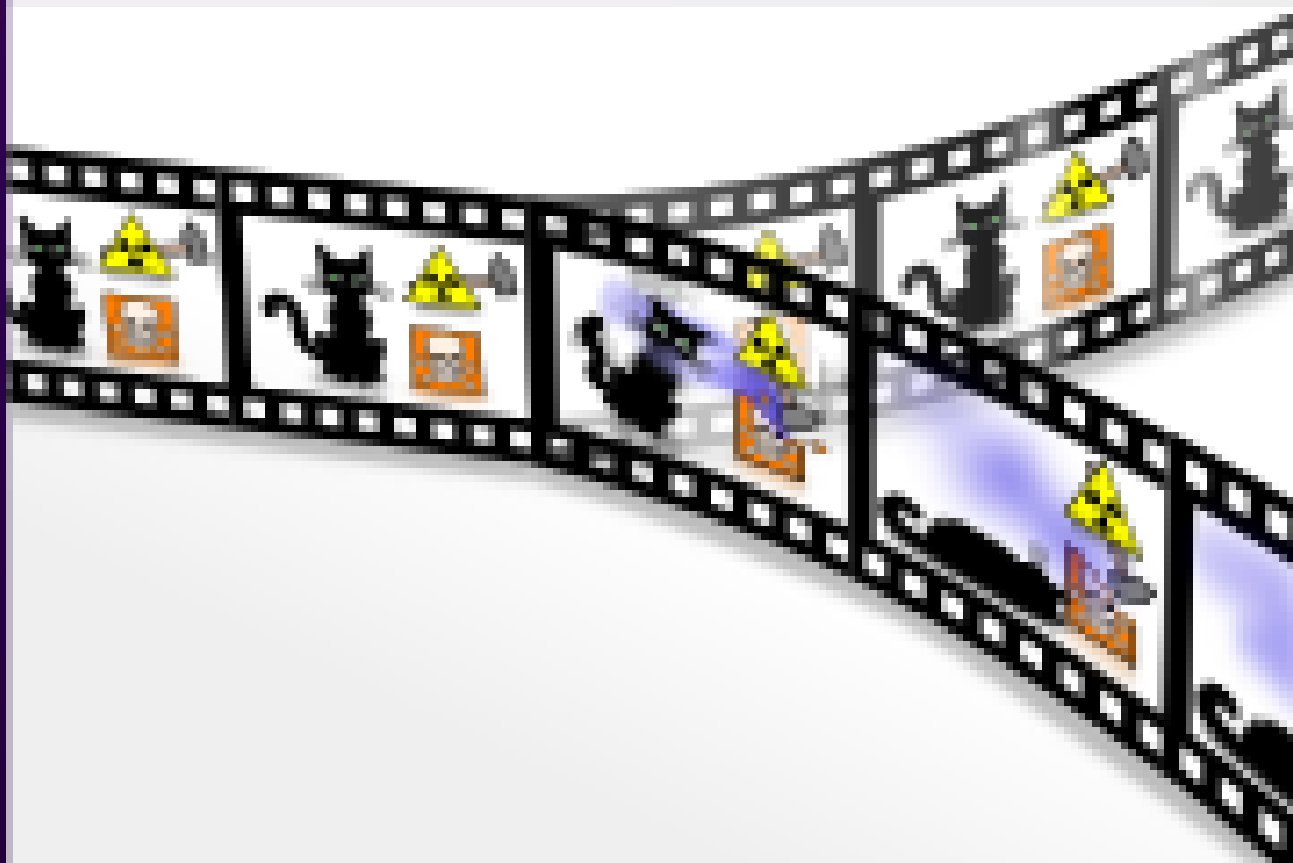
NOBEL 2022

NO LOCAL HIDDEN VARIABLES



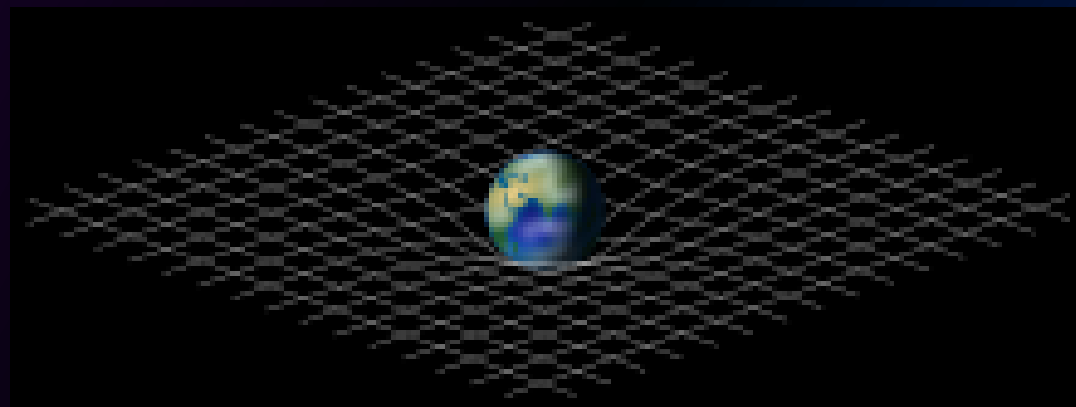
MANY WORLDS

AN ATTEMPT AT RESCUING DETERMINISM



A LESSON FROM HISTORY

NEWTON'S LETTER TO BENTLEY



Einstein: There is no such thing as a gravitational force

THANK YOU

Yosi Avron