



# **Phenomenological versus Statistical Thermodynamics - the argument that has never been settled (we will settle it today, of course)**



## **APPLIED PROBABILITY AND STATISTICS SEMINAR**

Misha Shvartsman,

University Of St.Thomas

November 19, 2010



## **Abstract:**

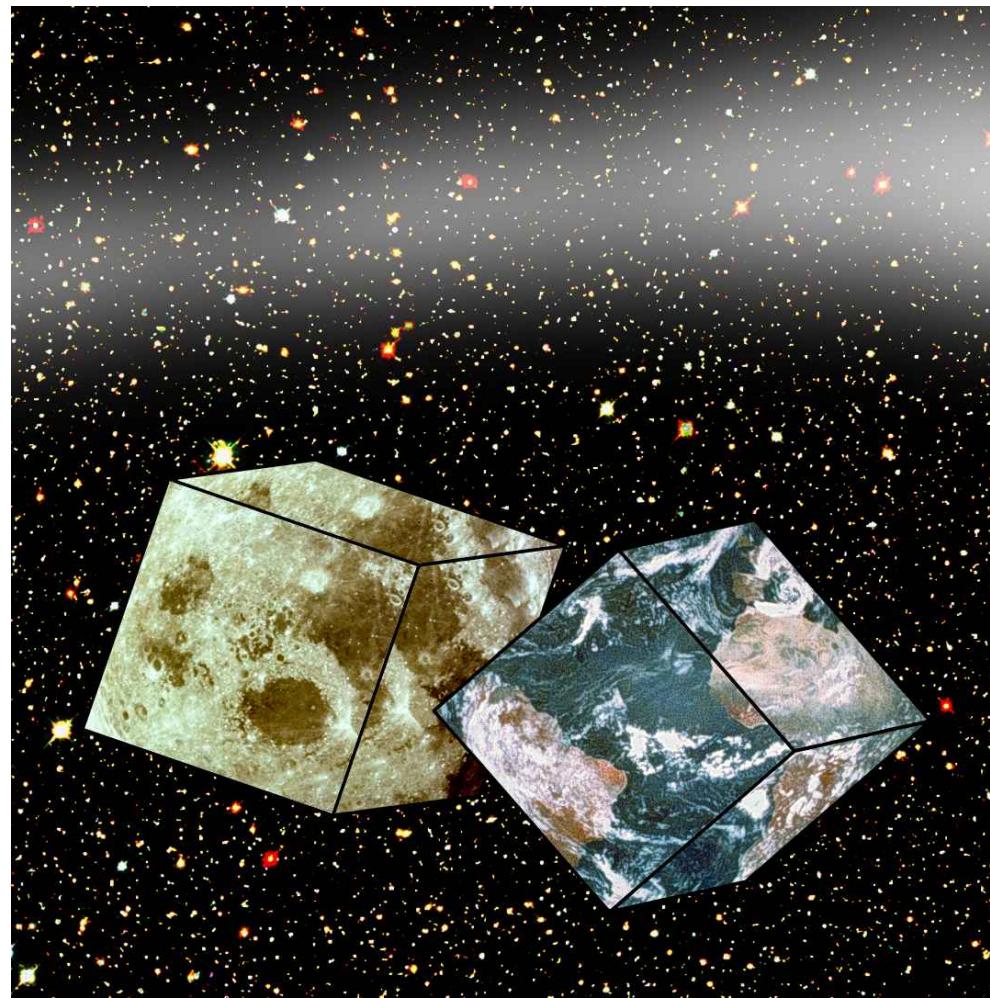
We will compare deterministic and statistical approach to modeling

## **Certainty vs Uncertainty**

**or**

## **Does God plays dice with the Universe ?**

# God playing dice





## **Does God plays dice with the Universe ?**

The question could be asked by philosophers and theologians. However, in earnest it was asked by a physicist and directed at other physicists.

### **Einstein-Bohr debates**

Albert Einstein: **No**

Niels Bohr: **Yes**



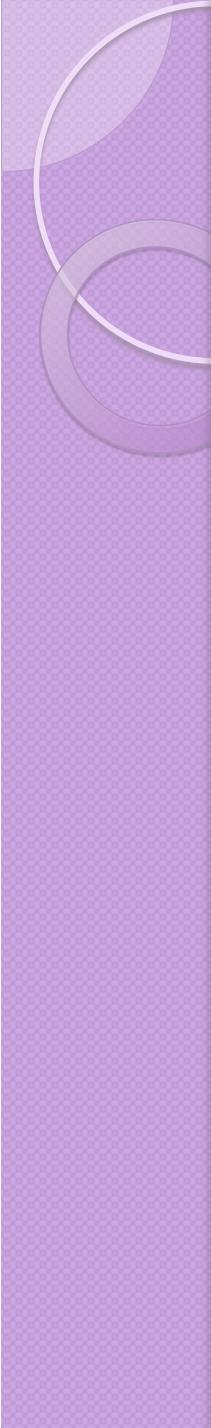
# **Outline**

- I. What I know about History of the Problem**
- II. What I know about Philosophy of the Problem**
- III. What I know about Physics of the Problem**
- IV. What I know about Certainty vs Uncertainty**



# **Outline**

- I. What I do not know about History of the Problem**
- II. What I do not know about Philosophy of the Problem**
- III. What I do not know about Physics of the Problem**
- IV. What I do not know about Certainty vs Uncertainty**



In 1977 (my second year in college)  
I took a course in **dialectical materialism**  
Not by choice – something like Core Curriculum.  
For my course project I was assigned to interpret  
Einstein-Bohr debate as a philosophical argument.

### **Three laws:**

1. Unity and conflict of opposites.
2. Passage of quantitative changes into qualitative ones.
3. Negation of the negation

# **Niels Bohr (1885 – 1962)**

**Model of an Atom**

**Quantum  
Mechanics**





## **Niels Bohr:**

.... interaction between object and measuring agencies .... because of the impossibility of controlling the reaction of the object on the measurement instruments ... *dictates* necessity of a final renunciation of the classical ideal of causality and a radical revision of our attitude towards the problem of physical reality.'

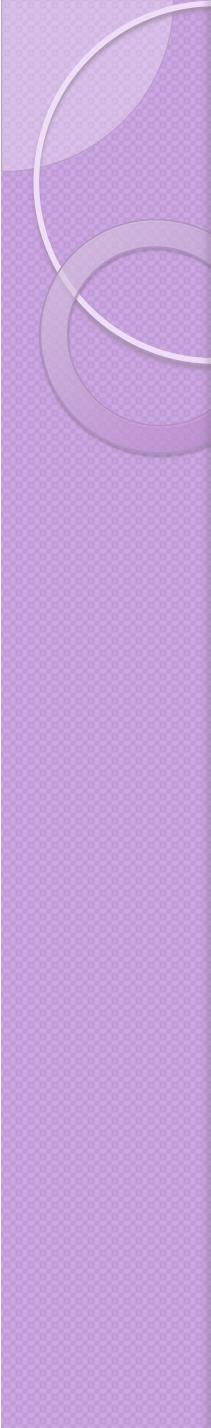
# **Albert Einstein (1879 – 1955)**

**Nice Going**

**Photo Effect**

**Special and  
General  
Relativity**





## **Albert Einstein:**

I want to know how God created this world. I am not interested in this or that phenomenon, in the spectrum of this or that element.

I want to know His thoughts; the rest are details.

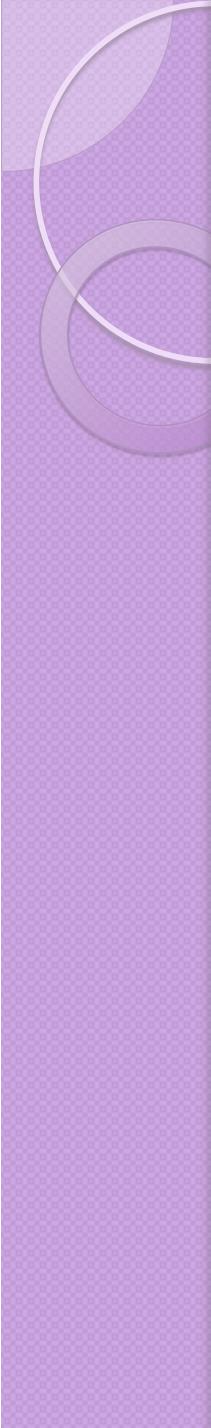
I believe in Spinoza's God who reveals himself in the orderly harmony of what exists, not in a God who concerns himself with the fates and actions of human beings.

# **Ernst Mach**

**Reality is  
subjective**



Library of Congress



## **Pavel Yushkevich**

Primary notions are sensory experience and  
the conceptual theory is a symbol.

In addition to the human mind, there is higher  
intelligence, the supreme empirio,  
or the laws of nature.

## **Chernov, Mikhailovsky, Voroshilov**

## **Vladimir Lenin:**

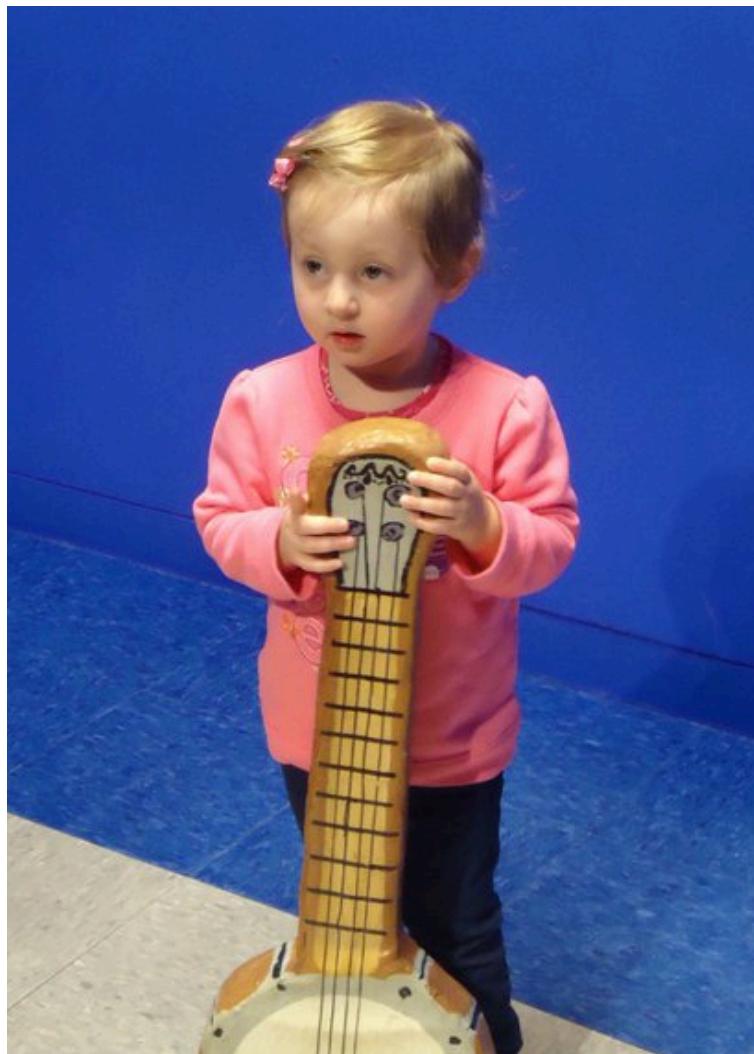
Henri Poincaré is an eminent physicist but a poor philosopher, whose errors Yushkevich declared to be the last word of recent positivism, so “recent,” indeed, that it even required a new “ism,” *viz.*, *empirio-symbolism*.

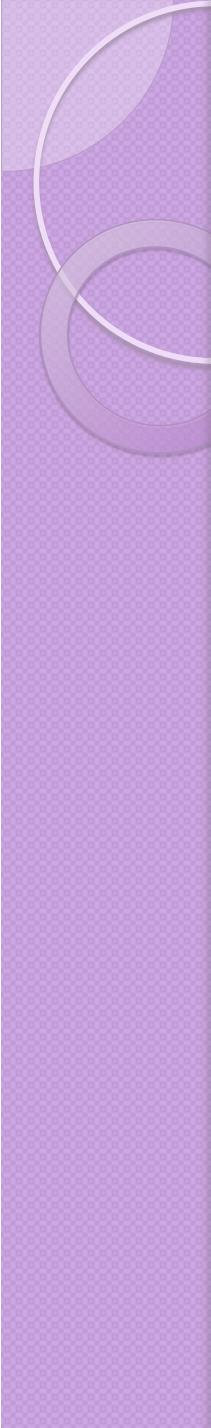


# Vladimir Lenin



# No Picture for Pavel Yushkevich His Great Great Great Granddaughter





**Is philosophy of science important to physics?**

**Is physics important to philosophy of science ?**

**Do physicists care what philosophers think?**

**Do philosophers care what physicists think?**

## **Richard Feynman**

Philosophy of science is about as useful to scientists  
as ornithology is to birds



## Copenhagen interpretation

A system is completely described by a wave function  $\psi$ .

Uncertainty principle: it is not possible to know the values of all of the properties of the system at the same time

Matter exhibits a wave-particle duality

Measuring devices are classical

Quantum mechanical description of large systems should closely approximate the classical description

# **Il Barbiere di Siviglia**

Ah, what a crowd! (Rodney Dangerfield ??)

One at a time, please!

Hey, Figaro! I'm here.

Figaro here, Figaro there,

Figaro up, Figaro down...

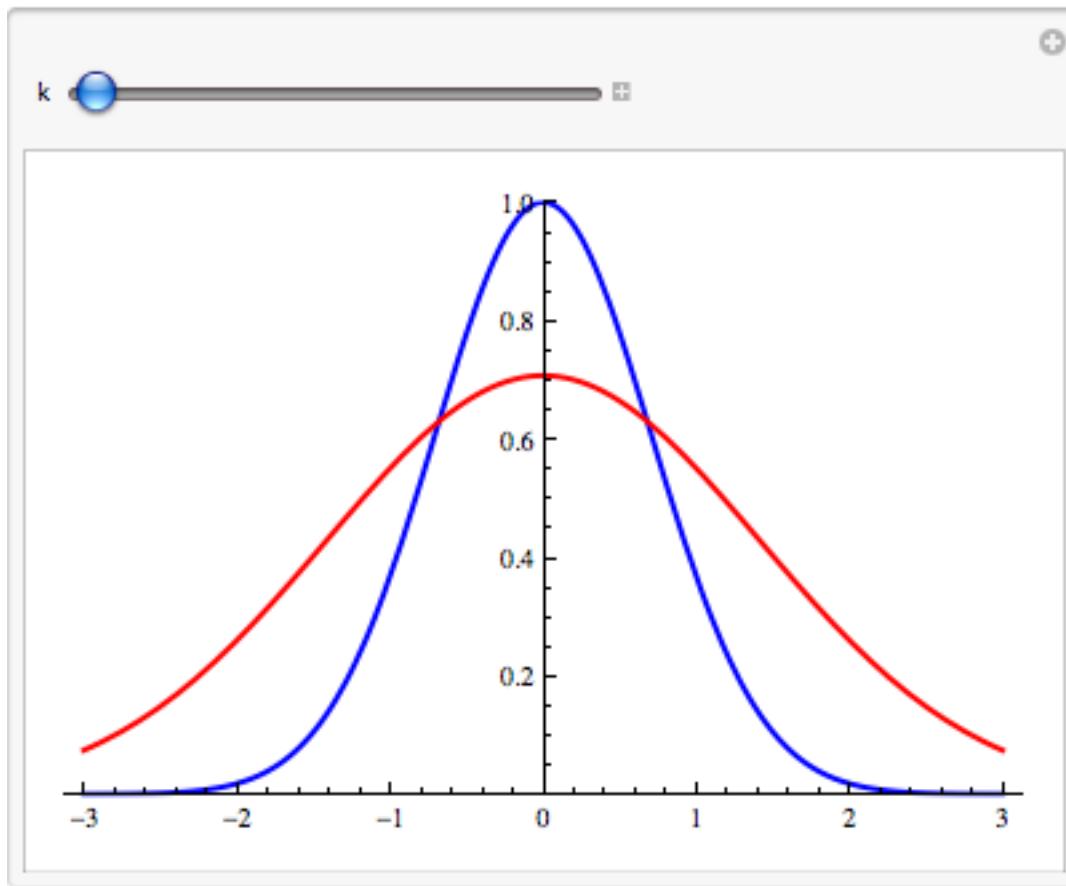


- Classical Mechanics:  
position  $x$ ,  
linear momentum  $p = m\dot{x}$

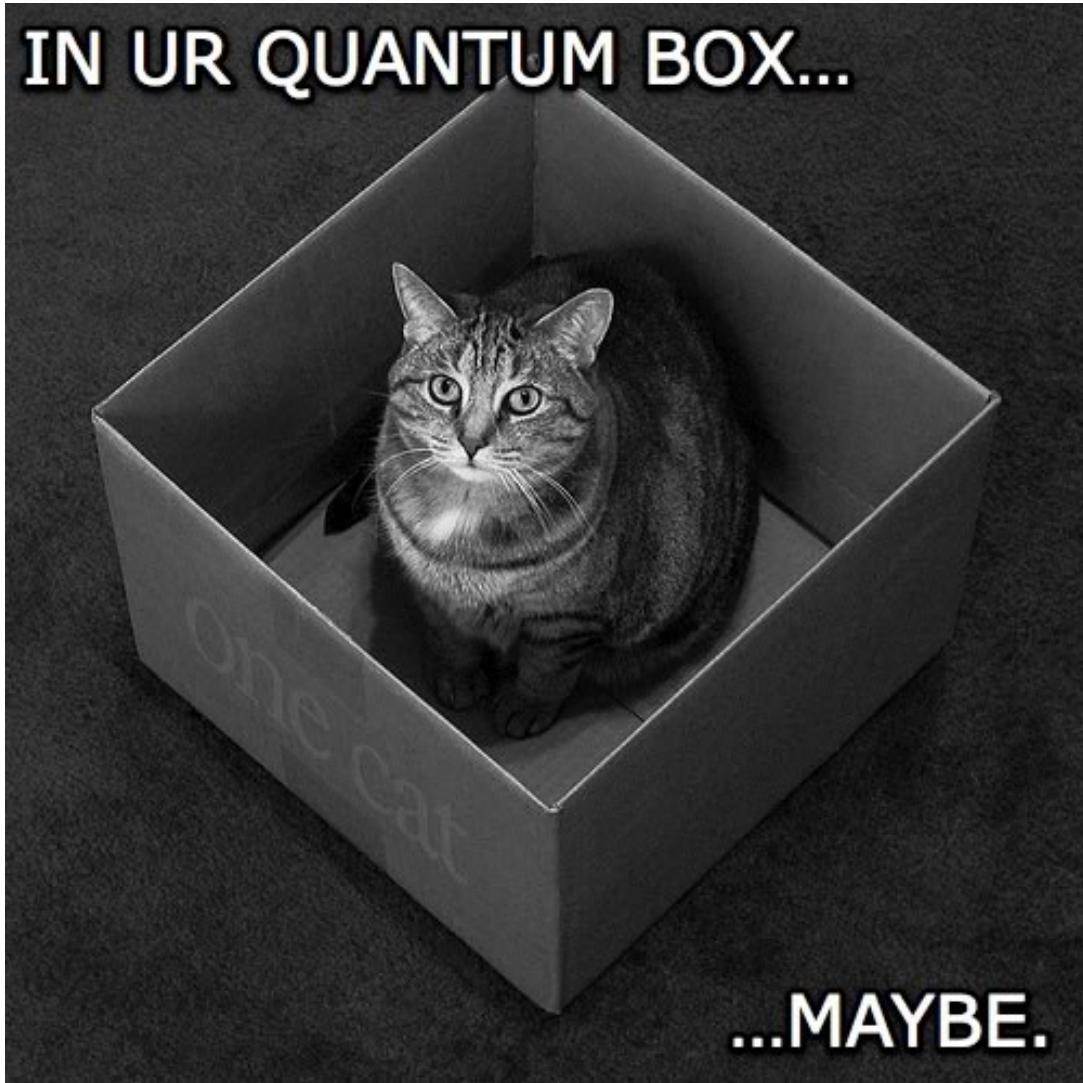
Quantum Mechanics:  
 $\Psi(x,t) = e^{i(kx - \omega t)}$

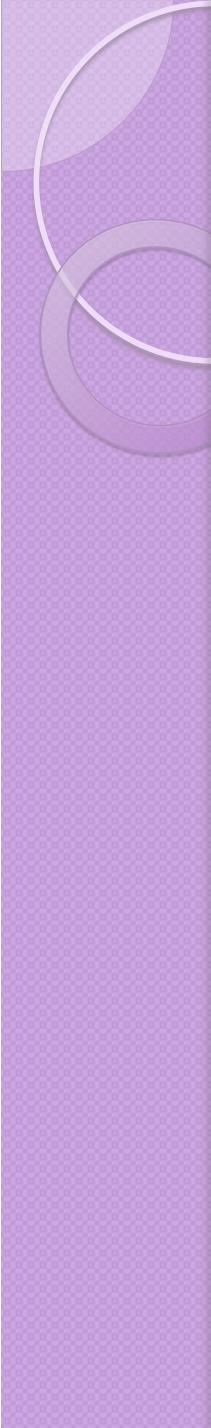
Heisenberg Uncertainty Principle  
Shrödinger Equation

# Fourier Transform of a Wave Function

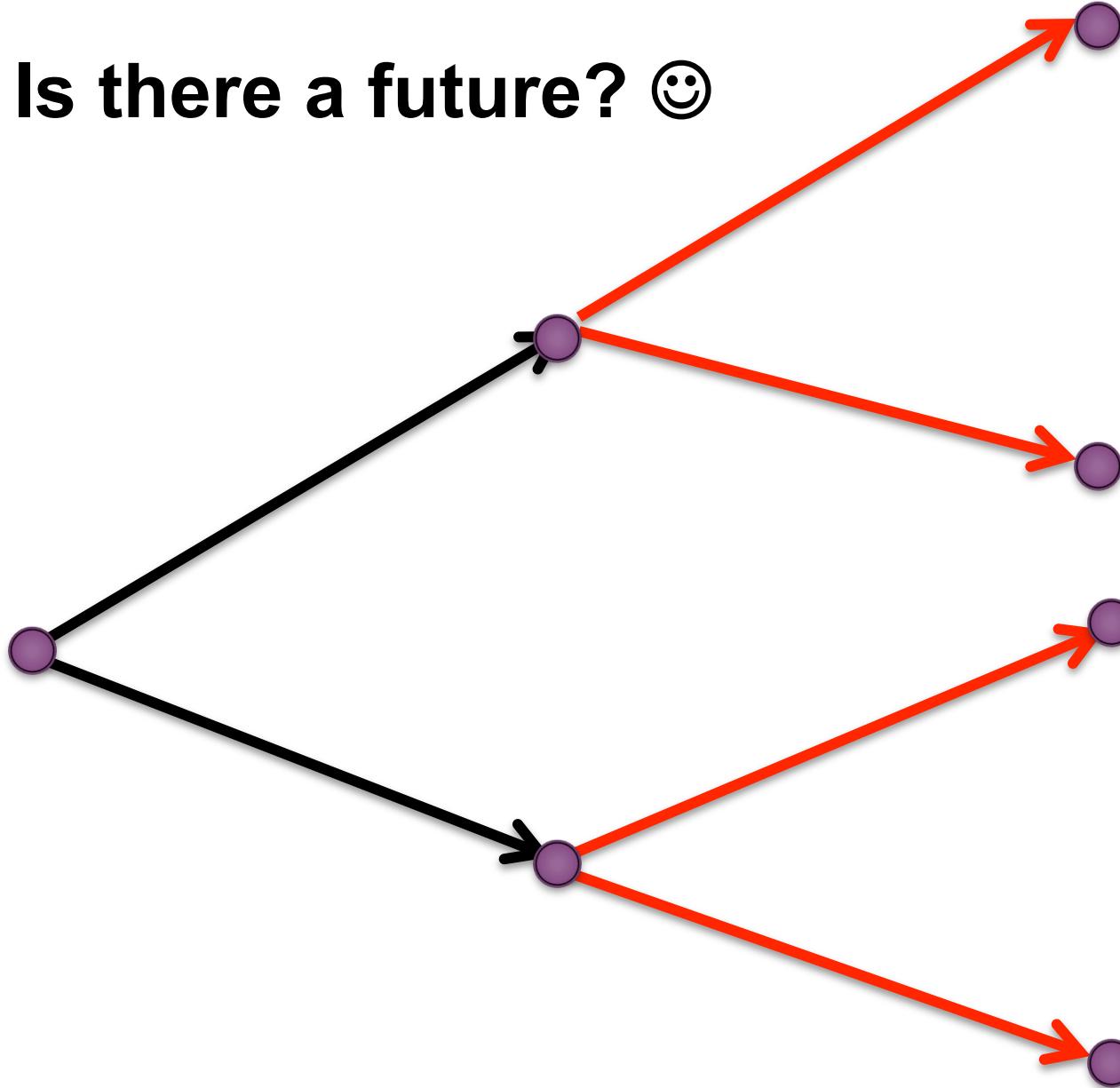


# Schrödinger's Cat

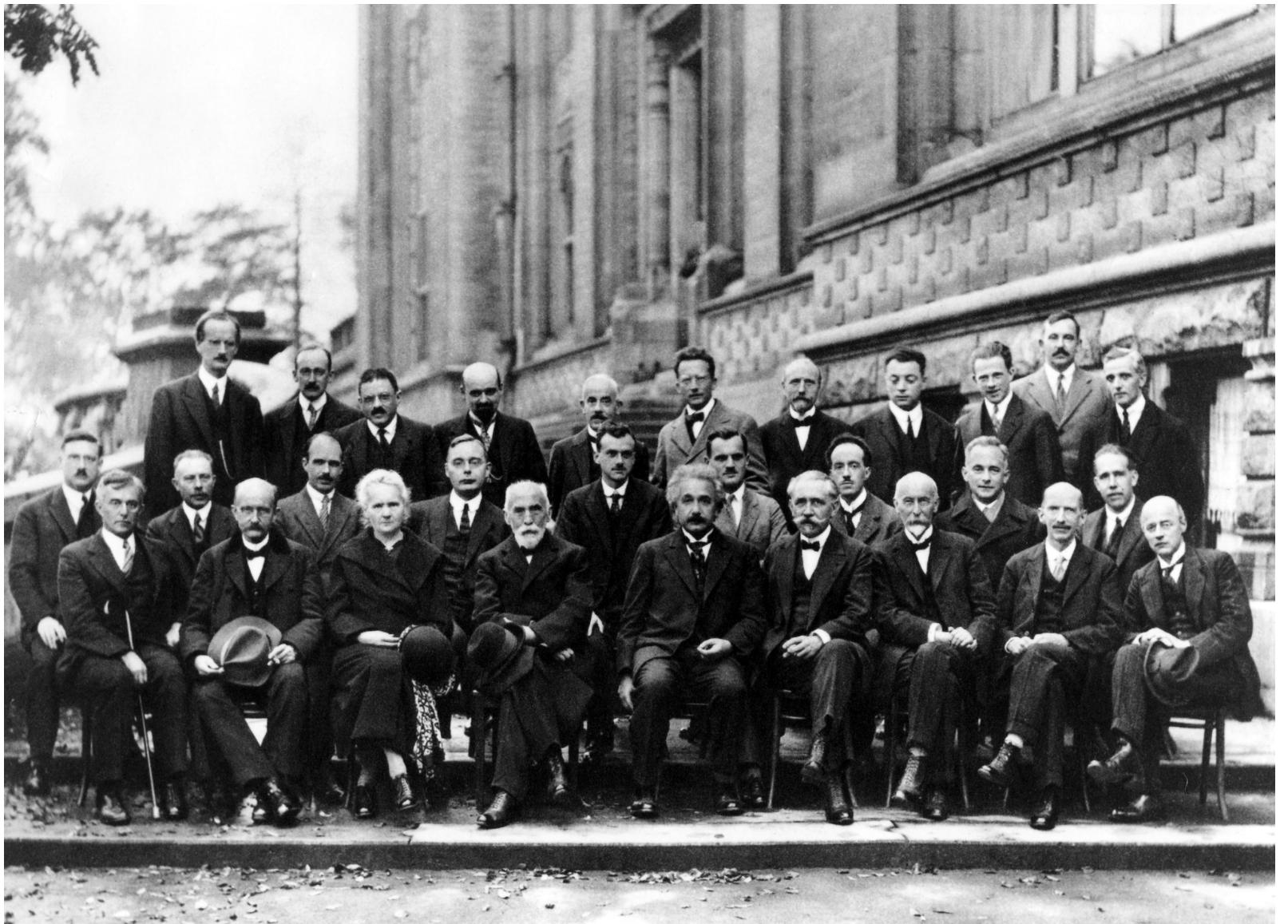




**Is there a future? ☺**



# UST Physics Department





## Solvay Conference, 1927:

**Einstein:**

God does not play dice!

**Bohr:**

Einstein, stop telling God what to do!

## Statistical Mechanics:

$$\circ \quad N = \sum_{i=1}^k n_i \quad E = \sum_{i=1}^k n_i E_i$$

$$W(n_1, n_2, \dots, n_k) = \frac{N!}{n_1! n_2! \dots n_k!}$$

Maximize W subject to 2 constraints

$$n_i = e^{-a - bE_i}$$



2005:

**Gerard Hooft:**

The Standard Model shows the way

**Ed Witten:**

"God plays dice" results from trying to describe  
a quantum reality in classical terms.

**Paul Davies:**

Complexity could define the boundary  
between the quantum and classical worlds.