Title: Foundations and Interpretation of Quantum Theory - Lecture 6 (Part 1 of 2)

Date: Feb 02, 2010 02:30 PM

URL: http://pirsa.org/10020010

Abstract: After a review of the axiomatic formulation of quantum theory, the generalized operational structure of the theory will be introduced (including POVM measurements, sequential measurements, and CP maps). There will be an introduction to the orthodox (sometimes called Copenhagen) interpretation of quantum mechanics and the historical problems/issues/debates regarding that interpretation, in particular, the measurement problem and the EPR paradox, and a discussion of contemporary views on these topics. The majority of the course lectures will consist of guest lectures from international experts covering the various approaches to the interpretation of quantum theory (in particular, many-worlds, de Broglie-Bohm, consistent/decoherent histories, and statistical/epistemic interpretations, as time permits) and fundamental properties and tests of quantum theory (such as entanglement and experimental tests of Bell inequalities, contextuality, macroscopic quantum phenomena, and the problem of quantum gravity, as time permits).

What the hell is probability?

Robin Blume-Kohout

Send questions to: Robin@Blumekohout.Com

A

The problem

- In logic, statements are either:
 (i) TRUE
 (ii) FALSE
 (iii) undecidable
- Some statements seem to be neither:
 "This coin will come up heads."
 "Joseph's next child will be a boy."

Pirsa: 10020010

The Higgs boson exists."

"Of course the main goal of science is to predict and control phenomena... But we also want to understand how Nature works." -Joseph Emerson, Lecture 1

Probability

- At its most elemental, probability theory lets us assign "intermediate truth values" to some such statements.
 - This coin will come up heads with probability 1/2." ==> Pr(heads)=1/2
- Everybody agrees that probability is sort of like logic, & that probabilities obey similar consistency relations -- this is coherence.

a We just disagree about what probability is

"Few branches of scientific method have been subject to so much difference of opinion as the theory of probability."

-M.G. Kendall

Two Broad Schools of Interpretation

- Physical Probability: Probabilities are real existing quantities (like mass).
 - inherent to the object (physical system)
 - cannot be directly observed.

 the word "probability" can (like mass) only be used in certain restricted contexts.

 Evidential Probability: Probability measures how much somebody believes a statement.
 inherent to the subject (observer or agent).
 different agents may assign different probabilities.

[T]he probable is that which for the most part happens. -Aristotle

Physical Probability (Frequentist Probability)

- The probability of X is defined as the limiting value of n(X)/N as N goes to infinity.
- The probability of a coin coming up heads is 1/2 because we flipped it a lot of times and the relative frequency looked like it was converging to 1/2"
- Probability" can only be used in when there is an [infinite] ensemble of samples.

"The probability of a 7 [when a die is thrown] is a physical property of a given die and is a property analogous to its mass, specific heat, or electrical resistance... The theory of probability is only concerned with relations existing between physical quantities of this kind."

-R. Von Mises

"We state here explicitly: The rational concept of probability, which is the only basis of probability calculus, applies only to problems in which either the same event repeats itself again and again, or a great number of uniform elements are involved at the same time. Using the language of physics, we may say that in order to apply the theory of probability, we must have a practically unlimited sequence of uniform observations." -R. Von Mises

"...`[T]he collective'... denotes a sequence of uniform events or processes which differ by certain observable attributes, say colours, numbers, or anything else....All the peas grown by a botanist concerned with the problem of heredity may be considered as a collective, the attributes in which we are interested being the different colours of the flowers....The principle which underlies the whole of our treatment of the probability problem is that a collective must exist before we begin to speak of probability. The definition of probability which we shall give is only concerned with the probability of encountering a certain attribute in a given collective."

-R. Von Mises

"We state here explicitly: The rational concept of probability, which is the only basis of probability calculus, applies only to problems in which either the same event repeats itself again and again, or a great number of uniform elements are involved at the same time. Using the language of physics, we may say that in order to apply the theory of probability, we must have a practically unlimited sequence of uniform observations." -R. Von Mises

"...`[T]he collective'... denotes a sequence of uniform events or processes which differ by certain observable attributes, say colours, numbers, or anything else....All the peas grown by a botanist concerned with the problem of heredity may be considered as a collective, the attributes in which we are interested being the different colours of the flowers....The principle which underlies the whole of our treatment of the probability problem is that a collective must exist before we begin to speak of probability. The definition of probability which we shall give is only concerned with the probability of encountering a certain attribute in a given collective."

-R. Von Mises

Physical Probability (propensity)

- Probability is a basic physical property of a system, which causes it to tend to behave in a certain way.
- Probability of a coin coming up heads is 1/2 because that's its propensity for coming up heads."
- Hard to avoid circularity & complexity.