Quantum Mechanics Chapter Zero

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We should begin our QM courses with a brief explanation of the following points

1. QM is INTRINSICALLY probabilistic, unlike classical physics. The origin of uncertainty here comes not from imprecise measurement of initial conditions, or interaction with unmeasured DOF, but with a simple mathematical generalization of Boole's laws of thought

This generalization is intrinsic to the mathematical formulation of ordinary logic. Only special choices of evolution laws (Classical physics) can avoid taking it into account.

2.The intrinsic probability theory thus defined does not satisfy the ordinary rules of probability, derived from classical logic (interference and Q entanglement).

3. There are simple general arguments based on locality of interactions and the existence of microscopic correlation lengths in macroscopic systems, which show that under most circumstances, the peculiar quantum interference effects are of order e^{-N} with $N >> 10^4$. As a result, experiments designed to measure these effects would take a time so long that “it is essentially the same

the age of the universe".
Discussion of such hypothetical experiments has no place in science.

4.This fact, combined with the theory of the evolution of the brain, provides ample explanation for why we find it so hard to accept the rules of QM – this is the only place where human consciousness need enter into the discussion

5.In this context, the idea of “collapse of the wave function” is nothing more than the usual procedure of discarding those predictions of a probabilistic theory, which are not realized in experiments.

6.We should stop regarding our eqns as “elements of reality”. Instead they are algorithms/models with which our limited brains can

The Essence of the Argument

Boole: Logic is a form of algebra

For a single question, the algebra is generated by $P^2 = P$. P=0 NO, P=1 YES

Unique irreducible representation as a linear operator in 2D Hilbert space

Eigenvectors

$P \mid Y \rangle = \mid Y \rangle \qquad P \mid N \rangle = 0 \mid N \rangle$

States of the system in which question has definite answer.More general states (incomplete knowledge) $\langle P \rangle = Tr\ \rho\ P$: Expectation value.

$\rho = py\ P + pn\ (1 - P) \qquad py + pn = 1$

evaluate Tr ρ A for ANY hermitian A and get $\Sigma \rho_i A_i$ where these are the eigenvalues of A and the diagonal matrix elements of ρ in the A eigenbasis. The latter have the properties of a probability distribution. The formalism of classical logic automatically generates a distribution for ANY hermitian A. If [A,P] not 0, A will be uncertain even in what YOU call

If the QM prob formalism is intrinsic to Boolean logic, we shouldn't have been surprised to find it showing up in physics. Why were we surprised? The answer is that e^N for $N \sim 10^{20}$ is such a huge number. For example, if it's a time interval, it's essentially the same number of Planck times (10^{-44} sec) as it is ages of the universe (10^{17} sec)

Consider a collective coordinate of a macrosystem and a semi-classical state corresponding to a trajectory of the collective coordinate. A good model for these collective coordinates are field averages over large volumes in QFT. The rest of the field degrees of freedom in that volume are the microscopic DOF making up the “object”.

General properties of QFT imply that typically there are of order e^N such states, macroscopically indistinguishable. N is o(V) in microscopic units. Consequence of locality. The motion of the c.c. induces evolution in this vast subspace. All phase correlations between different macrostates wiped out. System acts as environment for its collective coordinate.

Only ways to avoid this: Motion of c.c. leaves micro system in its ground state. Fluxes in superconductors and other topological variables best candidates.

But this requires intricate preparation, highly untypical in real macro-systems

Conclusion: QM is a mathematically inevitable consequence of Boole's mathematical formulation of logic. It defines intrinsic probability distributions, which don't reflect ignorance, and obey peculiar rules. Macro-systems fuzz out those rules, reducing them to "ordinary" unpredictability. Our brains evolved to deal with problems posed by

to terms with quantum logic.

Could an intelligent organism exist with “an intuitive understanding of QM”? Maybe, but if it did, it would have as much chance of explaining it to us as we have of explaining calculus to a cat.

MY LOGO