Mermin's Mouse

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- Can a a mouse be a Qbeast?

It is all about Ψ and Quantum Mechanics

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- It has a "position" representation: $\Psi : \mathbb{R}^{3N} \to \mathbb{C}^n$. What does 'position' mean? Why $3N$?
- What is that thing called Ψ?

History: Heisenberg about Ψ

The probability function combines objective and subjective elements. It contains statements about possibilities or better tendencies (‘potentia‘ in Aristotelian philosophy), and these statements are completely objective, they do not depend on any observer; and it contains statements about our knowledge of the system, which of course are subjective in so far as they may be different for different observers...
....Therefore, the transition from the ‘possible‘ to the ‘actual‘ takes place during the act of observation....We may say that the transition from the ‘possible‘ to the ‘actual‘ takes place as soon as the interaction of the object with the measuring device, and thereby with the rest of the world, has come into play; it is not connected with the act of registration of the result by the mind of the observer. The discontinuous change in the probability function, however, takes place with the act of registration, because it is the discontinuous change of our knowledge in the instant of registration that has its image in the discontinuous change of the probability function.

The mouse says:

The mouse says: What?

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What has the Hilbert space Ψ to do with three dimensional physical space with localized objects in it?

The mouse asks:

The mouse asks: Can't I be the recorder if not the observer?

The great John Bell in 'Against Measurement'

> *Was the wavefunction of the world waiting to jump for thousands of millions of years until a single-celled living creature appeared? Or did it have to wait a little longer, for some better qualified system . . . with a PhD?*

Mermin's mouse

Albert Einstein famously asked whether a wavefunction could be collapsed by the observations of a mouse. Bell expanded on that, asking whether the wavefunction of the world awaited the appearance of a physicist with a PhD before collapsing. The QBist answers both questions with "no." A mouse lacks the mental facility to use quantum mechanics to update its state assignments on the basis of its subsequent experience, but these days even an undergraduate can easily learn enough quantum mechanics to do just that.

David Mermin in Physics Today 2012: Fixing the shifty split

What does that mean?

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What does that mean?

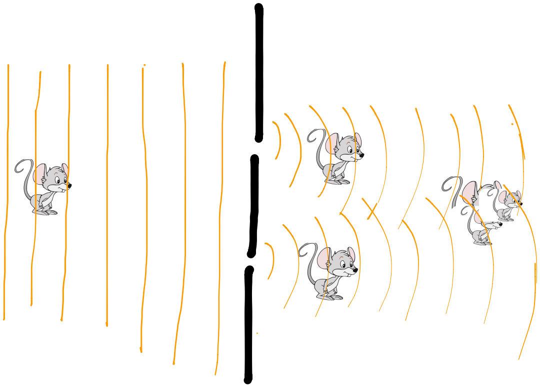
1. is the mouse a quantum system?
2. is the undergraduate in physics not a quantum system?
3. can an undergraduate in financial mathematics not register the outcome of a quantum measurement?

1. if the mouse is quantum system it can be a Schrödinger cat

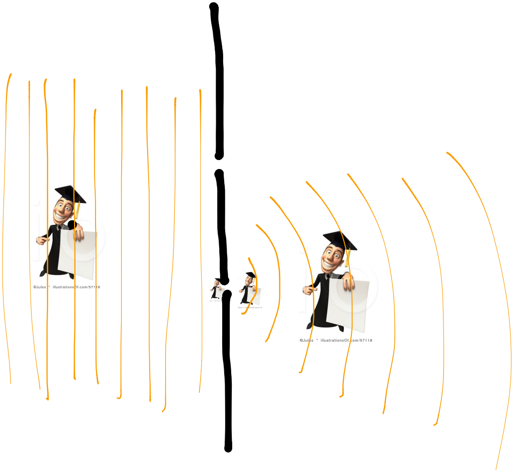
Mermin's mouse can be in superposition of a normal and a super mouse if upon decay of the atom the mouse gets a super pill for super strength. It just lacks the education to update its state

mouse turns into a superposition of mouse and super mouse

or Mermin's mouse can be a Banach Tarski mouse



but not a bachelor in physics



while a bachelor in financial mathematics

Honestly, I didn't do that. I do not even know whats wrong with that cat.

an undergraduate student of physics could easily kill a cat by looking


COMICS-THAT-90%-OF-THE-GENERAL-PUBLIC-WON'T-UNDERSTAND WEEK
Uh, Mr. Schrödinger?
Oh, hello Jeffrey?
Your mail came in today with this package.
I opened it up and...
Why the hell would someone send you a dead cat?
Cyanide and Happiness © Explosm.net

A Qbeast headmaster, Carlton M. Caves, is the source of all ...

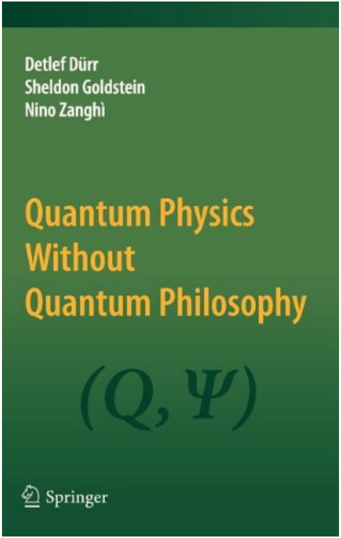
What is a measurement? It is the acquisition of information that is used to update the quantum state (collapse of the wave function, to use less neutral terms). Can dogs collapse the wave function? This is a dumb question, since dogs don't use wave functions. What they do use is the emergent reality, in which they and other agents gather and process information and make decisions based on the results.
In: Resource Material for Promoting the Bayesian View of Everything

and on goes on and on, here with Ontology in Qbism

> *In the Bayesian interpretation, the states of quantum systems do not have objective reality - they are states of knowledge, not states of the world - and the values of the properties of microscopic systems do not have objective reality. The apparatus of quantum states and associated probabilities is an elaborate theory of inference - a law of thought, in Chris' phrase - in which we put in what we know and get out statistical predictions for* **things*** *we can observe. In my version of the Bayesian interpretation, the objective parts of the theory - the ontology - lie in the other part of quantum mechanics, i.e., in the physical laws that govern the structure and dynamics of physical systems. These physical laws are encoded in Hamiltonians and Lagrangians.*

*my boldface

That is why we chose the title



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What is the wave function of the system after measurement?

Who or what collapses the wave function?

What has the abstract wave function to do with the three dimensional world and with the localized objects in it?

It is all about $\Psi \to \psi$

[1] Tim's phrase

It is all about $\Psi \to \psi$

- Option 1: The QBeast: The wave function is nailed to my head[1], it does not determine the physical behavior of matter. I see that the apparatus shows value β. I collapse Ψ to $\Psi_\beta = \varphi_\beta \Phi_\beta$ and update my state assignment of the system to φ_β. I compute probabilities according to quantum rules and when they turn out not to be logical, I call them quantum logical. Sorry for the mouse. Just to dumb to see reality emerge.

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- Option 3: The measurement problem is a real philosophical mystery. The physics is clear. Just look at what the apparatus shows. Do I need to look at the apparatus so that is shows something definite? That's a trick question! I don't answer that.

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- Option 4: Mermin's mouse says: What?

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Here are some words which, however legitimate and necessary in application, have no place in a formulation with any pretension to physical precision: system, apparatus, environment, microscopic, macroscopic, reversible, irreversible, observable, information, measurement

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in other words: $\Psi \rightarrow \psi$ must come from the analysis of a theory and not from the use of many worlds

Bohmian Mechanics solves it all with one stroke

When you say “particle”, mean it!
When you say “wave” mean it!
There is no harm in calling a particle particle and a wave wave! But beware: The wave is not a wave in physical space. So you better have something in our theory which is in physical space – what you have: the particles.

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$$Q = (Q_1, ..., Q_N) \text{ and } \Psi(q_1, \ldots, q_N)$$

$$Q_k \in \mathbb{R}^3 \text{ is the position of the } k\text{−th particle}$$

Particles Move

$$\frac{d}{dt}Q(t) \sim \mathrm{i}\nabla \ln \boldsymbol{\Psi}(Q(t))$$

$$\nabla = (\partial_{q_1}, \ldots, \partial_{q_N})$$

$\boldsymbol{\Psi}$ solves Schrödinger's equation

The handy tool of Bohmian Mechanics: the little ψ

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4. Normalisation

$$\psi^{Y}(x,t) = \frac{\psi^{Y}(x)}{\int dx|\psi^{Y}(x)|^{2}}$$

.

Quantum Equilbrium, DGZ 1992

$|\Psi|^2(Q)$ is a typicality measure: In typical Bohmian universes (with respect to $|\Psi|^2(Q)$)
in ensembles of subsystems having conditional wave function ψ^Y
the conditional empirical distribution of X coordinates is $|\psi^Y(x)|^2$.

the little ψ can be big

In measurement situations (preparation procedures)

$$\psi(x)\Phi(y) \xrightarrow{\text{Schrödinger evolution}} \Psi(x,y) = \sum_\alpha \varphi_\alpha(x)\Phi_\alpha(y)$$

if

$$(X,Y) \xrightarrow{\text{guided evolution}} (X,Y) \in \mathrm{supp}\varphi_\beta \times \mathrm{supp}\Phi_\beta \approx \mathrm{supp}\varphi_\beta \times Y_\beta$$

it happens that (normalization!)

$$\psi^Y(x,t) = \Psi(x, Y_\beta, t) = \varphi_\beta(x,t)$$

the little ψ can be big: it evolves autonomously

If

$$\psi^Y(x,t) = \varphi(x,t)$$

the little wave function can obey its own Schrödinger equation then

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If

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the little wave function can obey its own Schrödinger equation then

1. the empirical distribution of coordinates of the X particles is $|\varphi(x,t)|^2$
2. φ is for all practical purposes "the wave function" of the system. It is the "collapsed" wave function

Play it again Sam

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4. ψ collapses to φ_α
5. by quantum equilibrium the "collapse happens" with probability $|\langle\psi_\alpha|\varphi\rangle|^2$

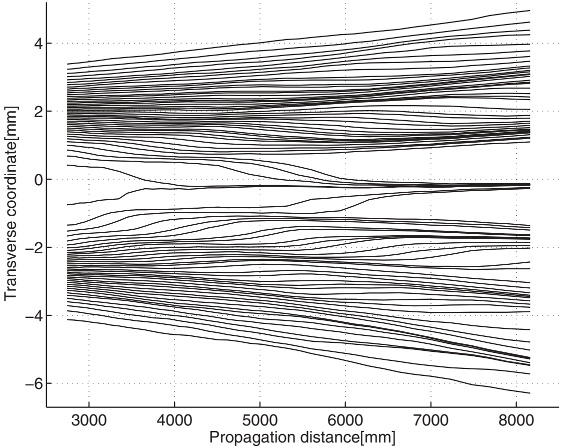
Understanding Quantum Mechanics means to analyze the little wave function

For that one needs ontology, stuff out there, the particles in BM

the physics is in the little ψ

ψ guides the particles of interest and $|\psi|^2$ gives the probabilities. That is all we need.

the little ψ guides a particle through a double slit



Exeperiment: S.Kocsis et al: Science 2011

to whom it may concern: observables

$$\Psi = \varphi\Phi \overset{\text{Schrödinger evolution}}{\longrightarrow} \sum_{\alpha} \varphi_{\alpha}\Phi_{\alpha}.$$

Suppose the Y_α point to values α on a scale. Suppose the φ_α are orthogonal. Then the outcomes (values and probabilities) can be encoded in an operator $\hat{A} = \sum_\alpha \alpha|\varphi_\alpha\rangle\langle\varphi_\alpha|$.

to whom it may concern: uncertainty relation

[2] Nino's phrase

to whom it may concern: uncertainty relation

The little ψ changes in measurement experiments and as one cannot simultaneously pee on a piece of wood and set it on fire[2], one cannot measure position and momentum: Position is here and now and momentum is: where will the particle be after a long time. The little ψ will say where.

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The moral: Operators don't commute!
Observables have nothing to do with properties of stuff– they are and always will be boring book keeping devices

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Question: Who wrote

> *In current quantum theory, probabilities express our ignorance due to our failure to search for the real causes of physical phenomen; and, worse, our failure even to think seriously about the problem. ... the central dogma simply asserts this and draws the conclusion that that belief in causes, and searching for them, is philosophically naive. ... But it seems to us that this attitude places a premium of stupidity; to lack the ingenuity to think of a rational physical explanation is to support the supernatural view.*