

# What's wrong with "standard" quantum mechanics?

Asking this was once taboo, but nowadays it is an exciting and active field



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BIFI, ZCAM, DFTUZ, University of Zaragoza, Spain*



Zaragoza, December 3, 2013 – Martes cuánticos

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- If a measurable physical quantity corresponding to the Hermitian operator  $A$  is measured and the eigenvalue  $a_k$  is obtained, the state of the system experiences an immediate change known as **collapse**:  $|\psi\rangle \rightarrow |\psi_k\rangle = P_k|\psi\rangle/||P_k|\psi\rangle||$

**“Measurement” seems like a very important thing in the theory**

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**except when** a “measurement” is made

# So... what is it?

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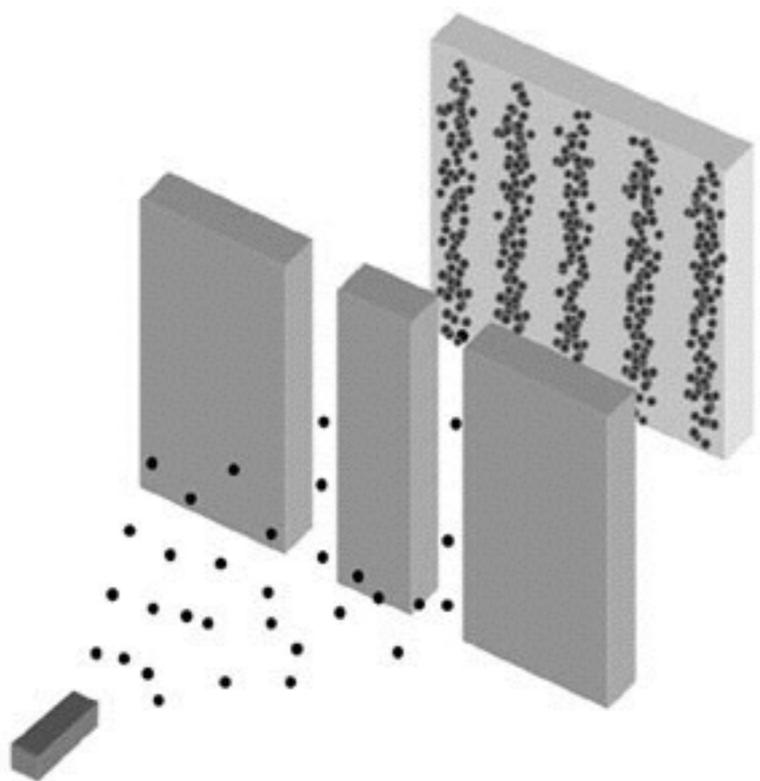
J. S. Bell

The concept of “observable” lends itself to very precise mathematics when identified with “self-adjoint operator”. But physically, it is a rather woolly concept. It is not easy to identify precisely **which physical processes are to be given the status of “observations”** and which are to be relegated to the limbo between one observation and another.

J. S. Bell, *Speakable and unspeakable in quantum mechanics*,  
*Cambridge University Press*, 2004, p. 52.

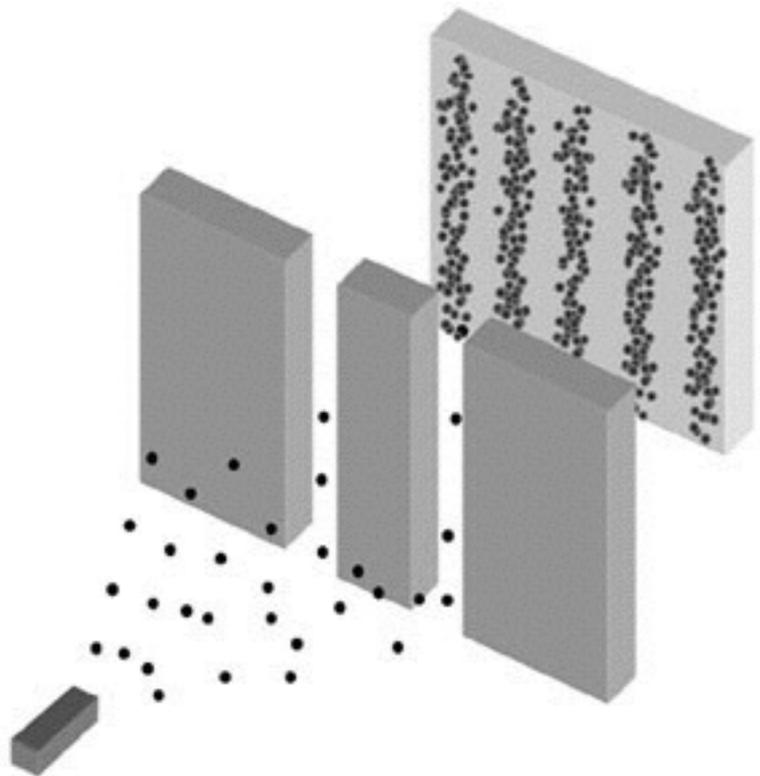
# At what point the evolution stops being unitary?

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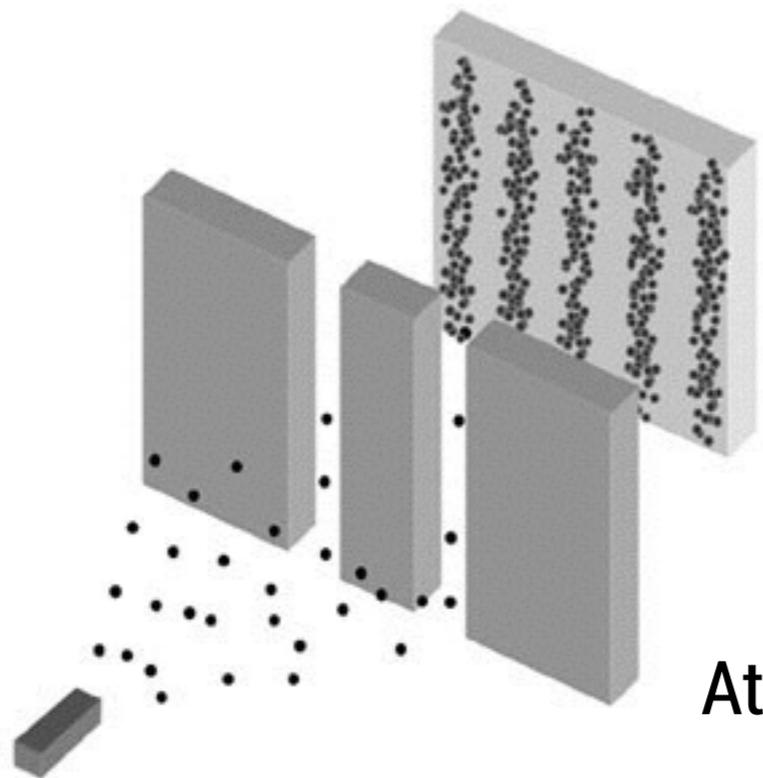
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At the screen?

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At the screen?

At the double-slit plank?

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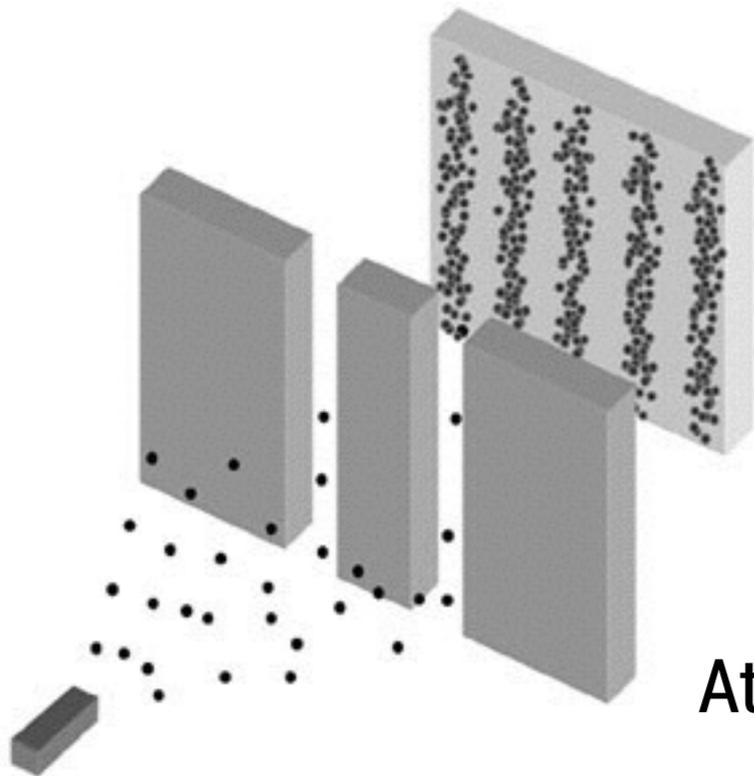
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At the microscope I use to look  
at the microscopic interference pattern?

At the screen?

At the double-slit plank?



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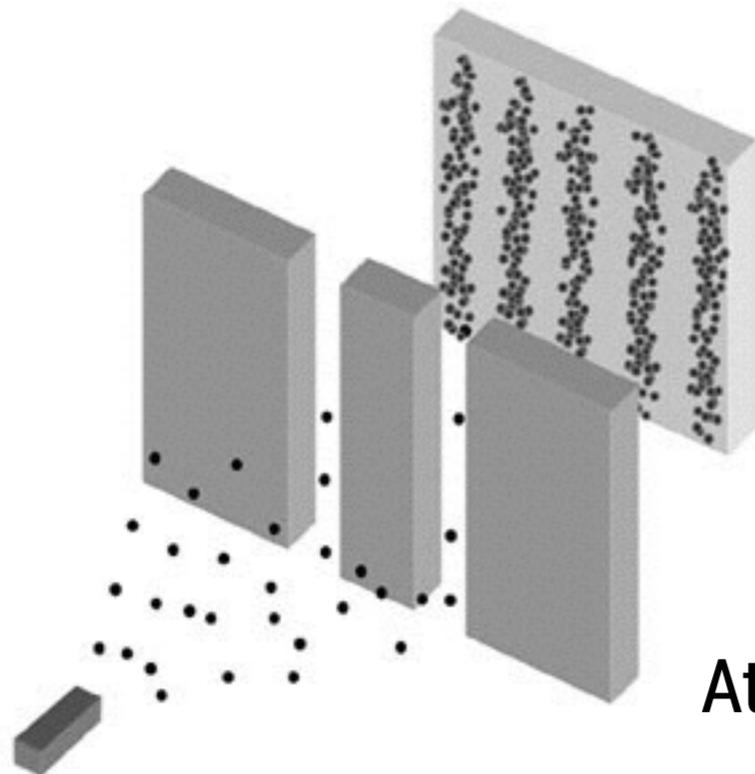
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At the computer I use to register the microscope data?



At the microscope I use to look at the microscopic interference pattern?

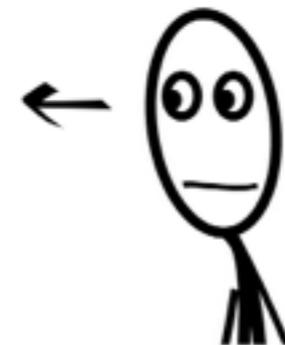


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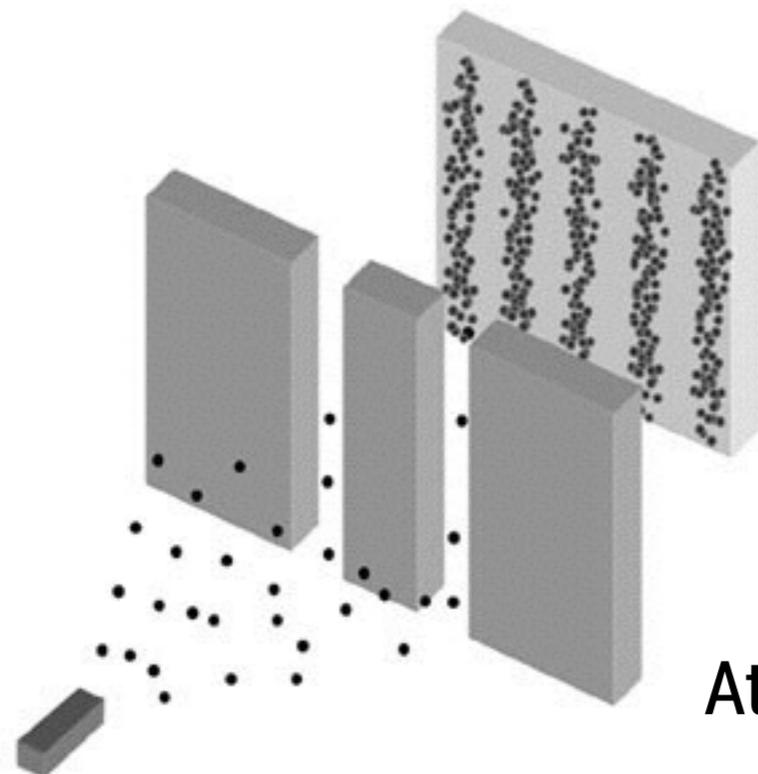
At me?



At the computer I use to register the microscope data?



At the microscope I use to look at the microscopic interference pattern?



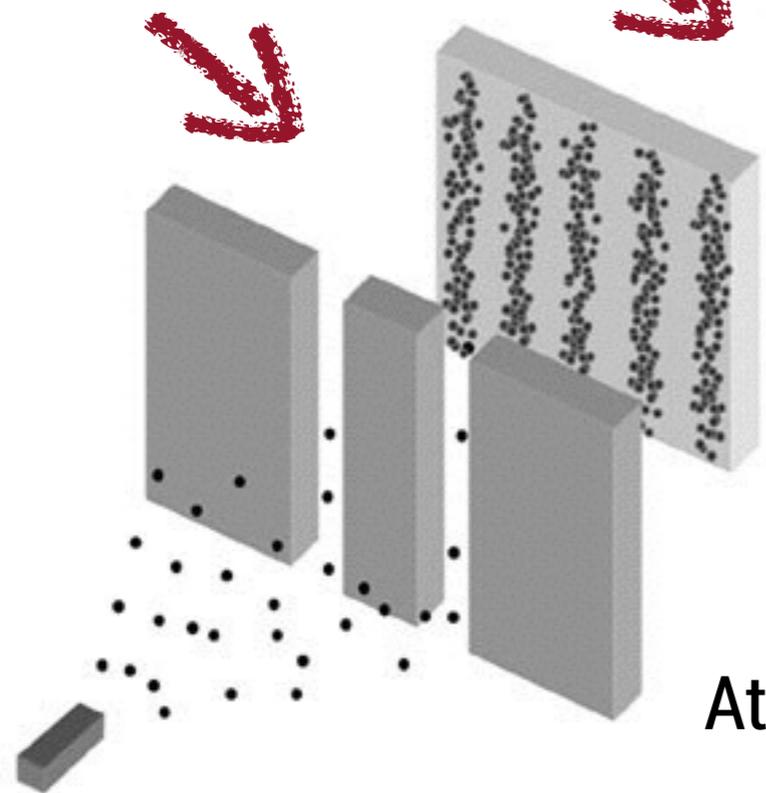
At the screen?

At the double-slit plank?

# At what point the evolution stops being unitary?

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Somewhere between some of these steps?



At the double-slit plank?

At the screen?

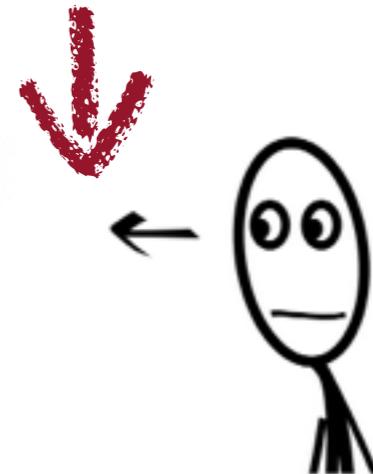
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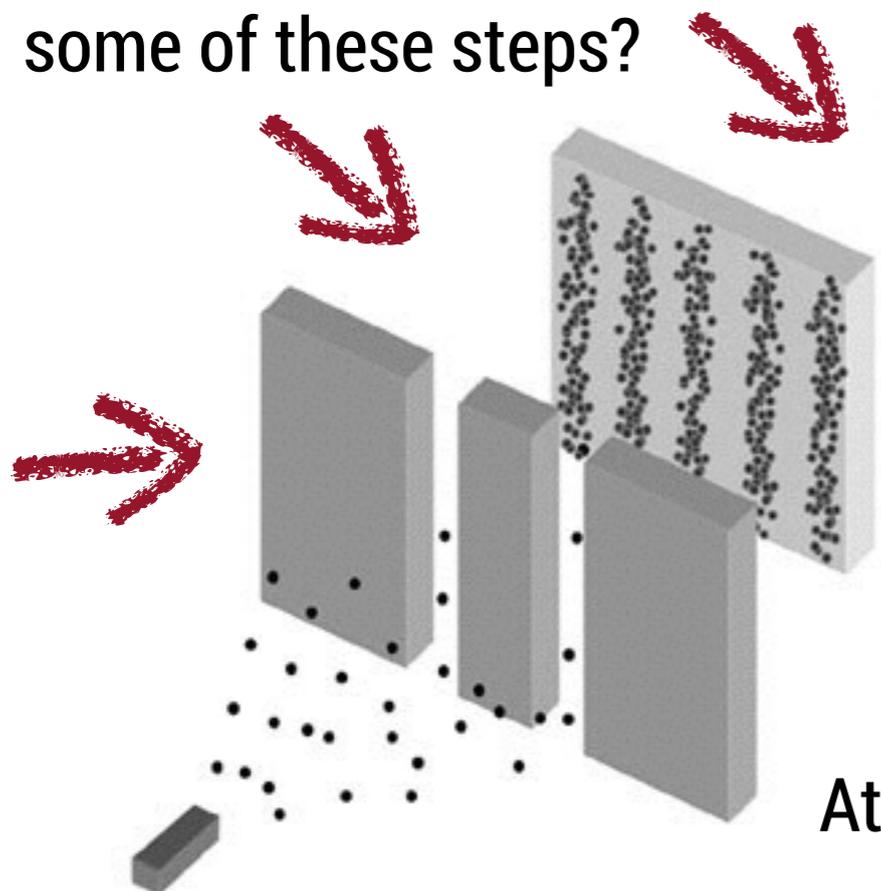
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At some specific internal part of some of these systems?



At me?

Somewhere between some of these steps?



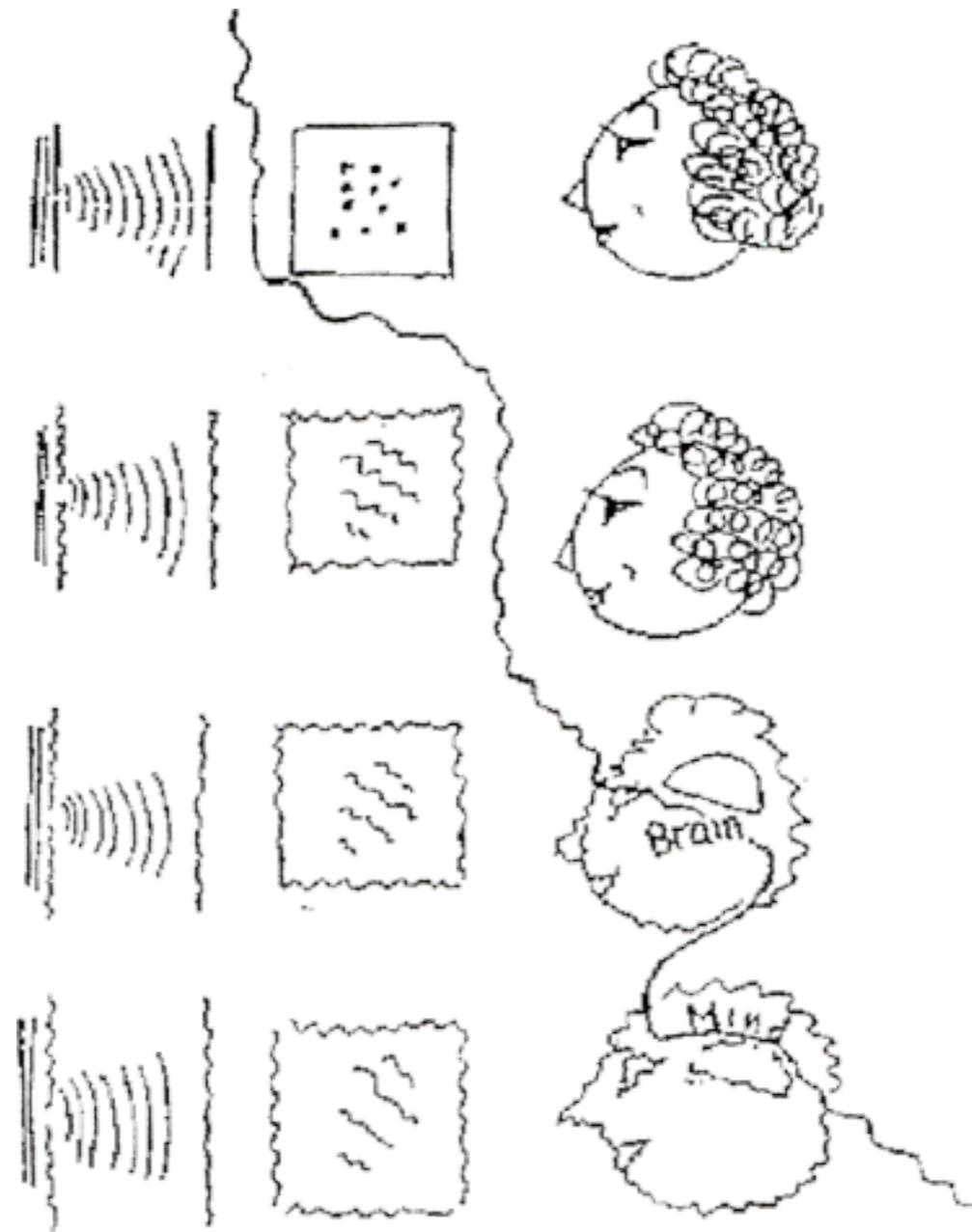
At the computer I use to register the microscope data?

At the microscope I use to look at the microscopic interference pattern?

At the screen?

At the double-slit plank?

But wait, it gets worse: Maybe “measurement” happens in my mind...



# Maybe...

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In the absence of a conscious entity, the moon remains a radically ambiguous and ceaselessly flowing quantum soup.

# A Nobel prize-winning physicist proposed it (not joking)

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E. P. Wigner

When the province of physical theory was extended to encompass microscopic phenomena, through the creation of quantum mechanics, the concept of consciousness came to the fore again: **it was not possible to formulate the laws of quantum mechanics in a fully consistent way without reference to the consciousness.**

It follows that the being with a consciousness must have a different role in quantum mechanics than the inanimate measuring device...

E. P. Wigner, Remarks on the mind-body question, in *Symmetries and Reflections*, Indiana University Press, p. 171.

**Oh my! But why?**

A thick, textured red brushstroke underline is positioned directly beneath the text "Oh my! But why?".

# The usual reason for these things

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E. P. Wigner

Until not many years ago, the “existence” of **a mind or soul** would have been denied by most physical scientists. The brilliant successes of mechanistic and, more generally, macroscopic physics and of chemistry overshadowed **the obvious fact** that thoughts, desires, and emotions **are not made of matter**, and it was nearly universally accepted among physical scientists that there is nothing besides matter. [...] **Even today**, there are adherents to this view though fewer among the physicists than –ironically enough– among biochemists.

E. P. Wigner, Remarks on the mind-body question, in *Symmetries and Reflections*, Indiana University Press, p. 171.

# More relevant data

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E. P. Wigner

Near the end of his life, Wigner's thoughts turned more philosophical. In his memoirs, Wigner said: "The full meaning of life, the collective meaning of all human desires, is **fundamentally a mystery beyond our grasp**. As a young man, I chafed at this state of affairs. But by now I have made peace with it. I even feel a certain honor to be associated with such a mystery." He became interested in the Vedanta philosophy of Hinduism, particularly its ideas of **the universe as an all pervading consciousness**.

Eugene Wigner entry at *Wikipedia*.

# But don't think this is old history

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Journal of Cosmology, 2011, Vol. 14.

JournalofCosmology.com, 2011

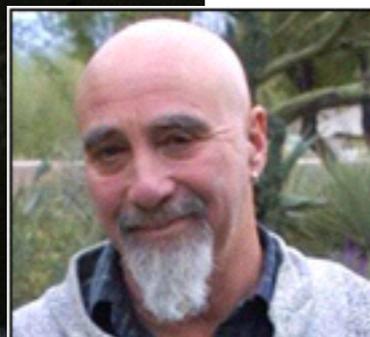
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## Consciousness in the Universe: Neuroscience, Quantum Space-Time Geometry and Orch OR Theory

**Roger Penrose, PhD, OM, FRS<sup>1</sup>, and Stuart Hameroff, MD<sup>2</sup>**

<sup>1</sup>Emeritus Rouse Ball Professor, Mathematical Institute, Emeritus Fellow, Wadham College,  
University of Oxford, Oxford, UK

<sup>2</sup>Professor, Anesthesiology and Psychology, Director, Center for Consciousness Studies, The University of Arizona,  
Tucson, Arizona, USA



*The New Frontier in  
Brain/Mind Science*

*Stuart Hameroff MD*

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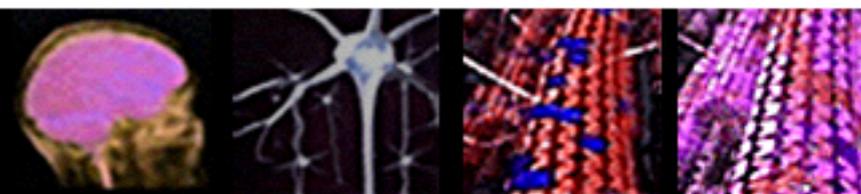
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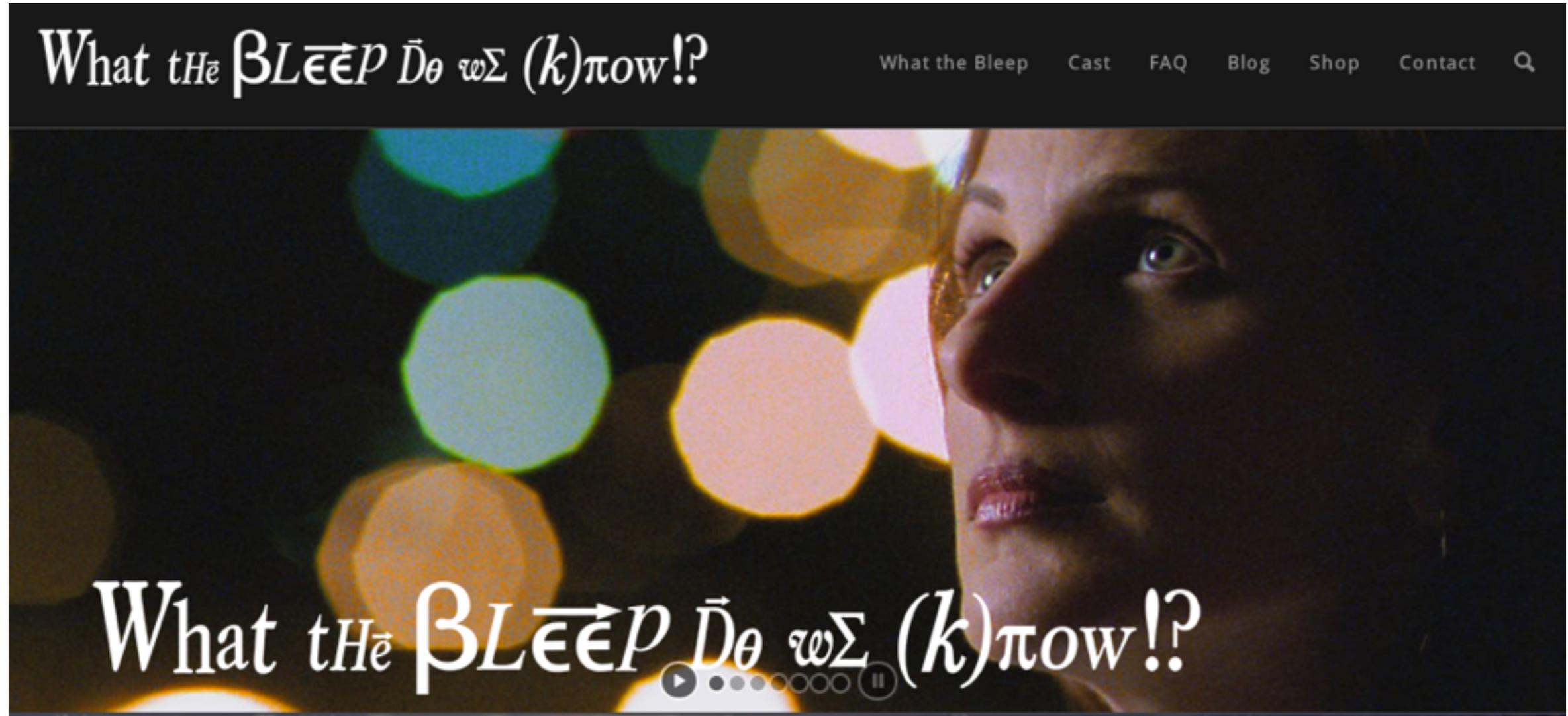
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They make it very difficult for us to complain about this



# ... or about this

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*Foundations of Physics, Vol. 12, No. 12, 1982*

## **FLASH<sup>1</sup>—A Superluminal Communicator Based Upon a New Kind of Quantum Measurement**

**Nick Herbert<sup>2</sup>**

*Received January 15, 1982*

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*The FLASH communicator consists of an apparatus which can distinguish between plane unpolarized (PUP) and circularly unpolarized (CUP) light plus a simple EPR arrangement. FLASH exploits the peculiar properties of "measurements of the Third Kind." One purpose of this article is to focus attention on the operation of idealized laser gain tubes at the one-photon limit.*

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## How the No-Cloning Theorem Got its Name

Asher Peres  
Department of Physics,  
Technion—Israel Institute of Technology,  
32000 Haifa, Israel

February 1, 2008

### **Abstract**

I was the referee who approved the publication of Nick Herbert's *FLASH* paper, knowing perfectly well that it was wrong. I explain why my decision was the correct one, and I briefly review the progress to which it led.

# ... or about this

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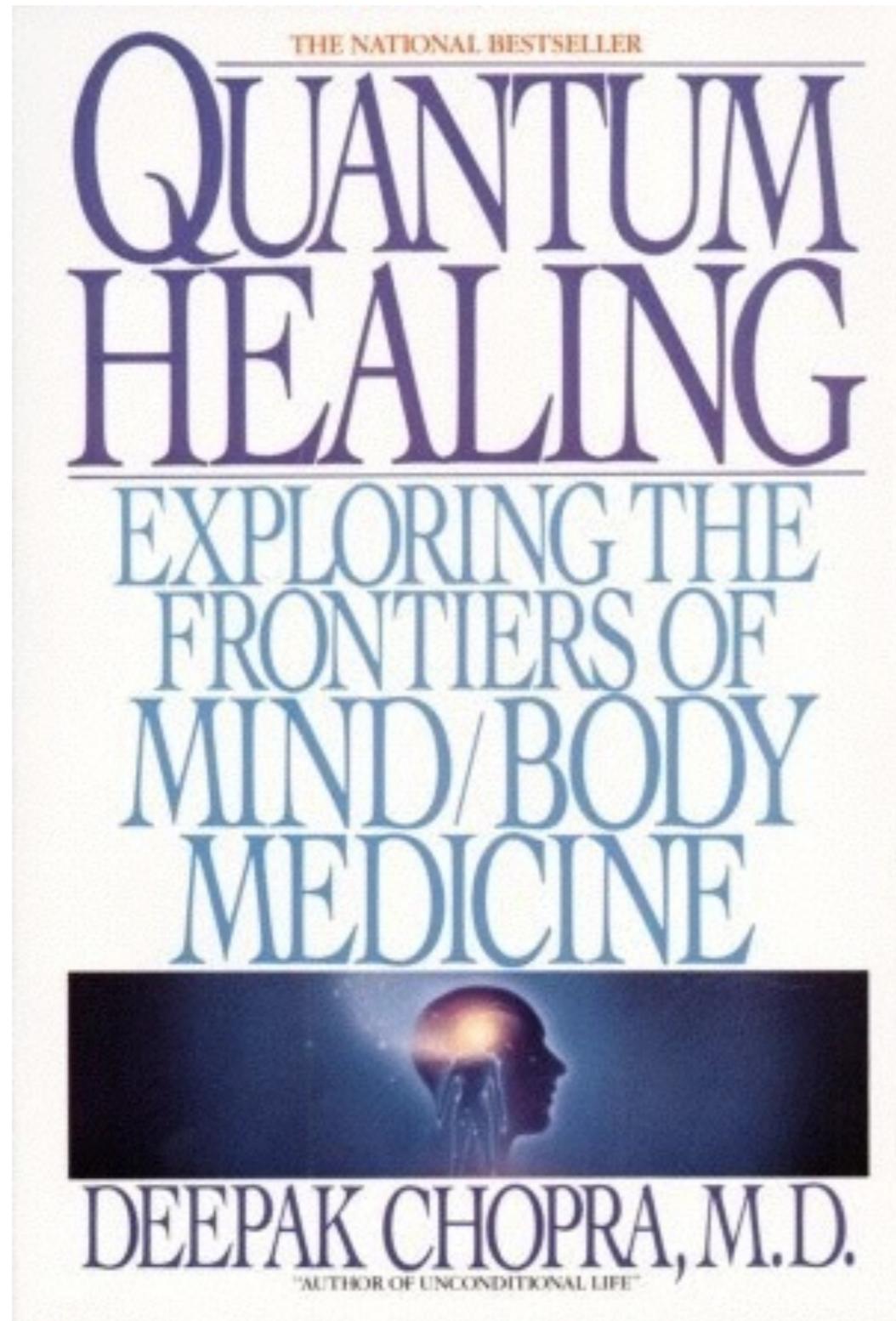
Shall I look at Her  
Or shall I not?  
Hard, small, separated  
If I look;  
Soft, spread-out, connected  
If I don't.

Hard particle and soft wave: both?  
Small right-here and spread-out everywhere: both?  
Deep connected yet lonely separate?

Honey  
Some day You gotta show me  
How You do that.

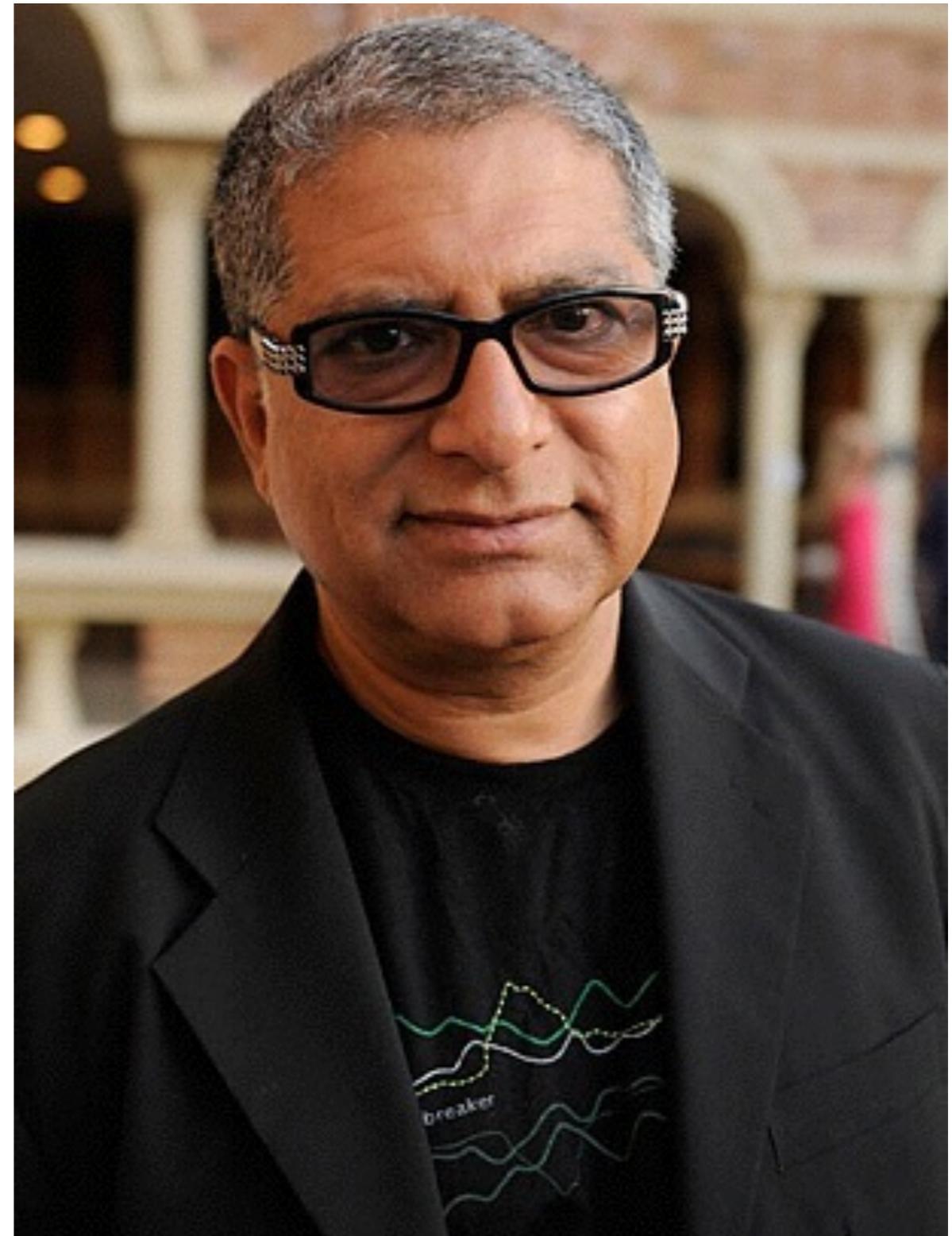
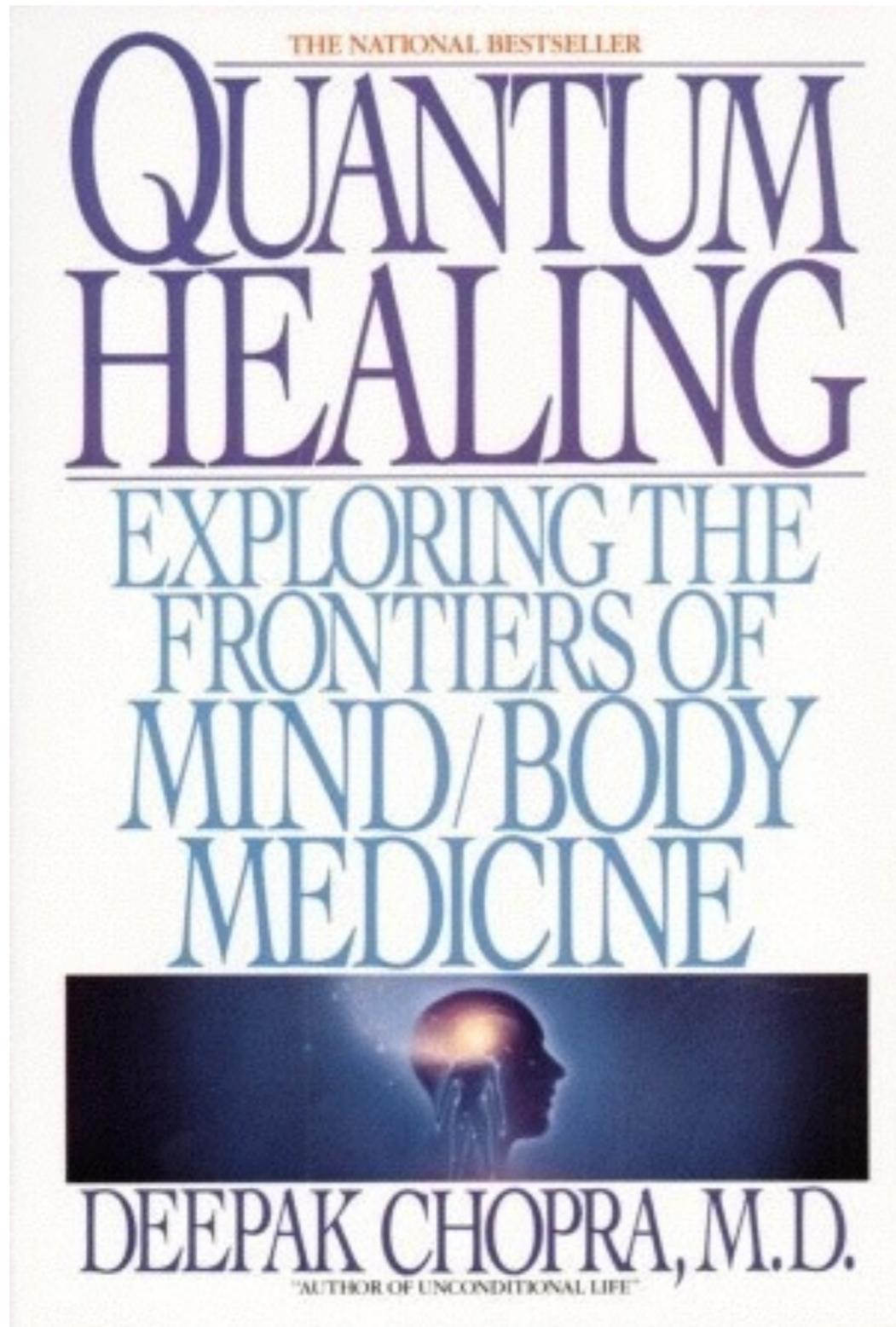
N. Herbert, *Physics on all fours*,  
*Sea Creature Press*, 2000.

... or about this



... or about this

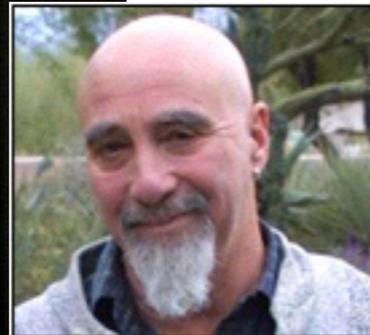
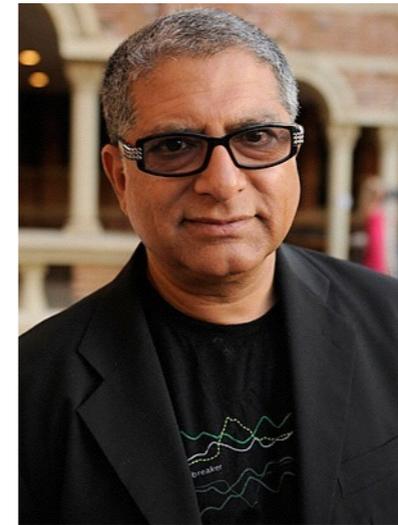
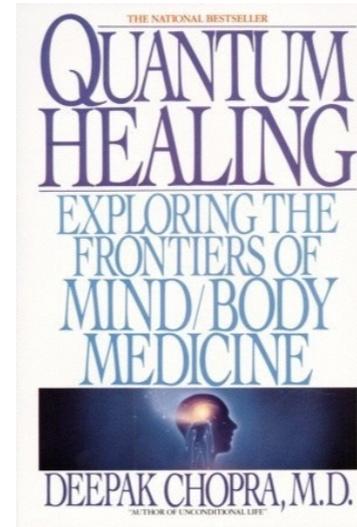
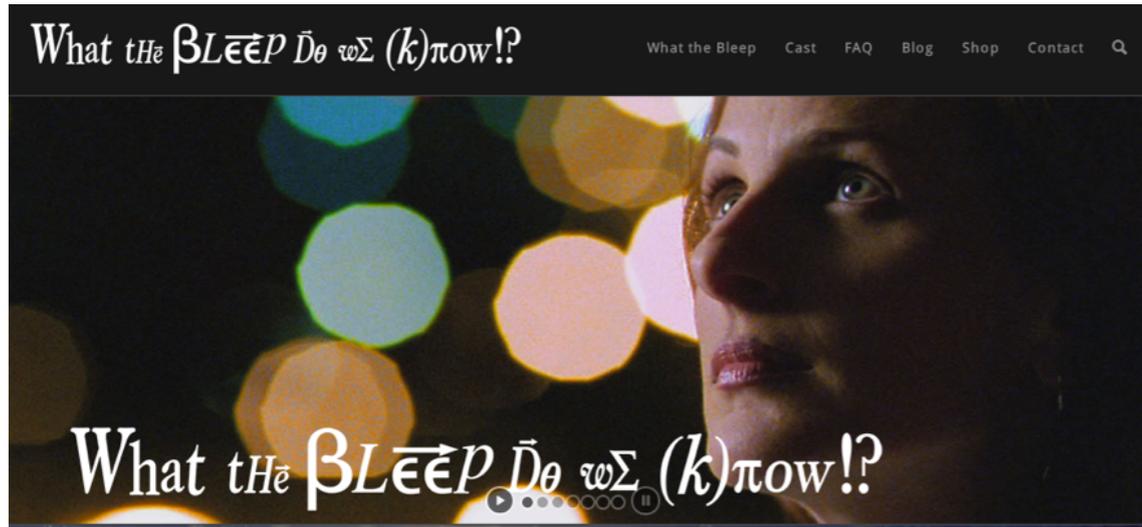
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... or about this



# This...



The New Frontier in Brain/Mind Science

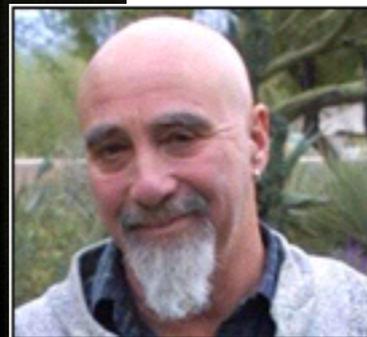
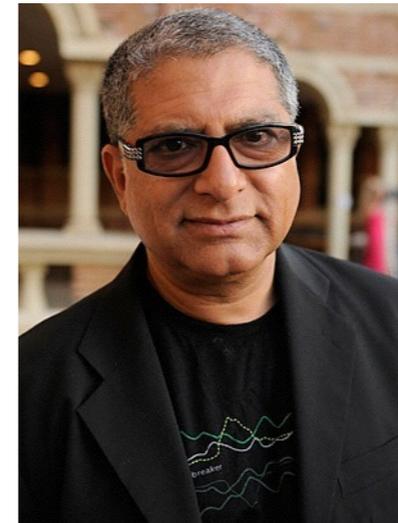
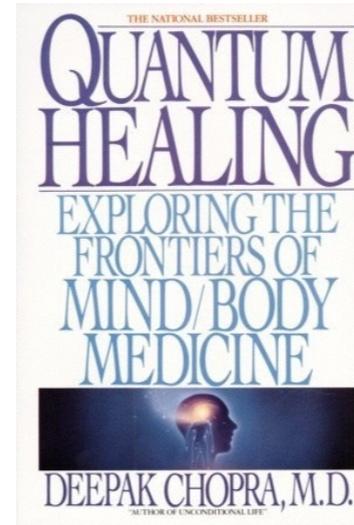
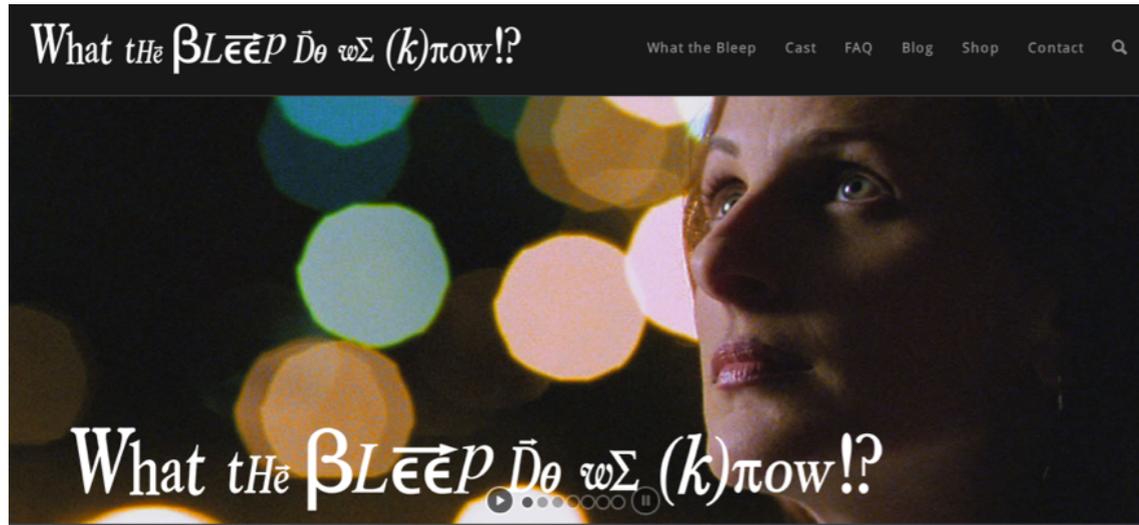
Stuart Hameroff MD

## QUANTUM CONSCIOUSNESS

Personal Publications Media Views Quantum Mind Archives Ultimate Computing

The image is a banner for "The New Frontier in Brain/Mind Science" featuring Stuart Hameroff MD. It includes a navigation menu with links for "Personal", "Publications", "Media", "Views", "Quantum Mind Archives", and "Ultimate Computing". The banner also features several small images: a brain, a neuron, and a DNA double helix.

# This... **magic**



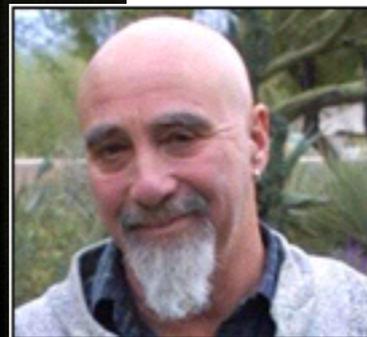
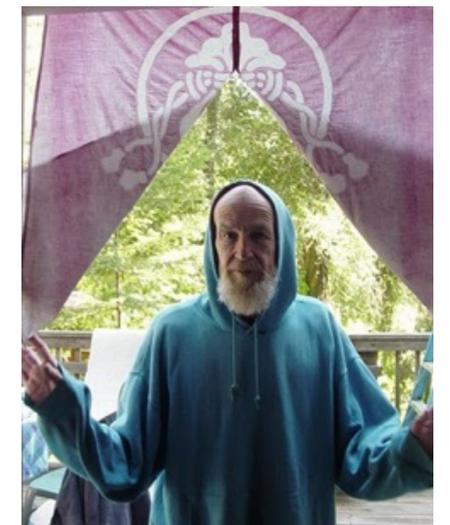
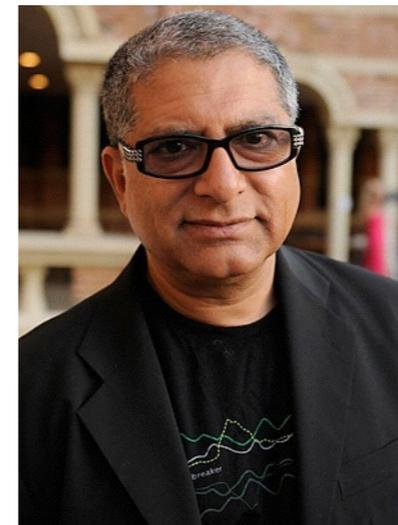
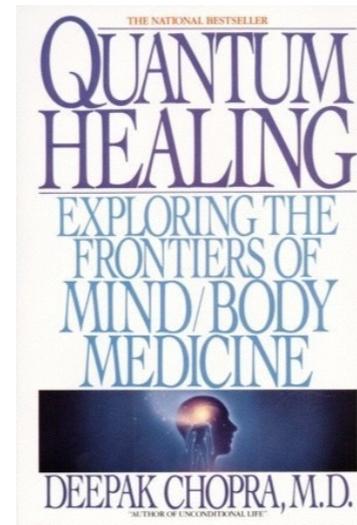
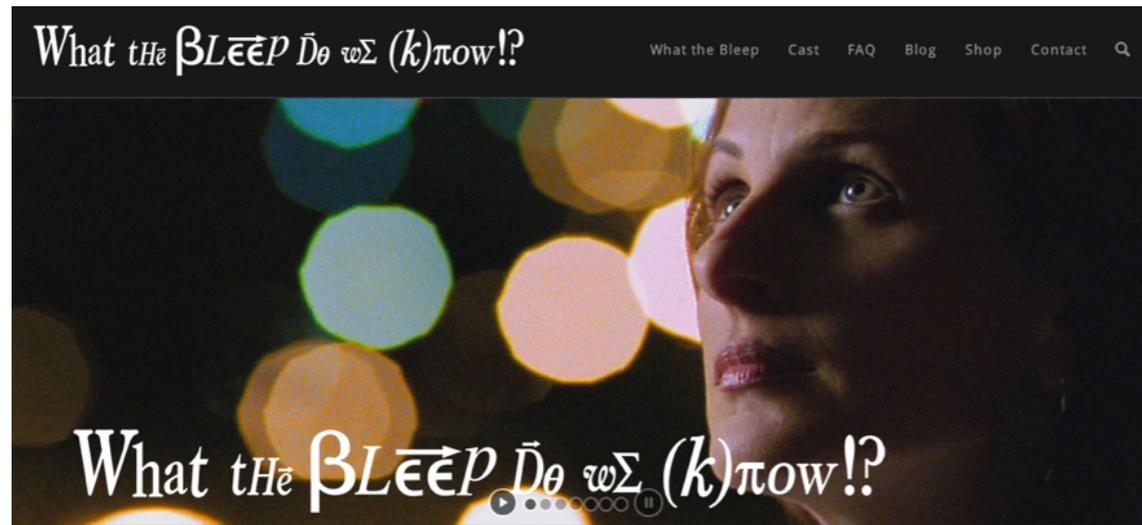
The New Frontier in Brain/Mind Science

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# This... **magic**



The New Frontier in  
Brain/Mind Science

Stuart Hameroff MD

**QUANTUM CONSCIOUSNESS**

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... is a **natural** consequence of the vague, ambiguous talking that we physicists have allowed and even encouraged for too many decades now.

# The vague talking reaches as deep as it gets

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I don't mean vague, ambiguous talking in the department corridor, or in brainstorm meetings, or in the bar.

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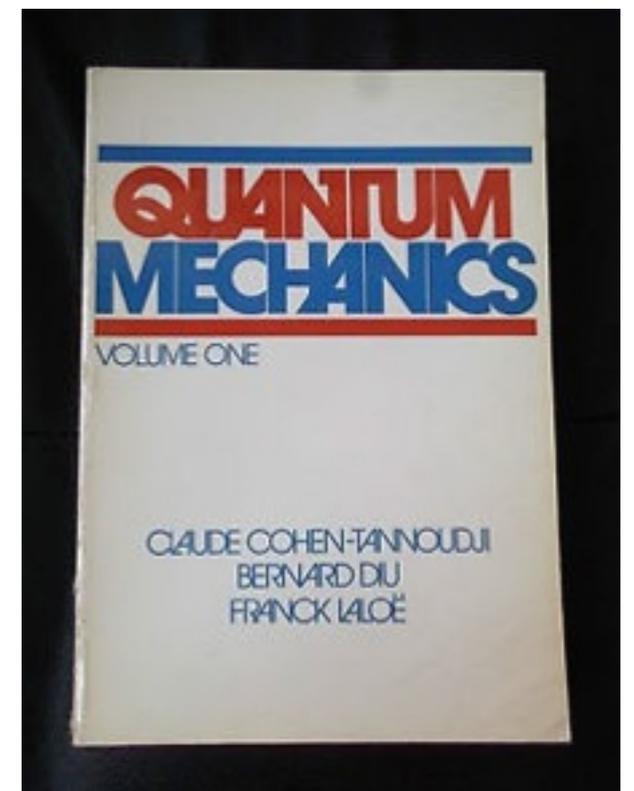
I would be too naive if I didn't know that real research requires that we use language with different levels of definiteness depending on the phase, depending on the purpose.

I mean vague, ambiguous talking in the very **postulates** of the theory, in the **best textbooks** that we use to teach quantum mechanics to the new generations.

*Second Postulate:* Every measurable physical quantity  $\mathcal{A}$  is described by an operator  $A$  acting in  $\mathcal{E}$ ; this operator is an observable.

*Third Postulate:* The only possible result of the measurement of a physical quantity  $\mathcal{A}$  is one of the eigenvalues of the corresponding observable  $A$ .

*Fifth Postulate:* If the measurement of the physical quantity  $\mathcal{A}$  on the system in the state  $|\psi\rangle$  gives the result  $a_n$ , the state of the system immediately after the measurement is the normalized projection,  $\frac{P_n |\psi\rangle}{\sqrt{\langle \psi | P_n | \psi \rangle}}$ , of  $|\psi\rangle$  onto the eigensubspace associated with  $a_n$ .



# The Copenhagen interpretation (postmodernism at its best)

---



N. Bohr

There is no quantum world. There is only an abstract quantum physical description. It is wrong to think that the task of physics is to find out **how nature is**. Physics concerns **what we can say about nature**.

Copenhagen interpretation of quantum mechanics,  
<http://www.informationphilosopher.com>



W. Heisenberg

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Copenhagen interpretation of quantum mechanics,  
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W. Heisenberg

This again emphasizes a subjective element in the description of atomic events [...] what we observe is not **nature in itself** but **nature exposed to our method of questioning**. Our scientific work in physics consists in asking questions about nature in the language that we possess and trying to get an answer from experiment by the means that are at our disposal.

Copenhagen interpretation of quantum mechanics,  
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# The “official version” of quantum mechanics

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J. S. Bell

John Stewart Bell, responsible of the rebirth of the field of quantum foundations and of many very important results about quantum mechanics, once famously said: “I am a quantum engineer [referring to his very relevant ‘day job’ at CERN as a particle physicist and accelerator designer], but on Sundays I have principles.”

Opening sentence of his "underground colloquium" in March 1983,  
as quoted by N. Gisin in *Quantum [un]speakables: from Bell to quantum information*,  
Springer, 2002, p. 199.

# Shut up and calculate!

---

Now a lot of scientists recognize the Copenhagen interpretation for what **it really is**: an excuse, a “pragmatic”, fast-and-dirty way out of a difficult, unsolved problem.

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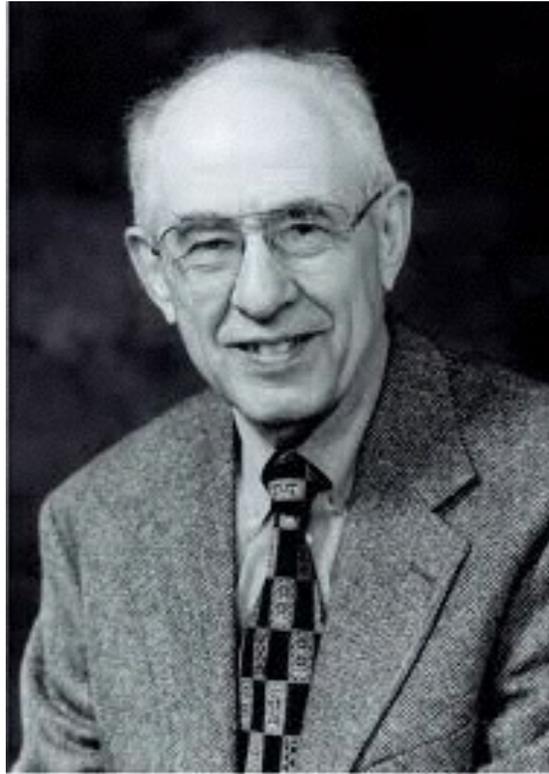
N. D. Mermin

If I were forced to sum up in one sentence what the Copenhagen interpretation says to me, it would be “Shut up and calculate!”

N. D. Mermin, What's wrong with this pillow?,  
*Physics Today* **42** (1989) 9.

# “Bohr brainwashed a generation of physicists”

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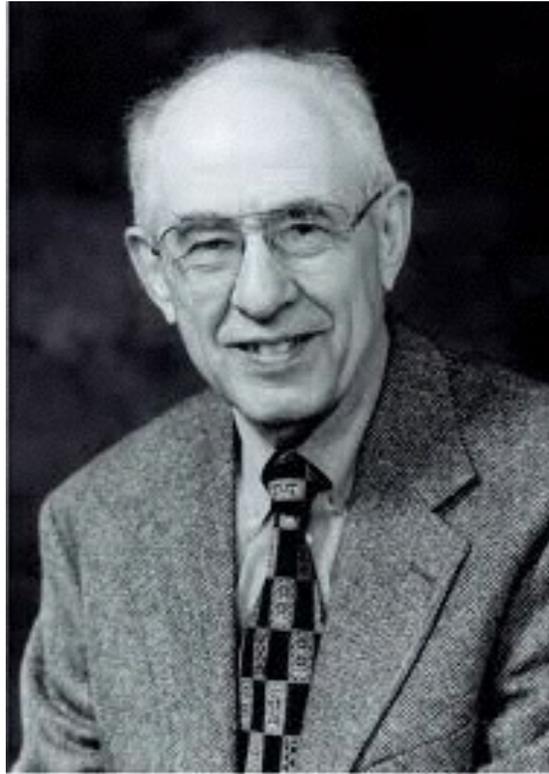


H. Putnam

... it took a long time for physicists to admit that there is [...] a problem. I can tell you a story about that. In 1962 I had a series of conversations with a world-famous physicist (whom I will not identify by name). At the beginning, he insisted, ‘You philosophers just think there is a problem with understanding quantum mechanics. **We physicists have known better from Bohr on.**’ After I forget how many discussions, we were sitting in a bar in Cambridge, and he said to me, ‘You’re right. **You’ve convinced me there is a problem here; it’s a shame I can’t take three months off and solve it.**’

# “Bohr brainwashed a generation of physicists”

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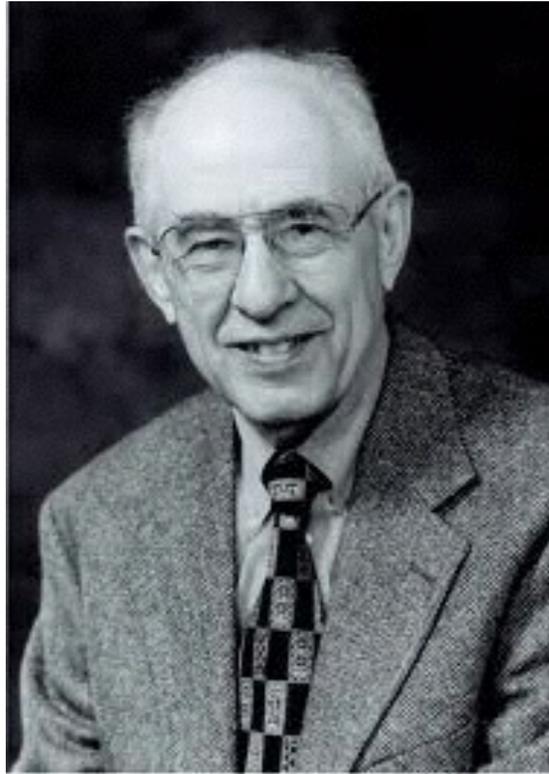
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H. Putnam, A philosopher looks at quantum mechanics (again),  
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M. Gell-Mann

The unnamed physicist was **Murray Gell-Mann.**

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It's more like a **zombie interpretation**, with its "arguments" inadvertently creeping into conversations and papers, into discussions and books, into opinions and careers, long after it died.

**First, the weak arguments in favor of “Shut up and calculate!”**

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- *You can only talk about what can be measured.*

This is just **a position among many**. In no way this has been “proved” by quantum mechanics. Any person working in Bohmian mechanics will advise you differently, also people working in collapse models, and Bell, and Jean Bricmont, and Tim Maudlin and many more.

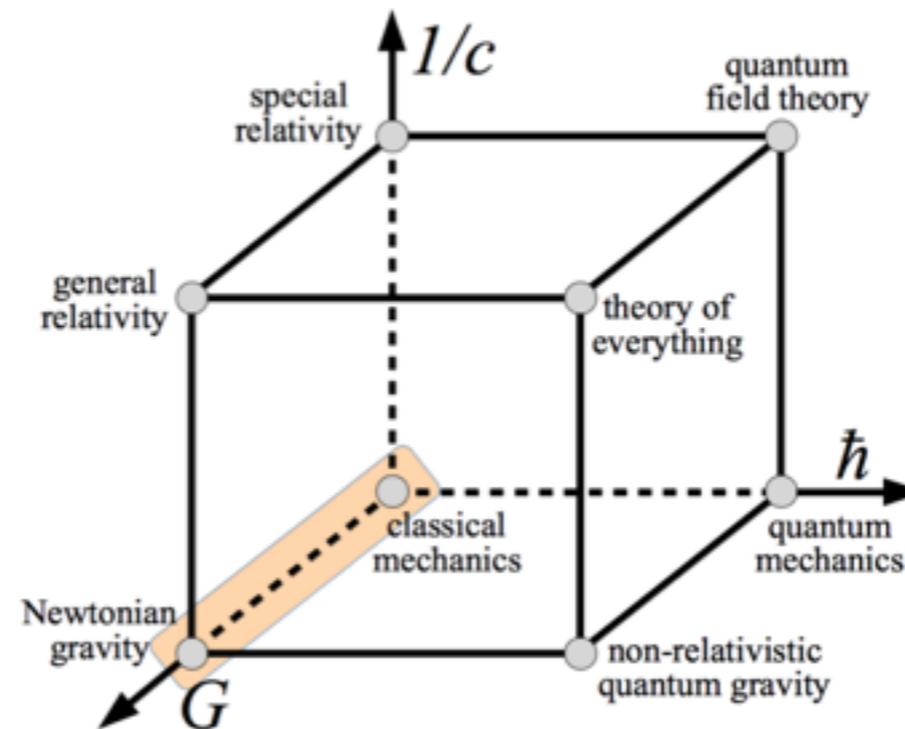
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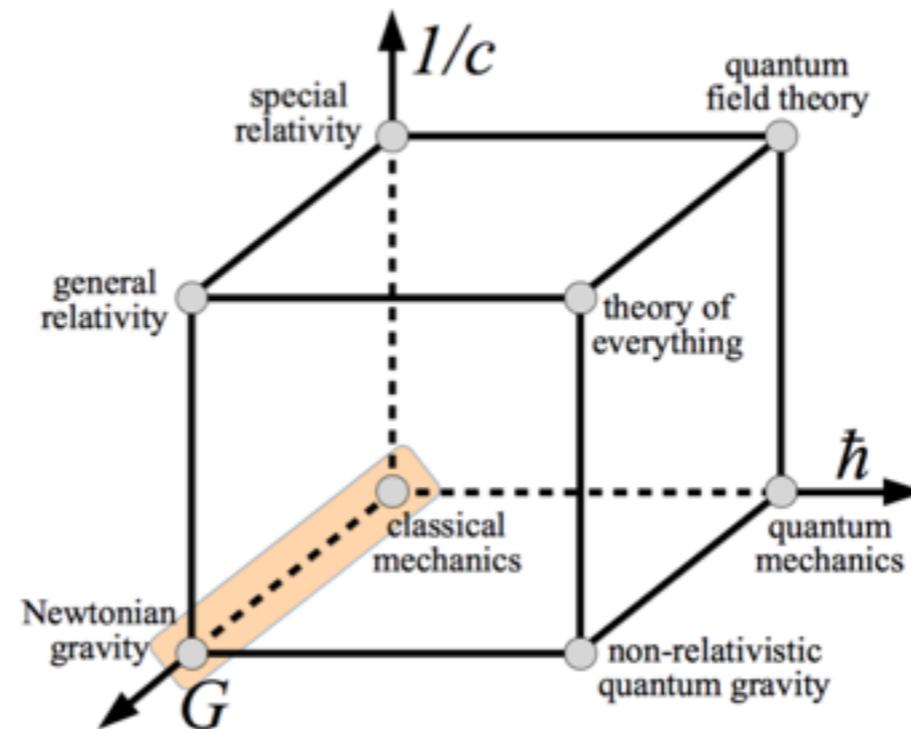
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Again, this is not true. I am not at all bothered by special relativity, although it is also a very nonclassical, and hence counterintuitive theory. In fact, nobody is. There is no field about the “foundations of special relativity”. **The problem with QM is not this one.** Its problem is that it is ambiguous at the postulates level.

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Third, I can introduce you to a couple philosophers who know more QM than you do. Yes, **including** the mathematics.

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People that knew (know) a great deal of QFT, such as Bell or 't Hooft, also knew (know) that there is a problem in QM and worked (work) to fix it.

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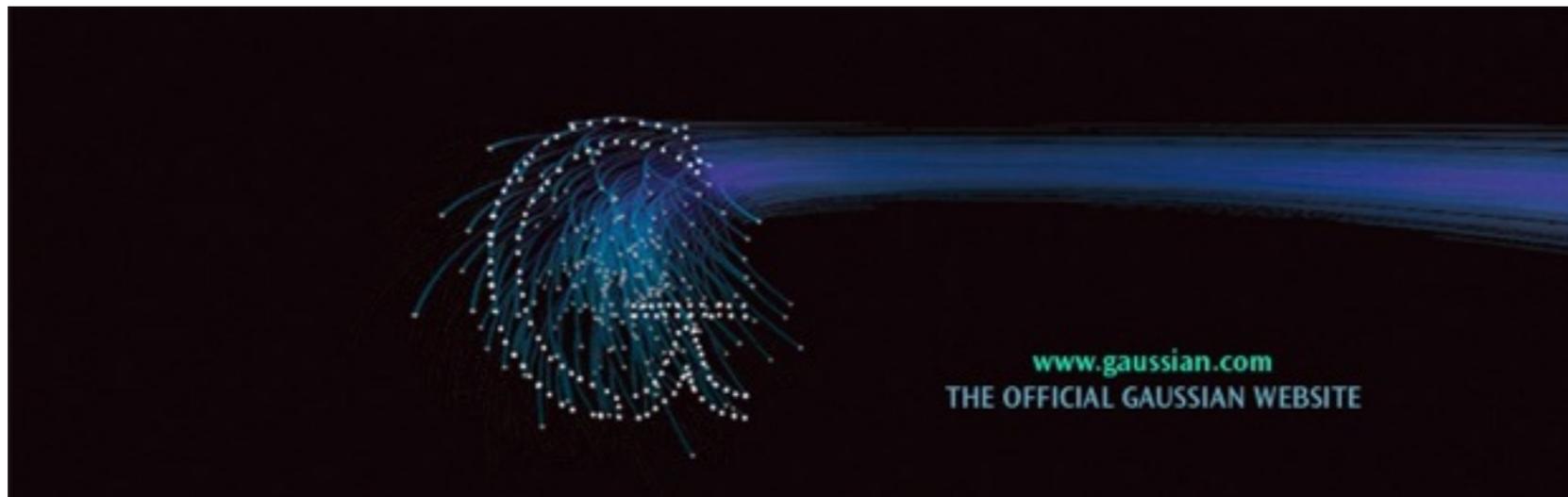
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So much so that people is making **a lot of money** with it.

**Ok, it happens... but how?**



# Let me try some analogies: How does this work?

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# How does this work?



... or this?

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**Simple: Because people is intelligent**



# Coping with vagueness

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What is more frequent: QM experiments working or your plane landing safely, or your computer doing what you expect it will do?

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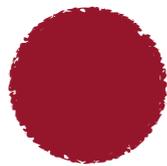
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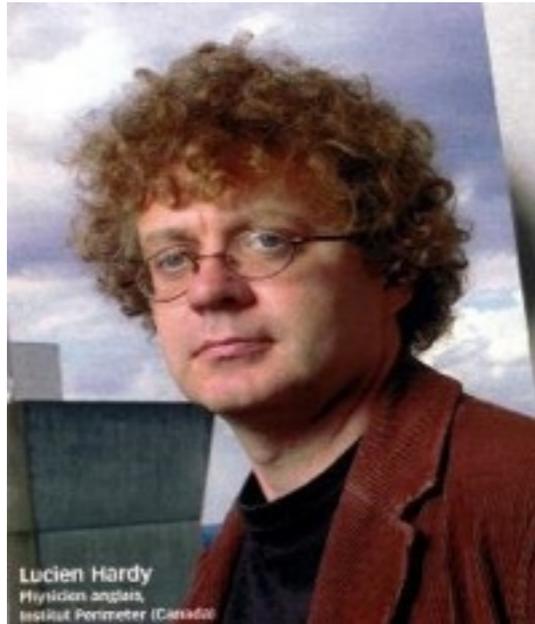
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Yes. Quantum mechanics works... and, still, **it is vague**.

# We know how to use it, but we don't understand it

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L. Hardy

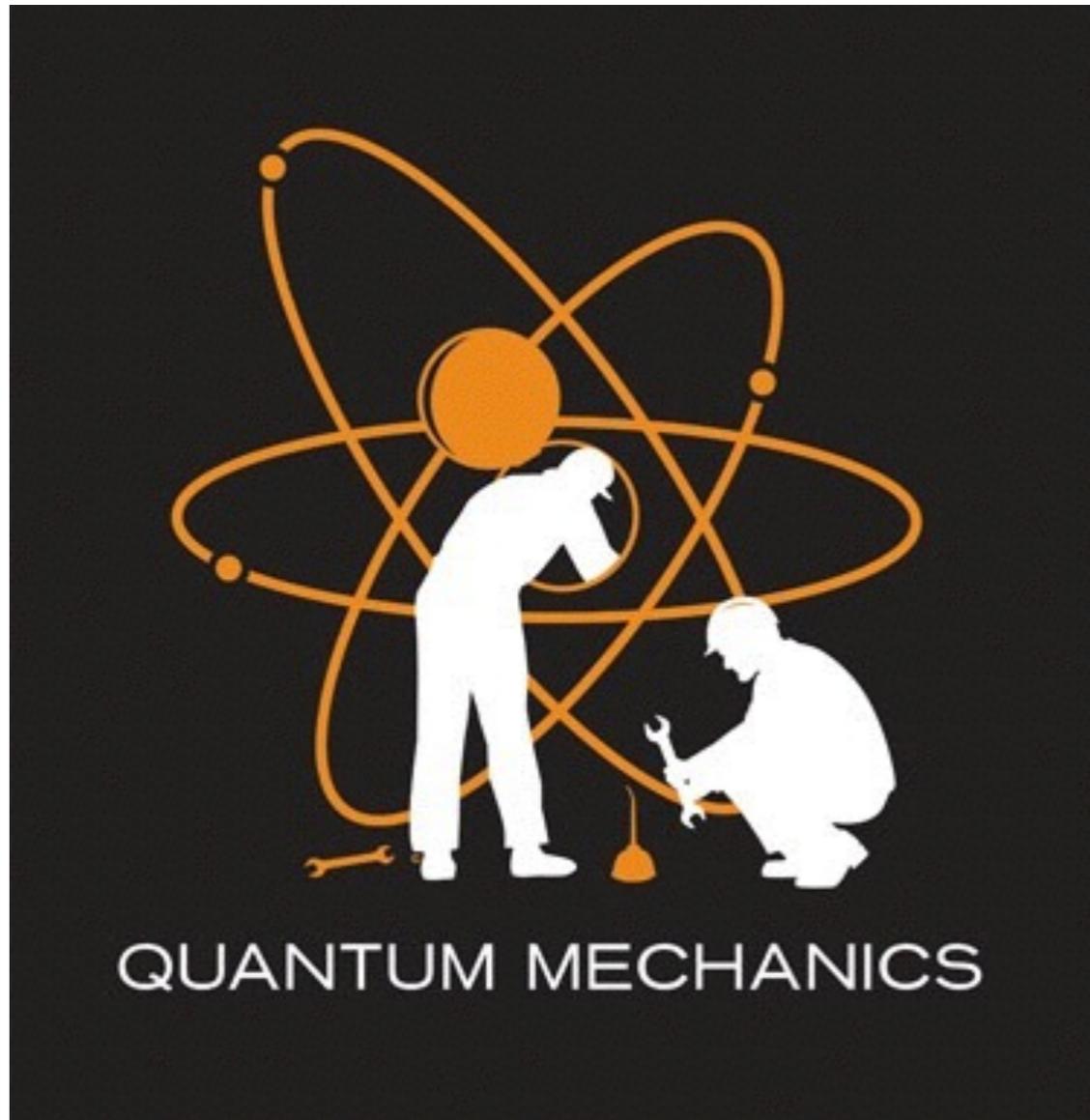


R. Spekkens

There is no question that quantum theory works well as a tool for predicting what will occur in experiments. But just as understanding how to drive an automobile is different from understanding how it works or how to fix it should it break down, so too is there a difference between understanding how to use quantum theory and understanding what it means.

Why physics needs quantum foundations,  
*Physics in Canada* **66** (2010) 73-76.

# Do you want to be a quantum physicist or a quantum mechanic?



$$\frac{1}{\sqrt{2}} | \text{cat sitting} \rangle + \frac{1}{\sqrt{2}} | \text{cat lying} \rangle$$

**Thank you for your attention... questions?**

Now... or later: [pablo.echenique.robba@gmail.com](mailto:pablo.echenique.robba@gmail.com)