


Title: Foundations and Interpretation of Quantum Theory - Lecture 14

Date: Mar 09, 2010 02:30 PM

URL: <http://pirsa.org/10030005>

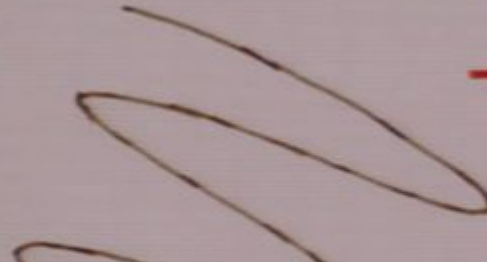
Abstract:



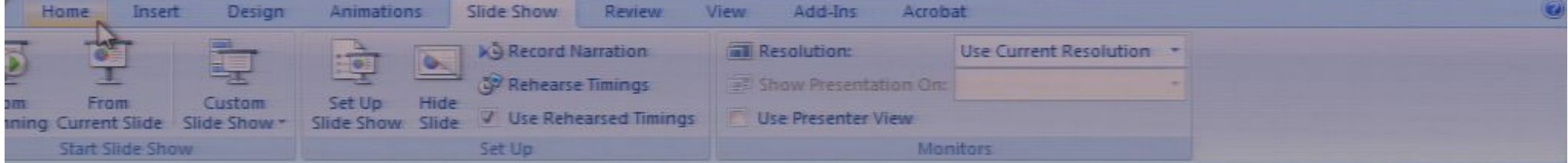
My thesis, paradoxically, and a little provocatively, but nonetheless genuinely, is simply this:

QUANTUM STATES DO NOT EXIST

The abandonment of superstitious beliefs about the existence of phlogiston, the cosmic ether, absolute space and time, or fairies and witches, was an essential step along the road to scientific thinking. The quantum state, too, if regarded as something endowed with some kind of objective existence, is no less a misleading conception, an illusory attempt to exteriorize or materialize the information we possess.



— the ghost of
Bruno de Finetti



My thesis, paradoxically, and a little provocatively, but nonetheless genuinely, is simply this:

QUANTUM STATES DO NOT EXIST

The abandonment of superstitious beliefs about the existence of phlogiston, the cosmic ether, absolute space and time, or fairies and witches, was an essential step along the road to scientific thinking. The quantum state, too, if regarded as something endowed with some kind of objective existence, is no less a misleading conception, an illusory attempt to exteriorize or materialize the information we possess.



— the ghost of
Bruno de Finetti

Click to add notes

- Bookmarks
- Bookmarks Toolbar
- Most Visited
- Bookmarks Menu
- Banks
- TD Canada Trust
- Kiki
- arXiv.org
- Libraries
- U Waterloo Library
- Waterloo Public Library
- KW Weather
- Perimeter Institute
- PI Home
- PI Intranet
- Christopher A. Fuchs
- Weight Watchers Points
- Norman Records UK | vi...
- Album Art Exchange - H...
- Discogs - Database and ...
- Internet Archive
- Unsorted Bookmarks

Christopher A. Fuchs
(PDF file, 189 KB, 13 pages, quant-ph/0204140)

In this note, I try to accomplish two things. First, I fulfill Andrei Khrennikov's request that I comment on his "Växjö Interpretation of Quantum Mechanics," contrasting it with my own present view of the subject matter. Second, I try to paint an image of the hopeful vistas an information-based conception of quantum mechanics indicates.

[Book Review: 'Statistical Structure of Quantum Theory,' by Alexander S. Holevo](#)
(PDF file, 60 KB, 2 pages, [QIC 3(2), 191 (2003)])

[The Activating Observer: Resource Material for a Paulian/Wheelerish Conception of Nature](#)
(PDF file, presently 733 KB, 188 pages, not ready for viewing yet)

This is the third and final installment of three in the Cerro Grande Fire Series. It reflects the following thought. What has always struck me as most wonderful in quantum mechanics is its indication of how our world may be more malleable than was thought in classical times. With our experimental interventions into nature, we---in the capacity of physical systems and nothing more---may have the opportunity to shape the world in unforeseen and perhaps significant ways. This document catalogs and annotates various materials exploring this idea, from the potentially deeply profound to the just-plain silly. Personally I suspect many of the works cited herein lean toward the profound, but that is an issue for science to decide. The 522 citations below are meant to be a starting point for future science.

Talks

[The Oyster and the Quantum](#)
(PowerPoint, 2,768 KB, 56 slides)

I say no interpretation of quantum mechanics is worth the philosophical ones. In this talk, I hope to convey the deepest truth of quantum information theory to you. The deepest truth of quantum information theory is that it is a theory about the touch. When we irritate it in the right way, the theory reveals itself to the whole show, with the quantum calculus portending a future science.

Downloads

Oyster.ppt	2.7 MB — perimeterinstitute.ca	2:30 PM
Oyster.ppt	2.7 MB — perimeterinstitute.ca	2:02 PM
FuchsPresentation.ppt	4.4 MB — perimeterinstitute.ca	2:02 PM
0712.0149v1.ps.gz.ps	262 KB — arxiv.org	Thursday
0601205		March 2

Clear List Search... Page 4/54



In this note, I try to accomplish two things. First, I fulfill Andrei Khrennikov's request that I comment on his "Växjö Interpretation of Quantum Mechanics," contrasting it with my own present view of the subject matter. Second, I try to paint an image of the hopeful vistas an information-based conception of quantum mechanics indicates.

[Book Review: 'Statistical Structure of Quantum Theory,' by Alexander S. Holevo](#)

(PDF file, 60 KB, 2 pages, [QIC 3(2), 191 (2003)])

[The Activating Observer: Resource Material for a Paulian/Wheelerish Conception of Nature](#)

(PDF file, presently 733 KB, 188 pages, not ready for viewing yet)

This is the third and final installment of three in the Cerro Grande Fire Series. It reflects the following thought. What has always struck me as most wonderful in quantum mechanics is its indication of how our world may be more malleable than was thought in classical times. With our experimental interventions into nature, we---in the capacity of physical systems and nothing more---may have the opportunity to shape the world in unforeseen and perhaps significant ways. This document catalogs and annotates various materials exploring this idea, from the potentially deeply profound to the just-plain silly. Personally I suspect many of the works cited herein lean toward the profound, but that is an issue for science to decide. The 522 citations below are meant predominantly as historical tabulation and as motivation for such a future science.

Talks

[The Oyster and the Quantum](#)

(PowerPoint, 2,768 KB, 56 slides)

I say no interpretation of quantum mechanics is worth its salt unless it raises as many technical questions as it answers philosophical ones. In this talk, I hope to convey the essence of a salty, if not downright briny, point of view about quantum theory. The deepest truth of quantum information and computing is that our world is a world wildly sensitive to the touch. When we irritate it in the right way, the result is a pearl. The speculation is that this sensitivity alone gives rise to the whole show, with the quantum calculus portraying the best shot we can take at making predictions in such a world.

- Bookmarks
- Bookmarks Toolbar
- Most Visited
- Bookmarks Menu
- Banks
- TD Canada Trust
- Kiki
- arXiv.org
- Libraries
- U Waterloo Library
- Waterloo Public Library
- KW Weather
- Perimeter Institute
- PI Home
- PI Intranet
- Christopher A. Fuchs
- Weight Watchers Points
- Norman Records UK | vi...
- Album Art Exchange - H...
- Discogs - Database and ...
- Internet Archive
- Unsorted Bookmarks

Christopher A. Fuchs
 (PDF file, 189 KB, 15 pages, quant-ph/0204140)

In this note, I try to accomplish two things. First, I fulfill Andrei Khrennikov's request that I comment on his "Växjö Interpretation of Quantum Mechanics," contrasting it with my own present view of the subject matter. Second, I try to paint an image of the hopeful vistas an information-based conception of quantum mechanics indicates.

[Book Review: 'Statistical Structure of Quantum Theory,' by Alexander S. Holevo](#)
 (PDF file, 60 KB, 2 pages, [QIC 3(2), 191 (2003)])

[The Activating Observer: Resource Material for a Paulian/Wheelerish Conception of Nature](#)
 (PDF file, presently 733 KB, 188 pages, not ready for viewing yet)

This is the third and final installment of three in the Cerro Grande Fire Series. It reflects the following thought. What has always struck me as most wonderful in quantum mechanics is its indication of how our world may be more malleable than was thought in classical times. With our experimental interventions into nature, we---in the capacity of physical systems and nothing more---may have the opportunity to shape the world in unforeseen and perhaps significant ways. This document catalogs and annotates various materials exploring this idea, from the potentially deeply profound to the just-plain silly. Personally I suspect many of the works cited herein lean toward the profound, but that is an issue for science to decide. The 522 citations below are meant predominantly as historical tabulation and as motivation for such a future science.

Talks

[The Oyster and the Quantum](#)
 (PowerPoint, 2,768 KB, 56 slides)

I say no interpretation of quantum mechanics is worth its salt unless it raises as many technical questions as it answers philosophical ones. In this talk, I hope to convey the essence of a salty, if not downright briny, point of view about quantum theory. The deepest truth of quantum information and computing is that our world is a world wildly sensitive to the touch. When we irritate it in the right way, the result is a pearl. The speculation is that this sensitivity alone gives rise to the world's best shot we can take at making predictions in such a world.

PIAF Home Cooking.pdf - Adobe Acrobat Pro
 Emerson-Laflamme Class.pdf - Adobe Acrobat Pro

Christopher A. Fuchs - Mozilla Firefox

Edit View History Bookmarks Tools Help

http://www.perimeterinstitute.ca/personal

Bookmarks

Christopher A. Fuchs

(PDF file, 189 KB, 13 pages, quant-p)

In this note, I try to accomplish Interpretation of Quantum Mechanics and paint an image of the hopeful vision.

[Book Review: 'Statistical Structure of Quantum Mechanics'](#)
(PDF file, 60 KB, 2 pages, [QIC 3(2)])

[The Activating Observer: Resource Materials](#)
(PDF file, presently 733 KB, 188 pages)

This is the third and final installment of a series that has always struck me as most wonderful. It was thought in classical times that the world was made of systems and nothing more---materialism. This document catalogs and analyzes the various just-plain silly. Personally I suspect that the future of science to decide. The 522 citations are a glimpse into future science.

Talks

[The Oyster and the Quantum](#)
(PowerPoint, 2,768 KB, 56 slides)

I say no interpretation of quantum mechanics, only philosophical ones. In this talk, I discuss quantum theory. The deepest truth is that quantum theory is the touch. When we irritate it in the end, it is the whole show, with the quantum

Emerson-Laflamme Class.pdf - Adobe Acrobat Pro

File Edit View Document Comments Forms Tools Advanced Window Help

Create Combine Lock Comment

1 / 53 55.2%

Find

A quantum state is not a mirror in which a reality external to us is faithfully reflected; it is simply a biological function, a means of orientation in life, of preserving and enriching it, of enabling and facilitating action, of taking account of reality and dominating it.

— CAF, stealing from a forgotten pragmatist, Adriano Tilgher

Christopher A. Fuchs - Mozilla Firefox

Edit View History Bookmarks Tools Help

http://www.perimeterinstitute.ca/personal

Bookmarks

Christopher A. Fuchs

(PDF file, 189 KB, 13 pages, quant-ph/0608207)

In this note, I try to accomplish a new interpretation of Quantum Mechanics that will paint an image of the hopeful vision of quantum physics.

[Book Review: 'Statistical Structure of Quantum Mechanics'](#)
(PDF file, 60 KB, 2 pages, [QIC 3(2) 1-2])

[The Activating Observer: Resource Materials](#)
(PDF file, presently 733 KB, 188 pages)

This is the third and final installment of a series of talks that has always struck me as most wonderful. It was thought in classical times that the world was made of systems and nothing more---materialism. This document catalogs and analyzes the various just-plain silly. Personally I suspect that the future of quantum science to decide. The 522 citations are a work of future science.

Talks

[The Oyster and the Quantum](#)
(PowerPoint, 2,768 KB, 56 slides)

I say no interpretation of quantum mechanics, only philosophical ones. In this talk, I discuss the quantum theory. The deepest truth is that quantum theory is the touch. When we irritate it in the end, it goes to the whole show, with the quantum

Emerson-Laflamme Class.pdf - Adobe Acrobat Pro

File Edit View Document Comments Forms Tools Advanced Window Help

Create Combine Lock Comment

1 / 53 55.2%

Find

A quantum state is not a mirror in which a reality external to us is faithfully reflected; it is simply a biological function, a means of orientation in life, of preserving and enriching it, of enabling and facilitating action, of taking account of reality and dominating it.

— CAF, stealing from a forgotten pragmatist, Adriano Tilgher

Christopher A. Fuchs - Mozilla Firefox

Edit View History Bookmarks Tools Help

http://www.perimeterinstitute.ca/personal

Bookmarks

Christopher A. Fuchs

(PDF file, 189 KB, 13 pages, quant-ph/0608207)

In this note, I try to accomplish a new interpretation of Quantum Mechanics. I want to paint an image of the hopeful vision of quantum mechanics.

[Book Review: 'Statistical Structure of Quantum Mechanics'](#)
(PDF file, 60 KB, 2 pages, [QIC 3(2) 1-2])

[The Activating Observer: Resource Materials](#)
(PDF file, presently 733 KB, 188 pages)

This is the third and final installment of a series of notes that have always struck me as most wonderful. It was thought in classical times that the world was made of matter and nothing more---matter and motion. This document catalogs and analyzes the various interpretations of quantum mechanics and just plain silly. Personally I suspect that the future of quantum science to decide. The 522 citations are a list of the future science.

Talks

[The Oyster and the Quantum](#)
(PowerPoint, 2,768 KB, 56 slides)

I say no interpretation of quantum mechanics is more philosophical ones. In this talk, I discuss the quantum theory. The deepest truth is that quantum theory is just the touch. When we irritate it in the end, it goes to the whole show, with the quantum mechanics.

Emerson-Laflamme Class.pdf - Adobe Acrobat Pro

File Edit View Document Comments Forms Tools Advanced Window Help

Go To

Zoom

Page Display

Rotate View

Reading Mode Ctrl+H

Full Screen Mode Ctrl+L

Menu Bar F9

Toolbars

Navigation Panels

Grid Ctrl+U

Snap to Grid Shift+Ctrl+U

Rulers Ctrl+R

Guides

Line Weights Ctrl+5

Cursor Coordinates

Automatically Scroll Shift+Ctrl+H

Read Out Loud

Comment

55.2%

a reality external to us

logical function, a means of

orientation in life, of preserving and enriching it, of enabling and facilitating action, of taking account of reality and dominating it.

— CAF, stealing from a forgotten pragmatist, Adriano Tilgher

Christopher A. Fuchs - Mozilla Firefox

Edit View History Bookmarks Tools Help

http://www.perimeterinstitute.ca/personal

Bookmarks

Christopher A. Fuchs
(PDF file, 189 KB, 13 pages, quant-p)

In this note, I try to accomplish
Interpretation of Quantum Mech
paint an image of the hopeful vis

[Book Review: 'Statistical Structure of](#)
(PDF file, 60 KB, 2 pages, [QIC 3(2)

[The Activating Observer: Resource M](#)
(PDF file, presently 733 KB, 188 pag

This is the third and final installm
always struck me as most wond
than was thought in classical tim
systems and nothing more---ma
This document catalogs and an
just-plain silly. Personally I susp
science to decide. The 522 cita
future science.

Talks

[The Oyster and the Quantum](#)
(PowerPoint, 2,768 KB, 56 slides)

I say no interpretation of quantu
philosophical ones. In this talk, I
quantum theory. The deepest tr
the touch. When we irritate it in
to the whole show, with the qua

Emerson-Laflamme Class.pdf - Adobe Acrobat Pro

File Edit View Document Comments Forms Tools Advanced Window Help

Go To

Zoom

Page Display

Rotate View

Reading Mode Ctrl+H

Full Screen Mode Ctrl+L

Menu Bar F9

Toolbars

Navigation Panels

Grid Ctrl+U

Snap to Grid Shift+Ctrl+U

Rulers Ctrl+R

Guides

Line Weights Ctrl+5

Cursor Coordinates

Automatically Scroll Shift+Ctrl+H

Read Out Loud

Zoom To... Ctrl+Y

Actual Size Ctrl+I

Fit Page Ctrl+0

Fit Width Ctrl+2

Fit Height

Fit Visible Ctrl+3

Reflow Ctrl+4

a reality external to us
ical function, a means of
orientation in life, of preserving and enriching it, of enabling and
facilitating action, of taking account of reality and dominating it.

— CAF, stealing from a
forgotten pragmatist, Adriano Tilgher

Christopher A. Fuchs - Mozilla Firefox

http://www.perimeterinstitute.ca/personal

Christopher A. Fuchs
(PDF file, 189 KB, 13 pages, quant-ph/0608202)

In this note, I try to accomplish a simple but important task: to paint an image of the hopeful vision of quantum mechanics.

[Book Review: 'Statistical Structure of Quantum Mechanics'](#)
(PDF file, 60 KB, 2 pages, [QIC 3(2) 1-2])

[The Activating Observer: Resource Materials](#)
(PDF file, presently 733 KB, 188 pages)

This is the third and final installment of a series of notes that always struck me as most wonderful. It was thought in classical times that the world was made of systems and nothing more---mathematics. This document catalogs and analyzes the various interpretations of quantum mechanics, just-plain silly. Personally I suspect that the future of quantum science to decide. The 522 citations are a reality external to us.

Talks

[The Oyster and the Quantum](#)
(PowerPoint, 2,768 KB, 56 slides)

I say no interpretation of quantum mechanics, but only philosophical ones. In this talk, I discuss quantum theory. The deepest truth is that quantum theory is just the touch. When we irritate it in the end, it is the whole show, with the quantum world.

Emerson-Laflamme Class.pdf - Adobe Acrobat Pro

File Edit View Document Comments Forms Tools Advanced Window Help

- Go To
- Zoom
- Page Display
- Rotate View
- Reading Mode Ctrl+H
- Full Screen Mode Ctrl+L**
- Menu Bar F9
- Toolbars
- Navigation Panels
- Grid Ctrl+U
- Snap to Grid Shift+Ctrl+U
- Rulers Ctrl+R
- Guides
- Line Weights Ctrl+5
- Cursor Coordinates
- Automatically Scroll Shift+Ctrl+H
- Read Out Loud

by a reality external to us
logical function, a means of
orientation in life, of preserving and enriching it, of enabling and
facilitating action, of taking account of reality and dominating it.

— CAF, stealing from a
forgotten pragmatist, Adriano Tilgher



A quantum state is not a mirror in which a reality external to us is faithfully reflected; it is simply a biological function, a means of orientation in life, of preserving and enriching it, of enabling and facilitating action, of taking account of reality and dominating it.

— CAF, stealing from a forgotten pragmatist, Adriano Tilgher

The hypothesis that there is an external world, not dependent on human minds, made of something, is so obviously useful and so strongly confirmed by experience down through the ages that we can say without exaggerating that it is better confirmed than any other empirical hypothesis.

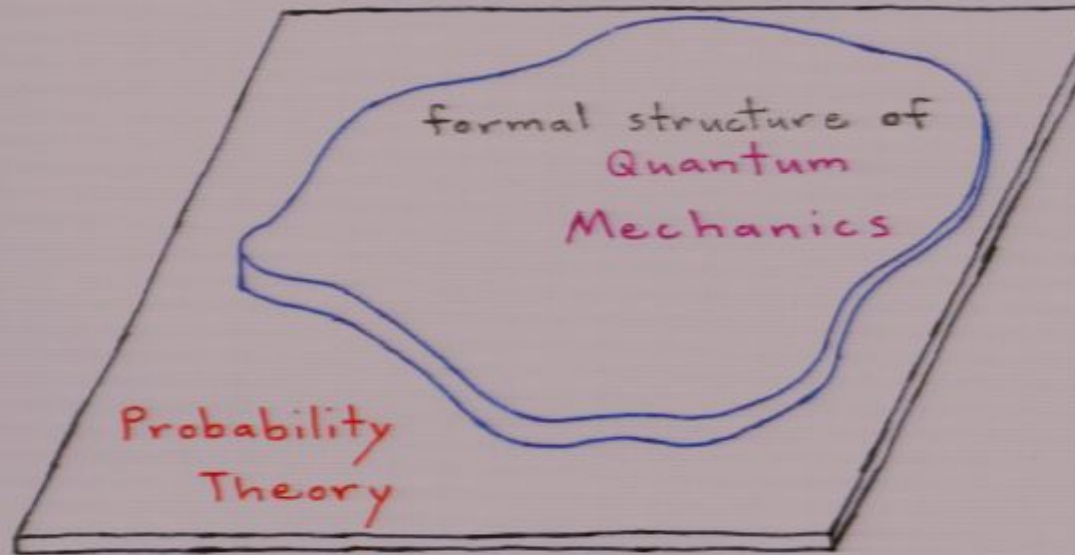
— Martin Gardner

A Single-User Theory

- probability theory
- quantum theory

"The Bayesian, subjectivist, or coherent, paradigm is egocentric. It is a tale of one person contemplating the world and not wishing to be stupid (technically incoherent). He realizes that to do this his statements of uncertainties must be probabilistic."

— D. V. Lindley



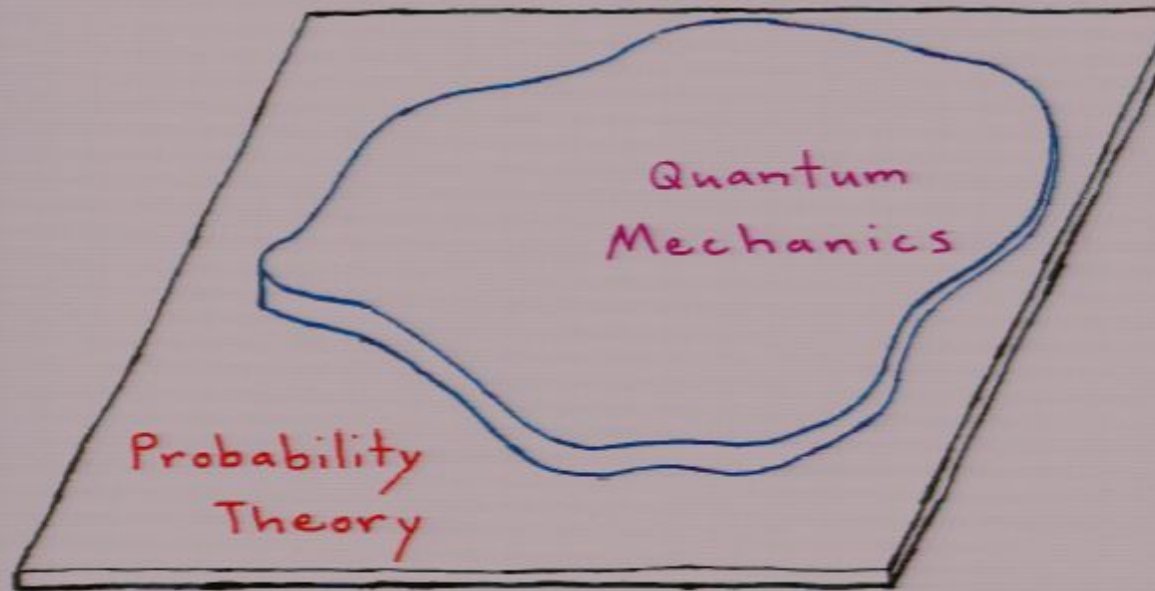
Quantum Probability
Theory

A hand-drawn diagram consisting of a large, rounded rectangle with a black outline. Inside this rectangle, centered, is a smaller, roughly oval shape, also with a black outline. The text 'Quantum Probability Theory' is written in red ink inside the large rectangle. The text 'classical probability theory' is written in orange ink inside the smaller oval.

classical
probability
theory

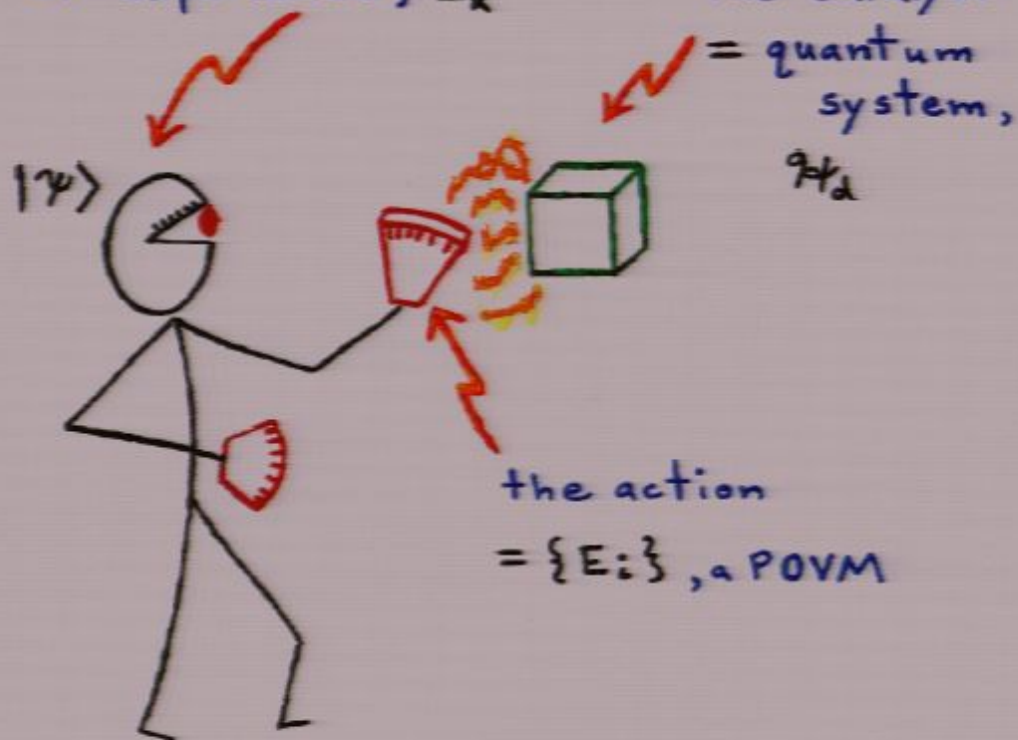
Classical probability is "just" the
commutative case.





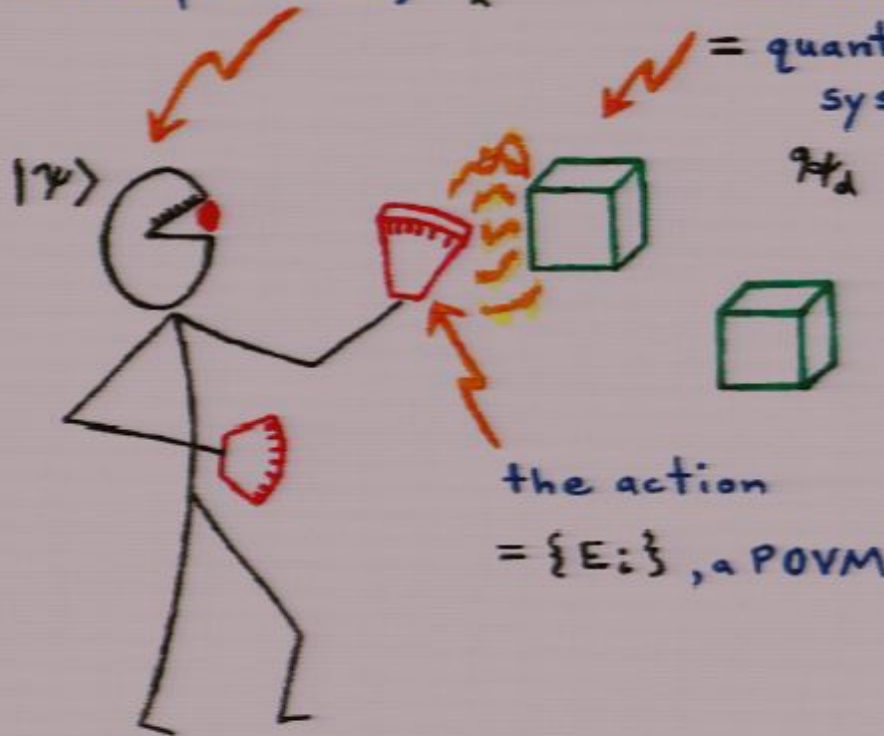
the consequence
= an experience, E_k

the catalyst
= quantum
system,

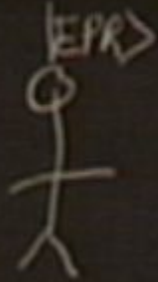


the consequence
= an experience, E_k

the catalyst
= quantum
system,

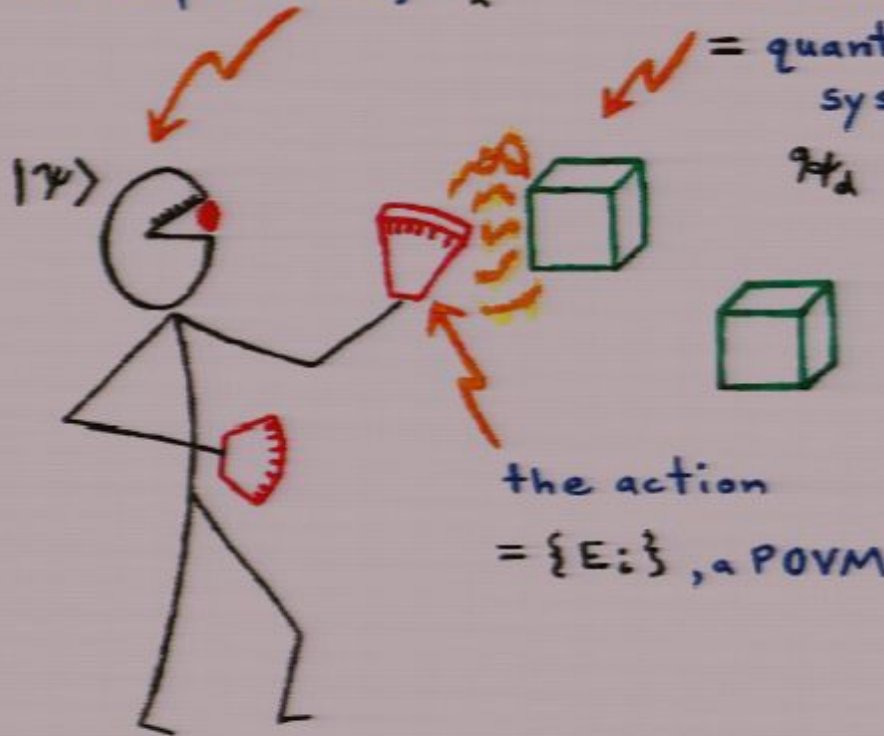


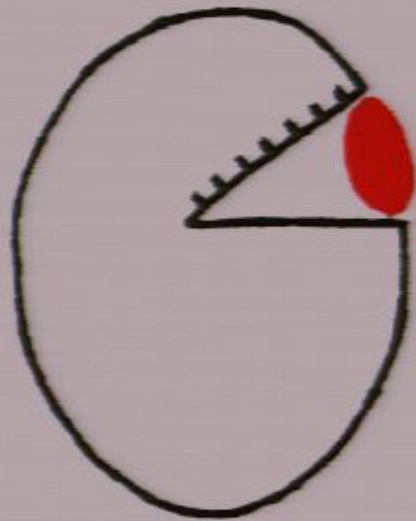
the action
= $\{E_i\}$, a POVM

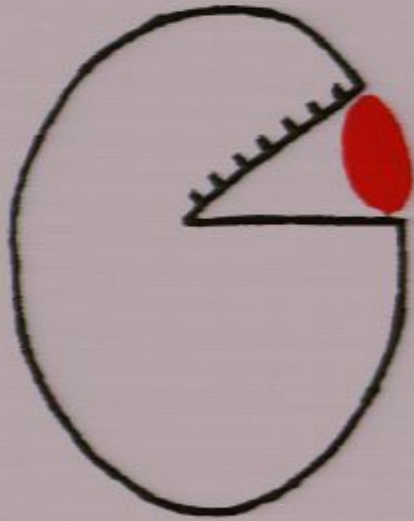


the consequence
= an experience, E_k

the catalyst
= quantum
system,

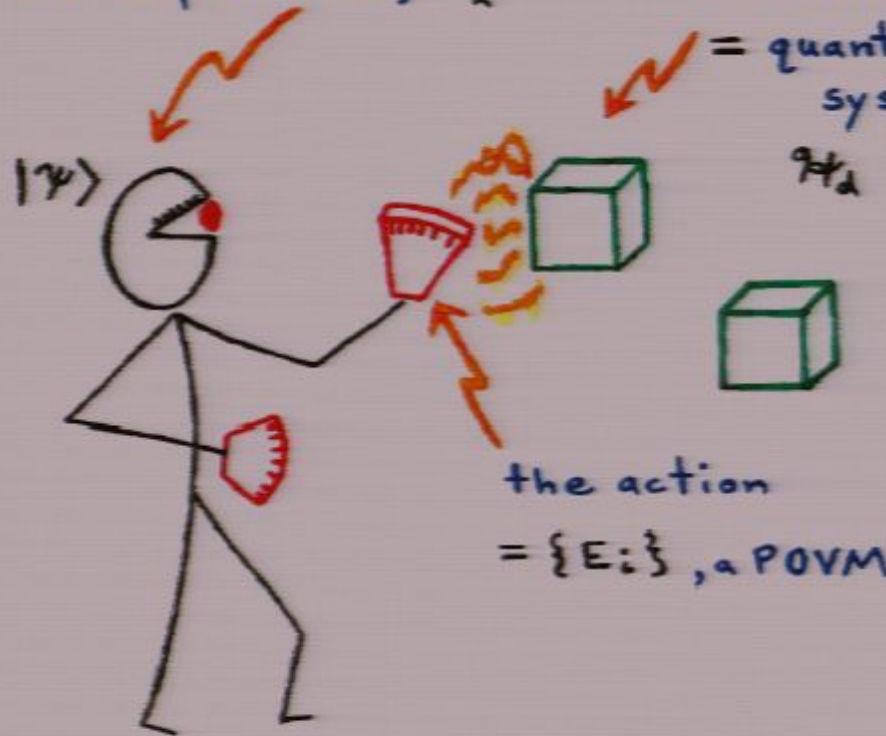


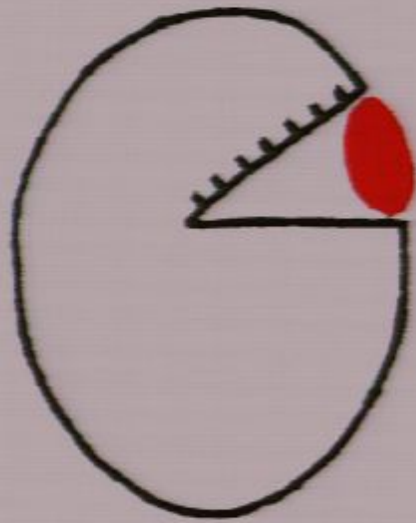




the consequence
= an experience, E_k

the catalyst
= quantum
system,



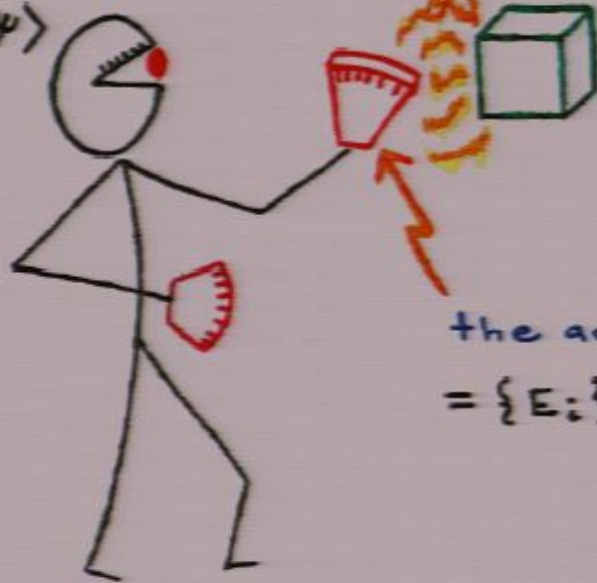


the consequence
= an experience, E_k



the catalyst
= quantum system,

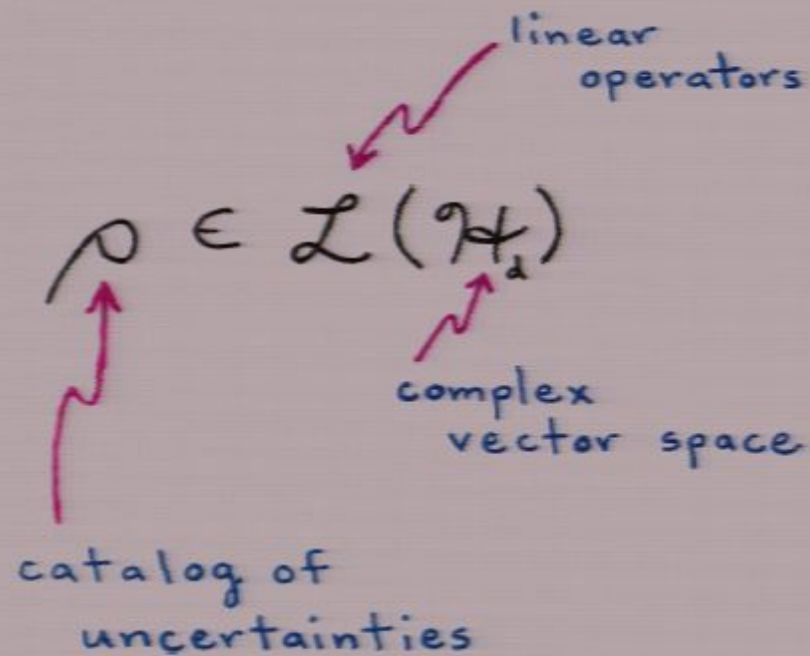
$|\psi\rangle$



the action
= $\{E_i\}$, a POVM



Density Operators



-
- 1) $\rho^\dagger = \rho$
 - 2) $\text{tr } \rho = 1$
 - 3) $\lambda_i(\rho) \geq 0$
- eigenvalues
- convex hull of the set $\{|\psi\rangle\langle\psi| : |\psi\rangle \in \mathcal{H}_d\}$
-
- The list contains three properties. A green arrow points from the text 'convex hull of the set...' to the right side of the list, encompassing all three items. A green arrow points from the text 'eigenvalues' to the $\lambda_i(\rho)$ term in the third property.

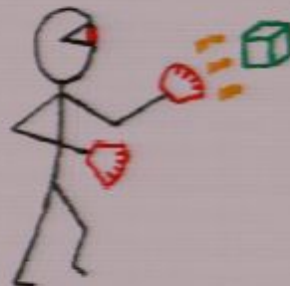
the consequence
= an experience, E_k



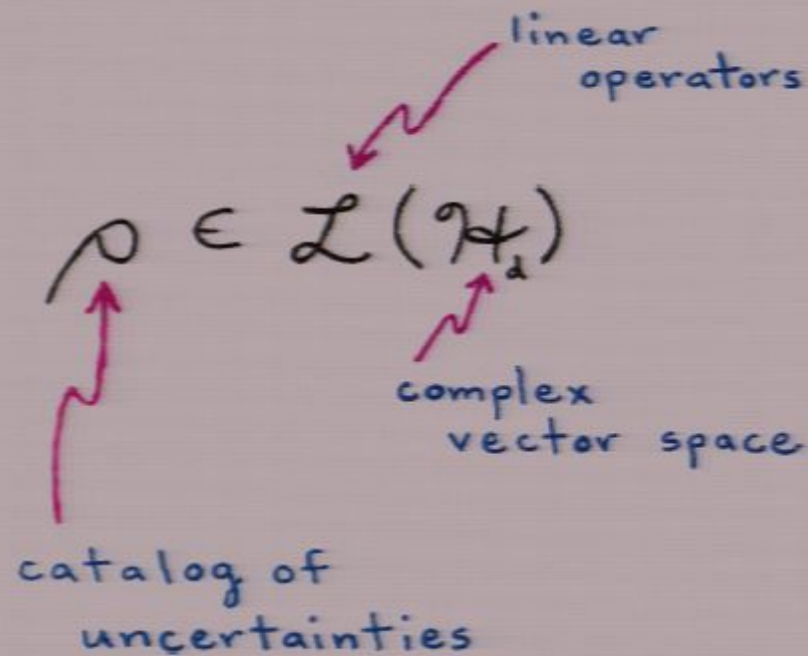
the catalyst
= quantum system,



the action
= $\{E_i\}$, a POVM



Density Operators




-
- 1) $\rho^\dagger = \rho$
 - 2) $\text{tr } \rho = 1$
 - 3) $\lambda_i(\rho) \geq 0$
- eigenvalues
- convex hull of the set $\{|\psi\rangle\langle\psi| : |\psi\rangle \in \mathcal{H}_d\}$
-
- The list contains three properties of density operators. A green arrow points from the text 'convex hull of the set...' to the right side of the list, indicating that the set of density operators is the convex hull of the set of pure state projectors.

Calculus 1  Character 1

Calculus 2  Character 2

Calculus 3  Character 3

A superior statement about the objective characteristics of our quantum world, of the things in it, would contain no $|\psi\rangle$'s at all.

 Really, none!



Windows Vista™

I think there are professional problems [with quantum mechanics]. That is to say, I'm a professional theoretical physicist and I would like to make a clean theory. And when I look at quantum mechanics I see that its a dirty theory. The formulations of quantum mechanics that you find in the books involve dividing the world into an observer and an observed, and you are not told where that division comes ... So you have a theory which is fundamentally ambiguous ...

— J. S. Bell

I think there are professional problems [with quantum mechanics]. That is to say, I'm a professional theoretical physicist and I would like to make a clean theory. And when I look at quantum mechanics I see that its a dirty theory. The formulations of quantum mechanics that you find in the books involve dividing the world into an observer and an observed, and you are not told where that division comes ... So you have a theory which is fundamentally ambiguous ...

— J. S. Bell

I think there are professional problems [with quantum mechanics]. That is to say, I'm a professional theoretical physicist and I would like to make a clean theory. And when I look at quantum mechanics I see that its a dirty theory. The formulations of quantum mechanics that you find in the books involve dividing the world into an observer and an observed, and you are not told where that division comes ... So you have a theory which is fundamentally ambiguous ...

— J. S. Bell



I think there are professional problems [with quantum mechanics]. That is to say, I'm a professional theoretical physicist and I would like to make a clean theory. And when I look at quantum mechanics I see that its a dirty theory. The formulations of quantum mechanics that you find in the books involve dividing the world into an observer and an observed, and you are not told where that division comes ... So you have a theory which is fundamentally ambiguous ...

— J. S. Bell

I think there are professional problems [with quantum mechanics]. That is to say, I'm a professional theoretical physicist and I would like to make a clean theory. And when I look at quantum mechanics I see that its a dirty theory. The formulations of quantum mechanics that you find in the books involve dividing the world into an observer and an observed, and you are not told where that division comes ... So you have a theory which is fundamentally ambiguous ...

— J. S. Bell

The Born Rule

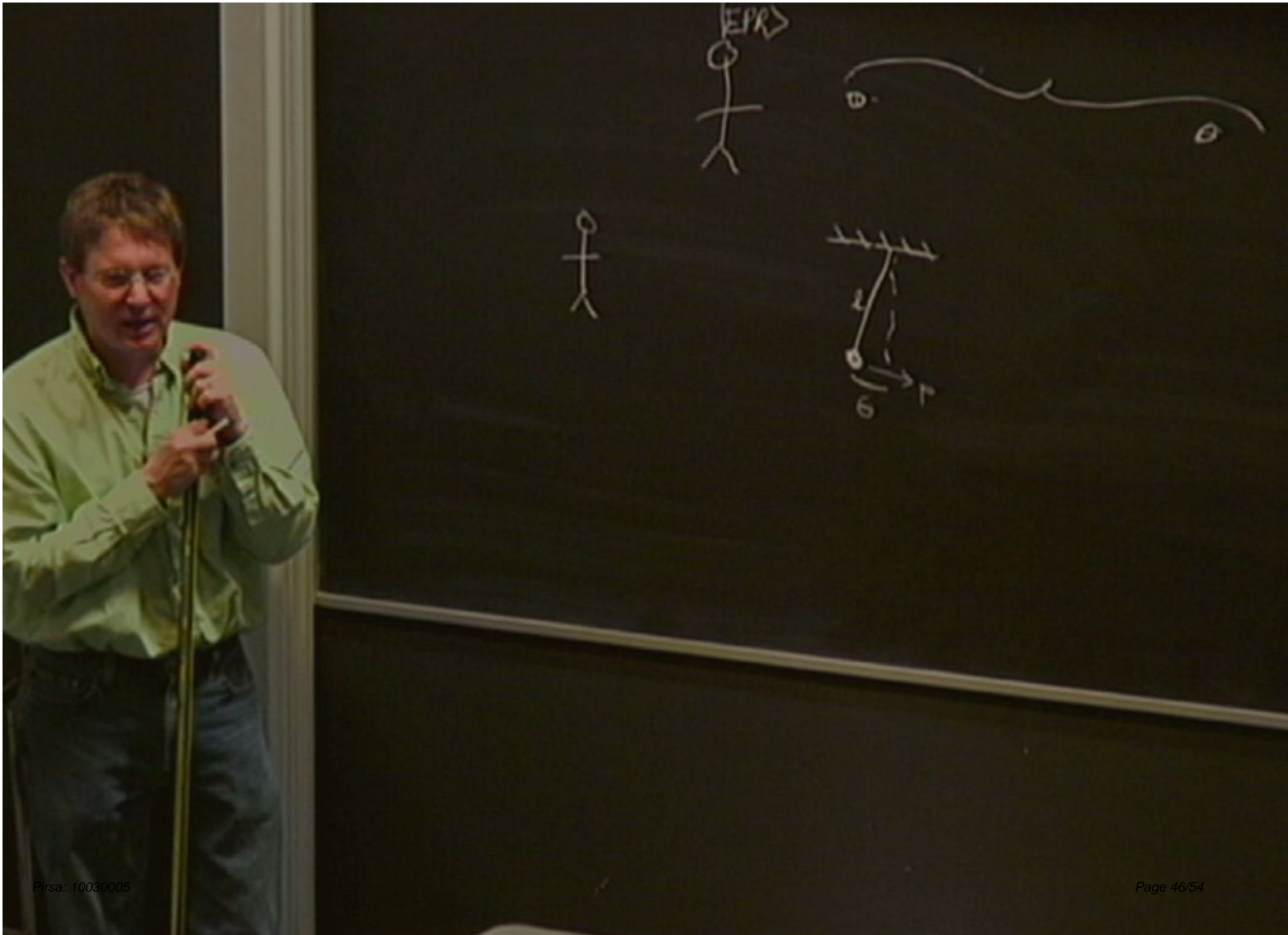
Given ρ and $\{E_i\}$,

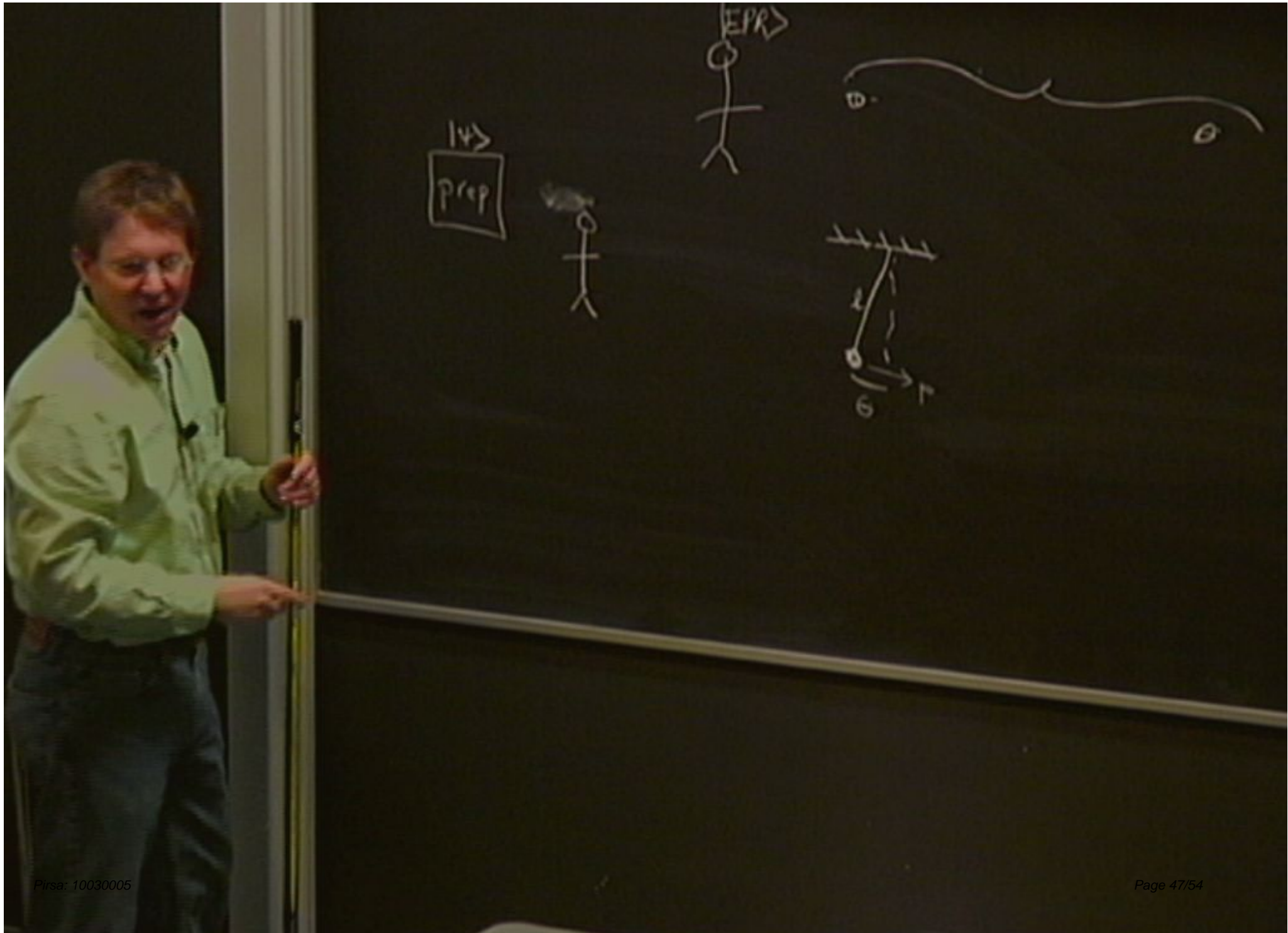
quantum
state

POVM
measurement

$$p(i) = \text{tr } \rho E_i$$


"The
Born
Rule"






The Born Rule

Given ρ and $\{E_i\}$,


quantum
state

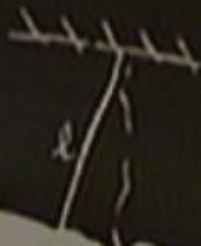

POVM
measurement

$$p(i) = \text{tr } \rho E_i$$

"The
Born
Rule"

$|\psi\rangle$
prep

$|EPR\rangle$





$$\Phi(\rho) = \rho'$$

$$\Phi \otimes \Phi(\rho^{AB}) = \text{min entropy}$$

The Born Rule

Given ρ and $\{E_i\}$,


quantum
state


POVM
measurement

$$p(i) = \text{tr } \rho E_i$$

"The
Born
Rule"

The Born Rule

Given ρ and $\{E_i\}$,

quantum
state


POVM
measurement


$$p(i) = \text{tr } \rho E_i$$

"The
Born
Rule"

The Born Rule

Given ρ and $\{E_i\}$,


quantum
state


POVM
measurement

$$p(i) = \text{tr } \rho E_i$$

"The
Born
Rule"