PHYS 344 Introduction to Quantum Science

How to sit in 3 chairs at once,
and speed without getting a ticket.

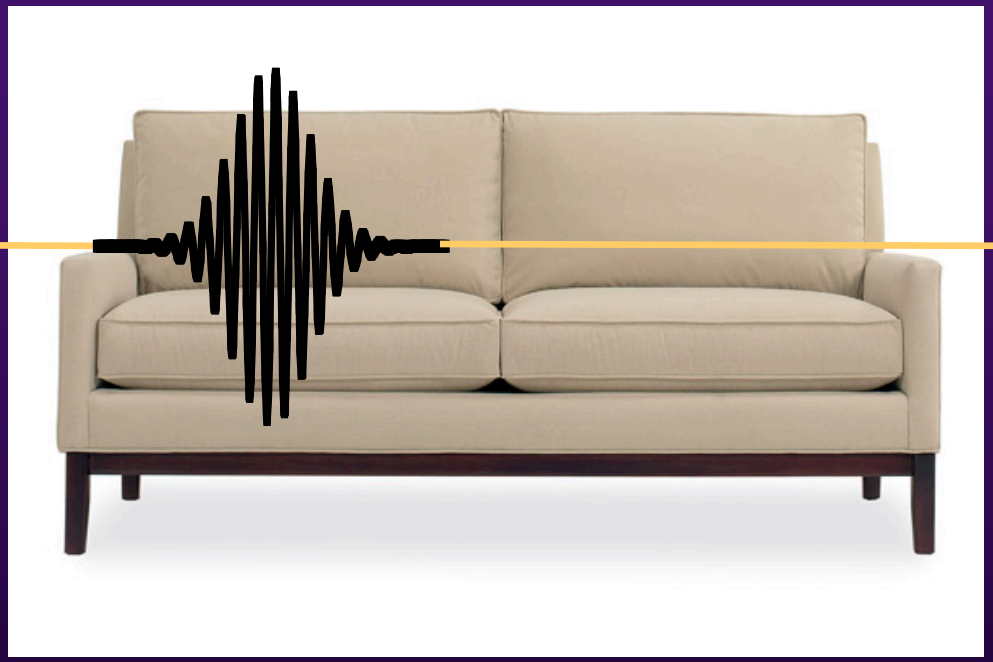
Lecture 02: Observers Disturb What They Measure

Waves can be in two places at once

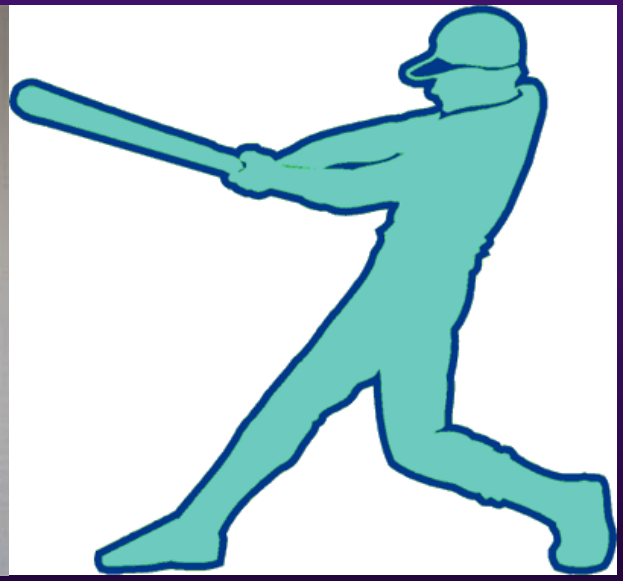
There's still only one particle!

30% "In the tree" state and 70% "On the couch" state

(No more movie theater dilemmas!)



Measurements Part II: Observers Disturb What They Measure



Quantum Weirdness

Wave can do *anything.*
But only certain answers are allowed when we ask questions.

Like a bad government form (what's your ethnicity?)

Or like a spinning coin…

Bad Government Form

What is your ethnic background? Choose one.

- ❑Native American
- ❑Latin American
- ❑European
- ❑African American
- ⋮

"Well, my great grandmother...."

Official Quantum Measurement Form 101

Ask the particle: Where are you?
(Choose only one)

- ❑On the couch
- ❑In the tree
- ❑On the ceiling
- ❑Behind the door
- ⋮

Only certain answers are allowed!

Answers must correspond to "pure states" according to the question asked.

Measurements

Ask the particle questions

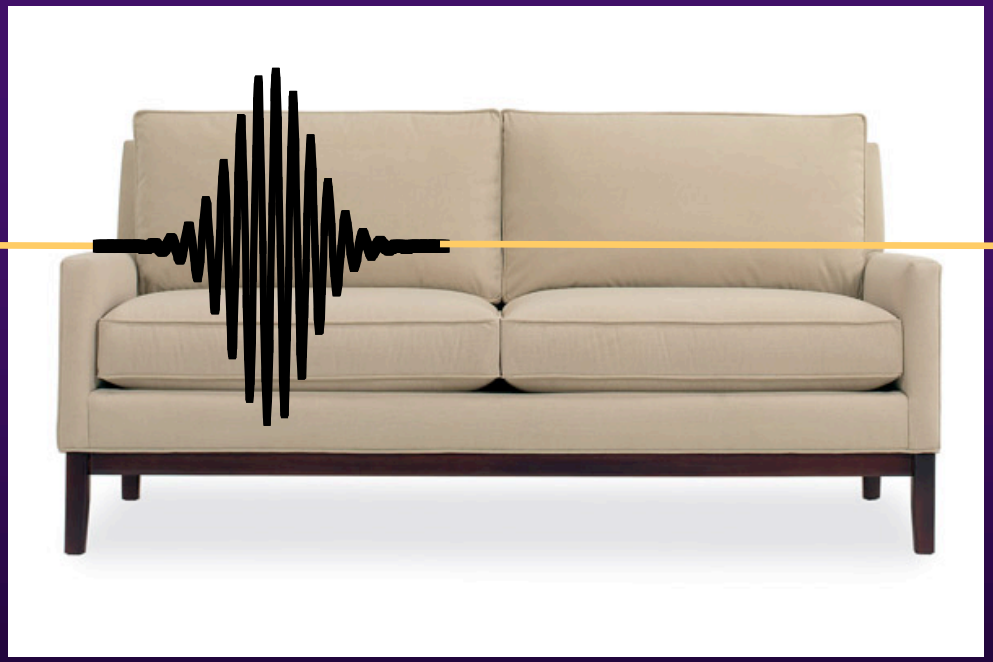
Where are you?

That was easy -- the wave was in a pure state.

Where are you?

- ❑On the couch
- ❑In the tree
- ❑On the ceiling

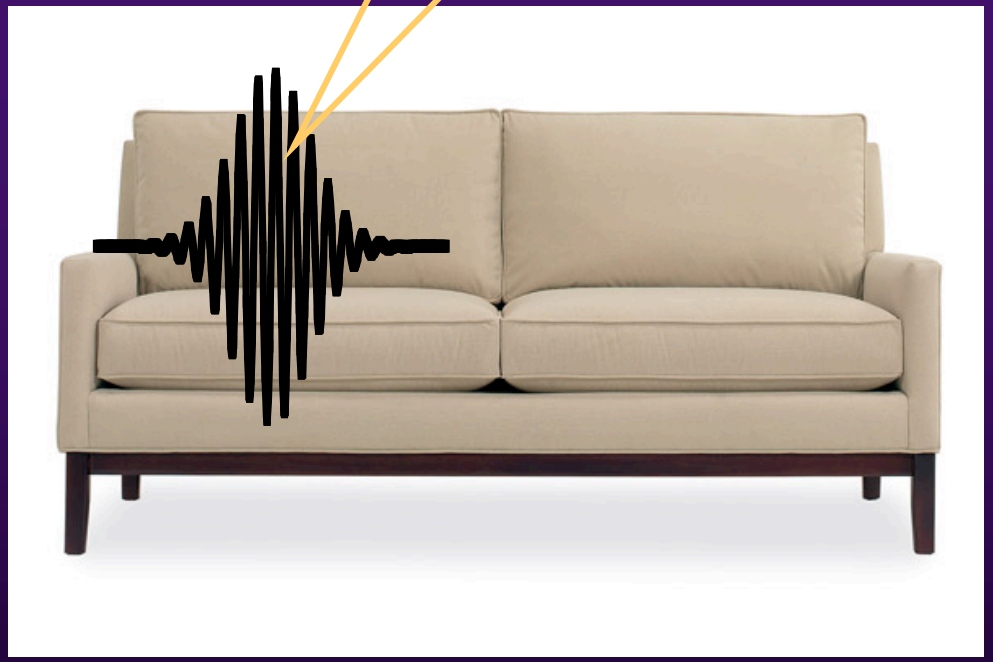
Quantum Mechanics forces the particle into an *allowed state* so it can give an *allowed answer*.



30% “In the tree” state and 70% “On the couch” state

Where are you?

- [x] On the couch
- [ ] In the tree
- [ ] On the ceiling



100% “On the couch” state

What happened?

Asking the question (taking a measurement)
forced the particle into an allowed state of that measurement.

Sudden, uncontrollable change.
The prior state only sets the probabilities.

The wavefunction is the real truth, and tells all.
Too bad we can't measure it directly!
We're stuck measuring position, energy, velocity…

What happened?

Spinning Coin

Question: Heads or Tails?

-- No heads or tails while spinning

-- Measurement forced a “pure” answer

-- 50/50 chance

Particle

Question: Where are you?

-- Two places before we asked

-- Measurement forced a “pure” answer

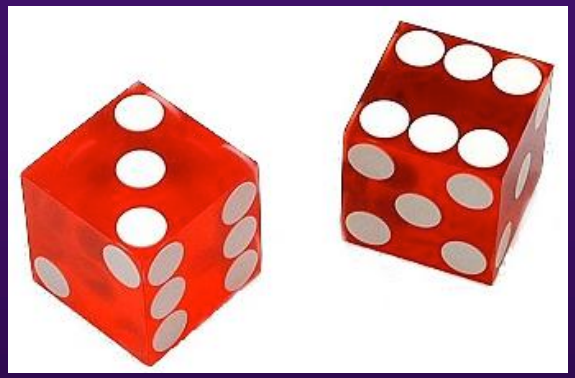
-- 30/70 chance

Observer Determines Reality?

In a very limited sense, yes.

By measuring, we choose the *allowed set of answers*

We never choose the *actual answer*



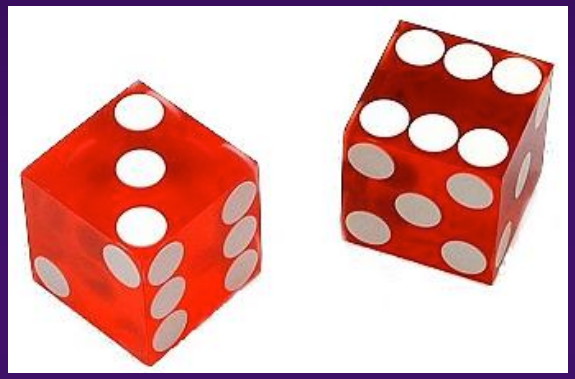
We only get to choose the dice…

Observer Determines Reality?

In a very limited sense, yes.

We can choose the dice, but not the outcome.

Is it really a dice roll?



The particle doesn't even know which answer it will give until asked!

Experimentally confirmed by Bell's Inequality:
There are no local "hidden variables" predetermining the outcome.

"God does not play dice" -- Einstein