Appendix: The Twisted World(s) of Quantum Physics, Script

The Twisted World(s) of Quantum Physics

Produced by the *Project Viola Ten*
For the *Healthy Minds & Healthy Bodies* Educational Outreach
As part of the *Project Viola Ten: Put On Your Thinking Caps* campaign

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No animals or children were seriously harmed during the making of this film

Hello there, ordinary little humans!

Welcome to the twisted world—or should I say *worlds*—of quantum physics!

There *will* be a test, so you'd better grab a pencil and start taking notes!

Hahaha. I'm just kidding. Luckily for you, there's a universe where you've already aced the test.

But do put on your *Viola Ten* thinking caps as we delve into the science of quantum mechanics.

But not in a dull sciencey way…. In a fun way!

"But how do you make science…fun?"

Haha… Why, by removing most of the science, of course!

You see kids, at the Viola Ten Laboratories we start with 100% boring facts and figures, found in dusty old peer-reviewed journals at the nerd library.

After skimming those for a good 20 minutes or so, we toss the books and come up with our own examples. Like this one:

If you pick up a rock and throw it, the rock will travel along a curved line until it comes to a stop in the grass, or in the mud, or hits your little brother in the face... Ooops! Be a little more *careful* next time, Lucy!

But if we look at things really closely, we find that everything's made up of tiny, tiny little pieces called sub-atomic particles. And these particles don't behave like the rocks here in the big world do.

If you were small enough to pick up one of these particles and throw it like a rock, it might land anywhere. The rock might even end up throwing you!

But that's the risk you take when you play in the quantum playground.

Or maybe it's payback for hitting your little brother in the face. I *told* you to be careful.

You see? This will be lots of fun, kids… even if nothing makes any sense… at all…

Title: The Heisenberg Uncertainty Principle, 1927

$$\Delta x \Delta p \geq \frac{\hbar}{2}$$

where H is Planck's Constant divided by 2 Pi

The world that we see around us is almost boringly predictable.

The normal sized world is ruled by Newton's laws.

And normal sized objects obey the law.

But these objects are squares.

Don't be a square, kids.

Come with me to the quantum world…

A world where, if you have a milkshake, you will probably not be able to find a straw.

And if you find a straw, your milkshake glass is probably already empty.

That is the quantum world of the Heisenberg Uncertainty Principle.

Formulated by Werner Heisenberg in 1927,

The Heisenberg Uncertainty Principle states that at the smallest known levels of existence --

The more you know about something, the less you know about everything else.

That's right kids… The only rule is… there are no rules.

Einstein was bothered by Heisenberg's principle.

Einstein said, *God does not play dice with the universe*.

Hahaha. Sorry, Albert! You can't be right ALL the time!

Title: The *Copenhagen Interpretation, 1927*

$$[\frac{-\hbar^2}{2m}\nabla^2 + V]\Psi = i\hbar\frac{\partial}{\partial t}\Psi$$

The *Copenhagen Interpretation* of 1927 states that sub-atomic particles exist in a *superposition* --

"But what's a … super… po stiition??"

I was afraid you'd ask! (Spoken as if saying "I'm glad you asked!")

A superposition is when a quantum object is both a particle AND a wave *simultaneously*.

"Cool! Thanks Mr.!, … Wait… What?"

Exactly! And dig this you little hepcats:

Observing the particle causes the wave probability to collapse to a single outcome.

You see, particles act like particles when they are observed.

Particles even act like particles if they are *going to be observed* in the future.

But when nobody is watching…

It's just one crazy hopped-up bacchanalian (BOCK A NAY LEE AN) orgy…

So, sit back, relax, and let the waves and/or particles of knowledge wash over and/or smack you right in the brain.

Title: Schrodinger's Cat, 1935

$$(|\text{dead}\rangle + |\text{alive}\rangle)/\sqrt{2}$$

In 1935, Erwin Schrodinger kicked the world while it was still confused.

Maybe he was putting too much Devil's lettuce in his Brownian Motion theories, if you know what I mean --

"Yeah, Daddy-O.. we're hip. We dig."

Really? -- because he came up with a very strange experiment, known as Schrodinger's Cat:

A cat is placed in a box – along with a flask of cyanide, a hammer, a Geiger counter, and radioactive material with a 50/50 chance of being detected by the Geiger counter.

If radiation is detected, the hammer smashes the flask, and the poison kills the cat.

If radiation is not detected, the cat lives.

Until the box is opened, the cat exists in a *superposition* --

Both alive *and* dead.

"But… can I check on the cat?"

Not so fast Timmy!

Your curiosity might kill the cat!

You see, it is only the *observation* of the system that forces the wave function to collapse.

And forces the cat to be *either* alive *or* dead.

The fate of the cat is intertwined with the observation of the system.

Schrodinger described this relationship as *Verschränkung* (FAIR SHRENK OONG) or *entanglement*.

"Okay, well, bye Mr… We're going to leave now."

I don't blame you… you little hooligans.

Title: Engtanglement

$$E=mc^2$$

Verschränkung (FAIR SHRENK OONG) *or* entanglement makes as much sense as a sandwich made out of soup.

Einstein described entanglement as a *spukhafte fernwirkung* (SHPOOK HAFTA FERN VIRK UNG) or a spooky action at a distance.

That was Einstein's TECHNICAL TERM!

Am I the only one who's alarmed by that?

Engtanglement is like telepathy between particles.

Let's say a small particle is spit in half --

and one half is taken to New York while the other half stays in Los Angeles.

If one of the particles is observed, the other particle will react *instantly.*

Einstein’s theory of relativity prohibits information from travelling faster than the speed of light.

So how could the particles communicate?

According to the theory of entanglement,

the information does not travel.

Rather, the particles are still connected

and time and space merely creates the *illusion* of separation.

And since everything was connected at the time of the big bang

everything may still be connected…