PROFESSOR: interpretation of the wave function.

--pretation--

the wave function.

So you should look at what the inventor said. So what did Schrodinger say? Schrodinger thought that psi represents particles that disintegrate. You have a wave function.

And the wave function is spread all over space, so the particle has disintegrated completely. And wherever you find more psi, more of the particle is there. That was his interpretation.

Then came Max Born. He said, that doesn't look right to me. If I have a particle, but I solve the Schrodinger equation. Everybody started solving the Schrodinger equation.

So they solved it for a particle that hits a Coulomb potential. And they find that the wave function falls off like 1 over r.

OK, the wave function falls off like 2 over r. So is the particle disintegrating? And if you measure, you get a little bit of the particle here? No.

Max Born said, we've done this experiment. The particle chooses some way to go. And it goes one way, and when you measure, you get the full particle. The particle never disintegrates.

So Schrodinger hated what Max Born said. Einstein hated it. But never mind. Max Born was right. Max Born said, it represents probabilities.

And why did they hate it? Because suddenly you lose determinism. You can just talk about probability. So that was sort of funny.

And in fact, neither Einstein nor Schrodinger ever reconciled themselves with the probabilistic interpretation. They never quite liked it. It's probably said that the whole Schrodinger cat experiment was a way of Schrodinger to try to say how ridiculous the probability interpretation was.

Of course, it's not ridiculous. It's right. And the important thing is summarized, I think, with one sentence here. I'll write it. Psi of x and t does not tell how much of the particle--

is at x at time t.

But rather--

what is the probability--

probability--

--bility--

to find it--

at x at time t. So in one sentence, the first clause is what Schrodinger said, and it's not that. It's not what fraction of the particle you get, how much of the particle you get. It's the probability of getting.

But that requires--

a little more precision. Because if a particle can be anywhere, the probability of being at one point, typically, will be 0. It's a continuous probability distribution.

So the way we think of this is we say, we have a point x. Around that point x, we construct a little cube.

d cube x. And the probability-- probability dp, the little probability to find the particle at xt in the cube, within the cube--

the cube--

is equal to the value of the wave function at that point. Norm squared times the volume d cube x.

So that's the probability to find the particle at that little cube. You must find the square of the wave function and multiply by the little element of volume. So that gives you the probability distribution.

And that's, really, what the interpretation means. So it better be, if you have a single particle-- particle, it better be that the integral all over space-- all over space-- of psi squared of x and t squared must be equal to 1.

Because that particle must be found somewhere. And the sum of the probabilities to be found everywhere must add up to 1. So it better be that this is true.

And this poses a set of difficulties that we have to explore. Because you wrote the Schrodinger equation. And this Schrodinger equation tells you how psi evolve in time.

Now, a point I want to emphasize is that the Schrodinger equation says, suppose you know the wave function all over space. You know it's here at some time t0. The Schrodinger equation implies that that determines the wave function for any time.

Why? Because if you know the wave function throughout x, you can calculate the right hand side of this equation for any x. And then you know how psi changes in time.

And therefore, you can integrate with your computer the differential equation and find the wave function at a later time all over space, and then at a later time. So knowing the wave function at one time determines the wave function at all times.

So we could run into a big problem, which is-- suppose your wave function at some time t0 satisfies this at the initial time. Well, you cannot force the wave function to satisfy it at any time. Because the wave function now is determined by the Schrodinger equation.

So you have the possibility that you normalize the wave function well. It makes sense at some time. But the Schrodinger equation later, by time evolution, gives you another thing that doesn't satisfy this for all times.

So what we will have to understand next time is how the Schrodinger equation does the right thing and manages to make this consistent. If it's a probability at some time, at a later time it will still be a probability distribution.