EPISODE 1

[00:04:58.03] B: A particle has zero energy.

C: It's not a particle.

B: A particle always has energy. It always has some intrinsic--

C: You can't have a particle with no energy. That's like saying I have a whole bushel of no apples.

[00:05:13.15] A: No. What I think they're saying is the difference, like, you could imagine, like in a classical sense, like a ball, in a well. It could just be sitting there. It could have no kinetic energy whatsoever.

[00:05:27.15] B: Although I do remember reading...

A: What they're saying, I think, is why in a quantum realm it can't--

[00:05:33.09] B: I do remember reading yesterday, in another physics book I have, that there's a minimum speed that a particle can have. And for a macroscopic object like a ball, it was like 10 to the -36. (laughing) So it's like basically zero.

[00:05:46.22] C: Then it would also be at 0 Kelvin, wouldn't it? If it had no speed?

B: Well, it's its translational speed, not its [inaudible].

C: Oh, ok.

[00:06:00.20] B: For a particle, though, it was much larger. Like for an electron it was like-- what was the number? I don't remember, but it was a lot [inaudible]. For a particle in a box, isn't there some sort of theorem that zero can't be an eigenvalue? Or is it can't be an eigenvector?

[00:06:22.17] A: Zero isn't an eigenvector.

C: 'Cause it's arbitrary.

A: Right. 'Cause then everything would be--

B: Oh, so eigenvector. Ok, so never mind, that doesn't work.

A: Zero can't--

C: Can't be an eigenvalue 'cause eigenvectors--

A: 'Cause any vector could be an eigenvector.

[00:06:33.17] B: Oh, so it can't be an eigenvalue.

A: No, no, zero can be an eigenvalue.

D: No, zero can't be an eigenvalue.

A: Zero can be an eigenvector.

D: Yes.

B: So if zero can't be an eigenvalue, then if the way--

A: It's whichever one makes it, like, trivial.

D: Trivial, I think it's eigenvalue.

[00:06:52.18] C: Yes.

D: 'Cause that would be like H psi = 0 psi. So that--

A: So it would work for any wavefunction.

B: In other words, I take H on psi and I get zero as an eigenvalue, that doesn't work.

[00:07:06.24] A: So we can say linear algebra.

(laughing)

D: 'Cause math.

A: No, what I was arguing at the very beginning was, I thought qualitatively it boiled down to like uncertainty principle, like there's always, you can't say it has zero energy.

B: Oh yeah! I think that's what it is.

?: Well yeah!

A: I really think it's the two- like

D: How do you explain that?

A: Well, I don't know--

B: If it has no energy, then, but now it has a definite position, and--

A: Something along the lines of--

D: Definite momentum.

B: Yeah! It has a definite position and a definite momentum, which is impossible. 'Cause you know its momentum is zero, and you know its position is right there, which is not possible.

A: Well--

C: Do you know where its position in the box is, if it has no momentum?

[00:07:51.25] C: Unless you know the initial state, you don't know, which, I don't know how that plays into it.

B: But you know it's somewhere in a discrete position, and you know once you find it it's gonna be right there.

C: But it's still a probability distribution of where it's gonna be.

B: That's exactly the point, so it's gonna have a probability distribution, and I think that gives it some kinetic energy.

[00:08:16.10] C: Wouldn't-- yeah, that would give it energy if it had a distribution, 'cause then you could do the Hamiltonian and it won't be zero eigenvector. Eigenvalue.

[00:08:26.19] B: (inaudible) I could answer this question.

[00:08:28.08] C: I think it's just indistinguishable from no particle, so you can't have a particle--

D et al.: I'm going with that.

(writing it down)

C: It just becomes trivial.

EPISODE 2

[00:13:33.06] C: (laughs) the speed of it?

(pause)

[00:13:44.29] D: Well, if you have the same--

[00:13:53.00] C: What is the speed of it?

A: Well, it's obviously getting at momentum, right?

B: (reading) If you were to measure the speed of the particle at some point in time, what would you expect to measure? Why? Will you get the same measurement every time?

[00:14:08.10] B: The speed of the particle.

C: Yeah, so that's pretty much momentum.

B: The momentum.

A: Yeah.

C: So you can just say, well, it's indeterminate based on, it's the uncertainty principle. Position, momentum. We already did position.

[00:14:21.16] A: 'Cause it's saying, like, is your answer consist-- well, I was just looking ahead to number 7.

C and D: Yeah.

C: No, that's what it is.

B: ...expectation value of the momentum.

C: 'Cause momentum times-- error in momentum times the error in position is--

B: (inaudible) Yeah, it's sigma-- sigma of p squared times sigma--

C: of x squared.

B: of x squared equals hbar squared over 4.

B: (inaudible)

C: Yeah. So I mean, if we're indeterminate on the position, we must be indeterminate on this. I think. For the same reason.

A: Yeah.

[00:15:06.11]

A: So what the-- what would we expect to measure, what values?

D: Wouldn't it just be--

B: p squared over 2m.

[00:15:19.09] C: Does the particle actually have speed?

B: Yeah, we just usually talk about it through the momentum.

C: Yeah.

[00:15:30.16] (pause)

[00:15:49.04] C: It's particle in a box. Just bouncing off the walls back and forth? (A laughs)

[00:15:58.07] C: Especially if we're just saying it's one-dimensional. Does it slow down at the edges?

D: Well, it has to.

A: Yeah, I think that's--

D: Velocity has to change.

A: Well, it doesn't, because the potential's constant.

E: It's just two walls, it's not (gesturing).

A: Right. So it's not like harmonic, it's not slowing down, it would go at the same speed. (multiple people talking at once)

A: ...going at the same speed...

D: Velocity has to switch direction.

C: The velocity would change its direction.

B: Now we sound like we're switching from quantum to classical explanations. (all laugh)

[00:16:23.14] C: Yeah. That's why I was worried about saying that.

A: But what I'm saying is, there's no-- if the potential is constant along the bottom of this well, there's no reason why its speed would change.

E: Yeah. It's true.

[00:16:42.08] C: But, because it's infinite, if it's infinite walls, then it can't, like, go into it at all.

A: Right.

C: So that disregards all quantumness. All of like the (gestures an exponential).

A: There's no like leaking into the (gestures).

C: Yeah. Leaking.

A: Forbidden region.

[00:17:03.11] C: So it's pretty much classical, isn't it.

B: I'd say it's pretty much classical. It's just--

A: Well--

C: Classical-ish. 'Cause it has no reason to change speed. This isn't about momentum, 'cause that would include velocity and the direction. The speed could be the same.

[00:17:31.27] B: This is speed, not-- basically the same as momentum.

E: Well, momentum defines a direction.

C: And the mass.

A: This is speed, not velocity.

E: Well, the mass will be constant too.

[00:17:39.28]

E: Hopefully. (all laugh) Hopefully.

D: You'd have more problems if it's not.

B: Yeah, it's just pretty weird quantum physics, just (inaudible).

C: Yeah, like absorbs its momentum into mass instead.

[00:18:00.22]