Zander

E: Yeah, so when you started this, you were talking about you use, you play with these guys ((points to spin problem)) in your work. Can you give like an example of a problem you play with?

Z: Sure, so it would be something like--

E: You can write wherever.

Z: Here, I've got some blank space on this page. So like, for example, one thing I, we, I've (done) more recently is metrology.

E: Oh cool.

Z: So the start with a state, and to be honest, we don't normalize the states. Because-

E: Why.

Z: Well because--

E: I mean, why not.

Z: Bec-

E: No, no. You don't need to, right?

Z: You don't really need to, and it just makes the notation just easier to work with if you normalize at the end. Um. Obviously you need to normalize at some point. But, like along the way. So we'll start with a state like this ((1)), and then we evolve under some, like we evolve under some, say there's like a magnetic field or something. Basically some phase that happens, so like you have, which is, this'll be like theta times the Pauli z operator. Sigma theta... Sorry no. This would be the Hamiltonian ((2)). And so the result is that U is theta ((mumbles)), ((3))... And so what happens is this state, call it psi zero, at time t becomes um, becomes i theta t ((4)).

E: Oh ok.

Z: And then what you want to do, is you wanna learn this theta because it's some unknown parameter. And so, what you actually have to do is, you have to write this, you have to change bases again. And so this becomes minus i theta t. Um. Plus plus minus ((5)).

E: Ok. So that's the z's in terms of x's?

Z: Yeah.

E: Ok um... So can I ask just like, um, so physically you're, you get some state right, you're measuring some state. And you know this interaction happened to it. And you're trying to figure out what was the interaction.

Z: Right. You know some type of interaction happened. Generally cus it's like you have some atom, and so it's got some dipole moment ((6)). And you know it's in some magnetic field of unknown strength.

E: Oh ok.

Z: And so the idea is, that will cause, if the atom has two energy levels that are sensitive to the, or one energy level that is sensitive, and one energy level that is not sensitive, and then you put it in this superposition, and you deal with that two level system as... I mean it doesn't literally have to be a spin 1/2 system, but as long as it's a two-level system, you can deal with it this way.

E: Oh I see.

Z: You sort of restrict the Hilbert space down to these two spaces.

E: Ah ok. Um. Ok, sorry. Go ahead.

Z: And then once you split like this, you can look and say ok, I've got a plus and a plus, so I'm gonna group these, and I get e(-i theta t) plus e(i theta t), plus, and then I get e(-i theta t) minus e(i theta t), minus, and, some normalization happens ((7)). And what you're gonna get is this is cosine theta t plus, plus i sine theta t, maybe minus i sine theta t, minus. And then so what you find is that as the, if this this is time, and this is expectation value of x-measurements after you're done with this evolution. And then this will go, and because this is cosine theta, and this is sine theta ((8)), this will vary with frequency theta, basically. Or not f but omega ((9)).

Z: And so you can use this to do, sort of measurements and you can talk, and when you talk in more complicated situations, or when you permit more general measurements, things like this, you can start talking about what's the best possible measurement you can make. Which is a, an interesting question especially when you start talking about many, I study a lot things about entanglement. So I, when you start talking about many qubits, and you have like entangled states. It's an interesting question to ask, what's the best thing to, to do this kind of measurement with. But this would be the very basic, like you have one two-level system and you want to measure this thing.

E: Oh ok.

Z: And I guess this is really, as far as like undergrad quantum goes, this is really the kind of thing you ask people to solve sort of, you have, you know you have something here, and it's going to pass through a region of magnetic field for some amount of time, and then when it comes out you wanna know, you make an x measurement ((10)).

E: Right.

Z: And you wanna know like sort of, how much signal will this box read. That's basically this calculation ((gestures to 1 --> 8 )).

E: Yeah. So. You started with some atom with a dipole moment, right, and then, can you say a little more how you knew that you could collapse that guy to modeling it with a two level system?

Z: Mhm. I mean anytime you have a, anytime you only have two relevant levels, which in our case, we kind of took, it was sort of an assumption. You could imagine doing this in a, in a more, for example, lots of atoms have like, a four level manifold. Where this'll be like, they all have different sensitivities, and these two will be negative and these two will be positive, kind of thing ((11)).

Z: And you can imagine doing that as well, but it would just make the algebra more complicated, I guess. I think, I mean I collapse it down to two levels because, I think this is generally what people do, because experimentally it's simpler to do, and it's easier to deal with algebraically. And also, just in quantum information, we're so used to dealing with these two level cubits, so that's what makes the most sense to people. Um, and so I guess I just have this idea that anytime I have a two level system, I know that, um with two levels, you know that, um, and you know that they have to evolve uh, let me see. You know they have to have this two level, you have to be normalized within that two level manifold, you have to, um, yeah. I think the thing is, as long as you have two level systems, you can always put them on the Bloch sphere.

E: Oh ok.

Z: And so you know that you always have, sort of, this rotation. Yeah, I guess what I think of, whenever you have two levels that are relevant, you can always know that you'll be able to write your state as some like cosine theta, 0 plus, like e to the i phi, sine theta 1.

E: Yeah.

Z: And this always gives you this spherical representation, where you put like 0 up here, and 1 down here. And then the state lies somewhere on the surface of this sphere ((13)). And then as soon as you have this, all this rotational kind of dynamics--

E: Fits in kinda naturally.

Z: Yeah. And people, people always use this. People talk about pseudospin, when they are using two level systems that are not true spins, because it's just so easy to deal with. And I would say that in, almost all of work involves either this kind of this thing ((gestures to algebra)), or involves a harmonic oscillator type of system. So those are two of the sort of building blocks that we use.