Quantum Stuff Swirls for Days with Pramodh Senarath Yapa

Nerdin' About Podcast Transcript, Season 1 Episode 8

Michael
Hey everyone! Welcome to Nerdin' About, I'm Space Michael, and with me as always, is my co-pilot who is going on an adventure - as I'm watching Buffy her favorite TV show, and she is watching Star Trek TNG (The Next Generation), my favorite TV show. How's it going, Kaylee?

Kaylee
Oh, it's going really well. I am somewhere at the end of season three, I've been really enjoying it. How has your Buffy experience been going?

Michael
I'm getting through it, it is really exciting. So, one thing that I'm very curious about, and right from the beginning of Buffy in Season One, the Bronze really stood out to me. So, what is the Bronze? Like it's not a club, because they're not drinking alcohol, they're drinking cappuccinos, and there's a live band playing, and they're kind of dancing?

Kaylee
The Bronze is really weird actually, because it is sort of like a bar, but there are underage kids in there, and they're just drinking like sodas, or waters, or tea, or coffee or something. It's definitely not a bar that I have ever been to.

Michael
Well, I think there should be more clubs like that, that have the band come on at like 5pm so all of us old folk can be in bed early.

Kaylee
Yeah, I'm definitely one of those people who now when I just go to concerts, I'm like, you know what would be really refreshing? Maybe don't do an encore so I can get home and go to bed sooner.

Pramodh
And turn it down just a tad, just a little less loud.

Kaylee
Pramodh, don't you think they should turn it up to 11?

Pramodh
Yeah, if they had 12. I would vote for that.

Kaylee
And if you're wondering who's telling us both to turn it up and turn it down, that is our guest today Pramodh Senarath Yapa. Pramodh is a PhD student at the University of Alberta, where he studies theoretical condensed matter physics. Pramodh is also infamous for his win of the 2018 Dance Your PhD Competition for his rendition of swing dancing electrons called "Superconductivity: The Musical". If you haven't watched that already, go check it out, do yourself a favor. Pramodh thanks so much for being here today. How are you doing?

Pramodh
Hello, I am really, really well, today. How are you?

Kaylee
You know I'm doing okay, we talked a little bit earlier, I somehow about an hour ago managed to delete an entire spreadsheet of data. So, I'm feeling a lot of emotions right now, but otherwise, I'm doing super great, and I'm really excited to be here to talk to you today about your work. Maybe let's start at the beginning. What the heck is condensed matter physics?

Pramodh
Sure. I mean, that's a question I've gotten used to answering a lot over the last few years, because we know theoretical physics from many of the different pop culture references that we consume. Big Bang Theory has quite a few theoretical physicists who are of the particle kind. So, everyone knows about smashing particles together, and seeing what comes out. The lesser known, but the backbone of physics - well, at least what I like to believe is the backbone of physics - is condensed matter physics, which is really looking at something that may be a little more mundane. We don't have a 10-kilometer ring that smashes particles together, but it looks at the physics that happens in materials all around us, and what happens when you cool it down, and what happens when you apply a lot of pressure to it. A lot of interesting stuff happens, and it happens mostly because of quantum stuff. So, I study the quantum stuff of material.

Kaylee
Great, great, great. Just a little, just a little side question. What's quantum stuff?

Pramodh
Quantum stuff! Oh, I mean, I could go off on a whole tangent about this historical aspect of quantum stuff. Essentially, if you want a SparkNotes version, it started in the 1900s, and people notice that when they study things that were really small, it didn't really fit into the conceptions of physics at that time of being able to measure things, and get precise results out. So, as they measured stuff like hydrogen atoms, and the electrons that were in the hydrogen atoms, a lot of the theory started to break down, and quantum stuff is kind of the mathematical theory that was built up from the 1900s onwards to explain what happens at the tiniest and the coldest, or even the really warm high energy, or low energy parts of the world. So, stars, or superconductors are on extreme ends, and both of them require quantum to understand.

Michael
Well, let's maybe start with stars Pramodh, because you do a lot of work in helium. When we're talking gases, hydrogen, nitrogen, oxygen, they get a lot of love. Helium, even though it's number two, it's right up there, it doesn't seem to get a lot of respect. Maybe tell us a little bit about helium and why it is so special.

Pramodh
Yeah, helium is my favorite substance of all time. I only learned about it really two years ago, but it kind of just captured me on a level that nothing has.

Kaylee
Sorry, did you just learn that helium existed two years ago? Or...

Pramodh
I was like, what is that stuff in balloons? No one would tell me what it was, and then two years ago all clicked! Ha-ha okay so helium, as we know it in balloons, in MRI machines, it makes stuff cold, but what really captured me was looking at helium when it's no longer a gas. With normal states of matter, you have liquid, gas, and solid, and if you think about pretty much any element on Earth, if you make it hot enough, it turns into a gas, if you bring it colder, it turns into a liquid, and then you make it even colder, eventually turns into a solid. Now all of the elements do this except helium. So, helium, gas at normal room temperature, you cool it down, it stays a gas until you reach about 2.7 Kelvins, which is about -270 degrees Celsius, and then it turns into a liquid. Then you're like, okay that took a lot of effort to get into a liquid stage, but maybe if we keep cooling it down, it'll turn into a solid, but it does not, you can go all the way to absolute zero, and it turns out helium does not turn into a solid. The only explanation for that is quantum.

Kaylee
Classic.

Pramodh
Actually, the opposite of quantum is classic, and it is definitely not classic. It is the very opposite, and it does so many weird things, and not turning into a solid is probably the least weird thing it does. The next most exciting thing that people know it for is if you keep cooling down it turns into a thing called a superfluid. That's what I study, and I could tell you what a superfluid is if you want me to,

Kaylee
Um, yes please, tell me what a superfluid is. Is it this beer I'm drinking?

Pramodh
So, we can explain it using your beer. So, imagine that beer that you have in front of you, grab a spoon, you pop it in there, and give it a swirl. It's going to form not quite a whirlpool, but it's going to create this little vortex in there, and if you wait like three seconds, that's going to stop,

and it's going to settle, and it'll become a flat normal drinkable beer again. If you did that with superfluid helium you'd see something very different. So, you'd put the spoon in, you'd give it a swirl, you take the spoon out, and then a whirlpool forms. Then you wait 10 minutes, there'll still be a whirlpool, you wait an hour, there'll still be a whirlpool, you wait 100 years, there will still be a whirlpool.

Kaylee
Whoa!

Pramodh
Superfluid helium is a frictionless liquid, it has absolutely no friction, it has no viscosity. So, if you imagine honey as being a very thick, viscous substance, water is less viscous than that, and then superfluid helium is on the exact opposite spectrum. It has zero viscosity.

Kaylee
So, it is truly that an object in motion stays in motion.

Pramodh
Absolutely, exactly. Yeah, it's like Newton's dream if friction and resistance did not exist.

Michael
So, what exactly could we use this superfluid helium for?

Pramodh
So, you know, when you go into theoretical physics, it's kind of hard to look into, what can we use it for? We're just looking at things because they're so darn interesting. One thing that we could use it for is actually related to a big kind of buzzwordy thing, there's a lot of money being poured into it right now in Silicon Valley, and that is building a quantum computer. So, here's a brief intro into what a quantum computer is. Normal classical computers, the stuff that we're using to record right now, the stuff that's running Zoom, runs on zeros and ones, that's kind of like a switch being turned on and turned off. A quantum computer has that, but also has these weird intermediate states where the things that make it up, can both be a zero and a one at the same time, and it uses quantum mechanics to do that. It turns out for not very obvious reasons, this is very useful, and can in some situations, make the computer solve problems really, really fast. So, it can be used for that, it can be used for breaking cryptographic stuff. A lot of the ways that we transfer information over the internet is we get a big prime number like a 200-digit prime number, and then we multiply it with another 200-digit prime number. It's hard to figure out what the original two prime numbers are from the multiplied number. So that's the only way we encrypt information. Turns out, if we had a quantum computer, we could do that in seconds. So, a quantum computer is good for many reasons. It can solve problems much faster than we're used to, and also it can bring about a new age of this quantum cryptography. So, there's a lot of money being poured into that right now, and trying to figure out what is the best way to build a quantum computer, and there are many different ways to do it. One of them involves superfluid

helium, basically floating electrons on top of the surface of the helium, and then you kind of poke the electron, and depending on the state the electron is in, it's either zero, or one, or it's somewhere in between. So, electrons floating on helium could be the basis of a quantum computer coming to a place near you.

Kaylee
So, if we go back for a minute to helium, how was helium discovered?

Pramodh
Yeah, so there's an amazing story about the origin of the helium gas. So, people pointed their telescopes at the sun, and figured out that the sun was full of this mystery element known as helium, but they had never really seen it on Earth, other than trace amounts of it in some rocks. So, I think it was like 1903 in a town in Kansas called Dexter, they found this gas well, and this is a time where natural gas was a way to economic freedom, you could make a lot of money in a very short amount of time if you found a natural gas well in Kansas. So, in this town they found a well, and the mayor gathered all these people together, and they decided that they were going to have a big old party to declare this gas well open to inaugurate their new economic future. So, the mayor gave a speech that they were going to have this grand unveiling by lighting a hale bale on fire, and then pushing it towards the gas well, and then seeing it erupt in flames. So, they did that, they set it on fire, and they slowly pushed it towards the gas well, it hit the gas well, and then abruptly went out, and everyone's like, what, that wasn't supposed to happen. So, they tried two times, three times, each time it hits a gas well it hits this outflow of gas and nothing, nothing would light on fire. So, everyone's hopes are dashed, but there was a scientist at the University of Kansas, he was like, oh, okay, I mean, sucks that we can't get rich off the gas coming out of that, but why did it not light on fire? So, he went back to the lab took a sample of the gas, and found out that it was mostly nitrogen, it wasn't this the carbon-based stuff that would light on fire, but it was mostly nitrogen. Something like 1 or 2% was this completely unknown element. It was helium. So that was the first time they found helium, and they didn't actually make a huge deal out of it because they didn't really realize what you could do with it. Then World War Two came around, and there was this Hindenburg thing, which was good while it was in the air, and kind of sucked when it blew up, and caught fire and stuff. So, they're like, oh, what about this helium thing? Helium, lighter than air but also does not combust, and that's when this big boom for helium came about. So that's the origin story of helium. Its scientific use only came by much, much later when they discovered that you could use it for cooling a lot of different things like building a fridge, and instead of going down to -20, -30, at most in your normal fridges, you could go down -250 degrees, and if it goes down to - 273.1, something, then it's going to be a mix of helium-4 and helium-3, which are two very, very different things.

Kaylee
What is the difference? What's happening?

Pramodh
Wow, it's almost like I prompted that question. So, helium-3, helium-4 are just isotopes of helium. So, you know, helium, like Michael said, is the second thing on the periodic table, because it has two protons, but you can also have many neutrons in there. It doesn't really change the element, but it does make the nucleus heavier. The most common helium on earth is helium-4, which has two protons plus two neutrons. So, two plus two makes four, so very unsurprisingly, they named it helium-4 and that was the thing that was mostly abundant naturally. It was like 0.001% was helium-3, which had two protons, and one neutron, and nobody really had vast quantities of it. So, they didn't really do much with it, but as they made nuclear weapons, helium-3 turned out to be a byproduct of that. Then they got a hold that stuff and figured it out. It behaves mostly like normal helium until you cool it down to very, very low temperatures, then it behaves like a completely different animal.

Kaylee
And then like swirls for days!

Pramodh
Yeah, it swirls. So, both helium-4 and helium-3 swirl for days, but they are swirling in extremely different ways, and that's actually what I study. Basically, the difference between the kinds of superfluid that helium-4 makes versus the superfluid helium-3 makes.

Michael
That brings up a question I've seen occasional things come up on my science feed that may be alarmist I don't know, that are saying that the world is running out of helium. Are we running out of a particular kind of helium? And what would happen if we did run out of helium?

Pramodh
Yeah. So, we are, in a sense, running out of helium because it's a non-renewable resource, right. So, helium gets out into the world, and it is lighter than air, which is precisely the first use people found for it. So, what it does, it just rises and keeps on rising, and then escapes out into space, and we're never getting that helium back. So, we are running out of helium. Why is that concerning? It's because a lot of our technology needs cooling. So, MRI machines they need helium. A lot of the scientific equipment that people use requires helium for cooling. The scientific study of helium itself actually doesn't use a lot of helium, but apparently the balloon industry coupled with the MRIs are making us run out of helium. They have in recent times found some new wells. I think there are some new wells in like, Tanzania, and a few other countries are getting into it. So maybe it's not as dire as people think. I think actually, in my backyard, Alberta. Alberta is opening up some helium plant within the next year or something. So maybe we won't run out of it in the near future, but it is something that we probably shouldn't be doing our thesis defenses with.

Michael
Or just filling up thousands and thousands of balloons, you know, just for fun just to kind of like have in our house.

Pramodh
Yeah, it's weird that we still allow that - I don't understand. I think it's just because we've just normalized that, like helium is for balloons without really realizing that it's a thing that will run out someday, and it's very important for other things, non-balloon related reasons.

Kaylee
So, we've talked a little bit about helium, we've talked about how it's super cool. We've talked about how helium-3 and helium-4, even though they're like, real close together, they're not the same thing, and they swirl for days, but like differently. Am I getting a PhD in physics? Hard to say.

Pramodh
That's going to be the last line of my thesis, they just swirl differently,

Kaylee
You also are doing a lot of science communication, and that's actually how I know you because we're both on this organizing committee for ComSciCon Canada. One of the very cool science communication things you did was this dance your PhD "Superconductivity: The Musical". What is it about electron behavior that could be like a dance?

Pramodh
Yeah, so it's funny. It A lot of it translates really well, which is astounding. It wasn't even me forcing it, I wasn't "you must dance electrons". It was like, the electrons are dancing, so why not actually put them into a human form? So, my master's thesis was slightly related, but not completely the same. I wasn't studying helium at the time, I was looking at superconductors, and I was actually looking at superconductors for use in quantum computing. So, they use superconductors as the basis for their quantum computer, and what a superconductor is, is just pretty much a normal metal, aluminum. Aluminum is actually a superconductor, but only under very specific circumstances. Only if you cool it below a certain temperature, I think it's like 4 Kelvin, which is -269 degrees Celsius. What happens in aluminum, is aluminum is normally full of electrons marching in a straight line to bring electricity into your devices. Well, I don't know if aluminum is actually used in wires, but if it were, that's what would happen. You have lone electrons that are traveling down this aluminum wire, and then if you cool it down something really strange happens. Earlier the electrons were just walking single file in this wire to get to their destination, but suddenly, if you cool it down, they start to notice each other, and they start interacting. It is like a dance, it's like the DJ turned the music on. The electrons immediately just pair up into a thing called a Cooper pair, and they kind of swirl about, and they move as one unit. So instead of lone electrons moving up and down the wire, you have now only pairs of

electrons, and actually exact same phenomenon as superfluid helium doing swirly things. You have infinite swirly pairs of electrons going down this wire.

Kaylee
What I'm learning is that physics is just infinite swirly things.

Pramodh
Yeah, it is. A wave particle duality is just waves.

Kaylee
That's exactly what I said wave particle duality. Ha-ha. So, if you were to cool it even further would those pairs, pair up again, like do you get larger and larger clusters of electrons?

Pramodh
That's a really interesting question, actually. Yeah, so something like that does happen. So, what happens when you cool it down further and further is more and more of the electrons actually pair up. So, if you're at -4 degrees Kelvin, versus 2 degrees Kelvin, it just means a larger proportion of the electrons have now paired up, but they're also pairing up closer and closer. So, the distance between the pairs goes down, and so there is an interesting bit of physics there, where it's called Bose-Einstein condensation. When the electron pairs pretty much are touching, they're as close as they'll ever get quantum mechanically speaking. So, there's superconductivity, and then there's something called Bose-Einstein condensation, which are very related concepts, but they're related by cooling it further down.

Kaylee
It's kind of reminds me of dancing when you're in sets. My dad and I have done this dancing in Nova Scotia and you dance in a pair, but there's like four pairs. So, you're still dancing in your pair, but you're like really close to the other pairs, and you dance in these four sets of pairs. I mean, I guess my analogy is breaking down, because at some point, you actually dance with other people, but you mostly stay in your pair. Forget my analogy.

Pramodh
No, that's a great analogy. That's actually what happens in a metal, because not all of them are dancing, and sometimes you want to dance with someone else. So, you swap out your partner for somebody else. That happens in a superconductor. So, perfect analogy.

Michael
All right. Well, let's get to some listener questions from the Nerd Herd. We'll, first start off with a question from Farah who wants to know, what are some of the big questions in Quantum Mechanics.

Pramodh
Quantum physics is you know different from condensed matter. There are a lot of questions in particle physics and condensed matter, but quantum kind of encompasses both. So, let me get into a historical digression here. You know, quantum mechanics started early 1900s with helium, hydrogen, they looked at electrons going on there. The lesson as they develop quantum mechanics - physicists developed a culture, instead of purely following the math. The philosophy behind it gathered around this idea of reductionism, which is basically saying if “I want to understand anything, I want to take it apart, I get to see what is the smallest thing that I can break it down into”, and that kind of became the philosophy of quantum mechanics and modern physics, from 1900s all the way up to like 10 years ago. Then people were like, "I'm going to get my particle smasher. I'm going to smash things and see the small things that come out". It was super successful, which is great, but ended up with a lot of different particles that people didn't expect. They were like, “we're going to find one explanation for everything - we're going to find a string”, string theory as you may have heard of it. People expected everything at the end of the day was made of little loops of strings that vibrated in the universe.

Kaylee
It's like a cat's paradise.

Pramodh
Absolutely. Unfortunately for the cats that has not panned out, and so the last 20-30 something years of physics has been trying to find the elusive strings that permeate everything, or trying to find some other things called supersymmetry, or some sort of exotic physics, and it's kind of failed, unfortunately. So, the paradigm is kind of shifting in physics, where people are like, oooh, that reductionism thing, it's not kind of working out for us. While condensed matter physics from like the 1940s to now have just been like, yeah, we don't want to break things down into their smallest parts, we're going to actually look at when we have a lot of atoms and electrons hanging out together, what are the things that emerge out of that? So, we're not breaking down things into one part, we're looking at a collective, and then seeing what can we understand from that collective. That has kind of become the guiding philosophy in the last few years. So, people are trying to figure out when we get a collective of things, what are the emergent properties of that. Much like, if you have birds in the sky, if you're looking at one bird, you won't be able to tell all the amazing shapes that a whole flock of them can make. So, there are these undulating shapes that starlings make when they flock together. You can think of that as an emergent animal in a sense that come out of many different birds interacting together, and working together. Condensed matter physics kinda does the same thing, and then a lot of people are starting to think of emergence as the next big thing in quantum physics.

Michael
Next question comes from Alex, which is kind of a fun question. What is the opposite of theoretical condensed matter physics?

Pramodh
I mean if we break it down, let's take the reductionist approach. Let's break it down into individual components. So, theoretical is experimental, condensed is let's say, diffuse. Condensed matter, is anti-matter. So, experimental diffused anti-matter is I guess the literal answer to that question.

Kaylee
One more question is from Richard who asks, I remember reading a few years ago about metallic hydrogen being the next miracle material, a superconductor, a rocket fuel. What happened to those ideas?

Pramodh
Yeah, super interesting idea. To be honest, not the area of physics I look at, but I do remember the story, and the story surrounding it, because the discovery of superconducting metallic hydrogen happened I think, in 2017. I remember the story, because it turned out that the postdoc who put that experiment together was from Sri Lanka, and went to the same university as my dad. I was like, Oh, my God, another Sri Lankan physicist is doing kind of similar things to what I'm doing, and I became really excited. That's the only reason I really know about this. To answer the actual question here, I think reality isn't as simple as - you find something that is a super material, and it does a really great thing that would be useful to us - for example, take superconductors, it'd be amazing if we had superconductors everywhere, and we use them to transport electricity from power stations to our homes, because then we wouldn't lose any of the electricity, which is a major concern, we lose a lot of electricity in the power lines getting to us. If we were to build superconducting power lines all the way to our homes, we'd need to keep it at -260 degrees Celsius, and you'd probably end up consuming more electricity than you would save in a superconductor. It's a similar reason why metallic hydrogen didn't actually end up being the wonder material, or whatever it was purported to be, because to get metallic hydrogen it took a lot of effort. They had to make a diamond anvil, and they made a tiny piece of hydrogen. They had to squeeze it with this diamond anvil to just redonkulous pressures, and they had to cool it down to redonkulously low temperatures. That's the only time they saw metallic hydrogen, and it was for like an hour, and then it just exploded, and they never saw a metallic hydrogen again. So, entirety of history, we've seen metallic hydrogen for like 10 minutes, after squeezing as hard as humanly possible, and making things as cold as humanly possible. So, if you have to go to that effort to make a wonder material that can solve all of the problems on Earth, it's kind of easy to imagine why it didn't become as popular as it should have.

Michael
I think there might actually be metallic hydrogen at the core of Jupiter.

Pramodh
That makes sense, right? So, if we think of high pressures, what has higher pressure than the center of the largest planet in our solar system.

Michael
All right, well, this has been some amazing nerd time. Should we nerd out even more?

Kaylee
Bring on those nerd outs.

Michael
All right, Pramodh. What have you been nerding out about recently?

Pramodh
So, I'm going to do two quick ones, please forgive me. So, one thing I discovered last week was there's this program online called oscilloscope music, which basically takes any 3D model that you want to a computer, and you feed it into this machine. One, it converts this model into sound. So, you can hear what your 3D model sounds like, like someone's face for instance, but it also converts it into this vapor wave, oscilloscope, green matrix like structure. So, I've been playing around with that trying to figure out how can I make music out of 3D modeling, and so I'm very excited to play around with this more. The second one, also kind of about music. I've been going on YouTube rabbit holes that just lead me to finding weird things, but I was watching some videos of physicists and Nobel Prize winners, and I discovered a lot of them play music. So, I've been going on YouTube, finding clips of Nobel Prize winners in physics and Fields medalists, playing their instruments, and I want to create a band out of all the clips that they make. So, I've been slowly over the last week, I have like five or six different people playing piano and tabla, and I'm going to try and put them together, and make a band out of them. So, stay tuned.

Kaylee
Michael, if you were to create a sound off of a 3D structure, what 3D structure would you put into this machine?

Michael
Can I say the Enterprise?

Kaylee
It just sounds like "make it so". That's the only thing it sounds like. So, Michael, what have you been nerding about?

Michael
So, previous guest Johanna Wagstaff introduced us in her nerd out about the show Devs, which I delved into and holy smokes, this is my favorite show of the year. Speaking of supercomputers now, I can't tell you what the show is about because the whole premise of the show is that they are developing something, which is Devs. They're developing something that is secret, and is going to basically change the world. Once you find out what Devs is that dives you into this

rabbit hole of humans, and our perception of the universe. What is quite interesting is thinking of this new kind of supervillain. When science was first discovering these things like helium and nuclear physics, there was this arch villain of the mad scientist, where now it's more like the mad developer. That's not to say that the character that Nick Offerman plays is a villain in the show, but he is perhaps someone that is not really thinking about morality in the way that most humans are. Kind of the way that mad scientists think about the next leap in science, but they're not quite thinking of the morality, and if we should do this. I wonder if we'll see more of that kind of supervillain in stories, and we can see them in the world right now doing these things, and we don't know what they're developing, and it could destroy us all.

Kaylee
That got real dark real fast.

Pramodh
Zero to 100! Also, the thought of Nick Offerman being a supervillain I now really want to check it out.

Michael
He has that whole sort of disheveled, I don't dress up kind of vibe, that most CEOs of tech companies have. Kaylee, what are you nerding about?

Kaylee
So, I've been thinking a lot recently about science communication, and that's partly because Pramodh and I are both work on organizing ComSciCon Can which is a science communication workshop for graduate students. By the time this airs, it will have already happened this year. If you're a graduate student interested in science communication training, you should check it out for next year. It's been making me think about how I like to consume science. I generally like my science communication to sort of be fun and interactive. Here in Vancouver, there's a new podcast called Science Telephone. I love the idea of it. The basic idea is you tell your science to a stand-up comedian, and then they tell that science that they've got from you to another stand-up comedian, and then they pass it down the line, and then it comes back to you, and you see how it sort of went through the process. It's a really fun way to look at science, and the idea of what happens when you communicate poorly, and how it gets transcribed. So that's one that I think is a really cool idea, and if you haven't listened to Science Telephone, check it out. I hope to hear Pramodh on it at some point. Another one that I've been really nerding out about lately is RCI Science. So RCI Science is a really cool platform where they have these weekly takeovers where scientists will come on, and they'll share their science for a week, and right now Farah Qaiser is doing the science takeover there, and it's been really fun watching because it's covering not only DNA and what DNA is, but it's also talking about science policy and diversity in STEM. So, these two very different approaches are really engaging. So, if you don't already follow RCI Science, that's another really cool platform for you to check out to meet a lot of different scientists.

Michael
Amazing. Pramodh thank you so much for joining us today. Where can people find you if they want to contact you, and ask you more questions on the internet?

Pramodh
Thank you so much. I had a blast. This is great. I love talking about helium. I would love to talk more about helium on Twitter, actually. So, Twitter is where I do most of my science communication, kind of do it on Instagram as well but @PramodhYapa. Yeah, ask me things. I would love to talk your ear off via 280 characters.

Kaylee
We obviously already follow Pramodh, and if you like this podcast, and you want to hear more from us. You can follow us @NerdNiteYVR on Instagram, Twitter and on Facebook. We'll be back in a couple weeks, but until next time, make like helium-4 and stay super cool.