LIGO Wrangles Wiggles in Spacetime with Corey Gray

Nerdin' About Podcast Transcript, Season 2 Episode 6

Michael
Hey everyone welcome to Nerdin' About! I'm Space Michael, and with me as always is someone who is growing out her hair, looking pretty good, and that's Dr. Kaylee Byers.

Kaylee
Oh my gosh, thank you so much. I do think it looks good. I also think it's starting to look a little frazzled, which is, you know, kind of how I feel about myself in general. Like I'm doing pretty well, but I'm also pretty frazzled. How about you? How are you doing over there with your haircut?

Michael
Well, I've got a bit of a swoop going. So, when I have the hair in a part it swoops down, it's very emo. So doing anything to try to dissuade people from knowing what my actual age is.

Kaylee
Yeah, next week there'll be some heavy eyeliner.

Michael
Absolutely.

Kaylee
Well, we're both not the only ones growing our hair long. Actually, our guest today is also growing out their hair. So, today we're joined by Corey Gray. Corey is Scottish and Blackfoot, and a member of the Siksika nation of Alberta. Corey is a detector operator for LIGO, which stands for the Laser Interferometer Gravitational Wave Observatory at Caltech. Corey's worked with teams to build and operate gravitational wave detectors. Hi, Corey. How are you doing?

Corey
Hey, good evening. How are y'all doing? I'm doing good.

Kaylee
Well, we're really excited to be here with you today. I'm especially excited to learn what the heck gravitational waves are. So maybe we can start there? What the heck are gravitational waves?

Corey
So, the whole idea of gravitational waves come from a long time ago, from over a century ago, they come from a gentleman by the name of Albert Einstein. Albert Einstein flipped the world of physics on its head by coming up with a completely new way of thinking about what gravity is. So, prior to Albert Einstein, gravity was thought of as a force between two objects. I mean, there's the idea of Newton sitting under a tree, and the gravitational force of the Earth is pulling

down on that apple, and it hits him on the head. Einstein went completely different, he thought of a different way of thinking of gravity, because he didn't think that explained everything well. So instead of a force, gravity is the effect of any mass on the space around it, and space or spacetime, I'll use those words interchangeably. So, every object bends the space around it. My water bottle right here is bending the spacetime around it, and I'm bending space around me as well, but those effects are so tiny that we can't detect them, we can't observe them. The main reason is because spacetime, this medium that we live in, in our universe is very stiff, it's a rigid medium, so it's hard to bend it and warp it, unless you are an object that is hard to comprehend. If you're something like a neutron star, if you're like our Sun, or if you're like a black hole, all those objects are much bigger, and they do have effects that are a little more observable with how they affect the spacetime around them. I'll go with the extreme case, black holes are these areas in spacetime, where you have super bending, or warping of space around them. If you take a black hole, or a neutron star, something that's very strong with gravity, and you move it around in spacetime, as you're moving it around in space, you're causing these little wiggles in that medium in spacetime. Those little wiggles are what gravitational waves are. So, a year after Einstein talked about the general theory of relativity and released that to the world, he did the math for gravitational waves. So, in 1916, a year after, and on the back of an envelope, he put in what he knew about back then, and if you take two stars and smash them together, would you be able to see these signals? Would you be able to see these wiggles in spacetime? With what they knew back then, it would just be so hard these events would be so far away, and by the time these wiggles in spacetime come to the earth, they'd be monumentally small, and it would be too hard to detect them. Fast forward a century later, and things would change.

Kaylee
Oh my gosh, I love that they're wiggles! Okay, so gravitational waves are adorable, little wiggles in space time. So, you were talking about how we move space around us. Do I have wiggles, like really little wiggles?

Corey
Yes, and ours are going to be super small. I should say that if you were next to a black hole and a neutron star, or two black holes as they're dancing around each other, if you were there next to them as they're wiggling space around them, the gravitational waves from their movement would rip you apart. It would stretch you, it would compress you, and it would oscillate you into different directions, until you're no longer with us anymore. Luckily, that's a good thing. Luckily, all of these strong gravity objects are millions and billions of light years away. So, it's a good thing that they are teeny tiny by the time they pass through the earth.

Kaylee
Okay, so gravitational waves, real cute from a distance, but not so cute really close up, because they will tear you apart. So, you were talking about this prediction made by Albert Einstein over 100 years ago. How then did LIGO prove that prediction that these little wiggly wiggles exist?

Corey
So, I'll go back a few decades in the past and talk about how gravitational waves were proven indirectly by some astronomers at Arecibo. Michael, you might know Arecibo in Puerto Rico, that's a big radio telescope dish that just collapsed.

Michael
RIP

Corey
Yeah. So, some astronomers there in the 60s and 70s saw two neutron stars that were orbiting each other. One thing that they saw was that there was energy that was leaving that system, and they were able to see mathematically that the energy that was leaving was gravitational waves. So indirectly, they were able to prove the existence of gravitational waves. So that's decades ago that those two gentlemen, Taylor and Hulse, received a Nobel Prize for that. Also, around that time, other physicists were coming up with other ways to detect them. So, one gentleman by the name of Dr. Rai Weiss, who's from MIT, and Dr. Kip Thorne, from Caltech, were trying to solve that, they were talking about it, and thinking of ways that they could do it. Rai Weiss came up with this instrument that he thought would be able to detect these signals. In its most simple terms, basically, Rai came up with a ruler, like the most sensitive ruler that you could build. I like to think of it as we have this ruler that has two objects at the end of it. So, I'm in Washington State right now, and my work is about a 20-minute drive away out my window, as I look out here, and at the detector we have these two objects, they're mirrors or masses, and they're eight kilometers apart. What we can do is we could tell precisely the distance between them, and we can resolve any change in the distance between them down to a distance 1000 times smaller than the diameter of a proton. So, a teeny tiny length change is what we could see over those eight kilometers between those two mirrors. That's the sensitivity that we need to be able to detect or feel these wiggles in space time that are showering through the Earth all the time. So, you need a big signal, but if you have one that's big enough, our machine is sensitive enough to detect those wiggles, and it moves our mirrors around. That's how we record and can directly detect gravitational waves.

Michael
You know, Corey, you're describing gravitational waves as being sensitive, and Kaylee, you described them as cute, but they're also really harsh and they'll destroy you. This is sounding very emo. I think gravitational waves are the emo forces in the universe.

Kaylee
Gravitational waves for sure have an asymmetrical haircut that covers one eye.

Corey
Exactly, I need to get a new haircut. I think I need to copy Michael.

Michael
So, Corey, you work in Washington State at the detector there, but there is another identical detector in Louisiana, I believe, right?

Corey
That's correct. We have two detectors for LIGO. LIGO stands for the Laser Interferometer Gravitational Wave Observatory. For advanced LIGO, which is the configuration that we have at both observatories. That's what we've been running since about 2015, off and on. So, we've been online and recording data, three different periods over the last five years, and then we go online record data, then we go offline like we are right now and do upgrades to the hardware or to the instruments. So that's what we're doing, we're not recording data right now, and we will currently be down until the middle of 2022, that's when we'll come back online, and then it won't just be us as well. So, for the last two observing runs, that's what we call these runs when we're online, there's another detector in Italy by the name of Virgo, and they've been with us as well. So, we have three detectors that have been online for the last two observing runs, and there's a fourth detector in Japan, that's called KAGRA, and that one is also getting ready to come online.

Michael
So why do you need all of these detectors? Is it really just to verify the results? Originally, when you first detected the gravitational waves, it was the two observatories in Washington State and Louisiana, but why do you need all of these working at once?

Corey
That's a good question. So, for sure, that was one of the first ideas with the proposal for LIGO in the proposal for it, it's basically to confirm the results. So that's why in that proposal the idea was to build two detectors for LIGO. So that's one thing, but the other thing is that these detectors don't tell you exactly where events are coming from in the universe. So, we don't really know in what direction they're coming from. Well, we kind of do, but it's kind of a time of arrival thing. So, with just two detectors, when we record a signal with the two LIGO detectors, we're able to look in the sky and get a rough idea of where that event is coming from, but with just two detectors, it's a huge area in the sky. So, the way to make that better, is to have more detectors. So instead of having two detectors, the more you add, that area in the sky gets smaller and smaller. So instead of two detectors, if you add a third one, that big, banana looking shape in the sky gets smaller and smaller. That's what optical observatories want, they want that, they don't want us to tell them, "oh, look into the sky" in this vague area of the sky. It's huge! If you tell them that, there's not much they could do, it would take them forever to find that signal. So, with more detectors, we can shrink it down and give them a much better area to point their instruments and find events that we're looking at.

Michael
So, if I just pull back just for a second, just to talk about the wiggles, as Kaylee described them, we're talking about a very precise measurement of something that is almost imperceptible. But essentially, we're also on Earth, we're creating lots of these wiggles, like a big truck rolls by and

the ground rumbles. Are we talking about the same thing, or are gravitational waves a different kind of thing from the kind of vibrations that we're used to here on Earth?

Corey
Yeah, it's a unique thing. These land based gravitational wave detectors can't see everything. They're designed to look at certain frequencies, frequency is the big unit that we use for this. So, for LIGO, the frequency window that we can look at and focus at is from a few 10s of hertz. So that's 10 wiggles per second up to several kilo hertz, or several thousand wiggles per second, that's the window we can look at. So, anything below about 20 to 30 hertz is going to be too noisy, our instruments are not going to be sensitive there. So, with the low frequency stuff, that's going to be a lot of cultural effects, so trucks driving by, earthquakes, anything magnitude six is something that would definitely move our detector around. We know that we're not going to see any low frequencies, stuff that's really slow. So, we're definitely an instrument that could only look at a certain band of frequencies. Luckily, within that band of frequencies are possible sources like binary systems, when you have two objects, it could be a black hole, and another black hole, or a black hole and a neutron star, those objects crashing into each other. So, those frequencies when those objects are spinning around, are right within that band of frequencies. Between 40 and 2000 hertz is what our machines are catered to. Earthquakes, we definitely feel them, trucks driving by, we definitely feel them, big storms in the North Atlantic, we'll see them in Louisiana and Washington at our detectors. So that low frequency noise is stuff we just have to ride through, and we don't even try to look at low frequency or slow signals.

Kaylee
So, I have a question about something that you were talking about earlier, and this is just sort of a clarifying thing for me, black holes I think I have a basic understanding of, but what's a neutron star?

Corey
So, stars have a lifecycle, as they live, they burn different types of fuel. Towards the end of their lifecycle, they get to a point where they're running out of fuel to burn. They can either explode into a separate supernova and spew all types of matter throughout the universe, and that could be it, or they could explode into a supernova, and then collapse into something called a neutron star. You have this big object that's the size of our sun or a lot bigger, and then that thing could evolve into something that's a lot more compact, and heavy and dense, maybe about the size of the diameter of Vancouver. One of the things people say about neutron stars is that you could take a spoonful of a neutron star, and that material would weigh about the size of Mount Ranier or something. So, they're just very compact objects, and those are the ones that we love for LIGO, because those compact objects are the ones that would warp space a lot more than say our Sun. So those are the ones that are the best candidates for generating these large signals that we can detect with our detectors.

Kaylee
That's amazing. They almost sound like cake pops, a cake pop is about 10 cakes inside.

Corey
Oh, yeah. Wow.

Kaylee
They're the cake pop of the universe.

Corey
We've had several detections over the years, and the large percentage of them have involved black holes. I have a ranking of my favorite detections, and one of my favorites was our first binary neutron star detection. I think up to that point we had detected about eight detections, all of them binary black holes, two black holes crashing into each other. August of 2017, was the first time we saw two neutron stars crash into each other. I was actually on shift that week, that's one of the reasons why I love it. The thing was, it happened here, and it was like five in the morning, and I didn't know what was going on at first, I was just working and in the control room. Then my counterpart in Louisiana, called me up and he said, "Corey, you better jump into this meeting, there's a telecon, a conference call." I jumped in, and in that meeting, all I heard were scientists screaming at each other, and even cussing, and I didn't know what's going on. Then as soon as you heard the word neutron star, you knew that it was a huge thing. So, everybody was excited, because they wanted to confirm that this was a binary neutron star event. Then the other thing is that they were writing down the alert that we were going to send to astronomers around the planet, so that they would know where to look for this event. What's so cool about it was that was five in the morning, so when the sun went down later that day, 10 hours later, that's when the light from that same event that we saw in gravitational waves, 10 hours earlier, was observed with optical telescopes in Chile. Then it was seen in all the other different wavelengths. That happened months after we saw that signal in gravitational waves, so it was a really exciting event.

Kaylee
So, you're talking about being able to detect these big things, and these gravitational waves are really small, and here on Earth, we can't really feel them. But do they have an effect on our planet or to us as people? Why is studying them important?

Corey
I think what's good about it is just learning and knowing more about our universe. Gravitational waves, and gravitational wave astronomy, which began basically when we made that first detection is a completely new field. Gravitational waves are a different medium, or it's a different signal than any other type of astronomical signals that we have. So, everything else is light. So, the electromagnetic spectrum come from effects at the atomic level. So light, infrared, radio waves, gamma rays, x rays, etc. All of that is electromagnetic waves, or light. Gravitational

waves are completely different. They pass through matter, they pass through objects, they don't get impeded by any of that stuff, and they carry the information from where they come from, as well. Their effect is not at the atomic level, it's the actual objects themselves, that mass that's moving around, the ways that they generate comes from them versus atomic effects from them. So, it's just a completely different way of observing the universe. So, with land-based detectors, we're only looking at a little window, but there's other projects that are going to be looking at much lower frequencies and also faster frequencies as well. So, it's a completely new field of astronomy. So that's a big important thing about it.

Michael
Yeah, I can almost picture a building and you look at a Department of Physics and Astronomy, and they have all the different departments, and then all of a sudden, in an instance, you've just created a whole new branch.

Corey
It's kind of dramatic or theatrical the way everything happened. I mean, you have the main player of Einstein, who's involved here. A century, almost down to the month after general relativity was announced is when this first detection passes right through the Earth, from two black holes that crashed into each other a billion years ago, a billion light years away, and then five months later, we announced it. I think there should be a movie about it, you can't even think of a better way of it happening.

Michael
Who would play Corey in this movie?

Corey
That's a good question. (laughs) I like visualization, so in The Matrix, there's the scene at the end where Neo is bending space around him, because of his powers. So, when I show that in my talks, I always say that I think Keanu Reeves should probably play me.

Kaylee
Yes, and I love that this is two for two, because we just did our last recording with Vanessa and she talked about Keanu Reeves. So, I love that he's making an appearance in multiple episodes.

Michael
Well Corey I think that you should definitely be a character in this movie, because there's another part of the story that I'd love to get into. As we've mentioned, you're from the Siksika nation, which is outside of Calgary. One of the things that you've said that you're most proud in your time at the LIGO Observatory, is that you and your Mom translated the gravitational waves press release into Blackfoot? Could you maybe tell us about that story, and why that's so special for you?

Corey
Yeah, I mean, you learn to reflect on stuff after the fact, and that's something that I've learned to think about, because I didn't really think much of it when it happened. When people ask, what do you think most about with your work? Or what are you most proud of? Of course, with the other team members, our hands have been on the metal and glass of the parts that are of this machine that have been wiggled by black holes on the other side of the universe. And that's cool, but I think the thing I'm most proud of is that I had the chance to recruit my Mother to work with me, and it all happened during that five-month period, when we were under embargo. We couldn't say anything about this detection that we were sitting on, because you're analyzing the data, confirming that it's real, writing a paper for it. In the last month, January of 2016, we were getting ready to announce it. I'm in the outreach group for LIGO, and one of the topics that came up was the press release, and how we wanted to share it with the world in as many languages as possible. I didn't bring it up in the meeting, but later on that day, I emailed one of my fellow colleagues and asked her if it's okay if I share this story with my Mom so that she could translate this press release or the scientific document into an Indigenous language. Almost immediately, my colleague said, "of course", she asked me, "this is a trusted colleague of yours, right?" And it's my mom, so yeah, of course. (laughs) I think my mom had about a week and a half to two weeks to work on translating the press release, which was a two-page document. She finished it a day before we announced on February 11, 2016, and she got a lot of help with family up in Calgary and up on the reserve, so it was a family effort. Yeah, it was just a really cool thing, and like I said, I didn't really think too much about it at the time I guess, because I grew up with the language. I'd always hear my Mom speaking on the phone talking to my grandparents in Blackfoot. So that language was a part of my life and my siblings as well just hearing it all the time. So that's why it was such a natural thing for me to ask LIGO and my fellow collaborators, if it was okay, if we could do this.

Kaylee
That's so cool. You were saying your Mom worked with other family members on it, did you work with them also? Did they have questions about it as you were going through? I think if it was me, I'd be like, once again, what are gravitational waves?

Corey
So surprisingly not. I thought I would get more questions with it, but a good chunk of the text in the press release has Blackfoot words for it. Eventually they come up to different concepts. I mean, gravitational waves, there's not a Blackfoot word for that. So, my Mom would ask me to describe what they are. black holes, she was able to make a word for that, just using the Blackfoot word for black, and also for hole, and putting it together. There're other concepts of relativity where I explained it to my Mom in as simple terms as I could. Then I let her take it over, and make new Blackfoot words from my descriptions.

Kaylee
I mean, with science communication, generally just describing things, instead of using terminology can be the most powerful way to explain what you're seeing, right?

Corey
Yeah, definitely.

Kaylee
So, Corey, you've actually made a bit of an appearance on the podcast before. Previous guest, Kim Senklip Harvey spoke about interviewing you for her creative work, Break Horizons, which we're all excited about. Part of the conversation that we had was around Indigenous perspectives in science. So, I'm curious about where you think science and the Indigenous perspective converge and what western science can learn from interweaving of Indigenous knowledge in your field?

Corey
That's a bit of a journey, and it's something that is a little newer for me, just because I've been focused on my studies, and then my career. It's something that I've learned through science communication, and trips, and just speaking to different audiences, and just hearing about the science of our people, and specifically, just hearing about my tribe, just learning how Blackfoot culture and people have connection to the sky. I don't know if you've been outside of Calgary, and see how big the sky is and how dark it is, and all the objects you can see out there. It's amazing when you're out there, and you witness that, and you can understand why, or how it could be such an important thing to a people. So, with my tribe, there's different ways. So, a lot of our stories come from different beings in the sky with regards to the sun, and different constellations as well. Then a lot of our teepee designs, I never knew this, but a lot of them reflect astronomy as well. There's something that's a little newer to me, which is instruments that are called medicine wheels that are used throughout this latitude of Calgary and North America. There are areas where you have cairns, or piles of rock that are aligned in certain angles and directions, and the idea is that they're used to watch the sky as one. They're 1000s of years old, and Stonehenge is also at that same latitude, and it's a similar instrument on the other side of the planet at that same latitude. So, it's an interesting thing to learn about, and those are things that I'm excited to learn about, concepts of Indigenous science, Indigenous technology. This is a personal thing, but I built a kayak, a wooden kayak for the first-time last summer, that was my pandemic project. I didn't even think about it, but kayaks are Indigenous engineering and technology that's been around for thousands of years, you know, 4 to 5000 years. It's just amazing to be sitting in my boat and thinking about this technology that was honed and perfected over many centuries. So, I get addicted to learning more about that this kind of stuff.

Michael
Oh, should we get to some nerd herd questions?

Kaylee
Oh my gosh, yes, please.

Michael
If you want to get in on the nerd herd questions, we post them on our socials @NerdNiteYVR. Our first one comes from Russ, who asks, "How far along is the LIGO detector? What will it be useful for, for other reasons? What kind of other detections do you think it could make?"

Corey
So, we're not quite at the design sensitivity that the proposal for the project was written for. So, like I said earlier, we alternate between going online and offline. So, when we're offline, that's when we improve the detector and make changes to it, to build it and get its sensitivity better. So, we have a couple more steps to go until we get to that design sensitivity. When I talk about sensitivity, it's basically how quiet can we make our machine. How sensitive can it be to events in space? So, the other way to think about it is, the better your sensitivity means the farther out in the universe you could detect signals, and that just means we can make more detections. What's in store for the future? I mean, I kind of talked about the types of detections that we make. A lot of them have been black hole, binary black holes, but there's been a couple of binary neutron stars. Now we've had a black hole and a neutron star. In total, so far, we've confirmed 50 of these types of gravitational wave events. I think what's going to be exciting is the thing that is going to be new and a surprise to us. Because in almost all areas of astronomy, there's discoveries that happen that were a complete surprise to the astronomers. There has to be a gravitational wave signal, that's going to be something totally that the theorists didn't have an idea about.

Kaylee
We have a question from Armin who asks, "Can gravity go faster than light?"

Corey
So, I would rephrase the question and just say, "Can gravitational waves move faster than light waves?" And what we confirmed with that detection I talked about earlier with the binary neutron stars is that they move at the same speed, they move at the speed of light. So that morning, when I was in the control room, I did get an alert that told me we had a gamma ray burst that that was registered by a satellite up in sky. We get those all the time, and so I didn't really think anything about it, but that's why my colleague told me to call in and listen to those people. When we analyze the data, it’s being recorded online, and it usually takes us a few minutes to confirm that we see a signal. The way everything went down was that the gravitational waves pass through the earth first, and then a fraction of second later we saw gamma rays, so that's what the satellites saw. Then you're seeing the whole story, you're seeing the different colors from that event, then x-rays, and then radio waves. So, you're seeing the whole story in gravitational waves, and then light that comes at different wavelengths all at the same speed.

Michael
Our last question comes from Amy, who asks, "Do you think we could ever surf these kinds of waves?"

Corey
I've heard a few people ask this question before, and I would not know how you do that. I mean maybe if you had some alien technology from billions of years in the future, maybe I don't know. I'm not sure about that.

Kaylee
What size of particle could surf those waves?

Corey
I don't know if you'd want to do it. I didn't talk about how these waves are moving through space. I said, they're moving as a wave, but you can't really jump on the wave because they're spacetime. So, it's the actual spacetime that's vibrating, and we're all a part of spacetime. So as that wave is coming towards you, it's going to compress you in one direction, and then expand you in the other direction. So, you're a part of spacetime, and you're in there you're going to be feeling that, and so it would be hard to ride that. You might feel it, it might move your body around, and it'll be hard to ride that I would think.

Kaylee
You'd definitely feel nauseous, I think.

Corey
Yeah, definitely.

Michael
Oh, wow. This is amazing. Should we nerd out even more?

Kaylee
Yes. I would love to nerd out.

Michael
Alright, if you want to get in on the nerd outs, hit us up on our socials, @NerdNiteYVR, you can even email us Vancouver@nerdnite.com. Our first nerd out comes from Lindsay who's nerding out about spiders, mostly Huntsman who hide in their room? How is the spider situation down there in Washington Corey?

Corey
I don't think it's that bad. I remember the spider situation being a lot worse in Southern California where I grew up. We do have black widows here, and we do see them at work sometimes as well.

Kaylee
Are they also curious about detecting gravitational waves? (laughs)

Corey
No, they just bite people, we've had one person bitten on the head by one.

Michael
Wait a minute, spiders are sensitively attuned, they create their web, and when there's a vibration, they know they've caught something. Could spiders detect gravitational waves? (laughs)

Corey
Maybe it was big enough? I don't know.

Kaylee
I love it. Next investment spider tech.

Michael
Corey, what have you been nerding out about recently?

Corey
My problem is that I'm all over the place, and I don't focus on a lot of things. So that's the reason why I don't really get anywhere. So, I've kind of alluded to Indigenous science, and then also science communication. Those are things that are always on my mind, but I think right now, it would probably be kayaking. I just built a wooden kayak, and my goal this year is to be able to kayak overnight, like on a journey. So, there's a big 50-mile lake that's near here and I want to kayak that, hopefully in July when it's super-hot.

Kaylee
Very cool. Have you rolled in it yet?

Corey
That's on my list. I mean, if it wasn't a pandemic, I would have already signed up for a lesson, but that's what I'd really like to do. Lake Chelan, which is where I want to paddle and then do this journey, is really cold. If I couldn't roll to get back, it would be just so hard to get back into the kayak. So that's something I want to learn how to do.

Kaylee
I took a rolling course a couple years ago, because I really like kayaking, but it's very hard, and I am a very buoyant person. So, I thought that my buoyancy would help me, it didn't.

Corey
Oh, you said it's hard?

Kaylee
I thought it was hard, you know, you go under, and then there's the big sweeping motion that you have to do to get yourself back up. My big problem is that I'm very enthusiastic, and so what happens is I get out of the water, and then immediately go back in on the other side.

Corey
Oh wow! So, you kind of did it then.

Kaylee
Full roll!

Michael
Hold on, because I've never kayaked before. But when you're describing this rolling, you're not doing this on purpose? It's just that if you accidentally tipped over, and you know how to get back up?

Corey
Yeah, yeah. So, when I jump into the kayak into the hole that legs go through, I could put this thing on that's called a skirt, and I could seal the rest of that hole up. So as I'm kayaking on the lake, and if a big wave happens, not a gravitational wave, but if a big wave happens to knock me over, instead of jumping out of the kayak, I could stay in the kayak. Then as Kaylee knows how to do, you just flip yourself back over, and then you're back in business. It's so hard to get back into a kayak in the water otherwise, you'd have to hold on to your kayak, and then swim to shore, you freeze, and then you jump in. So, it's just a lot easier to learn how to do a roll and stay in with your boat.

Kaylee
So, Michael, I can’t imagine then that you're nerding out about kayaking. What are you nerding out about?

Michael
My nerd out is on music, which is kind of weird, this pandemic has been very strange, very introspective place. So much self-evaluation this past year, I realized, I have not been listening to much music this past year, except when I go for runs, and that's just metal and techno, very functional music to get me going. The reason is that I haven't been listening music is that I find the act of listening to music very social. So recently, through the pandemic, my friends and I found this game, and it's called Music League. It's an app, and how it works is that you have a host, and they pick a theme, say songs for kicking ass or cover songs. Then people submit songs, and it generates a Spotify playlist, and then you up vote songs you like and possibly down vote songs you don't like, and in the end, you have a leaderboard, and then a bunch of comments about people liking your songs, or just trolling, making fun of you for liking a song. It ends up being pure chaos, music is very subjective, and for me, and for a lot of other people, it's

very personal, right? So, you think that a group of friends that are basically all the same age, we like the same things generally, and you'd think that we would be able to agree on certain things. But if there's anything that this league has proven, it's that people's interpretation of music can be very different, and very surprising. You know, like two people can really like the same song, but for very different reasons, and the same thing for not liking a song. So, this got me thinking about how important music is in society, and how it can be used in science communication, like Jay Ingram said in a previous show, and how in general, we've all been missing it because we have not been social. You can see already in videos of places in the world, like we're recording this in March of 2021. As places start to ease up in New Zealand, what's the first thing that people are doing? Big outdoor concerts. So, in recent years, I haven't been a big concert goer, but I think I am going to be now as soon as they're coming back. Because if there's people that need more support, right now, it's musicians. Certainly, cannot take music for granted, because it obviously plays such a really important role in our lives. So, support your local musicians. Buy those albums don't just listen on Spotify. Hopefully we can all go to a live show soon. We should definitely get Jay Arner who wrote our two themes for this podcast on our first live Nerd Nite back at the Fox Cabaret. What do you think Kaylee?

Kaylee
I think that's a really great idea. What about you, Corey? What kind of music are you into?

Corey
I don't know if it was the last episode, but Kaylee, you were talking about how your Dad loved ABBA.

Kaylee
Yeah, he loves ABBA

Corey
I was going to say, because the founders of LIGO, they won the Nobel Prize in Physics in 2017. I paid my own way, and I took vacation days to go there, and my family went with me, and we got to go with my Dad. We got to go to the ABBA museum. So, I have an ABBA shirt. (laughs) It takes you to another level. I thought I was an okay ABBA fan, but now I'm like, way up there. It's amazing. I mean, you got to take your Dad there, he has to go. The other thing I was going to say was with science communication and music. I mean, that is such a cool thing and important thing. When we announced in 2016, the reaction of the public was a crazy, and awe-inspiring thing to behold. There's a person his group is called Acapella Science.

Kaylee
Yeah, so good!

Corey
He made a song about our discovery, and it's an awesome song. I mean, I rock out to it. I sometimes play it at the beginning of talks just to get everybody energized. Music is so important with science communication.

Michael
So, Kaylee, have you been nerding out about music?

Kaylee
Actually, hilariously, I have been nerding out about music. So, I was recently interviewed on a friend's podcast, and that podcast is called Music for PhDs run by our mutual friend Sunita LeGallou.

Michael
Yeah Sunita!

Kaylee
It's all about our connection to music. On this episode, Sunita asked me about the types of music I like to work and study to. My answer centered around maritime music. Over the past few days, I've been putting together a bit of a Spotify playlist for her to link to the episode, and I'm calling it Maritime Vibes for Foot Tapping Productivity. While making this album, I was reading a little bit about the different types of fiddle music, which I should already know because my Dad used to pack me off to the Gaelic College in Cape Breton in the summertime, about jigs and reels. So, if anyone's curious on how to tell the difference between a jig and a reel, a jig is in 6/8 time so essentially 6 beats per bar and you can know if you sing jiggity, jiggity, jiggity, jiggity along with the beat. Reels are in 4/4 time and you can know if you're singing along and you can go rutabaga, rutabaga, rutabaga. While thinking about these tunes, it made me think about the songs we would dance to in Nova Scotia in the summertime. So, since the age of eight, my Dad, and I've gone to these square dances in Toney River, Nova Scotia. When I was younger, they were held once a week in this small community centre by the water. I was always the youngest person there, and my Dad was always the second youngest, and most folks were in their 70s and 80s, and we just fly around the dance floor doing this dance that we always affectionately called the Nova Scotia Stomp. Which actually, I think is made up, because the internet doesn't know what it is. The dance was a polka. So, you dance in a 123 hop, 123 hop, and the hop we'd jump super high in the air, and we just come down real hard on our feet, and stomp on the ground. These polkas would be mixed with waltzes, and you look around, and everybody would just be shuffling across the floor, you just hear their feet moving across what I think is sand they'd put down so that you'd move smoothly. You come out into the summer night and hear the fiddle music, and get some fresh air, and at 10 o'clock, they'd serve lunch, where volunteers would come around with an assortment of horrible little sandwiches, and tea. It was just such a beautiful memory as I was making the Spotify playlist, and then thinking about all these dances we've gone to, and then I also got thinking about the vaccine, and how the vaccines have been rolling out across the country. I've been thinking about these folks even

more, and hoping that if they haven't got their vaccines yet, hopefully they're close to it so that we'll be able to have another Nova Scotia Stomp in the summertime in the next couple of years. So that's what I've been nerding out about.

Michael
Oh, adorable.

Corey
It's on my list. Should I visit Nova Scotia when we can?

Kaylee
Oh, yeah, yes. And you can come hang out with me obviously. Come up. It'd be great.

Michael
Well, Corey, thank you so much for nerding out with us tonight. Where can people learn more about gravitational waves and LIGO, and what you folks are doing down there?

Corey
I would go to the LIGO scientific collaboration website, which is www.ligo.org. You can find out more about what we're doing. You can find out about each specific detection we've detected so far and find out what's coming next.

Michael
What about you and the progress of your kayak? Can people follow you on social media?

Corey
You could definitely follow me on Instagram @corey_m_ gray. For Twitter. I am @QuantumOfSalsa, and then Facebook you can look under Corey Gray as well.

Kaylee
You should definitely go follow Corey. It is therapeutic watching the kayak on the water, and it makes me feel like I'm almost kayaking. Thank you so much for spending time with us today. We had a blast, and thank you everybody who's listening. If you'd like to hear more from us, you can follow us on our socials @NerdNiteYVR on Twitter, Instagram, and Facebook. We'll be back in a couple of weeks, but until we meet again, get out there, and make wiggles in some spacetime.

Transcribed in part by Otter.ai