Getting Curious with Jonathan Van Ness & Dr. Moiya McTier

JVN [00:00:00] Welcome to Getting Curious. I'm Jonathan Van Ness and every week I sit down for a gorgeous conversation with a brilliant expert to learn all about something that makes me curious. On today's episode—ooh, this is such a good one—I'm joined by Dr. Moiya McTier, where I ask her: What is going on in the galaxy? Welcome to Getting Curious. This is Jonathan Van Ness. We have a very exciting episode this week. Every week is exciting, but this one's, like, really fucking exciting because it's about our galaxy. It's about, like, the world in which we live. So in the words of Mrs. Dooley, without any further ado, welcome to the show. Dr. Moiya McTier, who is an astrophysicist, folklorist, and science communicator based in New York City. Her new book is The Milky Way: An Autobiography of Our Galaxy. She also is the host of the podcast Exolore, which you all are going to want to listen to a lot after this episode of Getting Curious. Dr. McTier, how are you?

MOIYA MCTIER [00:01:00] Oh, my God, Jonathan, I am so excited to be here. I'm trying not to blow out my mic right now, but just seeing your gorgeous face and knowing it's talking to me, I am living right now.

JVN [00:01:09] Oh, my God, I'm living with your fucking gorgeous face. Also, just so people know, you're a literal doctor who is an astrophysicist. You literally went to Harvard and you're the first person in the school's history to study astronomy and mythology. What?!

MOIYA MCTIER [00:01:28] I like to break rules.

JVN [00:01:30] That is, like, a major, like, d-a-space-f-u-q moment, like, da fuq? I didn't even know that there are still students in college now that, like, could break a record like that, that they're the first to study. Like, that's just because you would have thought that it's all been done before, and you were, like, "Nuh uh uh."

MOIYA MCTIER [00:01:46] You would have thought, but no, Harvard is old, they're stuffy, they are set in their ways. So they have this list of pre-approved maj– double majors that you can do and surprise. Folklore and astronomy. Not on that list.

JVN [00:01:58] I just, I love the the duality of the brain that you can you can be serving, like, hardcore math, hardcore science. Like, "I will beat you at any math bee of all time, like, I'm a literal scientist," and also that you can go folklore and you can go esoteric and you can—, I just you must have, like, something where, like, the right and left hemisphere of your brain is like super on fucking fire.

MOIYA MCTIER [00:02:19] That corpus callosum. It's, it's super strong connecting the two of them.

JVN [00:02:23] Yes. Or, like, maybe you don't have one, maybe there is no divide. Maybe your brain is just firing on, like, 96% all the time. You're the one that uses all of it, as opposed to all of us who are using, like, 4% or whatever. Okay so anyway, back to the Milky Way. I think that part of my interest in the galaxy and stars and, like, the Milky Way, it started when coming from rural Illinois, like, there's not so much light pollution that you can't, like, see, like, a lot of stars. And we kind of lived out in the country, so we really got to see, like, some really clear stars. I thought when I went to Japan I was, like, "Oh my God, I'm going to be in the southern hemisphere so I can see, like, the Southern stars." Uh, no! And then same with the Philippines. And it was, like, "No." And then I was, like, "How fucking far have I got to go to get into the Southern Hemisphere around here!" So then Australia, finally, full Southern Hemisphere. So then I got that app on my phone and I was, like, looking at, like, the southern hemisphere constellations. And then I was, like, "My brain's going to break." We also had done an episode on the LIGO study and, like, Gravitational Waves, that also broke my brain because of, like, 3-D stuff. So here today, I'm going to try again to better understand galaxies. What's the deal? I just want to, I mean, I live in the Milky Way, I think. Like, I want to learn to be its friend and stuff, like, I want to learn to speak its language. So I'm minding my own business, I look up. I see all these stars and, like, we are in the Milky Way.

MOIYA MCTIER [00:03:49] Mhhm. We are a part of it, like, we–, we are the Milky Way. The Milky Way is us. We're made of the stars of the Milky Way.

JVN [00:03:58] So maybe you're on Grindr, maybe you're on Tinder. Maybe you're on Raya. I don't know your life, but you swipe across, you see a box, and it's shivering your timbers. It says "The Milky Way" on the top. It's all these stars. What's that profile looking like? How old are we? Is it location "Everywhere"? What are its interests, like, "Endless expansion"? What is it?

MOIYA MCTIER [00:04:24] Okay. Well, first of all, in the book, the Milky Way is in this long term epic romance with the Andromeda galaxy. So it being on one of these dating profiles, I actually think is very in line with the Milky Way because it's super sassy. And I think that it would love to get on dating profiles to make Andromeda jealous.

JVN [00:04:43] Can we see Andromeda from your telescope?

MOIYA MCTIER [00:04:45] Yes! You can see Andromeda on a dark enough night with your own eyes without a telescope.

JVN [00:04:52] Okay. So how old is the Milky Way?

MOIYA MCTIER [00:04:55] That is kind of a hard question to answer because galaxies don't, like, form in a snap moment. They form slowly over time by things collecting through gravity. So the best way to answer this question is probably by saying how old is the oldest star in the Milky Way? And we have found stars in the Milky Way that formed a few hundred million years

after the Big Bang. So the, the Milky Way, it's more than 10 billion years old. It's super frickin' old.

JVN [00:5:30] Okay, and the universe is always going outwards, they say in the news.

MOIYA MCTIER [00:05:35] Yeah, yes. The universe is expanding and that expansion is speeding up, which astronomers, even a hundred years ago would be surprised by. They thought that the expansion would be slowing down. So we don't have a good coordinate system for the entire universe. So it's not like I can give you coordinates for where the Milky Way is in terms of the whole universe. But I can say that the Milky Way is part of the Local Group of galaxies. We've found about 50 galaxies that are all gravitationally bound with the Milky Way. And outside of that there are other clusters of galaxies and you can find clusters in super clusters of galaxies. So it's kind of like the universe is fractal where you see these same patterns happening on bigger and bigger scales as you zoom out.

JVN [00:06:30] Is our 50 galaxies part of a super galaxy, or is the 50 galaxies that we're a part of, like, a super galaxy because there's 50 or is a super galaxy, like, 500.

MOIYA MCTIER [00:06:37] Super galaxy cluster would be, like, 500. So we are in the Local Group and the Local Group is a member of the Virgo Supercluster. It's named the Virgo Supercluster because the biggest cluster of galaxies at its center is the Virgo cluster of galaxies.

JVN [00:06:56] So where is it located? Like, where are we? Are we, like, kind of more, like, in the south part of the universe or more like the north part of the universe? Or we're more kind of in the middle because we're fierce? Or do we even know?

MOIYA MCTIER [00:07:07] I wish I could tell you! We have mapped a lot of the universe. There's this, this imaging survey called the Sloan Digital Sky Survey that has given us a pretty good idea of the large scale structure of the universe. But the universe doesn't have a center. It's, it's not like a sphere in the way that we can imagine a sphere, because the universe kind of exists in more dimensions than we can imagine. We say that the universe is flat. Even as someone who has studied astrophysics for ten years, like, I have a hard time understanding what it means for the universe to be flat. So I wish I could tell you an answer about where we are, but I cannot.

JVN [00:07:52] So physicists think the universe is flat?

MOIYA MCTIER [00:07:55] Yes.

JVN [00:07:56] Because it's so fucking big that it's like flat?

MOIYA MCTIER [00:08:01] Yeah. It's so big that it's flat. And it will, we think—we're not totally sure because we don't understand all of how dark energy and dark matter work. But we think that it's just going to expand forever. So if you imagine, like, a, a flat plane for something to be able to expand forever, it has to be flat. Because if it's curved at all, then it will eventually curved back in on itself given enough time.

JVN [00:08:28] Wow! What does the Milky Way like to do?

MOIYA MCTIER [00:08:34] Oh, I love this question!

JVN [00:08:35] Yeah. What does it like to do?

MOIYA MCTIER [00:08:37] The Milky Way loves to make stars. It makes about a handful of stars every single year. Most of those stars are much less massive than our sun. The Milky Way also loves to eat gas. So in the book, I say that it eats other galaxies because galaxies are eating each other. They're colliding. They're absorbing each other's gas all the time.

JVN [00:08:59] Girl, are we in danger, girl? Okay no, we're fine.

MOIYA MCTIER [00:09:01] No, not right now. The Milky Way is the biggest, strongest galaxy in the Local Group. We dominate this space, so other galaxies are in danger, but only for, like, you know, a billion years from now.

JVN [00:09:15] Hmm. So it eats gas. It makes stars. Are all stars hot like the sun?

MOIYA MCTIER [00:09:24] Some stars are hotter than the sun.

JVN [00:09:27] But none are cold.

MOIYA MCTIER [00:09:29] None are cold. But I'd say that our sun is about 6000 degrees, Kelvin, and that's pretty average. Most stars are around 3000 Kelvin, so half as hot as the sun. And then you get these really massive hot stars that can be, you know, like, 15,000 Kelvin at their surfaces.

JVN [00:09:52] Such that's just, that is hot as fuck. Okay, so does it have, like, a body, like, the Milky Way? Like, is it kind of like, is there, like, a head and, like, a middle and, like, legs or something?

MOIYA MCTIER [00:10:02] It is a body, but not like a human body. It's more like a jellyfish body maybe, or something that's more spherical because in the middle of the Milky Way is an area that we call the bulge. And when I was taking my stellar astronomy class where we were learning about the bulge of the Milky Way. I was 22 at the time, but I laughed every single time the professor said it because in my heart I'm, like, a 12-year-old boy. But in the center is

the bulge of the Milky Way, and it's this big kind of spherical, chaotic region where stars are moving really fast and they're super close together. And then the bulge is surrounded by the disk, which is what most people think of when they picture the Milky Way in their head. Those beautiful spiral arms moving in the disk. And that is where most of the stars are in the Milky Way. That's where we are in our solar system. And then if you zoom out from that, everything in the disk and the bulge is surrounded by the dark matter halo. This is this huge bubble, basically, of dark matter. There's some gas in there. There aren't many stars.

JVN [00:11:17] Can we see dark matter?

MOIYA MCTIER [00:11:19] Unfortunately not. Our human eyes cannot see it because it doesn't interact with light.

JVN [00:11:24] So because I got to set, you know, we keep talking about this dark matter, not me and you, but I feel like I read about it.

MOIYA MCTIER [00:11:34] Yeah, it's a big thing in the astronomy community. We're trying to understand it.

JVN [00:11:38] What…

MOIYA MCTIER [00:11:39] What is it?

JVN [00:11:40] Yeah!

MOIYA MCTIER [00:11:41] Yeah. Oof! Girl, I wish I could tell you. There are a lot of ideas about what it is.

JVN [00:11:46] So it's not the night sky?

MOIYA MCTIER [00:11:49] No, it's not the night sky. Because the night sky is just, like, the absence of light that we can see. But dark matter, it actually is material. Like, if you could get out there and interact with that, you'd be able to feel it, you'd be able to feel its gravitational pool. And that's actually how we study it because we can't see it. We have to study it by looking at how it moves stuff around it.

JVN [00:12:15] So it might pull stars, like, closer to it?

MOIYA MCTIER [00:12:19] Even more powerful than that. It pulls whole galaxies closer to us. Yeah, we actually kind of know the existence of the Milky Way to dark matter, because early on in the universe, the temperatures, the average temperature of the universe was much higher. Everything was packed closer together. It was harder for temperatures to cool down. And so dark matter, we think, was inherently cooler than the other types of matter in the universe. So

it made it easier for things to clump together, easier for gravity to take hold. So, yeah, we, we probably wouldn't have had a Milky Way galaxy without dark matter.

JVN [00:12:58] So gravity exists everywhere in the universe, right?

MOIYA MCTIER [00:13:03] Yeah. Mm hmm.

JVN [00:13:05] It's just, like, differently strong if there's, like, a gigantic star there or whatever, like, affecting the things around it, like, more.

MOIYA MCTIER [00:13:12] Yeah. The strength of gravity depends on the mass of an object. The more massive an object is, the greater gravitational pool it has.

JVN [00:13:22] Okay, so we're, like, in the disk-y part. And then it's jellyfish-y so, like, is there anything outside the dark matter that's still Milky Way? Or does that get into, like, Andromeda and other ones?

MOIYA MCTIER [00:13:31] Yeah. Then you're into the intergalactic medium or the IGM and that's, like, there's some gas out there, but mostly it's, it's empty space.

JVN [00:13:42] So how long until you get to Andromeda after the dark matter IGM?

MOIYA MCTIER [00:13:47] Well, if you were traveling at the speed of light then it would take two and a half million years. But nothing we have could possibly travel that fast, so even if you're still looking at the fastest rocket ships that humans have made so far, it's gonna take, like, forever.

JVN [00:14:02] So is that why we're probably safe from aliens outside the Milky Way? They would have to, like, build the technology and then, like, launch it, like, 100 million years ago or, like, have gone fast, like, invented something that goes faster than the speed of light, which is, like, probably not—, no one can be that smart. Probably.

MOIYA MCTIER [00:14:19] I don't know. There could be wormholes. I love science fiction so I think that…

JVN [00:14:24] You think wormholes could be a thing?

MOIYA MCTIER [00:14:25] Yeah!

JVN [00:14:26] Like a little, like, floo powder, like Harry Potter, like. you go to a certain point and you can maybe touch it and then, like, it could maybe transport you, like, faster?

MOIYA MCTIER [00:14:33] I think that if you have a powerful enough source of energy that you can do a lot. There are physicists who are coming up with ways that we could open up wormholes. We just don't have the power yet to do it or the power to sustain it and keep it stable. But there are galaxies closer to us than Andromeda.

JVN [00:14:53] Oh, there is?

MOIYA MCTIER [00:14:54] Yeah, there are. These little we call them dwarf galaxies, that kind of orbit. Yeah, I don't love it either. But they orbit around and in the dark matter halo. So have you ever heard of the large and small Magellanic Clouds?

JVN [00:15:09] No.

MOIYA MCTIER [00:15:10] You can see these with your eyes, too. If you go to the Southern Hemisphere, they look like two little splotchy clouds in the night sky named after Ferdinand Magellan, who, you know, was supposed to have circumnavigated the globe. But he did not. He died before he made it all the way around. But we still named them after him, whatever. And those are much closer to us than the Andromeda Galaxy. In fact, the, the distance between us and the large Magellanic Cloud is smaller than the size of Andromeda. So Andromeda could not squeeze between us and these, these clouds.

JVN [00:15:48] And those clouds are like dwarf galaxies.

MOIYA MCTIER [00:15:51] Yeah, they're, they're little. They're little galaxies that have fewer stars and fewer mass, massive things.

JVN [00:15:57] How many stars and planets does the Milky Way contain? Like roughly.

MOIYA MCTIER [00:16:02] 100 billion stars.

JVN [00:16:04] Oh, my God.

MOIYA MCTIER [00:16:05] I know, right. And we think that on average, most stars have a couple of planets. So there are hundreds of billions of planets in the Milky Way alone. [JVN TAKING IN THIS INFO] Yeah. Yep.

JVN [00:16:19] This is where I always start to feel overwhelmed because my brain just goes in so many–, and then I think about, like, Bible school when you're little and they're like, "These things are just too complex for humans to understand." And then I'm, like—

MOIYA MCTIER [00:16:31] I invite you to, like, sit with it and, like, really think, "What does, what does 100 billion look like and what does it mean to be just one of 100 billion stars?" Yeah.

JVN [00:16:42] Part of, I think the curiosity of, like trying to understand the Milky Way and just like galaxies in the universe is, like, that age-old question of, like, is there more of us or is there is there more like someone like is there there must be someone else because if there is 100 billion stars and how many are, like, sun-like, like, sun-ish.

MOIYA MCTIER [00:17:00] Only, like, 5 to 10%.

JVN [00:17:04] So five, 10% of 100 billion is still 10 billion. So if there was 5 billion suns, then that means there could be, like, 15. There's like three on average, you know, like just three. Like, the star chucks out three planets, right? That could be like 15 billion earth-like planets.

MOIYA MCTIER [00:17:22] Right. So many options. And planets can form and have life around different types of stars than the sun.

JVN [00:17:29] Because every once in a while I feel like in the news we'll see that, like, you know, astronomers and like astrophysicists, like, discovered like, you know, some, like, potential, like, you know—, the Goldilocks planets!

MOIYA MCTIER [00:17:38] Yes. Yes, exactly.

JVN [00:17:39] Is there, like, do you ever read about those? Do you think that's cool? Or are you, you know, like, "I'm, like, more, like, a physicist so I like the math, but I do read those because it's, like, you know, my email beeps cause it's, like, set to, like, Goldilocks planets."

MOIYA MCTIER [00:17:49] No, this is my bread and butter! My thesis in grad school was about the habitability of planets and where we can find planets that are suitable for life in the galaxy. So I think about that all the time. Unfortunately, we don't have the technology right now to learn enough about a planet outside of our solar system to say whether or not it's truly "Earth-like" because to say something is "Earth-like" we would need to know what type of star it orbits, which is pretty easy. We would need to know how far away it is from its star, which is also pretty easy because that gives us a sense for how hot or cold the planet might be. But what's not easy is learning about the atmosphere of that planet because they're so small and so far away that it's hard to see their atmosphere and it's even harder to figure out what's happening on their surface.

JVN [00:18:40] Yeah cause what if the water looks like water, but it's actually, like, like, the fucking Dante's Peak, like, acid river water. So it looks all peaceful. But actually how you jump in there like you're getting scalded because it's sulfuric acid.

MOIYA MCTIER [00:18:52] Mhm, exactly. And I, I firmly believe that when we're talking about life out there in the galaxy, that we need to be very careful about only looking for conditions that would work for life like us, because we like liquid water. We are very closely connected to,

to the molecular structure of water. But, you know, I can imagine life forms that evolve with liquid methane, for example, or science fiction writers have talked about liquid ammonia as a potential base for life. So yeah, there are so many types of planets out there that have so many different qualities and I think that life would adapt to those environments. Why should we be special in, you know, like, what we have is the only way that life can form.

JVN [00:19:44] Yeah, that's interesting, like, there's so many possibilities and it's, like, our Earth evolved in such a way that's, like, with so many improbabilities for us to actually, like, make it here, like, so much had to happen. So maybe that's, like, you know, equally improbable, but, like, just, like, different molecules in other places. Yeah. So you feel like that's, in all of your research and everything, like, like, do you like do you think that there must be other life even if it doesn't look like us and it's, like, not, like–, like, micro-organisms at the very least, right?

MOIYA MCTIER [00:20:13] Yeah, absolutely I do. We have even seen creatures here on earth that don't need water to survive. We have seen creatures that don't rely on the sun as the base of their food chain.

JVN [00:20:27] Like anaerobic thingies, or whatever.

MOIYA MCTIER [00:20:29] Yeah, yeah. There are anaerobic thingys. There are little plants at the bottom of the ocean that don't need sunlight. They do chemo synthesis. So the fact, like, we say often, that the sun is the basis for our entire food chain. It doesn't have to be. So we, we see examples here on Earth of life that doesn't exist in the conditions that we think are necessary. So why can't they exist elsewhere?

JVN [00:20:54] So okay, now I'm going back into my questions because I just really, like, hijacked my little questions. I just, I had to go there. Is it possible for us to see the galaxies, like, outside of the Milky Way and, like, into Andromeda or the other ones? Like, we can see other whole ass galaxies?

MOIYA MCTIER [00:21:09] Yeah, absolutely. We can see them. We can look at how their stars are distributed across their bodies. We can even get a sense for how dark matter is distributed throughout them. And in some ways it's easier to study other galaxies than it is to study the Milky Way. Because imagine trying to study a whole house. When you are stuck inside the house, it's really hard, right? You know, we can't see the outside of it. We have a lot of trouble actually seeing at the center of our galaxy because there's so much dust and gas in between us. So it's easier, kind of, to study other ones.

JVN [00:21:44] That's fascinating. So with our Local Group with, like, our 50, like, you know, United Galaxies out of the Milky Way. Um, how, like, what's it kind of like? Like, we're kind of like we're giving you like we're just kind of giving, like, big D energy, like, in the Milky Way or whatever. Like, what's it like to be part of this group?

MOIYA MCTIER [00:22:08] There are two big dominant galaxies in the Local Group. One of them is the Milky Way and the other is Andromeda. And they're kind of at opposite ends of the local group. They are the glue that holds this group together. And then there are a bunch of other smaller dwarf galaxies in between them, like the large and small Magellanic Clouds. There are a bunch of others that we haven't studied that much, and I don't mention them much in the book because in the Milky Way's mind, it's like, "Why would I even bother with them? I know that eventually I'm just going to, like, eat them and destroy them in a fight. So I don't want to get too emotionally attached." And that's why the Milky Way and Andromeda have such a strong connection, because they're, like, equal partners in, in the strength that they can bring.

JVN [00:22:58] But the Magellanic Clouds are probably going to get smashed up and die?

MOIYA MCTIER [00:23:02] They are probably going to get slowly absorbed. The word that astronomers use is "accreted," accreted into the Milky Way over time, through gravity.

JVN [00:23:13] But the Milky Way is, like, moving, right?

MOIYA MCTIER [00:23:19] Yeah! Oh, the Milky Way isn't sitting still at all. It's moving all the time. For example, the Milky Way is moving towards the Andromeda galaxy at about a hundred kilometers per second, that's about 250,000 miles per hour. So, yeah, we're moving really fast.

JVN [00:23:36] Why?

MOIYA MCTIER [00:23:37] Because of gravity.

JVN [00:23:38] So part of the big bang thing. So the Big Bang happens like forever ago, honey, it's like sets off this whole, like, you know, sheet of paper or sheet of flat paper. But they knew when they say flat, it's actually like this.

MOIYA MCTIER [00:23:48] Yeah, I think so.

JVN [00:23:49] Which is that why it's like there's the multi, you know, like, the continuum is like maybe there's like another meal, like a different one of the planes. Oh, my God. Oh, my God.

MOIYA MCTIER [00:23:57] Now we're going to get to the multiverse theory.

JVN [00:24:00] Oh, my God. Okay, I didn't mean to go there, so. Okay, but. So it's like that. So is that because at the beginning of the Big Bang, because of where the Milky Way and Andromeda was positioned, it just made them go towards each other, like, why aren't we going away from each other?

MOIYA MCTIER [00:24:13] Yes. I love this question.

JVN [00:24:14] And do we ever pulse! And do we ever pulse! Like towards each other right now and then we could go away? Or are we going to collide?

MOIYA MCTIER [00:24:23] Mhm. Okay. Oh, yes. There's so much here. Okay. So at the beginning with the Big Bang we saw in the early universe, these little over and under densities. And as the universe expanded, those over dense regions just collected more material. And we are—, it just so happened that the material that became Andromeda and the material that became the Milky Way were close to each other. And they were close enough to each other that even with the expansion of the universe, their gravitational attraction was stronger than whatever was expanding the universe. That is why we aren't being pulled apart like the rest of the universe, because gravity is still stronger on these small, local scales. We are eventually going to collide with the Andromeda Galaxy. It's going to happen in like 5 billion years, but it's not going to, like, they're not going to come together and just stick to each other. They're going to come together and they'll pass each other a couple of times, like a dance, actually. You know, they're like they're, like, tangoing together and eventually they will just come together. They'll mix all of their material and they will be one galaxy in, like, 8 billion years.

JVN [00:25:42] Will Earth explode when that happens?

MOIYA MCTIER [00:25:45] No. So one of the earliest calculations that I remember doing when I was training to be an astronomer was looking at this collision, this future collision of the Milky Way and Andromeda and estimating how many stars will collide. And it turns out that even though each of these galaxies has hundreds of billions of stars in them, only about a handful of those stars will actually come in contact. Our solar system will be totally fine. What will happen, though, is that a bunch of new stars will form. So the night sky will not be as dark anymore. You'll have all these new stars coming in from Andromeda. A burst of new star formation will happen. So I think it's going to be like a beautiful light show in a few billion years.

JVN [00:26:35] This could be really out of left field, but it's just where my curiosity went: what was happening on Earth 5 billion years ago was that just, like, methane mass extinction, like, there was no life yet? Or was there life yet?

MOIYA MCTIER [00:26:47] The planet wasn't here yet 5 billion years ago.

JVN [00:26:49] It wasn't.

MOIYA MCTIER [00:26:50] No. The sun formed about four and a half billion years ago, and then it takes, like, ten-ish million years for planets to form.

JVN [00:26:58] Fuck me! That's going to be forever for us to collide and see that. It's, like, forever.

MOIYA MCTIER [00:27:03] Yeah. Yeah. This is what I'm saying. Space is so huge that it takes time for things to happen. It takes time for things to come together.

JVN [00:27:10] There's gonna be, like, fifty mass extinctions by then!

MOIYA MCTIER [00:27:13] Yeah. Yeah, probably. We have, we have another, like, 4 billion years before the sun changes its evolutionary stage. The next stage for the sun is what we call a red giant. So it's going to puff up, get, I think, as big as our orbit here at Earth. So unless our Earth moves out to a more distant orbit from the sun, our planet will get engulfed by the sun.

JVN [00:27:41] Maybe we could do a "Don't Look Up Style"-like, not the end, but maybe we could build something that, like, because you know how, like, if you fart in space, you would, like, go forever, like, the opposite direction. Maybe we could, like, make our whole earth fart towards the sun to, like, live, but it has to be really powerful to just, like, push us away.

MOIYA MCTIER [00:27:59] Okay, so we need to get everyone on Earth eating a steady diet of beans for, like, a month.

JVN [00:28:03] Like a machine that would, like, push so much air that it would, like, move us. Or maybe would have to be, like, nukes in space. And then, like, the thing would push us and we wouldn't get radio, like, radiation or something. But four billion years, mama, you know, we'll be right. [CROSSTALK] Unless reincarnation is real, unless reincarnation is a thing. And then we are so fucked.

MOIYA MCTIER [00:28:24] Yeah. Yeah.

JVN [00:28:26] I'm gonna be so mad, like, if my outfits are cute and in 4 billion years, then they get, like, all fucked up from the sun. So because the Milky Way is not still, it's constantly in flux. That means that it's in flux due to, like, gravity and, like, Andromeda and actually not the Big Bang, because it was, like, our gravitational fields are just, like, always kind of, like, we were just, like, always into each other. Which is why you said that we would go on a social media site to make Andromeda jealous. Okay. That makes sense. So you wrote that the Milky Way has spent "billions of years trying to strike a balance between creation and destruction." That's, we talked about that a little bit just now, like, that's going to continue to be a thing. So what does stars, planets and black holes have to do with the creation?

MOIYA MCTIER [00:29:12] Hmm. Yes. Well, the, the Milky Way creates stars. It's not as intentional in reality as I say it is in the book. Obviously, it's a, it's an autobiography. So I had to assign some agency to the Milky Way. But in the book, the Milky Way is like a scientist that takes a lot of pride in figuring out how to create stars from scratch. And then it feels really,

really bad when those stars eventually die and stop fusing and stop glowing. So that's, that's creation and destruction right there when the most massive stars die. I say die, but, you know, they're not, they're not really dead and death. It doesn't, it's not the same.

JVN [00:29:56] They just don't have, like, the same energy to glow anymore?

MOIYA MCTIER [00:29:59] Yes, exactly. They're not fuzing in their cause. So when the most massive stars stop fusing, they explode in supernovae. And then what's left at the center is a black hole. So that, again, is creation and destruction happening kind of at the same time. So the Milky Way knows that kind of, to create one thing, you almost have to rely on the destruction of something else to give you that material.

JVN [00:30:25] So we kind of covered this in the LIGO study because I was, like, trying to understand black holes, but it was, like, 2016 me. So I think I maybe even got a little bit better since then. But so basically all black holes used to be gigantic stars that turn into supernovae and then they turn into black holes.

MOIYA MCTIER [00:30:41] Yes. Yes.

JVN [00:30:43] Okay. Yes. So and then black holes do suck up, like, every fucking thing around it, right?

MOIYA MCTIER [00:30:49] They don't– they're not sucking like a vacuum. They are just a big gravity pit. So they are just waiting for things to fall into them.

JVN [00:31:00] But it's going to be cold because the sun's not fusing anymore, right?

MOIYA MCTIER [00:31:03] Yeah. Yeah. It's going to be cold. Although there is a lot of energy in these systems. If you have a massive enough black hole, it can form the disk around it. Did you see the picture of the event horizon around the black hole that was taken a couple of years ago?

JVN [00:31:18] No!

MOIYA MCTIER [00:31:19] Oh! Oh my. Okay, so if I can pull up a picture of this m87 black hole, it was one of the most popular science images two years ago. Let me share my screen, maybe?

JVN [00:31:33] Yes, please!

MOIYA MCTIER [00:31:34] Here you go.

JVN [00:31:37] Wow. So what am I looking at?

MOIYA MCTIER [00:31:39] So here in the center is the black hole, and then this big red ring around it, that is the accretion disk around the black hole. So stuff falling into the black hole when it gets really close. It starts moving fast enough that you actually get friction in between the like these particles that are interacting and that creates heat which glows. So we can see stuff around a really powerful black hole.

JVN [00:32:07] Wow.

MOIYA MCTIER [00:32:09] Mhm, mhm. I love this image because we had never taken a picture of a black hole before. Because they don't emit light, they just absorb it. This is the center of the black, of the black hole. We actually can't see it, but we can see everything right around it.

JVN [00:32:25] So what is this picture picking up then? Then, like, what were those, like, so that was heat. And that was, like, a thermo picture?

MOIYA MCTIER [00:32:31] Yeah, it's heat. I think that this is, this was a radio image. So we are seeing energy created as this material swirls into the black hole and gets really hot because it's moving together.

JVN [00:32:46] So what's the difference between a supernova and a supernovae?

MOIYA MCTIER [00:32:51] A supernova is one and supernovae is multiple.

JVN [00:32:56] Ah! Okay, fierce. Now what are these other, like, sexy, like, astronomy words, like, gamma ray bursts.

MOIYA MCTIER [00:33:04] Hmm. Yes. That is an active area of research, but a gamma ray burst is when you see a lot of energy in the gamma part of the spectrum coming from one part of the galaxy. But, like, really short, like, a stream of gamma energy that lasts for, like, a couple seconds. And we don't know what forms them. We used to think that it was a sign of aliens. We do not think that anymore, but we are trying to figure out what's making them happen.

JVN [00:33:35] Okay, wait. What, what picks up a gamma ray burst again, then—a telescope?

MOIYA MCTIER [00:33:41] Yeah. A telescope that is able to see in those high energy frequencies.

JVN [00:33:47] But you're not. But it's, like, you see it with your eyes. It's not measuring, like, heat or something.

MOIYA MCTIER [00:33:52] Right. Heat is infrared. So if you're looking, if you're using, like, night vision goggles or if you're using, like, heat sensors, that's going to be looking at the infrared part of the spectrum, which is less energetic than the visible part of the spectrum that we can see. And then gamma rays are more energetic than what we can see.

JVN [00:34:15] Interest! Okay, then what's tidal ripping?

MOIYA MCTIER [00:34:18] Ah! Tidal ripping is when, it's basically when gravity is so strong that it pulls something apart. And you see these, you see tidal effects pretty much everywhere in space. One of the moons of Jupiter called Europa has liquid water under its surface, even though it has an icy core because of tidal forces from the other moons, like using their gravity to stretch and contract Europa. You also see this around black holes where the gravity is so extreme that it can tear stuff apart. And we have a really fun word for that around black holes. It's called "spaghettification."

JVN [00:34:59] And it's just where things get pulled apart.

MOIYA MCTIER [00:35:00] Mm hmm.

JVN [00:35:01] Okay, wait. So back to the title ripping. So that Europa has an ice core.

MOIYA MCTIER [00:35:07] A rocky core, and an icy surface.

JVN [00:35:10] So in the way that our core is, like, you know that core, then there's, like, the liquid hot magma, there is, like, a core. And then it's like the ice, but. But then the tidal ripping is so strong that there's, like, liquid water within the ice because it literally gets pulled apart into water?

MOIYA MCTIER [00:35:27] Yeah. So there's, like, a mile or so of ice at the top, this big ice sheet. And then underneath that is a liquid water ocean. Because when you, when you stretch something over and over again, that creates friction and that creates heat. So the ice melts.

JVN [00:35:45] Could there be arctic-ass ice fish down there?!

MOIYA MCTIER [00:35:47] [SINGS] We think maybe!

JVN [00:35:50] How can we figure that out? Could we do, like, a Mars lander, but a Europa lander?

MOIYA MCTIER [00:35:53] Yes, that is actually something that astronomers are planning right now.

JVN [00:35:57] Now is it gonna take fifty billion or, like, some stupid amount of time to get over there?

MOIYA MCTIER [00:36:02] No, it's not going to take a lot of time. It will take a lot of money, though.

JVN [00:36:05] How much time? Like, if it's how long it takes, like, to eight months to get to Mars or something, doesn't it? Or like six months. How long did they say? Because we did an episode but I can't remember!

MOIYA MCTIER [00:36:13] Yeah, it depends on, like, when you leave, because sometimes Mars can be on the other side of the sun from us, right. Because we're not orbiting at the same speed.

JVN [00:36:22] So if you did a well-timed a launch.

MOIYA MCTIER [00:36:24] You can get there in a few months.

JVN [00:36:26] And would the biggest deal to get to Europa be that fucking, that asteroid belt, huh?

MOIYA MCTIER [00:36:32] Mmmh, yeah. We're going to have to navigate through that. But we have sent telescopes out there. Both Voyagers went out there. But the really hard thing, Jonathan, would be digging through that ice.

JVN [00:36:44] Oh, because it's a mile.

MOIYA MCTIER [00:36:46] Yeah, it's a lot of ice to get through.

JVN [00:36:48] And it would be, like, unethical to send a bomb to the sea because it fucks stuff up.

MOIYA MCTIER [00:36:53] Yeah. We don't want to contaminate other potential ecosystems. There's a whole branch of law called space law that looks at stuff like this.

JVN [00:37:02] So you would basically have to figure out a way to get, like, a big enough ship with, like, a huge drill.

MOIYA MCTIER [00:37:07] Mm hmm. Yes. And that is a mission that we are planning for Europa. I think it's called the Europa Clipper mission.

JVN [00:37:14] Well, maybe when they got there, they would maybe realize that maybe it's not a mile deep.

MOIYA MCTIER [00:37:19] Mm, maybe!

JVN [00:37:20] Maybe you won't have to go because, like, how are you gonna get a mile worth of fucking…

MOIYA MCTIER [00:37:24] I think that what they're going to have to do, they'll want to study the ice. So they'll dig out a little, like, core of ice and study that. And then they'll probably try to find a place where there's, like, a natural fissure or something. There's a moon around Saturn called Enceladus that has geysers. So it's a similar situation and water ocean under a sheet of ice, but it shoots out these plumes of water. So we've actually sent a telescope flying through one of those geysers around Enceladus.

JVN [00:37:56] But it couldn't send anything back, obviously. So we'd just, like…

MOIYA MCTIER [00:37:59] It sent some stuff back!

JVN [00:38:01] Really?!

MOIYA MCTIER [00:38:02] It sent enough back for us to know that it is a liquid water ocean underneath.

JVN [00:38:05] No, it's that thing all the way back to Earth? Or just a picture.

MOIYA MCTIER [00:38:09] Not like a–, it sent data back.

JVN [00:38:11] Data. Wow, okay! Okay. So. Okay. So in my, in my little memoir Over The Top, I talk about my first partner, Sergei, and how I kind of refer to him as, like, he was, like, a, like, the love was, like, a black hole. And then I couldn't help but notice in this book you talk about, like, the central black hole Sarge. Yeah, very, very close. Can we talk about that relationship and like, what's, like, the scientific hot goss about, like, the Milky Way's, like, central black hole Sarge?

MOIYA MCTIER [00:38:44] Yes. So I was writing this book during a pandemic when I was depressed, like, I was really sad. And I, I don't think it was conscious at first, but I just thought, you know, "Why can't galaxies be depressed? And wouldn't it be so cool if I could use this book to kind of work through my mental health and maybe help other people do the same?" So it made sense for me to use black holes as a metaphor for depression and anxiety and other mental health struggles as if it were a physical manifestation. So in the book, Sarge, the black hole, it's everything you hate about yourself. It's all of the intrusive thoughts. It's all of those little voices in your head saying that, "You're not good enough and no one else loves you and you're not worthy." And. I needed the Milky Way to see that and to acknowledge it and then to figure out how to deal with it. And I wanted it to be inspired by the science, too.

So the gravity of a galaxy cannot control a black hole, but if the galaxy is like a sentient being, then it can control what happens around the black hole. It can control the the material that falls into it. So maybe it doesn't feed the black hole as much or it can insulate the black hole. So just, like, keep stuff away from it. And that was really powerful for me because I realized, you know, "I—, this is a part of who I am. This is a part of how my brain works. I can't change that necessarily, but I can change how I approach it. I can change what I surround myself with. I can change how I think about it." And so, yeah, that's that's what Sarge was.

JVN [00:40:32] I love Sarge! Wait, so, galaxies really can, like, they can't control what falls into the black hole, but they can be, like, "Oh, I really like this planet, so I'm just going to, like, scooch it away" or, like, "I'm gonna use my gravity. It's like, get it away from there" or something?

MOIYA MCTIER [00:40:46] Or we see in other galaxies that don't have as much material around their black holes. If the black hole can't eat as much of the material, then it can't grow as fast. And we've seen on the other side of the spectrum, we've seen galaxies that have succumbed to their black holes and their black holes can—, actually, we call it "quenching." They can make galaxies stop forming stars, which is essentially killing the galaxies. And so, you know, we've we've seen galaxies succumb to it and we've seen galaxies that are better. This is, this is me anthropomorphizing again. But we've seen galaxies that aren't as dominated by their central black holes. And so I wanted to show the Milky Way getting to that point of realizing what it can do to quiet down Sarge.

JVN [00:41:41] I think because of all of the, like, existential threat to, like, queer joy that I see, I always get, like, PTSD when I think about black holes. So again, we're not going to get a black hole, like, we're not all gonna get sucked into one. It's fine.

MOIYA MCTIER [00:41:51] No, no, no.

JVN [00:41:53] Cause there's just, like, not one strong enough in the Milky Way.

MOIYA MCTIER [00:41:55] Exactly. Yeah. The, the black hole at the center of our galaxy is so far away that we are not affected by it.

JVN [00:42:02] Oh, because we're in the rings.

MOIYA MCTIER [00:42:03] Yeah, yeah, we're out in this disk. We're so far away from it. But I want to push back against the common—very common—misconception that black holes suck everything in because they are just gravity pits. So if our sun became a black hole, like, if we woke up tomorrow and the sun was a black hole, but with the same mass as the sun, we wouldn't fall into it. We would just continue orbiting the same way we always have.

JVN [00:42:25] And freeze to death, right?

MOIYA MCTIER [00:42:27] Well, yes, that would be an issue, but we wouldn't fall in.

JVN [00:42:31] And is not going to be what happens in 5 billion years? Like, the sun is going to get really big and then it will be a super—, it won't be a black hole after it begins and expands and stuff. It's never going to happen to the sun?

MOIYA MCTIER [00:42:41] No, our sun isn't massive enough, so our sun will puff up into a red giant. It will shed away its outer materials. Like, it's, like, "Oh, I'm too hot, let me take all my clothes off," and then it's going to shrink back down into a white dwarf star.

JVN [00:42:55] And then it won't be as hot as it is now.

MOIYA MCTIER [00:42:57 Nope, it's going to be a very cool rock, and then it will just radiate away the rest of its heat until it is, like, a chunk of rock in space.

JVN [00:43:07] But that's not for 5 billion years.

MOIYA MCTIER [00:43:09] That, well *that* isn't for another, like, 10 billion years. 5 billion years is when it will become the, the red giant and then it'll spend—, actually I'm not sure how long but, you know, millions of years, at least, in that phase.

JVN [00:43:24] Do we have telescopes that are strong enough to see, like, on the surface of planets? Like how we can look at a plane and see, like, the ground, like, are any of our telescopes, like, strong enough to see that, like, really, really, really far away or can you only see, like, the planet.

MOIYA MCTIER [00:43:36] We can do that for some of the planets in our solar system, but we cannot do that for exoplanets outside of our solar system.

JVN [00:43:43] Oh, so exoplanets outside of just this solar system, not outside the Milky Way.

MOIYA MCTIER [00:43:47] Correct. I think the first time we saw a planet in a different galaxy was just last year.

JVN [00:43:56] Wow.

MOIYA MCTIER [00:43:57] Yeah.

JVN [00:43:58] So, because, I am curious what we're going to look like after the sun is a white dwarf. Was there ever a solar system that, like, maybe supported life and we could just, like, go see the wreckage of, like, all, like the crumbled, like, you know, Manhattan or something.

Like, there was probably, like, people there, but then, you know, but then, like, the sun did its thing and then it just, like, all went away, but like the ruins are still there.

MOIYA MCTIER [00:44:20] That's a really great question. We are actively interested in solving this because we live around a star that will eventually turn into a white dwarf. So we want to know if Earth could survive that. So we've looked for other systems where there's a white dwarf star that used to be a star like the Sun. And we have seen planets orbiting in the habitable zone of these white dwarf stars.

JVN [00:44:45] So there would be a habitable zone of a white dwarf, even though it's not that hot anymore?

MOIYA MCTIER [00:44:49] It would have to be much closer to the star. what we think would happen is that planets would have to migrate in after the star becomes a white dwarf. Because if the planet were actually that close to the star when it puffed up into a red giant—

JVN [00:45:05] You would just burn.

MOIYA MCTIER [00:45:07] Yeah, burned up, it would have been eaten by the star. So we think that planets would have to move in and out to closer orbits.

JVN [00:45:14] Have we seen another example where maybe, like, because the red dwarf got so big, it kind of pushed, like, the planets out and then as it contracted and got skinnier, the planet kind of came back in with it?

MOIYA MCTIER [00:45:24] We think that that's possible, but we haven't seen it in action because these things take so long to happen. [JVN SIGHING] So what we would have to do is observe multiple different systems at these different stages. And we, we haven't yet.

JVN [00:45:40] Okay. Yes. Okay. So, you note that myths were some of humans', like, first attempts at scientific inquiry. You know, because it's, like, we just can't—, it's, like, how in fifth grade I told everyone that I was, like, I was, like, best friends with Hanson. So what are some of the standout creation stories about the Milky Way?

MOIYA MCTIER [00:45:55] Oh, I love, I love this question. One very popular one that I didn't talk about in the book because I wanted to kind of avoid the classical Greek myths, was the story of Hera, the goddess of marriage and, like, childbirth. She was married to Zeus, who was Hercules' father. But Hera was not Hercules' mother. So there's one story where Hera, while she's sleeping, Zeus, like, puts Hercules up to her bosom so that she can nurse him. And then when she wakes up, she sees this baby who is not hers nursing at her teat. Didn't think I would say that out loud. So she sees that and she's, like, "This isn't my baby." So she throws Hercules away and like, there's a spurt of milk and that becomes the Milky Way. So that's one story.

JVN [00:46:54] They were creative, honey.

MOIYA MCTIER [00:46:56] Oh, yes. So the word, the word galaxy actually comes from the ancient Greek word, galactose, which means milk.

JVN [00:47:06] Shhh, so I'm trying to say breast milk, which would have made a little bit, but yeah, but I guess it's, like, all milk is breast milk.

MOIYA MCTIER [00:47:10] It's all milk, yeah!

JVN [00:47:11] I would just be remiss if I didn't mention because any time I talk about breast milk, I always have an intrusive thought from a League Of Their Own when Madonna is teaching them one girl to read and then, like, the girl who's learning to read is, like, "M-m-m-melky wet breast." I say it every time, if you ever talk about milk. I just, like, we can edit it out– cause it's, like, a reflex. Like, someone says, like, "breast milk." I feel completely compelled to, like, recap that story from their bus trip. Like, it's, like, I honestly can't continue having the conversation until I say, "M-m-m-melky wet breast." So I did it.

MOIYA MCTIER [00:47:46] We did it!

JVN [00:47:47] We can progress. What are the other creation stories around the–, obviously there's, like, the whole, I was thinking like, I don't think the Milky Way gets, like, a name check in the Bible, but the Bible says that like, you know, the Earth is like 10,000 years old and all, and, like, you know, [UNCLEAR and whatever.

MOIYA MCTIER [00:48:00] Well, a lot of these, like, "newer" religious texts, I say, like, Christianity is a newer religion, if you look at the whole time scale of the planet. And those texts tend to focus more on the creation of our planet instead of the creation of the universe. Or, you know, there's a lot of blending, you know, like the words universe and world and planet, they have meant different things at different times and there's a lot of overlap between them. So I haven't found a lot of Milky Way creation myths in Christian and Abrahamic texts.

JVN [00:48:39] Oh, because they were all about, like, Earth.

MOIYA MCTIER [00:48:41] Earth. Yeah. But if you look at older, some more, like, polytheistic religions. One of my absolute favorites that did make it into the book, but I want to highlight it here is the Khoisan Milky Way creation myth. So the Khoisan people live in southern Africa and they have this myth of the Milky Way that this young girl was dancing around a fire at night and she needed to get home for dinner because, you know, dancing makes you hungry. And she at the time, there were no stars in the sky, so she didn't have a way to light her path home. So she took embers from the fire that she was dancing around and she threw them up into the air. And that became the Milky Way that lit her way home. And I just love that myth so much that it needed to be in the book. But there are others in the book I talk about a Finnish Milky

Way creation myth. There are surprisingly many Milky Way creation myths that do talk about milk. So it's interesting that even though not every country in the world has called it "the Milky Way" or thought of it as a milky path across the sky, several have.

JVN [00:49:50] Ah, I love that story.

MOIYA MCTIER [00:49:53] I know!

JVN [00:49:54] So one thing that I feel like has surprised me in Getting Curious is, like, sometimes people are, like, "Actually, girl, like, you are kind of a scientist, like, you just didn't really know." I think about, like, we got to interview this, like, fierce anthropological biologist. And she studies, like, the evolution of hair, and so when we were talking, she was, like, "Well, you're kind of like a practical scientist because, like, you were out there doing, these hair things that we do in the lab but, like, you have, like, a different experience of it cause, you know, you're, like, in the salon." And I think a lot of us do scientific stuff that we don't even realize is scientific. You know, cause we just, like, become separated from, like, education or something the older we get. So like some of those are early, you know, creation story myths or, you know, it was humans trying to attempt to explain to them they didn't have the, like, scientific language for. So, like, what makes some of those early story forms, like, really scientific inquiry?

MOIYA MCTIER [00:50:45] Yeah. The fact that they are basing these stories off of observations. So many myths that have been told throughout time have been an attempt to explain natural phenomena. This is why you see myths everywhere in the world about, like, "What makes thunder happen?" "What makes the changing of the seasons?" "What makes an eclipse happen?" And they are telling these stories that are based on their framework for understanding the world. And they make sense. You can, you can see the, the, like, rigorous attempt at understanding nature. I say if you turn your head to the side and squint. When you look at myths, you can see scientific truths. And you know, there's kind of a resurgence now, at least in astronomy, of respecting and acknowledging Indigenous knowledge, because these stories that people have been told, these stories that people have been telling, they, they hold truth in them. One, one story that comes to mind is monarch butterflies. They migrate and other birds migrate, too. And for a long time, these, like European scientists, did not know where the monarch butterflies were going. And then they sent a scientist man, person to go and figure out where they were going. And they found them in Mexico. But indigenous people in Mexico, they knew that the monarchs were flying there. There is Indigenous knowledge about the world around us and it gets codified in these stories and in these myths. So yeah, I see myth and science as, like, two sides of the same coin, and that coin buys us an understanding of the world around us.

JVN [00:52:25] I think that is so fascinating. We had the honor to talk to Dr. Jessica Hernandez, who is an incredible Indigenous scientist, and she has this really cool book, it's called Fresh Banana Leaves, and she talks about that. And I think I also think of like Eastern and Western

health like that. I have a lot of, like, doctors in my family and it's like the second you talk about like acupuncture or, like, any Eastern thing, it's like, you know, eye rolls. But it's like these are all beautifully legitimate, all of integrity in different forms of science from different places. And they all deserve respect. They all deserve time and knowledge and attention. And I just, I love that and I love that that's kind of happening. And astronomy, astrology—oh my god.

MOIYA MCTIER [00:53:02] Astronomy!

JVN [00:53:03] Astronomy, yeah! See that's how I ended up in astronomy class when I was 17, because I thought I was going to learn about, like, Zodiac stuff. And then I went in and I was like, "What is all this fucking math?" Like, it was, it was, like, the worst mistake I ever made in college. And then, of course, I—

MOIYA MCTIER [00:53:15] That's a rude awakening for sure.

JVN [00:53:16] It happened twice! Because I failed the first semester and then I had to retake the ninth fucking. And then I think I told this story on Getting Curious but I'll just say it again really fast. Okay. So in the second because I actually didn't really good until the final in season —or, in season one—in the first semester, I was, like, "I kind of understand." Then the final I just fell off and I, like, I failed it, and that pulled my grade down so I failed and had to take it again. But I was, like, "I did so good in the first half, I'm, like, not going to go to class for the first three weeks." So then when I went for the first time, it was a midterm and it was right after the tsunamis of 2004.

MOIYA MCTIER [00:53:43] Oh no.

JVN [00:53:44] So I fictitiously killed my stepsister who had never been to Thailand. But I just said that, like, we just had, like, a death in the family and that, like, we weren't sure where she was, but we were, like, trying to find her. And it had just been, like, a really traumatic, like, you know, January for us because, like, you know, so this was, like, the last week of January. And so I was just, like, "Can I please come back in a week and, like, retake the midterm? Like, it's just I don't, you know, I failed last, like, the first semester that I got." And then I just dropped out of school after that. I was so embarrassed. I just, I kind of dropped to my knees and, like, cried in from the entire, like, auditorium of, like, you know, 200 students in there. And so then I just, like, when I walked out of the door, I was just, like, "Ah!" and then I just dropped out. I was like, it's just like the worst. It was just the worst person.

MOIYA MCTIER [00:54:22] Wow, it was astronomy that pushed you out.

JVN [00:54:23] It was astronomy and it was, like, just, like, it's such a hard core lie that I just, that's, like, you just learn when you're 17, you just learn, like, you make mistakes and then you, like, learn to not do such gigantic. So, you know, I didn't mean to take that detour. We're coming back. So I think I see a lot of my, like, even just in this episode that we've done so far,

it's, like, a lot of my, like, Eurocentric, like Christian centric. Like, it's, like, I'm really scared of a doomsday thing. But it sounds like we're really just going to, like, blend with Andromeda and it's going to be—, or wait, no! To even blend with Andromeda we've got to survive the sun first.

MOIYA MCTIER [00:55:01] Yeah. So if we survive that, then Andromeda will come, we'll merge, and that should be totally fine. But if you zoom forward many billions of years, then we start talking not about the end of our solar system or our galaxy. Then we're talking about the end of the whole universe.

JVN [00:55:21] Why?

MOIYA MCTIER [00:55:22] Because we physicists and astronomers think of the universe as this collection of energy. There's energy moving around all the time. And eventually that energy will fizzle out. The universe will get so big that the average temperature is basically zero degrees Kelvin. Everything will be so far apart that they can't interact anymore. So you don't get these big collisions of galaxies forming new stars. So when we get to the point in the universe when stars aren't forming and when everything is super cold, that stuff can't move around anymore, then the, the universe is kind of dead. There are, like, five different potential scenarios for the end of the universe. The one that we think is most likely would take trillions of years. That's a long time.

JVN [00:56:12] And it's just, like, a slow death. And then would it re-Big Bang again? And restart?

MOIYA MCTIER [00:56:19] That's not what we think is the most likely scenario, because for it to Big Bang again, the universe would have to expand, stop, contract back in on itself until it gets to like the tiny little point that it was at the Big Bang and then it might re expand. But what we think is going to happen is that the universe will continue to expand so much that eventually the galaxy clusters are all isolated. Within a galaxy cluster they'll, all of the galaxies will merge. So all of the galaxies in the local group will merge and become one big galaxy. And then it'll take time for all of the gas in that one big galaxy to get turned into stars. It'll take more time for all of those stars to stop fusing. And, and after that happens, when there's no material to make new stars and all of those stars die, then, then everything's done. [JVN SIGHS DEEPLY] But, like, Jonathan, trillions of years, trillions of years from now.

JVN [00:57:18] I just am saying that I'm advocating for, like, the Big Bang times two theory, like, whichever one of the five that that is, like, I'm mean, like, I just like even if it is only trillions of years because like that just makes me want to go do drugs.

MOIYA MCTIER [00:57:29] Mhm. The–, we can call that the Big Bounce theory, the Big Bounce is if there's another Big Bang.

JVN [00:57:35] There has to be—, because I also just feel like I would love to come back as, like, a cat-human hybrid.

MOIYA MCTIER [00:57:40] Oooh, love.

JVN [00:57:42] Like I wanna be like a real, like version of like the most recent Cats. Like, I want a furry butthole. I want to be, like, life-sized, like, I just like that's what I want. And I don't want to live in a world where that is going to, like, just expands so far and, like, and also fully, I didn't see that coming. TBH, that, like–, that's going to be what we, that's really what you guys think?

MOIYA MCTIER [00:58:03] That is what we think. But, you know, theoretical physicists are always coming up with new ideas.

JVN [00:58:10] Can you advocate for one? I don't like that one.

MOIYA MCTIER [00:58:13] Yeah, okay. I will. Here's one. It is possible that every time a supernova happens that forms a black hole that that on the other side of the black hole makes a whole new Big Bang. Makes a whole new universe. So maybe, maybe that's what's going on.

JVN [00:58:31] That one I like a lot better.

MOIYA MCTIER [00:58:33] And in one of those universes, Jonathan, you can be your cat human hybrid for sure.

JVN [00:58:38] I'm so obsessed with you, can't stand it. So there's, like, five kind of—, there's, like, Big Freeze, Big Rip, Big Slurp, Big Crunch, Big Bounce. Big bounce is the whole on every other side of a black hole, there's a new universe starting.

MOIYA MCTIER [00:58:50] Big bounce is the universe will expand and then contract and then expand again in a new Big Bang.

JVN [00:58:56] So we're just, like, so maybe in that Big Bang theory, we're just, like, in the midst of one of the ever expansions, contract. Like maybe that could have been, like, this could be, like, the fifth one by now.

MOIYA MCTIER [00:59:03] Yeah, exactly. It's a never ending cycle. And there are some mythologies that have that cyclical universe in Hindu mythology and Norse mythology. The universe forms, ends, and then forms again, and it's always moving.

JVN [00:59:17] Okay, so that's Big Bounce. What's Big Crunch?

MOIYA MCTIER [00:59:19] Big Crunch is the universe expands and then contracts, but there is no re-expansion.

JVN [00:59:24] Big Slurp?

MOIYA MCTIER [00:59:26] Big, Big Slurp is theoretical. It has to do with quantum physics and the way that our energy states are working. So basically the, the quantum rules that make our reality work, they might not be in their most energetically favorable state. And so it could be possible for those states to, like, reset themselves to be more energetically favorable. And if that happens, then it's almost like a computer being turned on and off, like we would our universe would end and we wouldn't know it. It would happen, like, at the speed of light.

JVN [01:00:07] And then what?

MOIYA MCTIER [01:00:09] And then there would be a new universe with new rules of physics.

JVN [01:00:14] So, like, every one, like, gravity would just stop. We'd all, like, float off the planet. Everyone, like, goes out into space, like in Interstellar. Their head gets crushed because there is no, like, you know, a helmet. And we weren't ready for everything to switch. And then it just, like, all resets with new rules, like right away.

MOIYA MCTIER [01:00:28] Right away. Yeah.

JVN [01:00:30] But that would be in, like, trillions of years.

MOIYA MCTIER [01:00:32] It could happen any moment.

JVN [01:00:34] Okay, great. And then what's the Big Rip?

MOIYA MCTIER [01:00:36] The Big Rip is if the universe continues to expand forever and gets faster and faster so that even galaxy clusters get pulled apart and even, like, individual atoms get pulled apart.

JVN [01:00:48] Perfect. So that's a messy ending.

MOIYA MCTIER [01:00:51] Oh, yeah, that is the Milky Way's least favorite way for the universe to end, because it would take Andromeda away.

JVN [01:00:57] Hmmm! And then Big Freeze is the one that we talked about. Yeah. Everything except so much. We just…

MOIYA MCTIER [01:01:03] Just cool down until there's no energy left.

JVN [01:01:05] It seems like there are two ways to see ourselves in relation to the Milky Way. One is that our lives are insignificant. That's the one that made me want to go do drugs. You know, because it's going to end. And other is that our lives are precious, which we ended up getting there because, you know, like they're, ah! So how do you make, how do you make, like, how do you make sense of that choice?

MOIYA MCTIER [01:01:23] Jonathan, I think you're really going to appreciate this because I don't see it as an either or. I see it as a "both and." We are both insignificant in the grand scheme of the universe. *And* we are precious because if the universe is so big, we are all we have. So, you know, why not treat everything that we have with the utmost respect and care? Because we, we're not going to interact with anything else. I said before and I hold to it. I do believe that there's life out there, but it is so far away and it probably doesn't look or sound or behave anything like us. We are all we have. So let's, let's love each other as, like, cheesy as that sounds.

JVN [01:02:07] Well, and as, like, many stars is there are, like, you know, the planets and the stars like the 5 billion, the 15. I mean, like I always think and I think I said this in this podcast a lot before. It's like there is so many, like, eggs and sperm is that we had to like become America's or whatever country you are born in the next top model of your mom's uterus, you know, from your dad's verso. So it's, like, that is precious. So even though there is so many of us, there still could have been so many more and different. And it's like all of us have, like, such a unique chance to be here because it's like it really is like a wonder of mathematics that we even got here in the first place.

MOIYA MCTIER [01:02:38] Absolutely.

JVN [01:02:39] So what helps you wrap your head around the Milky Way? Is it just like time and you're like extreme scientific expertise?

MOIYA MCTIER [01:02:46] I think that I just take a very chill approach to it. Like, when, when I was in one of my early astronomy classes and we were talking about the expansion of the universe and these billion year timescales, I did not let myself get to the point where I was like, "Oh, my God, what's what is a billion years?" I can't imagine that. Instead, I was, like, "Oh, okay, a billion years. That's a number. I can look at that number." And I think of space in terms of data. I think of it in terms of, like, matrices of numbers that I can run calculations on. And since writing the book, I have expanded that view to thinking about, like, I have a very good mental map, I think, of the galaxy. Like, I can picture the disc swirling in my brain and I can see stellar orbits moving around the galaxy. But I, you know, it's zoomed down to, to my brain size. And when I feel myself getting caught up in wondering how big a trillion is, I'm just, like, "You know what, Moiya? That's a number and it's a big number. But, you know, it's, it's not an intimidating number, like, this is a number that has been with the galaxy, has been with the universe since the beginning of time and just, like, accept it." I don't know if that's helpful for anyone else, but that, that's how I do it.

JVN [01:04:11] Fuck yes! It just helped the fuck out of me, I'm obsessed.

MOIYA MCTIER [01:04:14] Oh good!

JVN [01:04:15] So as listeners can tell, you know, you are really good at science communication. It's like what you've dedicated your life to, so. How did you find your voice as a scientist? Was it just, like, being chill? Was it, like, being patient with yourself and patient with people?

MOIYA MCTIER [01:04:28] Oh, that was the opposite. This was an intentional decision. This was years of building skills. So the one thing that I think I did that helped me the most was in 2018, I had a "Year Of Yes," it was a year where I said yes to every professional opportunity that came my way and I got so far out of my comfort zone and it helped me so much with my impostor thoughts because before that year, if someone invited me to give a talk, I'd think, "Oh, am I the right person for this? Can I really do this?" But for my year of yes, it didn't matter if I thought I was the right person for the job. I said yes and then I did it and I killed it. And that, like, begot more opportunities. So in that year of yes, I really focused on finding my voice and finding the audience that I love to work with. And I did a bunch of different stuff. I did my first stand-up routine. I went to South Africa on, like, two weeks' notice and spent almost a month there traveling around the country and talking to people about science and my journey. I decided to write this book proposal. This, this book came out of my year of yes. So I really encourage people to have their own year of yes. If there's something that they want to move towards or if they want to make a career pivot or even just, like, improve on some of their skills. A year of yes is a great way to do that.

JVN [01:05:51] How did you make science successful without losing meaning and nuance?

MOIYA MCTIER [01:05:55] I think it's a matter of meeting people where they are. I am not afraid of using jargon because I know that if I explain what the jargon means, then someone can learn that. So I like to meet people where they are. I love to use metaphors. We humans are really good at understanding metaphors as long as they're explained clearly. So I use a lot of those and I, you know, just, like, talk like a normal person. I don't think I have to use stuffy academic language to talk about these academic concepts. In fact, I think that if you can only talk about these concepts in this stuffy language, that's a sign that maybe you don't understand it as well as you think you do. Because if you can translate it to just, like, "normal" language, if you can use slang while you're doing science communication, that means you really understand what you're saying.

JVN [01:006:46] So the book is really just like, so incredible. And you guys, even in this time, we still only scratch, like, the very surface of the book, and there's so much more for you to take from it. I think that writing it in this autobiography form was so genius. What do you hope that people gain from, from, from the book?

MOIYA MCTIER [01:07:03] I really want people to shift their perspective of how they see the world, because it is so easy to fall into the trap of thinking, like, in your tiny little view of the world, I'm cupping my hands over my eyes as if you can see it. But the world is so much bigger than what we can see in our everyday life. And the Milky Way sees that, the Milky Way sees everything at once. And I was hoping that by giving people the chance to get into the mindset of a galaxy for a little bit, that they would shift to that mindset and, and, I don't know, think about people other than themselves or their, like, immediate friends and family.

JVN [01:07:44] So then you write that, like, "Science fiction stories are aspirational myths," which I love this. "They're humanity's dreams for the future." What are your hopes for this future and what mysteries of the universe to most excite you?

MOIYA MCTIER [01:07:58] First and foremost, I really hope we get climate change figured out. We have the tools to do what we need to do. We know how to scrub CO2 from the atmosphere. We understand the policies that we should put in place to protect the environment, but we're just not doing it. So I hope that we can get the people who have power to understand that or that we can, like, get new people in power who already understand it. So that's hope number one. Hope number two is kind of, like, the shift in perspective thing. I hope that we can start seeing ourselves as this, this global unit, as, as humanity. Our identities are really important. But I think we're missing the identity of, like, human when we really define ourselves. So I hope we can get there. And for mysteries of the universe, I want to know if there are aliens. I really do. I think that if, if we discover definitive evidence that there is alien life out there, that is when I can die happy. Aside from that, it's, and I guess understanding dark energy would be cool, but really it's the aliens for me.

JVN [01:09:05] Extraterrestrial life, aliens, dark matter. That's, like, really good goals, I'm really here for you for that. I'd like for us to wind down on this note courtesy of the Milky Way. "I'm fly as hell, I'm beautiful and strong, and I do my job well." How can we harness the power of the Milky Way in our own lives?

MOIYA MCTIER [01:09:21] Oh, yes! Let's, let's think about Sarge for a second. Sarge is the physical manifestation of everything that the Milky Way hates about itself and everything that it thinks other galaxies hate about it too. And we humans have that. We have these voices in our heads. We have these external factors that are, you know, making us think less of ourselves. I think it would be great if everyone could embrace the Milky Way's philosophy a little bit more and really try to tune out those voices. Think about what makes you awesome, because there there are things that make everyone awesome. So figure out what that is for you and really embrace it and love that about yourself. Because, you know, the Milky Way doesn't love you. But I do.

JVN [01:10:04] Ah! Dr. Moiya McTier, I'm so grateful for your time, for your scholarship, for your work. Your new book, The Milky Way: An Autobiography of Our Galaxy, is out. You guys got to listen to it or read it. Did you do the audio, too, of it?

MOIYA MCTIER [01:10:16] I am, yeah.

JVN [01:10:17] Yeah. So listen to it, read it. Get into her podcast Exolore. So good. Dr. McTier, thank you so much for your time and coming in, getting curious.

MOIYA MCTIER [01:10:25] Oh, my God. Thank you so much and thank you for everything you do. Jonathan, this is an amazing second podcast. Like, I don't–, you are really an amazing sci-comm and I'm so grateful that you're out here doing this.

JVN [01:10:37] Noooo, I'm pausing it on that! [LAUGHTER] You've been listening to Getting Curious with me, Jonathan Van Ness. Our guest this week was Dr. Moiya McTier. You'll find links to her work in the episode description of whatever you're listening to the show on. Our theme music is "Freak" by Quiñ - thanks to her for letting us use it. If you enjoyed our show, introduce a friend, honey, and please show them how to subscribe. Follow us on Instagram & Twitter @CuriousWithJVN. Our socials are run and curated by Middle Seat Digital. Our editor is Andrew Carson. Getting Curious is produced by me, Erica Getto, and Zahra Crim.