Episode 19: The Northern Lights
Physicists: Sean Moran, Laura Hainline
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Transcribed by Denny Henke

Ben: Over the course of my studies in theoretical physics I've traveled across the continent and around the world sampling new ideas and tasting different answers to the questions of how and why. And still I find there remains a deep hunger which lives within me, a burning desire to share these great ideas with the people around me. And so, I have assembled a team of some of the greatest, most lucid, most creative minds, I have encountered in my travels and I call them my Titanium Physicists. You're listening to the Titanium Physicists Podcast and I'm Ben Tippett. And now allez physique!

[1:49]

Alright, today we're going to start the show with a story. Once upon a time there were twins. A boy and a girl. They were about twelve years old, fourteen years old when this happened. They lived in the northern part of a northern country on the planet earth. One day, in the middle of the night in the middle of a cold winter their mother woke them up from their beds. She forced them to put on their winter boots and their winter coats and hats and gloves and then all three of them went outside. The mother told the children to look up and north. And there, above the shoulders of Orion lay a mist of green and white light. It glowed far above their heads like a shimmering curtain that was slowly being pushed about by a breeze. These are the Northern Lights, the mother said. When I was younger and lived up north we saw them all the time. The daughter replied, it's really cold out, how much longer will we have to watch. The mother said, people come from all around the world to see them, they pay thousands of dollars in travel to Yellowknife and to Whitehorse to stand out in the cold just to see them. The son said, I bet it would be nice if we could watch them from a hot tub but right now it's so cold. I am so cold. The mother said you should pay close attention, we will be moving south soon and you may never see them again. But, the poor cold teenagers were very cold. Their necks hurt to look straight above them and their beds were so much warmer. It was colder than -20° C outside and they were teenagers so the two children went back into the house and soon they moved to Vancouver and they never saw the Northern Lights again. Well, I was one of those two children and this episode of the Titanium Physicists we're going to be talking about the Northern Lights. Okay, today, our guest is Dr. Nathan Lowell. Dr. Lowell writes great science fiction novels and then reads them on the Internet as part of the Podio book movement at podiobooks.com. His stories take place in the golden age of the solar clipper. A time in the future when people and goods will travel between the stars using a combination of faster than light drives and good old fashioned solar sails. The stories always show a contrast, combining the deep dark of space with the cramped quarters and political complications that arise on a small spaceship. In 2011 his novel Owner's Share, won the best speculative fiction parsec award. Congratulations and welcome to the Titanium Physicists Podcast Dr. Lowell.

Nathan: Why thank you very much.

Ben: Oh, we're so excited to have you. So excited in fact that I have assembled, for you today, two of my most notorious titanium physicists. Arise Dr. Sean Moran. Nice. Dr. Sean, did his PhD in astrophysics at CalTech and is currently a postdoc at Johns Hopkins University in Baltimore

Maryland. He's an observational astronomer who looks at galaxy evolution. Now, arise Dr. Laura Hainline. Dr. Laura did her PhD in astronomy at Caltech as well, and she’s currently working as a postdoc at the United States Naval Academy. She studies accretion disks around black holes.

So... Nathan, do you know anything about the Northern Lights?

Nathan: I've seen them several times actually. I used to see them all the time when I was a boy. We lived in rural Maine and we saw them quite frequently there and then I spent a year and a half in Kodiak, Alaska and they were quite common there.

Ben: Huh. That's great. Okay, so the story of northern lights starts at the sun so let's start explaining it at the sun.

Laura: Okay, as Ben said, the northern lights start at the sun, specifically they start in the part of the sun that we call the corona. So when you look at the sun in the sky. Well, okay, I'm not advocating that you look at the sun, you know, with your bare eyes because that's bad. But if you were to look at the sun the part that you could see, we call it the photosphere. So, during a total solar eclipse when the moon completely covers the sun, all we can see of the sun are these fluffy outer layers.

Nathan: Wait a minute. The sun is really big and the moon is really small. How could the moon cover the sun.

Laura: It's because we're at just the right distance from the Sun for the moon and the Sun to have exactly the same size in the sky because the sun is so much further away.

Nathan: Ah, I see. So, it's further away so it looks smaller.

Laura: Yeah. It looks smaller.

Nathan: And the moon is closer so it looks bigger and they just happen to match once every hundred years or so.

Laura: Yes.

Sean: Some weird cosmic coincidence.

Laura: Yes.

Sean: Almost exactly the same size in the sky.

Nathan: How interesting.

Laura: So, the corona are those fluffy outer layers you see during a total solar eclipse. And...

Nathan: Is that a technical term.

Laura: Yes, that is a technical term. If you'd like the technical term it is a low density, high temperature region of the sun's upper atmosphere which basically consists of ions and mostly that's going to be hydrogen ions and maybe some helium ions. So, what happens is that it is so hot in the corona of the sun that the ions are moving really fast and some of them can achieve escape velocity from the sun so that means that these ions can escape the gravitational field of the sun and then those ions then basically just flow out into the solar system along the magnetic field lines of the sun's magnetic field. And basically that's the solar wind, it's this continuous ejection of ions from the outer layers of the sun. It's really a slow rate of mass loss.

[7:34]

Sean: The sun isn't shrinking.

Laura: The sun is not going to shrink on us. In fact while it looses a mass equivalent to the earth fairly frequently...

Sean: The sun is a lot bigger than that so it ends up being small potatoes.

Laura: Exactly.

Nathan: It's a rounding error.

Laura: It's a rounding error, sure. So, anyway, it's a plasma because it consists of charged ions. Basically, it's mostly portions and electrons because hydrogen ions are just protons. The plasma travels through space until it reaches the earth's magnetic field at which point the plasma then interacts with the earth's magnetic field and causes the northern lights.

Ben: Okay Nathan, you have experience with electromagnets right?

Nathan: Yeah. Yeah, that's like when you wrap a wire around a nail and something.

Ben: That's write, you take a wire and you wrap it say counterclockwise around a nail and then you drive a current through it, so you drive electrons down the wire, they run loops around the length of the nail. So what happens in that case is that moving electric charges, if they are moving in a circle, generate a straight up and down magnetic field. So, with the running loops around the nail, this forms a magnetic field that goes straight down through the nail.

Nathan: So far so good. Yeah, yeah.

Ben: Okay. So, the kicker here is that charged particles if they move in a circle they cause straight magnetic fields. But the converse is also kind of true, if a charged particle encounters a straight up and down magnetic field, what it will do is it will start running in little loops around it. I'll get into the details of this in a second. But, just macroscopically what's going on is, you've seen what the earth looks like, what the magnetic sphere of the earth looks like, right? It's got a North Pole and a South Pole and the magnetic fields look kind of like big wires that start at the North Pole and loop around like big lobes and then reconnect at the South Pole of the earth, right?

Nathan: I didn't know you could see those.

Laura: No, there's no way of imaging the magnetic field, I don't think. I think you have to do it indirectly. I think you have to go look for another effect.

Ben: Yeah, okay, you could do it if you had like a bar magnet on your table top, one way to image these magnetic fields is to scatter a whole bunch of iron filings around. Because what happens is each of these iron filings becomes magnetized so each of them kind of becomes magnetic and these magnetic fields like to realign themselves with the magnetic field that is kind of flowing around them.

Nathan: So if we had a whole bunch of ferrous iron asteroids and we got them really close to the earth and we could ground them up into little pieces we would be able to do that.

Ben: Yeah, in fact, you could do it with a compass because all a compass is it's a little magnet...

Nathan: It's a little magnetic field detector.

Ben: Right. So the little magnet reorients itself with the magnetic field of the earth wherever you are so it will always point to the magnetic north.

Nathan: Yeah but that would be hard to see in a big picture like that because you'd have to have like a billion magnets.

Ben: Yeah, but, I mean, let's say you took a billion magnets and you made them all phosphorescent and you took a photograph from outer space of all these people holding up their magnets you'd be able to image them and essentially it would look just like a bar magnet. There's a North Pole and a South Pole and these magnetic field lines run kind of like wires looping from the North Pole to the South Pole.

Nathan: I still want to see all those ground up asteroids.

Ben: Yeah. No, me too. That would be best. So, the thing is, we had all these charged particles moving in from the sun and when a charged particle runs into the earth, before it can even hit the atmosphere it hits these big magnetic field lines and all these magnetic field lines start looking like, say, imagine a forest of wires. If we actually set wires going from the North Pole to the South Pole what it would look like as you encountered it as you were moving towards the earth is all the sudden you'd come across a big forest of these north south wires, they were all kind of lying parallel. So, when these charged particles run into these fields close enough effectively it looks like a whole bunch of straight magnetic field lines. Instead of being able to cross this forest of magnetic field lines these charged particles end up stuck on them. So a fun way to imagine them is imagine that an electron as like a person on roller skates and they are skating through a parking garage that's full of poles going straight up and down. If you're a charged particle it's like you have an umbrella so it's got a little hook on the end. As you skate through these things you won't be able to cross the forest because effectively you'll kinda get hooked. As soon as your umbrella hooks around one of these things you'll start spinning around the pole instead of moving through the forest.

Nathan: So, basically what you're talking about is one of those old Ed Sullivan style jugglers, the guy that's got the plates on the sticks and the little particles coming in are the plates and they are spinning and the sticks are all going up and down and as the magnetic particles interact with the sticks don't they get like siphoned up or something, don't they like head for the north.

Ben: Well, that's, that's really good. Aw man, you bring an author on and their metaphors are so much better than your own.

Sean: Yeah.

Nathan: Well, just don't ask me to give you the derivation of the math, I couldn't possible do it.

Laughter

[12:30]

Ben: We have a particle and it's moving into this forest of magnetic field lines. So, what happens is, if we break down its velocity it's going to be part of velocity that's heading straight towards the middle of the earth, and part of its velocity that's moving either north or south because each particle's not going to be aimed straight at the center of the earth. Some of them will be aimed at, like, North Africa, some of them will be aimed at Antarctica, and so they won't be able to penetrate this forest of magnetic field lines. But, as they spin around the magnetic field lines they can move along the magnetic field line. You know those kids toys that are just a whole bunch of wires connected to a board and each wire has a couple beads on them? You can slide the beads back and forth along the wire.

Nathan: You see them a lot in doctor's offices.

Ben: The ones at doctors offices, yeah.

Laura: Yeah, exactly.

Ben: So, effectively, all of the electrically charged particles are stuck like beads on these magnetic field lines. So, they can either only move to the North Pole or only move to the South Pole. But because they enter the field moving a little bit to the north or a little bit to the south, when they get stuck on these magnetic field lines like beads they end up drifting north or drifting south because of the natural initial velocity. So, as a result, what happens is you have this big cloud of electrically charged particles that hit the earth's magnetic field and it splits them up, it sorts them based on the ones that were kind of drifting northwards or the ones that were drifting southwards. But all of them get stuck on the magnetic field and then they migrate north or they migrate south and so you get a big cloud of charged particles heading up towards the magnetic North Pole and a big cloud of charged particles moving to the magnetic South Pole. So, here's the thing about the magnetic field lines, they don't just run parallel to the surface of the earth. The North and the South Pole, all of these field lines reconverge and enter the earth, okay. Because all of the magnetic field lines are, essentially, they're big loops. So, they come out the North Pole go around the earth back in through the South Pole. And so, what this means is that if these charged particles are stuck to these magnetic field lines they're all going to end up entering the atmosphere at the North Pole or at the South Pole and they're only gonna enter the atmosphere in these regions where the magnetic field lines start collecting and entering the surface of the earth again. Is that clear.

Nathan: Surprisingly, yes.

Ben: Surprisingly.

Laughter

Sean: Alright, so what happens now is when you have these charged particles all sort of spiraling in towards the North Pole or towards the South Pole as they go further north they start angling down further towards the impact with the ground right at the magnetic north pole but before they get there they start running into the earth's atmosphere, the thicker part of our atmosphere. Before I go too far into it, maybe I should talk about what happens when a charged particle hits an atom, like what might happen at the top of our atmosphere. Imagine these particles are starting to sort of seep into this region of our atmosphere way up a couple hundred kilometers where they start encountering a couple oxygen atoms.

Ben: Okay, Nathan, just to preface the next section, you've seen the northern lights a lot, yourself.

Nathan: Oh yeah, yeah.

Ben: They're different colors right?

Nathan: Sometimes they're green, sometimes they're yellow. I've seen blue.

Ben: Right.

Nathan: I've seen orange, I don't know that I've seen red.

Ben: So, the deal is that you never really see an amalgam of colors. If every color in the spectrum was emitted in these northern lights phenomena then they'd be white, right?

Nathan: Right.

Ben: But their not white. Their actually, they always come out as some kind of pure color or other and the reason for this is, it depends on, kinda, how deep into the atmosphere these charges hit. The purity of the color that you see in these northern lights is kinda like, you know how they have neon signs, you see them a little bit less these days, but then it's just like orange neon signs or bright green neon signs, and it's a really, really pure color.

Nathan: Yeah.

Ben: And the reason that those colors were the colors they were has to do with quantum mechanics.

Nathan: No.

Ben: Yeah. Everything comes back to quantum mechanics.

Nathan: Ahh, the stuff that dreams are made of. I guess it's the other way around. It's dreams that stuff is made of.

Laughter.

Ben: Anyway, okay. So, ah, you have these really pure colors and it has to do with quantum mechanics. You remember Jr. high school science class, we're drawing models of the atom. They look kinda like the solar system right. You drew the nucleus and it has a positive charge and then the electrons live in little orbits around that, right. This is the very start of quantum mechanics. The thing that they were studying was how, if you just took a gas of really pure hydrogen, so it was only made of hydrogen then there's no way you can make it emit white light. You can only make it emit light at really, really specific frequencies. There's a tool called the spectrometer.

Nathan: I've heard of this thing, it measures the various wavelengths of light.

[17:23]

Ben: Yeah, that's right. Essentially it's just a prism, right. The prism breaks up the white light that comes in one slot into all of the different colors and what happens in this case is, if you took this excited hydrogen gas and you looked at it with your spectrometer, instead of seeing a rainbow of colors you'd see little bands of color so there would be a little band of orange and a little band of red, and so, early mechanics scientists like Neils Bohr were trying to explain this and they were using this model of the atom that I was talking about. So you draw your little nucleus and then you draw these orbits around it. And what happens is the electron can only live on one of these orbits, it can't live between them. It can't orbit at an intermediary radius, say, and so there's always a finite, well defined difference in energy between each orbit. And so to jump from one orbit to another orbit you need to either absorb or emit a really specific color of light.

Nathan: Hence the word quantum.

Ben: Hence the word quantum.

Sean: Exactly.

Ben: Yeah.

Nathan: Words I know, math I'm a little Shaky on.

Ben: No, that's fine. This isn't a math podcast. So, what we have here is, essentially, if you excite an atom, so, if you have a whole bunch of atoms and you get them really excited, let's say you heat them up.

Laura: Or you can just shine a light on them... Or, you know.

Sean: Yeah

Nathan: You know why neutrons always drink free? There's no charge.

Ben: There's no charge.

Laughter.

Laura: I'd never heard that one.

Ben: Ok, so, in a neon light, right, it's full of this gas, it's full of this pure gas, this tube...

Nathan: I have that problem sometimes.

Laughter

Ben: Drive a current through this tube of gas and this excites them, an excited atom is one where an electron is orbiting at one of these higher radiuses than it needs to and so as it cools down it will randomly jump to a lower orbit and in doing so it will emit these photons of very specific light.

Nathan: Okay. Alright, alright. You've stumbled onto something that I've always heard but didn't really quite grasp before and that's if we look at a hydrogen atom in it's simplest form, we have the nucleus with one proton and one neutron and we have an electron that could be going around it in its little shell, its little, whatever shape it is, we'll call it an orbit, and that orbit unlike something that might be around the earth it's always going to be at the same distance from the surface of the earth, the orbit of an electron is going to be at different levels based on different energy.

Ben: Yeah.

Laura: Yeah.

Nathan: Different excitation levels within that particular atom?

Ben: Yes, that's right.

Sean: So, there's what they call the ground state which is just the atom sitting by itself and the electron is as low down orbiting as close to the nucleus as it can, that's how it is normally. But something happens to the atom and it absorbs some energy somewhere often times what happens is that electron gets kicked up out of that ground state and into one of these higher orbits but when it gets that kick it can only settle into one of these very specific quantum levels that are...

Nathan: Right. It has to go to the next notch, it just can't slide up...

Sean: That's right.

Nathan: ... an indiscreet amount, it actually has to notch up to that next level to get to that next higher shell. Does it, can that light, when it goes up or only when it comes down.

Sean: In the case we're going to be talking about, when it comes down is when it gives out light but it can do the reverse in that it can absorb a photon, absorb a quantum of light at exactly the right frequency to go up.

Nathan: And that might notch it up.

Sean: Yes.

Nathan: Got it.

Sean: If we want to get back to the aurora, we have these charged particles coming in on the field lines and it is in fact these electrons that bounce into one of the atoms and that's what gives it a kick to put one of the atoms' electrons up at one of these higher energy levels. Ah, it's just a plain old collision with, you know, one particle into another in this case, that's giving it the initial excitement.

Nathan: And it's bumping it to the next level.

Laura: Yeah.

Sean: Yeah.

Nathan: Okay.

Sean: So, this is happening at all different levels of the atmosphere from a couple hundred kilometers up down to about a hundred kilometers up so all really high but across sort of a range of heights. And what happens is that depending on what height you're at these charged particles are more or less likely to hit certain types of atoms so it turns out that the very top of our atmosphere has a lot of atomic oxygen in it, just single oxygen atoms so when one of these electrons smashes into an oxygen atom at these high altitudes it excites it and then the oxygen atom will sit there for a little bit in this excited level and then it will decide, well, I don't need to be in this excited level, I'm going to give off a photon, I'm going to let out some light and go back down to my ground state. So, it will do that and then most of the time it will give off one of these green light photons. That I guess is one of the most common colors in the auroras, one of the most common things that happens is the oxygen gets hit, goes up to this higher level and then emits this green light.

[22:24]

Nathan: Most frequently when I've seen it it's this pale green.

Sean: Yeah, the oxygen can give off that green light but at the very, very high end of the atmosphere, it can also actually give off a red photon and what happens there is actually kind of interesting. Ah, the red photon, ah, we don't have to get into the details but it's what they call a forbidden transition.

Laura: They're actually both forbidden transitions.

Sean: Oh, they're both forbidden transitions but the red one is more forbidden. It has a longer lifetime so when that electron knocks the oxygen atom up into this specific level the oxygen atom doesn't really like to give off that photon, it needs a couple minutes just sitting there in this excited level before it will finally give up that photon and emit that red light. And at the lower levels of the atmosphere it turns out that that oxygen atom is probably going to bounce into another oxygen atom before that ever has a chance to happen. So, lower in the atmosphere that red light never gets emitted. The energy gets washed away by other oxygen atoms. But at the very top of the atmosphere it has the time to sit around for a couple minutes and wait for that red light emission to happen because...

Laura: There aren't enough...

Sean: It's not going to hit any other atoms, it's too diffuse up there.

Laura: There aren't enough collisions.

Sean: Yes.

Nathan: So, that's why you don't see that many people in red light districts.

Laughter.

Nathan: But they're all excited.

Sean: Exactly.

Laughter.

Sean: Very excited.

Nathan: Okay. Okay. I'm getting this I think. Where were we.

Sean: Okay, so the at top, yes...

Nathan: I mean, with your

Sean: We've got this oxygen that is doing most of the job for creating this glow in the sky. But actually when the aurora is particularly strong, when you have a lot of charged particles, some of them sort of make it down even further into the atmosphere, even closer to the ground. And that's where you get to the point where you actually start getting more of the nitrogen molecules the N2 molecules which are what we have most of our atmosphere down at ground level is actually nitrogen and there's lots of it. So, once you get down below this very tenuous upper oxygen layer you start getting more and more of this nitrogen and what you get is that instead of hitting the oxygen atoms these electrons from the solar wind are now smashing into nitrogen as well and those produce a whole different set of colors. Nitrogen tends to emit both red light and blue light so you end up sometimes getting a sort of magenta-pink combination of those two and that's one of the other colors that sometimes people see in the aurora.

Nathan: Okay, so why does it look like curtains?

Sean: That has to do with the field lines, it's the way that the electrons get sort of tangled up and run down the field lines.

Ben: So, all of these charged particles in this big cloud of hot charged particles end up running along these specific field lines. And so, because they are all running parallel to one another you end up with, essentially long filaments, and so it looks like the northern lights are made of these shimmering filaments.

Nathan: Sort of like a beaded curtain or something.

Ben: Yeah. Sorta like a beaded curtain. A glowing beaded curtain. Like it the...

Nathan: A glowing beaded curtain.

Ben: Like it's the 70's and the 80's.

Nathan: Unintelligible crosstalk.

Sean: Also, an effect where the lights seem to dance from the top down to the bottom. There's also an affect that has to do with the fact that that red light at the very top of the atmosphere, there's a time delay, right, because those oxygen atoms that I said have this forbidden transition, they sit around for a couple of minutes before they emit their light but the same little chunk of electrons, some of them excited oxygen that's going to emit green light that happens a little bit faster than, there's a whole couple of different time scales for that emission to happen and so you end up with this effect where it dances up and down.

Nathan: Sort of pulses. Yeah. Is this the point where I can just toss in a random question just for fun.

Ben: Yeah man.

Nathan: This solar wind plays heavily in my books because we have solar sails and that's what drives my ships. But one of the problems that one of my ships ran into in one of my stories was a coronal mass ejection as opposed to this just general wind and that was a lot of fun for me to research. Do those things come close to earth, are they different from what we've been talking about in terms of the ionized plasma or are they actually something different.

Laura: Well they are actually the same composition more or less as they are an ionized plasma. It's just often what's in the coronal mass ejections are the same particles but with higher energies so they are moving faster, they have more energy.

Sean: They're not always directed towards the earth but when they are then you're likely to see some really fantastic auroras.

Laura: They can be more directional because the coronal mass ejection will often come out of a coronal hole in the sun. Just like a, it's like a kind of a hole in the magnetic field in the sun.

Ben: Yeah, it's interesting that bring that up because on episode 17 we were talking about sunspots and coronal mass ejections and this is interesting because there is something like an 11 year cycle on highs and lows of strong northern lights.

Nathan: Does that correspond to the 11 year sunspot cycle.

Ben: It corresponds to the 11 year sunspot cycle. So, we get into this a lot more in episode 17 but in essence what happens is the sun has this big magnetic field.

Nathan: I should have listened to that one first.

[27:29]

Ben: It's okay, don't worry about it. The magnetic field of the sun because the sun is this big ball of plasma, it turns and it wraps and it pretzels up it's magnetic field until sometimes deep inside the sun a hoop shaped magnetic field will form. So, it will get pinched off from the rest of the magnetic field and this hoop shaped magnetic field will bubble up from inside the sun and where this hoop of magnetic field lines crosses the surface, it will cross the surface in two points, because it's a hoop. At the those two points, those two points are sun spots, so those two dark spots correspond to where this hoop is crossing the surface and earlier I was telling you about how anytime you have a magnetic field line charged particles get stuck on magnetic field lines like a bead on a wire. So, what happens is, as these hoops of the magnetic field emerge from the sun, they get all these charges stuck on them. And so, as these hoops emerge the magnetic field kind of whips out into space and in doing so it accelerates and shoots off all of these charged particles that run along this expanding magnetic field and so more often you get these sunspots the more often these hoops of magnetic fields start bubbling out through the surface of the sun. In essence I'm describing coronal mass ejections. You end up with these long, kind of tails of plasma that flail off into space. And if we get hit by a flailing tail of charged particles suddenly that throws a ton of charged particles into the earth's magnetic field and that causes aurora. So, that's the big connection between, I mean, all coronal mass ejection is it's just, instead of a constant kind of blowing breeze of these charged particles, is it's a firehose of charged particles that shoot off the sun and if we get blown by one of these geysers of charged particles, it's the thing that knocks off all the satellites and everybody predicts doom and gloom when it's about to happen. It can knock out power grids.

Nathan: So, it is sort of related to the northern lights but just more so.

Ben: That's right. In fact it causes big northern lights. So...

Nathan: Big northern lights.

Ben: We're kind of around the time where we should see more coronal mass ejections, more sunspots, so that means that in the years around now, so, in the next couple years we should see a lot more northern lights than we will in 5 years time.

Nathan: So, we have to be far enough north to see them, that's why, or south. We've been talking about northern lights but there are southern lights right?

Ben: Yes, that's right.

Nathan: And so we have to be far enough north to see the top of the atmosphere from where we are when it's dark.

Sean: Yeah, essentially.

Nathan: We don't have to be really far north, we only have to be far enough north to see where these excited atoms give off there photons and if they give off their photons, what are we talking about, 50 km up? A 100 km up?

Sean: A 100 to 200 km up is where most of it happens so.

Nathan: So, we run a cord across the surface, how far away do you have to be? I mean, I've seen them in Maine, you know, 45° North.

Ben: Right, right.

Sean: Right.

Ben: So, incidentally, there's something I haven't researched but I've come across it a bunch while I was prepping the show so I'm not exactly sure how it works but I think what happens is sometimes when one of these big coronal mass ejections comes and smacks the earth, slaps the earth, associated with it is a big magnetic field and that kind of smushes the earth's magnetic field lines.

Laura: Yeah, it's a disruption.

Ben: Yeah, and it causes the entry point of the plasma into the lower atmosphere where we see it creating aurora, it causes that to happen at a lower latitude than we're used to. So, you know, when they say, we're going to see northern lights in Maine, it's because this has just happened. The earth's magnetic field has just been slapped by the sun and it has deformed it enough that it has rerouted the plasma so that we can see it at these southern latitudes.

Laura: I think it' something having to do with how close you are to the magnetic pole.

Sean: Right.

Nathan: That would make sense.

Sean: So, the magnetic pole and the geographic pole aren't quite aligned.

Laura: Or, yeah.

Sean: The magnetic pole being in the middle of Canada basically. It's actually a little bit closer to people in North America than it is to people in Europe. You can be further south in North America and still see it than in Europe. Interestingly enough.

Nathan: I'm an amateur astronomer and one night in Maine and I'm going to say, 30 years ago, it was one of those nights where the seeing was marginal I was not really happy, it was early winter, and that was the only time that I ever saw the entire sky flooded with northern lights. It went from horizon to horizon.

Sean: Interesting.

Nathan: And this was in Southern Maine and we were in the middle of some huge solar storm that happened. It had to have been 30 years ago now. But it was astonishing and one of the things that has always stayed with me, the reason the northern lights have always stayed with me, growing up as a boy we would go outside and see them quite frequently at the farm. And then, growing up as an adult to see the whole sky go electric green and swirl was just staggering.

[32:25]

Sean: That sounds pretty awesome.

Laura: It does.

Ben: Yeah. Did you know about aurora on other planets?

Nathan: I would assume that it was any planet that had a magnetosphere should, well, it would have to have some sort of atmosphere as well, right?

Ben: Yeah, that's right. So, Mercury has a magnetosphere. It's got a magnetic field around it but it doesn't have an atmosphere or much of one so you don't really see aurora and then Venus doesn't really have a magnetic field and so you see aurora but you only see them kind of on the dark side. I think?

Nathan: Right.

Laura: Yeah, the night side.

Nathan: But that would be more of a direct impact rather than a magnetosphere directed particle right?

Ben: That's right. Yeah.

Sean: Yeah.

Ben: So they're not streamed up to the north and South Pole.

Laura: Yeah, I think it's more diffuse on just sort of a general glow.

Nathan: Cool.

Ben: The big famous one that made the news fairly recently was Cassini around Saturn.

Nathan: Yeah.

Ben: Have you seen these photos?

Nathan: I haven't seen them yet. I keep hearing about them but I haven't dealt with them yet.

Ben: Oh, they're amazing. It's just exactly what you'd imagine. You look at Saturn and then at the North and the South Pole there's just a little ring of glowing blue.

Nathan: Oh, that's so cool.

Laura: And Saturn has a much stronger magnetic field than the earth does and a thicker atmosphere to boot so I think the effect can be much more pronounced.

Nathan: Even though, being that much further out the plasma is going to be thinner.

Laura: It's thinner but like I said, the magnetic field is stronger.

Sean: Yeah, it's...

Nathan: It's huge.

Sean: Saturn's would just be more efficient at sucking up the particles that do...

Nathan: Cool.

Laura: We also see it on Jupiter which also has a stronger magnetic field than the earth.

Ben: You see it on Uranus.

Sean: I think you do.

Laughter.

Ben: Well, that was great. So, thank you Laura, thank you Sean. You've pleased me. Your efforts have born fruit and that fruit is sweet. Here's some fruit. So, Sean, you get partridge berries.

Sean: hmmmmmm

Ben: How does that taste?

Sean: Delicious.

Ben: And Laura you get the southern most fruit, you get a kiwi. Nice. Alright, I'd like to thank my guest Nathan Lowell. Thank you for coming on the show.

Nathan: Thanks for having me.

Ben: I hope that we weren't too foolish and that you enjoyed it.

Nathan: I did.

Laughter

Ben: Okay, my Ti-Phi-ters. Let's suppose you want to interact with the titanium physicists a little bit more. There's a variety of ways you can do this. Why don't you go to our website at www.titaniumphysics.com. Once you're there you can follow a link to our online store where you can buy a cute Ti-Phi-ter t-shirt designed by none other than Chealsea Anderson or you can follow a link to our brand new forums where you can hang out with us and you can be our online friends. Or, if you'd like to send me an email directly, click the contact link on our website for some sweet addresses. So, please send me your ideas, send me your questions or even volunteer to be one of our Titanium Physicists. Now, let's suppose you want to listen to our show a little more conveniently. If you've got and iPod or an iPad you can try subscribing to our show using the iTunes store. While you're there write us a review. We read every review you write us and it helps new people discover us. If you have a Zune or a BlackBerry you can subscribe to our show on those doodads as well or you can download the Stitcher radio app which will will let you subscribe to listen to all of your favorite podcasts. You can download the Stitcher app for free onto your iPhone and android phone Kindle fire or other devices. Stitcher is convenient because it lets you subscribe to your favorite podcast. The titanium physicist podcasts is a member of the BrachioMedia if you enjoyed our show you might also enjoy Science Sort Of or the Weekly Weinersmith, check them out! The intro music is by Ted Leo and the Pharmacists and the end music is by John Vanderslice. Good day my friends and remember to keep science in your hearts.

[37:14]

Ben: Yeah, what's your next novel going to be?

Nathan: Uh, next novel is the one I'm working on right now is the sequel to Ravenwood, it's called Zypheria's Call.

Ben: Okay. Is it in a series? Should I read it.

Nathan: It's fantasy. I have a fantasy series.

Ben: Oh. Is it...

Nathan: It was a bet. In 2009 Mur Lafferty who's one of the other podcast authors dared me to do NANOWRIMO, National Novel Writing Month, in two weeks instead of a month so I had to write 50,000 words in two weeks and that was no big deal for me so I said sure, we'll do that and somebody else said, okay, well if you're going to do that then write a fantasy instead of science fiction because it's not fair for you to write your most familiar genre so you have to change it up a little. Alright, so I have to write a fantasy, a 100,000 words in the month of November and it has to be fantasy, and, uh, okay. And then another one popped up and said well alright if you're going to do that, you always write these male characters. All of your characters are always men, so I want your main character in this book to be a female. So, the challenge was thrown down that I write a female, fantasy, a 100,000 words in 30 days in November.

Ben: Awesome

Laughter

Nathan: And so in order to have it be a story that would be one of mine what I had to do is take the trope of fantasy and twist them enough they were still recognizably fantasy tropes but weren't the classic kind of fantasy that everybody has read seven thousand times and is growing quite bored with and hates.

Ben: Right.

Nathan: So, so I took the standard trope of the standard quest fantasy and the standard quest fantasy is young person leaves home, runs away from the farm gets puberty and power and saves the universe. Goes home and discovers that everybody's still there and nobody really wants to talk to them. So, that's a standard quest fantasy and so I thought, well, okay, this person who runs away from home is leaving all the chores for someone else to do, that's kind of crappy. And, why is it that they always comes into power as they come into puberty?

Ben: Right.

Nathan: I mean, I see the transition but aren't there other stories that we can tell. And so, my transition was looking at a different tradition of transition and that's, particularly in females from maiden to mother is the classic one. I went from mother to crone. So that as the all mother takes away the fertility she grants this other power to women of a certain age. And so, rather than leaving home, running away from home, the idea was that this woman was going to be trying to get home. Because she's been on the road for 20 winters and she wants to try to get home. And in her case home is not the farm that she left because she left an abusive husband and what she's trying to do is get to the last of the old witch women which holds some knowledge and some information that she wants about some, the herbs and medicinal plants of the world she's on. And if she can get there then she will have made the rounds of all the known witch women in the land of Coralay and she will be in the position then of being able to collect all of her notes together and to settle down in her final last big work is she's planning to write this book of all the medical lore of the land of Coralay. So that when she leaves the legacy, she'll have a legacy that will allow people who have not spent twenty years scouring the landscape to actually learn from what she's managed to put together. And so, the story is, the first book, it's a trilogy, the first book is Ravenwood, I wrote that in 50,000 words in 14 days and then 50,000 more in 11 days and wound up with 110,000 words at the end of the month. That's one's out. It's been out since Christmas of 2009. And I've had a lot of people who are very anxious to get the sequel and so I finally finished off the space opera, the Share books, the six Share books. I finished them off and so now I'm going to try to finish off the trilogy to give Tanyth Fairport who's the main character, her own little trilogy, her own little series to run out. So Zypheria's Call is book two, it's the middle portion of her journey where she's first discovered that she thinks she's going mad because she has these strange things happening to her that don't make any sense and she doesn't really quite understand what it's about but she knows she' supposed to go see this woman so her journey is in part exploring the world she's in and explaining it to the people who are new to it because they are the reader. And then her journey, the middle part of her journey is the sea voyage where she actually has to deal with the fact that she think she's going mad but the people around her are going no, you don't seem to be crazy, uh, this stuff is happening. So, we're not quite sure why or how but perhaps you should go visit Girdy Pinecrest and find out why. And along the way she gains more and more powers and more and more, what turns out to be magic, but magic doesn't exist in her world so for her it's strange, it's weird. It's not what people do and yet she's able to say her prayers which turn out to actually be quite powerful spells and she does it almost instinctively and as part of her danger, it's a part of what she does. And so as she goes through the menopausal change and she goes through this change of life she's also undertaking this new struggle for understanding for how does old age actually feel. How does this work? What does this mean and am I going crazy.

[43:44]

Ben:That sounds...

Nathan: So, I'm doing book two now and then book three is The Hermit of Lammas Wood, I've got that about a third of the way done. I need to go back and visit that because I've made some significant changes in the second book. But Ravenwood is out, you can listen to it, it's on iTunes. You can actually buy it, you can read it if you want. It's on Amazon, it's on Barnes and Noble.

Ben: Sweet. Okay, yeah, I need to give you a compliment by the way. So, I like to listen to audio books a lot. I'm addicted to information. So, anytime I go on a car trip I have to listen to audio books and my wife is exactly the opposite. She hates listening to stories while we drive, she likes music instead. Except for your stories, so she'll compromise and she'll listen to your audio books.

Nathan: And so, have you listened to Ravenwood?

Ben: No! Not yet!

Nathan: Try her out on Ravenwood. A lot of people who don't like science fiction like my science fiction and a lot of people who don't like fantasy like this because it's very, it's not swords and... It's swords and sorcery but it's not the classic standard trope and in some parts it's a little, I mean, there's, I mean, there's a body count. But the, my main character is a woman and at no point in the story does she ever have to be rescued by a man.

Ben: No, that's good.

Nathan: I get a lot of women who write to me and say they like the story and I get a huge number of men who write to me and say they like this story. So, a lot of the old, my science fiction stories get a lot of ex-navy, a lot of retired marines, a lot of people who have been out there floating who understand what this life of being watch stander actually is like and they will write to me and say, yeah, you had to have been, you had to have done it and I did and they pick up on that and they know it and they really like these stories because they are simple stories of simple people doing really extraordinary things without a whole lot of fanfare because that's just what they have to do. And so, with Tanyth Fairport and her stories, there's a similar kind of idea where we're not really trying to save the universe from the ultimate evil, what we're trying to do is figure out why this little old lady is trying to figure out why she thinks she is going mad.

Ben: Hey, when she has hot flashes do things around her melt?

Nathan: No.

Ben: Ohhhhhhh noooo! Okay, it's good that you told me because I would honestly spend the entirely trilogy waiting for that to happen.

Laughter.

Nathan: Waiting for that to happen. No, no. But I, I've had a lot of complimentary, I was very nervous about doing this book, I was very nervous about doing this book. It's bad enough for a man writing from a female's perspective, and in order to treat it with the respect that it needs and deserves, I was very trepidatious about that. But I, you know, you sit down and when you actually start to write and you think, well, she's a person first, and so we write about a person and oh yeah, she has this odd thing that happens to her every once in the while, she's in the middle of the winter and she wants to open the windows because it's too hot or all of the sudden for no reason whatsoever she can think of right off hand but suddenly these people who have been around her are way too loud and they're kind of being pissy and she really would just like to slap them and go have a cup of tea and sit in the corner for awhile. And you don't really you know, that's not really her, I mean, it's just a part of what being in that character is, and so I think that the ultimate compliment I got was one of my reviewers said that I was as comfortable in a woman's small clothes as I was in a spacers shoes. And I thought that was kind of an interesting comment but I took it as a compliment because it meant that I wrote a character that was recognizably not a man wearing a dress, and not a cliche. And which are both significant problems when trying to write the other.

Ben: I'm really looking forward to it.

Nathan: Give it a try, the next time you go for a ride, Ravenwood, I think it's like eight hours.