Episode 28: Smoke Like Swirls on the Moon
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Transcribed by Denny Henke

Ben: Oh. Hello old friend, it's good to see you. Let's talk about this word fascination. It describes an unquenchable urge which compels our hearts to quest and be captivated. As long as there are elegant explanations to complicated phenomena science will never lose its romance. Over the years I've traveled the world indulging in my fascination with physics and now I find that a new hunger has woken within me. A fiery need to share these great ideas with the people around me 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]

Hi everybody. I want you to close your eyes. If you're driving right now pull over and then close your eyes. Are you eyes closed? Alright. Imagine that you're sitting by a fire on a summer evening. It's warm and you're happy and comfortable. Can you see it all in front of you? You're by a lake and you just ate some dinner and the summer air is getting cool but the fire is nice and warm. Look at the smoke as it twists into the sky. It's wide in parts and narrow in parts and it puffs and billows and twists. Ah, so relaxing. Okay, you know the twisted, curled pillars of the smoke? We use the word swirls to describe it, smoke swirls up as it climbs up and up into the evening sky. Oh, look, there's the moon. Now, on clear summer nights the moon is a wonderful thing to talk about. Look up at the sky. There it is sitting just above the eastern horizon. It's a big full moon shining through the evening gloom like a friendly, gray friend. Wave at it. Hey old buddy. You've always been there. Ever since I was a kid. Thanks for watching over me. Yeah. The moon is nice. English people, you know, say that there is a man on the moon because of the dark patches on it kind of look like a face. The Japanese people say that it's got a rabbit in it and the rabbit is pounding rice cakes with a big hammer. Speaking of how the moon looks, did you know that there is still an unsolved mystery about the moon. It's true. It's not about cheese. Neil Armstrong tasted the moon when he was up there and he said it was made of rocks. No. The lunar mystery is that there are these little swirls on the face of the moon. Little is the wrong word, but it looks like somebody took a photograph of the smoke rising from our fire and then colored the moon in a few places to look like that. These features are big, I mean they are tens of kilometers wide. They're bigger than New York City big and no one knows why they are there. Well, that's not quite true. Today, let's take advantage of this warm summer atmosphere and talk about the lunar swirls.

So, you know, the thing about the moon is that people like to look at it and they think it's perfect and unattainable but that's not helpful or interesting to anybody. And sometimes people think that other people are perfect and unattainable too and that's even less helpful. You can't make friends with someone if you treat them like they are the moon. Anyway, a while ago a guy named Jordan Harbinger emailed me because he really, really wanted to become a guest on the show and Jordan is a magnet. He's built an empire teaching nervous men how to charm people. He has a podcast called the Pickup Podcast where he and his co-host talk with experts about Starting, building, maintaining and even healing from relationships. So I thought, hey, let's tell Jordan about the moon. Hi Jordan, welcome to our show.

Jordan: Hey, thanks Ben. It's good to be here. This sounds like, it was a very poetic entrance, I like it.

Ben: Yeah, well, it, lunar swirls, it was either that or butt jokes. So, for you today I have assembled two of my finest Titanium Physicists. Arise Dr. Catherine Neish! Awesome. Dr. Catherine was an undergraduate with me at UBC and she did her PhD at the University of Arizona in Planetary Science. She's currently at the NASA-Goddard Space Flight Center where she studies planetary science. Now, arise Dr. Sebastien Besse! Dr. Sebastien got his PhD at Marseille in France. He's currently at the European Space Agency in the Netherlands where he studies planetary science as well.

Okay. Well, so let's start talking about lunar swirls.

Catherine: So, swirls are these amazing features that we see on the moon. I think, honestly, you can see them with a very simple telescope so probably people have been looking at these things for hundreds of years and just not knowing what they were. But these wonderful features that we see, really all over the moon, are extremely bright. Brighter than most other things on the moon which is why they pop out so much. And what got really interesting, once we started sending spacecraft to the moon is it turns out they're, all them, are associated with these regions of really high magnetic fields on the moon. So, not only are they beautiful and bright but they also have this mysterious connection to the magnetic fields on the moon. And since then people have been coming up with all sorts of interesting ideas to try to explain these, these wonderful features. They're very strange although they have high albedo, and when I say albedo I just mean the brightness you see with your eye.

Jordan: Okay, so I can't see these from Earth though, can I?

Catherine: I think you'd need a telescope. You know, not a really good telescope but...

Sebastien: Sometimes when I look at the moon I think I see them but that's because I know what I'm looking for.

Jordan: Okay. So you're like, advanced moon people know what they're seeing whereas I'm like there's a little biddy spot like no, that's a swirl dude.

Sebastien: That's the problem, when you know what you're looking at, you see that, even if it's not there.

Jordan: Interesting. So, and how many are there? Like, are these all over the moon or are they just like, there's a few?

[6:53]

Sebastien: Um...

Catherine: About a dozen.

Sebastien: Yeah, there's about like between 11 and 12, counting, but that's.

Jordan: Between 11 and 12, there's 11.5 swirls.

Sebastien: Yeah, well, 11 and 12, 13, people are, just like, keep counting them. It's really, I mean, the way that you detect them is bright features and they're supposed to be swirly, that's why we call them swirls. And the distinction between the swirls and something bright and a little bit swirly is really not sharp so sometimes people count some features as swirls and sometimes not so the exact number is actually quite difficult to get.

Jordan: Okay, so why are they bright? Why do they have high albedo?

Catherine: We think it's related to something called space weathering on the moon. So, there are a couple of different processes that tend to make the moon darken over time. And so the lunar soil, what we call regolith, gets really dark whereas the stuff underneath it will remain bright because it's not exposed to the processes that are causing the top of the soil to get dark. But if you can expose that bright material underneath or somehow prevent it from being weathered in the first place, ah, you can get these bright features.

Jordan: So, something's exfoliating the moon and making these swirls.

Catherine: Or it's like sunscreen and you didn't need to exfoliate because you just protected yourself from the beginning.

Jordan: Okay.

Sebastien: Basically you can say that they're bright because they're young. And that's a, that's a one to one correlation can do on them easily when you're brighter usually means that you're younger. And uh, from the naked eyes you can see some bright ejecta craters on the moon and those usually mean that you are looking at the youngest crater that you can find on the moon so meaning the youngest impact that occurs on the moon. So, the swirls are, an easy description would be they are bright they are young.

Jordan: Okay. So, like something's oxidizing or whatever the surface of the moon and these parts have less than that.

Sebastien: Yeah, in that case that's ah, some part of the moon protecting the surface to be, ah, what we call space weathered to get darker.

Jordan: But there's no weather on the moon right so what is the weathering that is not happening in the swirly parts?

Sebastien: Well, what we call the space weather is how the surface, and this term is used actually for all planets, even for asteroids and whatever the solar system and beyond. Is all the interactions you're going to have with the surface of the planet is universe around you. And basically, in the case of the moon, because you don't have atmosphere, no atmosphere that is actually weathering the surface, what is weathering the surface is mainly the um, impacts. So, you have like asteroids or comets are going to impact the surface of the moon. And that's a part of the space weathering that's going to create some small rocks. The rocks are going to melt and you are going to create some new products on the surface and that's what's going to make part of the moon darker. The other part is actually through the interaction you have these really high energy particles coming from everywhere in the solar system. Coming from the sun, coming from the cosmic ray, coming from all over the Universe. And these high energy particles, they're going to interact with the surface, creating different kind of new material, on the surface. And these two processes, the impacts and the high energy particles, that's what we call space weathering.

Jordan: Okay, it's constantly being bombarded and these swirls happen to be the areas that are least bombarded.

Catherine: That's one idea. is that they are protected from these processes, at the very least, the solar wind processes. It's hard to protect things from impacts on the moon. Ah, the other idea is that somehow you are exposing the material underneath the top of the soil which is not weathered and therefore brighter. Oh, I guess a third idea would be that you're somehow depositing brighter material in there but as we'll talk about, I kind of favor the first idea, that you're just protecting the surface from getting weathered in the first place.

Jordan: What's protecting the surface then.

Catherine: Well, so, there are a couple of different ideas for what might be causing the formation of the swirls. And one of them is something I like to call shielding from space weathering. So we have this connection to the magnetic field. And that's really a hallmark of a swirl is, not only is it bright albedo, but it's, it's related, it's in the exact same place as we see these areas of high magnetic field on the moon. And so something about the magnetic field might be diverting the solar winds, say, and protecting the surface from these processes that Sebastien was talking about.

Jordan: Okay. But wait a second, so we're not really sure what's really, maybe protecting the moon in these spots.

[11:29]

Catherine: So, for a long time we didn't really have the best data in order to test several of these hypotheses and maybe I'll just touch on them briefly. So, the first idea I had mentioned was this differential space weathering that it's getting protected from the weathering by the processes of the magnetic fields. Another idea is that this comet sort of deals the moon a glancing blow and are able to sort of scour off the top meter or so of the soil there. More the exfoliation idea talking about. And then there's another idea that somehow the magnetic field sets up an electric field which causes all this dust that's on the moon to be picked up and thrown into these areas of high electric fields because it's attracted. Dust is electrically charged and so that electrically charged dust would be attracted to an electric field. So, those are the three main hypotheses that people have sort of put together to try to explain the swirls. And it was very hard to test these hypothesis for many years because we just didn't have very good data but in the last five years or so the whole Earth has sent an armada of spacecraft to the moon. Not only the U.S. but also the Japanese, Chinese, Indian space agencies have all sent lots of spacecraft to the moon So, we're getting these fantastic new data sets and we're really starting to be able to test some of these hypotheses for the first time. And my personal opinion I think the whole sunscreen idea, the protection of the lunar surface by these magnetic fields seems to fit the data the best so far.

Jacob: Okay. So, who discovered these in the first place? Just like old school astronomers?

Sebastien: Who discovered what?

Jacob: The swirls.

Catherine: I've not been able to find that anywhere. I assume it was just some astronomer hundreds of years ago. I don't know Sebastien, if you know.

Sebastien: No, no. That's just like people working on it so far away in time that we don't even remember.

Catherine: Yeah, maybe it was Galileo.

Jacob: Yeah, that's what I was going to say. That's the only astronomer I really know about, Copernicus and Galileo.
Catherine: Yeah. Yeah. I think people didn't know what they were though, because with these, you know, crummy little telescopes you just saw bright spots amongst dark spots and most of the bright spots are just craters. Although back then they didn't know that either.

Sebastien: On the moon you have this swirl which is the most famous one which is named Reiner Gamma which is actually pretty big. And it is located on the mare basalts you have on the moon which are darker materials because of the composition and not because the space weathering. And so you have these really bright features on a dark background, so you can really easily see that and it's just like on the near side of the moon so you can't miss it. So, I bet that, you know, Galileo should have seen it. No problem on that.

Jordan: So, do the swirls do anything? Is there any function whatsoever, or is it just like the way that they look like the red soil in Arizona?

Sebastian: No, they don't have any function that we can be described but there is um, I mean to go back to the um, to the theory and the fact that we kind of inferring one to the theory that we have is that with some of the data from the Indian Mission, we found that these swirls, based on the, I mean, probably you heard about this history of water on the moon. It was in 2009, where a lot of scientists put some new data and discovered that there is a really thin layer of water and hydroxide on the surface of the moon. What we found is that actually on the swirls they don't have water. It's kind of disappointing but they don't have water at all. And um, so the function they have, actually, protecting the surface of the moon, to be wet, that could be one function. And that was actually, a really be discovery when we, found that they were low in water, because the way that people thought that water might happen on the surface of the moon is that you have an interaction between the surface of the moon and the high energy particles coming from the sun. And when we had these ideas and we found that there was no water on the swirls a couple of us just were like damn we have the answer. This magnetic field that is protecting the surface from being weathered by the high energy particles from the sun. And because we don't have interaction of these particles with the surface, that's why we don't see the water on the surface where we have the swirls. And at the same time we just like came with one good answer of how you create this thin layer of water on the surface of the moon which looks really to be in the direction of the solar wind with the surface. And in the mean time we just say because you have the magnetic field that are protecting the surface from the high energy particles then you don't weather the surface and then you create the swirls. So with one set of observations almost only, we have to wait for a couple of years, we almost responded to two very important questions that a lot of people were still debating about. So it was a pretty big breakthrough and still some stuff to do on it I think.

Jacob: We haven't gone to the moon in a really long time, right.

Catherine: We haven't sent people to the moon in a really long time but we have spacecraft up there right now. Orbiting the moon, taking pictures, collecting data. This is what I was talking about, there's been this resurgence of lunar science in the past five years because of the new orbiting spacecraft. So, no we haven't landed on the moon recently, I guess we impacted it with a rocket a couple years ago. But basically we've just been observing it. But you can learn a lot about the moon simply by collecting images from orbit.

[16:51]

Jacob: Cool. Are the swirls all in one part of the moon or are they sort of evenly distributed across the surface?

Catherine: They're everywhere. And it's sort of curious why there are so many of these little, and we also see, like I said, with magnetic anomalies. So, where there's a magnetic anomaly there is a swirl. Although not all magnetic anomalies have swirls. A little digression there.

Jacob: Yeah.

Catherine: But basically we find these magnetic anomalies all over the moon.

Sebastien: All latitude and all longitude, almost.

Catherine: Yeah, they're pretty well distributed actually. It's not really well understood why these magnetic anomalies would be so well distributed but one of our colleagues published a paper last year suggesting they might be related to the largest impact basin on the moon. This is a crater called South Pole-Aitken basin that's on the far side of the moon so you can't see it from the Earth but it appears to be the biggest and the oldest impact crater on the moon. And there's actually been a couple of missions proposed to fly there and return a sample back to Earth from that location. But they have not been funded by NASA yet, unfortunately.

Jacob: We're busy with Mars.

Catherine: That's right, everyone loves Mars. So, anyway, there's this crater and like all craters when it was formed it probably ejected a whole bunch of material all over the moon. And when you correlate these magnetic anomalies you see that a lot of them are right at the northern edge of this crater. And so the idea is that maybe when this crater was formed it ejected a bunch of metal rich blebs of ejecta that got tossed all around the moon and perhaps when it was formed like, say 4 billion years ago, ah, the moon did have a magnetic field. It doesn't have a global magnetic field now but it's possible that it had one in the past.

Jacob: Cool.

Catherine: These blebs, these metallic rich ejecta got magnetized. And then once that magnetic field, the old magnetic field went away, they retained their magnetization. And so they're the remnants of the ejecta of this giant impact on the moon.

Jacob: I see. So, what might have happened is the moon had a magnetic field and then this metal retained it and then of course it got smashed and blasted all over the place. But since that stuff was magnetic and retained it's magnetic properties longer there are these weird, like, super magnets all over the moon from this explosion.

Catherine: Something like that.

Jacob: I'm trying to make it sound really bad ass but...

Sebastien: That's one of the hypotheses. Another one is that actually, a couple of the swirls, I think it's about half of them, they actually located at the antipodal of this big basin, impact basin, and one of the ideas is that this impact basin they create seismic waves and when they arrive on the other side of the planets you're going to create a localized magnetic field in this region and that's how you can create these pockets of magnetic anomalies that the swirls are correlated to. I think actually that one of the biggest challenges that we have to face to understand even better the swirls is to understand how you create these magnetic anomalies where the swirls are. And that is something that is still really debated and a lot of people are actually working out trying to understand how you create this magnetic anomalies. That's something important because you see that you always have swirls where you have magnetic anomalies, so this is really, the connection is really important. And if you understand better how you create these magnetic anomalies. Hopefully we'll also understand why we don't have swirls all the time when we have magnetic anomalies. So there is still a couple of things to do in terms of science to understand swirls and they're really not related to understanding the magnetic anomalies and how to create them.

Jacob: Okay, cool. And so, now, what are the swirls made out of entirely, like I don't...? Are they made out of, are they giant piles of dust? You said that they're, this is sort of two questions. So one, what are they made of and two you said that they are tens of kilometers wide, does that mean, are they like, elevated? Are they depressions in the moon?

Catherine: No. They are completely flat. That's the other interesting thing. They have zero topographic expression. Um, as far as we can tell. Really, I mean, you can't see even tens of centimeters or a meter worth of relief there. It is very flat. So, it just looks like a superficial coating. It's like I said, like an artist took a paint brush and painted lines on the moon. And so, that's another, you know, interesting piece of the puzzle. But, you could explain that simply by, you know, here you had a part of the moon that is was weathered by the solar wind or by tiny impacts. And right next to it was an area that wasn't weathered . And when you look at them in terms of their maturity, how old they are, compared to other parts of the moon they look extremely young. They look brighter than even the freshest craters we see on the moon. So, more likely it's just that that part of the lunar soil never got dark because it never got weathered but like the surrounding material.

[21:48]

Jacob: So, I'm kind of envisioning almost like the top of a cup of cappuccino. Like it's still just the same as all the other foam except for some is whiter and the other stuff is brown.

Sebastien: Yeah.

Catherine: Yeah.

Jacob: Or am I not getting the image.

Catherine: Sure, except, except the foam is extremely thin. I guess.

Jacob: Okay. So, yeah, it would be like if there was just like half, just the tiniest single bubble layer of foam on top.

Catherine: Yeah, exactly. A mono layer of foam. So, that would be a pretty terrible cappuccino.

Jacob: Yeah.

Sebastien: The thing is that because this is actually a really thin layer, these swirls are really fragile. And ah, the questions that you can ask is that in some places you see some features that, as I was saying before, look almost like swirls. But they're not very swirly and you wonder actually if they are older and probably with time because of impacts and all the processes you're going to slowly destroy them and you're not going to see them really as fresh swirls as you see from some others. And there is some debate, some people want to send spacecraft and to observe the swirls and to do that you have to be really close. There is also some projects that you know, crash spacecraft on the swirls. The problem is that, I think, that if you do that, well you have one time because after that you're not going to see the swirls anymore. So that's um, this is a fragile feature that we have on moon.

Jacob: Yeah, it sounds like, pretty dangerous. Like all the second graders have just made a bunch snow angels and then all the fifth graders are going to run over there to see what they look like but once they get there it's going to be all screwed up and ugly.

Sebastien: Well that looks like a good analogy.

Catherine: I don't know if they are that fragile. I mean, you'd need a lot to disrupt a 10 kilometer snow angel. A lot of fifth graders. But the thing is, I mean, the stuff underneath the swirls should also be bright so if you start, you know, messing with them it's possible you'll just expose more bright stuff so it won't look much different.

Jacob: Are these things dynamic at all. Like, do they change? Like is there any documented changes in any of these things or is it just like this is the way they've always been.

Catherine: Although they are pretty young in terms of lunar, you know, time scales, that could still be millions of years or more. So, unfortunately, there's no process we could observe that would cause them to change over our lifetimes. But since they are probably an active feature that is actively shielding the surface from the solar wind if you were to put a spacecraft there you might see, you know, plasma or different particles coming and going and getting deflected. So, there could be some interesting things there that you couldn't see with your naked eye necessarily but you might be able to see with the right instruments.

Jacob: Huh, okay, cool. So, they're not made of anything that we know of yet. But we think that it might be dust but it's not really, there's not a lot going on to change with these things.

Sebastien: Well, there was an idea from one researcher mentioning that it might be that kind materials or minerals. And the good thing is that is when you - the instruments we sent, we were able to say that no, the theory and the minerals you are invoking are actually not the ones that we see on the surface.

Catherine: Yes. Some materials are brighter than others on the moon. So that was one idea. You were preferentially depositing this brighter type of mineral in swirls but it looks like that's probably not the case. It's more just a case of sunscreen, you happen to put sunscreen on this one area of the moon and you didn't on the area next to it, so. You could imagine writing high on your arm in sunscreen and then you know sitting out is the sun for three hours. So, the high is going to stay white and the rest will be red.

Jacob: Right. It's like those girls tanning with little heart stickers on and then they peel it off... So when the moon is sort of shielding itself in these areas, from the weathering process, what's doing that, the magnetic field then in these swirls?

Catherine: Yeah. It's not well understood. But there was actually a recent study published this year and I kind of like the idea that they proposed. Um, they did some experiments to back it up. The idea is that the magnetic fields are strong enough to deflect electrons. So, there's two main types of particles, electrons and protons. Um, electrons are light and negatively charged, protons are heavier and positively charged. Ah, magnetic fields can deflect the electrons but since the protons are a lot heavier they are able to penetrate and reach the lunar surface. So, now you've set up this case where you've got all these positive protons on the surface, electrons are flying off into space. So, you set up an electric field. Ah, and once you have an electric field in place it can deflect the protons. And so now you are deflecting all the particles coming from the sun and the surrounding space environment.

Jacob: Proton penetration caused the swirls, got it.

Catherine: Yeah.

Ben: Actually, so one of the answers to your questions is actually kind of of subtle and it has to do with how magnetic fields and charged particles interact. So, you know the northern lights?

[26:42]

Jacob: Yeah, I've heard of those.

Ben: Yeah, I guess you're in California. So, you've heard of them.
So, the deal is, the same charges that are hitting the moon, the same protons and electrons coming from the sun are hitting the moon are also hitting the Earth. But the reason that we on Earth are not always being irradiated by charged particles is because when a charged particle meets a magnetic field it will kinda stick to it, vaguely. The answer is it will kind of circle it. The

Earth has a strong magnetic field, relative to the moon I guess, and it's shaped kind of like if you take a whole bunch of bike inner tubes and hold them in your hand.

Jacob: Like you're holding a ring, like a large ring with a hula hoop.

Ben: Yeah, yeah. So, just imagine that you're holding like just a whole ton of, your fist is full of these...

Catherine: Different sizes.

Jacob: Oh, I see. And they kind of span outwards.

Ben: Right, so they kind of splay out. It enters and leaves the Earth through the North Pole and the South Pole. Well, the North magnetic pole and the South magnetic pole to tell the truth. So, what happens is when a charged particle comes in and meets this it will get kind of stuck to the surface of these hoops and it will ride the hoop either to the North Pole or to the South Pole. Where these magnetic fields enter the atmosphere, that's where all the charged particles end up entering the atmosphere as well. Because all these charged particles are following these magnetic field lines up to the North Pole or down to the South Pole. And so that's why we only see Northern Lights up north and down south. And so similar things happen on a smaller scale on the moon, right. So, these magnetic fields, they're still hoop shaped but instead of spanning the entire moon, they're just kind of, it's just like, you know, this rock under the surface of the moon is holding a bunch of them and so different places on the surface of the moon will see different magnetic fields. They'll see the hoops but will also see the hoops kind of hitting them at different angles. Sometimes the hoops will be straight up and down. Well, if you walk five kilometers down west of where you are and the hoops will go sideways with respect to your right. So the magnetic field will have an orientation as well as just a strength. What this means is, this radiation coming in from space won't just be missing some piece, it won't just be blocked and shielded by the magnetic fields, it will also be guided down in places and hit the moon in other places. Right?

Jacob: Hmmm. Okay. Yeah.

Ben: So, when they look at the magnetic field they see a correlation between the direction of the magnetic field and how bright it is. So, the places where the, kind of the magnetic field hoops run parallel to the surface, so, any of these electrons trying to hit the surface will get caught on it and get shunted sideways instead of hitting the surface. Those parts are the really light, bright colored parts. And the parts where the magnetic fields are going straight down into the surface are the places where these electrons riding the hoops will get driven into the ground, those are the dark parts of these things. So, this here is a strong correlation between the shape of the lunar swirl and the magnetic field that's, you know, causing it, I guess.

Jacob: Okay, interesting. So, we don't, I guess it, to me, I don't really fully understand how magnetic fields and things like that work. You answered part of my question which was are there Southern Lights as well, on Earth, which I guess there are. How come the Northern Lights are the ones that are the more famous ones? Is it because there's not many people...

Catherine: Because nobody lives in Antarctica.

Jacob: How come the moon doesn't have magnetic poles anymore?

Sebastien: Well the idea of why you have a global magnetic field is that you have what we call the dynamo which is meaning basically you have kind of a liquid core that is going to be rotating inside the Earth, for example. And, ah, the interaction with the upper layers are almost solid, is actually going to create this dynamo which are going to make this magnetic field. In the case of the moon and for most other planets like Mars, also, for example, the planets are geologically inactive meaning that they have no more volcanic activity because the core is actually completely solidified. And because you don't have any melted, if not liquid core, you don't going to create and um, keep going, this dynamo. And finally the global magnetic field, if you ever created one, is probably going to collapse. And that's one of the ideas of why you may not have a global magnetic field on the moon. But we still have on the moon these small pockets of magnetic fields on the surface. And actually the Earth is one of the, ah, almost only planet that have a global magnetic field.

Catherine: Terrestrial planet.

Sebastien: Yeah, terrestrial planet.

Catherine: The gas giants have large magnetic fields as well.

Sebastien: And the thing, the moon has these small pockets of magnetic field that are completely correlated to the swirls. Make this feature actually very unique and we see them only on the moon for the moment. We've been looking at them on the other planets like Mercury where you kind of expect maybe some of them to be there because you have some magnetic field on Mercury too and you don't see them. And so far the swirls are really typical to the Moon. That's something quite unique and interesting.

[31:46]

Jacob: Very cool. I'm digging it. It's kind of an interesting thing to get interested in. What makes people care about this other than just for the sake of knowledge. Like, is there anything that these could tell us that could be important about the moon? What are these things maybe hinting at of consequence for lunar science?

Sebastien: Well, there's um one thing that I personally really like, and something that we found recently is because they don't have that much water on the surface or hydroxide. It really explains why you can make some of, really tiny amount of water or - on planetary surfaces. And you know that having water on other worlds is something that has been important for life or even if we want to travel or something. So, ah, by studying these swirls we probably understand a little bit better how you can create water on planetary surfaces actively those days. That is something that is actually very important or might be very important for other missions on other planets. Another thing that people are actually looking at the swirls as a very interesting place is that because they have these magnetic fields, they can be very important, very interesting region where you can put a basement, because you can have the magnetic field and that you can protect the settlements from the cosmic rays and the high energy particles. So, basically you can put the people's in these regions, so they're going to be protected. So that's also one of the other interesting things that people are thinking about using the swirls for.

Ben: Alright everybody. That was fantastic. So, thank you Catherine, thank you Sebastien. That was wonderful. Your efforts have born fruit and that is fruit is sweet. Here is some fruit. Catherine you get a banana because it looks like the moon.

Catherine: Nom, nom, nom, banananom.

Ben: Awesome. Sebastien, you get a pomelo because it also looks like the moon.

Sebastien: Oh, great. Nom, nom. I like it. It's yummy.

Ben: Awesome. Alright everybody. I'd like to thank my guest, Jordan Harbinger. Thank you Jordan.

Jordan: Thank you. I'll eat my own fruit over here.

Ben: I hope you had lots of fun. Good luck teaching nervous men how to act less creepy.

Jordan: It's not really nervous guys and the guys aren't worried about being creepy, it's just about developing a magnetic personality like the moon... Used to have.

[34:04]

Ben: Okay, so, hey Ti-Phyters, listen. I love the show and I hope you do too. But, for every listener of the show I know there are a hundred other people who would love to listen but they just don't know how and I want you to spread the word. There are three ways you can do this. First, iTunes. iTunes is still the biggest place where people go to find new podcasts and iTunes puts shows with the most ratings at the front where everybody can see them so if you've got a minute give us an iTunes review and it will increase our rank and more people can discover us. The second way is to teach people how to listen to podcasts. I know this sounds strange but everybody has a smart phone or tablet these days and a very low percentage of these people actually know how to listen to podcasts on their devices. So, if you know somebody who might like the show ask them if they know how to listen to podcasts. And if they don't point them to the Stitcher app. Why the Stitcher app? Well, it's free and it's easy to use and it works on every hand held device so surely your grandmother will thank you for it. The third way to spread the word about the show is to tell people online about us. Now the internet full of explanations about physics. If you see someone on the internet talking about a topic one of our episodes covers post a comment telling them about the show. It will be nice if people started treating podcasts in general, like ours maybe, as reference material instead of just entertainment. Well, anyway, that's it. I hope you'll help us out and point new listeners in our direction. So, thanks.

So, if you like listening to scientists talk about science in their own words you might also want to listen to other shows on the BrachioMedia Network like the Weekly Weinersmith Where Zack and Kelly Weinersmith talk to academics about their research or
Science Sort Of where we talk about science in the news. Editing support for the Titanium Physicists podcast is provided by a gentleman named John Heath. Thanks John. The intro song to our show is by Ted Leo and the Pharmacists and the end song is by John Vanderslice. Until next time my friends remember to keep science in your hearts.

[36:53]

Jacob: So, now, here's something that I've heard and forgive me if it's slightly off the swirl issue but people say that there's like the dark side of the moon and same side of the moon always faces the Earth. Is that accurate or is that a bunch of malarkey. And also, why is that the case?

Catherine: The far side of the moon is different from the dark side of the moon. The dark side of the moon is whatever half of the moon is you know, facing away from the sun just like, you know, happens on Earth everyday.

Jacob: Right, right.

Catherine: So, the far side of the moon is the part of the moon that faces away from the Earth, always. This is called, it's a big word, but it's called synchronous rotation. So, basically the moon rotates about its own axis about 30 days which is exactly the same time period that it takes to orbit around the Earth. So, what you're seeing is that as it's slowly turning its always facing towards the Earth because it's orbital rotation is the same as it's axial.

Sebastien: The funny part is that, if you take the ah, the bright face of the surface of the moon the dark side is actually the side facing us because the far side is actually much brighter than the near side.

Catherine: True. Yeah.

Sebastien: So that's really the, I think something that is really fun when people are talking about the dark side of the moon which I think actually we are facing.

Jacob: Okay.

Catherine: The albedo of the near side is lower than the albedo of the far side. And this just has to do with orbital mechanics that I don't know a lot about. It occurred very early in the Earth's history as the um, so the play between the orbit of the Earth and the moon. This happens to every moon in the solar system, basically.

Ben: Yeah, it will happen to everything. It's something called tidal locking. It comes about by a process called tidal locking. So, you know how there are tides on Earth?

Jacob: Yeah.

Ben: Essentially, the moon is doing work on the water on the Earth, right. We can take that water and we can build little dams and we can extract energy from it. And slowly, slowly, slowly what happens is, um, eventually all of that energy from the orbital motion of the moon is going to lock the earth so that its rotating along with the moon. I guess what I'm saying, it's kind of like a friction force. So imagine that you're looking at a blender. So, there are the blades inside the blender and then there's the water inside the blender. As long as the water is not spinning around the blender at the same speed as the blades are the blades can always accelerate the blender, ah, the water, a little bit more. Until, what will happen is, if you leave your blender on long enough, the water inside the blender will be spinning around the same speed as the blades and at that point the blades and water aren't going to push against each other anymore. And, ah, similar things happen to gravitational systems rotating in orbit around each other.

Jacob: Okay.

Ben: So, the moon at one point in time was spinning like a basketball in place. But in doing so it was kind of like, it's rotation around the earth was kind of like the blades of the blender and the rotation on its own axis was kind of like the water in the system so eventually the rotation of the moon around it's own axis synced up with its orbit around around the Earth. Because at that point in time it can't push against itself. It's kind of an end state that all orbiting systems end up moving towards. So, eventually the Earth is going to be tidally locked so that only one face of the Earth will end up facing the moon, right. And in that case the Earth will turn but at the same rate as the orbit, as the moon goes around it. So it will have, the Earth, one day will last you know, thirty days because it will turn to face the moon.

Catherine: Yeah, the orbit, the rotation of the earth is slowing down over time.

Ben: Yeah, just because...

Catherine: The length of the day.

Ben: Yeah, the action of the tides...

Catherine: Very slow though.

Ben: Yeah, yeah, it takes, it takes forever.