Episode 24: Higgs in a Blanket
Physicists: Tia Miceli, Matt Buckley

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 that 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]
On July 4, 2012 scientists at the Large Hadron Collider announced that they probably detected a particle called the Higgs Boson. This was big news. Big news for the politicians who'd spent billions on the Large Hadron Collider for the express purpose of finding the Higgs Boson. Big news for the media because the Higgs Boson is popularly referred to as the god particle and the god particle discovered by physicists is a wonderful headline. And it was big news for particle physicists. See, the current working theory for particle physics is the standard model and in the standard model there's a zoo of different elementary particles. Imagine yourself in a zoo. There are electrons in the zoo and muons and quarks and neutrinos. Anyway, so the last empty cage in the zoo was for this Higgs Boson and finding it and filling the last cage was a triumph of the theory behind the standard model so good work everyone. Anyway, the deal with the Higgs Boson is that it tells us that something called the Higgs Field exists, the same way that sound waves tell us that air exists. And this thing called the Higgs Field is important. It gives us mass. Ah, but how? How? Now that the hoopla has died down it's time for my Titanium Physicists to take a crack it. Today's topic is the Higgs Mechanism. So, there are two problems with the explanation of the Higgs Boson which I've heard. The first is that everybody wants their explanation to last about a minute. Well, sucks to that because we're going to explain it over many minutes. The second is that the explanations are always aimed at the stupidest people in the world. I'm not sure why, but the people writing the explanations, always imagine a five year old boy reading it and shaking his head and that makes the writer really sad. So, sucks for that too. We're going to aim our explanations at the smartest man in the world. Now, our guest today wears many hats. He is the celebrity in many different spheres. Old people might remember him from the improvisation TV show, "Who's line is it anyway?" Young adult nerds might remember him as the voice of the two headed announcer from the pod race from Star Wars Episode I The Phantom Menace and those of you who are American babies might know him as the voice of Bob the Builder. But those of you in the know, who listen to podcasts, might know him as the host of the amazing hit podcast The Smartest Man in the World. It's Greg Proops. Hi Greg.

Greg: Hi, how are you Ben?

Ben: I'm good!

Greg: Old people?

Ben: Hahahaha.

Greg: Really?

Ben: I'm getting there. It was in the 90s! Come on!

Greg: It was in the 2000's and don't be a weenis.

Ben: Ahh, ok, so Greg. For you today I have assembled two of my finest titanium physicists here they are. Arise Matt Buckley! Dr. Matthew got his PhD in theoretical physics from the University California Berkeley in 2008. He studies dark matter and LHC collider phenomenology. He is currently employed at Fermi Lab as the David Schramm Fellow in astrophysics. Now arise Tia Miceli. Tia is a graduate student at the University of California Davis we're she studies high-energy experimental particle physics and she is writing her thesis on zed decays. Okay Greg, you know what magnets are right?

Greg: Yes, I am aware of the concept of magnets.

Ben: You're aware of electricity and electrons and electric charge.

Greg: Yes.

Ben: So magnets and electrons and electrical generators and static electricity, they all fall under the same theory of a particular force called the electromagnetic field. So we have understood electromagnetism for at lease a hundred years now. It was in the late 1800s where we put it altogether. Starting in the early 1900s people started playing with radioactivity and investigating radioactivity. So you have these atoms, in the center of atoms in the nuclei there are protons and neutrons and they're all stuck together and sometimes they fall apart and you get radioactive decay. The reason for that is that there is a force inside the atom call the week force and essentially it means that all of these nucleons, these protons and neutrons, are pushing against each other and occasionally they push together hard enough and in such away that the atom crumbles. So in the last hundred years people have been studying what makes this happen. Specifically, we have been studying the particularities of this weak force. So we know a few things about it. One of them is that it is really weak. There are three other forces. One called the strong force, which binds all of the nucleons together. The electromagnetic force, both of those are much stronger than this weak force. The weak force only really pokes its head when it causes very large nuclei to fall to pieces. When we start to talk about quantum mechanics we talk about how different objects interact with each other at really, really, small scales. So it's like you zoom in and at scales that are smaller than an atom and it turns out that on these really really small scales when two electrons are pushing against each other we can describe them pushing against each other and sending back and forth little particles. So instead of this great big electromagnetic force we are describing it in very small terms as two electrons. They send these particles called photons back-and-forth, their particles of light. Essentially one electron sitting on your right hand, one electron sitting on your left hand, they send photons back and forth and the photons say hey buddy why don't you take a walk and then they move apart so we talk about this particle as mediating the force. So, instead of a force field we talk about two particles interacting with each other by exchanging a particle. It's kind of like…

Greg: So when they have this dialogue that you just described I assume it is a highly charged atmosphere and yet your delivery of it was hey buddy, take a walk.

[7:46]

Matt: So you can imagine like, a proton picks up a photon and throws it at an electron and when the electronic gets hit it gets told to move away. Right, so it's literally being bombarded with things to tell it to move and a particular direction. So, it's not a polite conversation.

Greg: Well, when you say it's told, isn't it a natural response of electromagnetism involved in the situation and that's why it shoots away.

Matt: Yeah, that is what electromagnetism is, it's particles throwing photons at each other.

Greg: Alright.

Matt: Conversation is perhaps a polite way of putting it.

Greg: I understand and so now we are at this point.

Ben: So, the principal idea here is that, at the really small-scale, we're not talking about the forces, it's like you said we are talking about an interplay. There are these little particles that act as messengers, little quantum messengers between the two big particles and those tell them what to do, right. So, you get two electrons, each one sends a little message to the other guy telling them to get lost and then they both move apart. So the deal is that this description of how forces work at the very, very microscopic, works for more than just the electromagnetic. It turns out that it also works for, say, the weak interaction.

Matt: So, the reason that we care about electromagnetism, we've known about it since forever, basically, is that it can act over huge distances, right. I mean you can use a magnet to pick up a piece of metal and that doesn't seem very impressive usually if you're playing with it on your table. But remember you're picking up a small object with another small object you're overcoming the mass of this giant planet right. It's really an amazingly powerful force if you think of it like that. And the reason that it can do that is that the things that is throwing back-and-forth, these little photons are massless, they could go forever basically and that makes it so you can kind of conjure up a little photon and throw it an another particle and that other particle can, you know, get hit by the photon and move in the way it's supposed to move. The weak force is so incredibly weak the reason that we don't see it, you know, interacting in our day-to-day life, is because the particles that it's throwing back-and-forth tell other particles how to move really really heavy. For scale, they are like 80 to 90 times heavier then a proton, heavier then whole atoms of elements, actually. And so, you kind have to conjure up a huge amount of energy to create a particle that you're going to throw to moderate the weak force. And so, it's really, really difficult. We can't move that far because you've got, kind of borrow this energy, throw it some distance and that makes the weak force really, really weak.

Tia: So, it's like, if I am trying to get my buddy electron move over there I can text message him and tell him to move that text message would be like a photon. But if I want him to move using the weak force then it would be like throwing a truck at him.

Greg: Why don't you offer to buy him a coffee or you know like a, or something, and maybe sit down. All this violent chucking and I just feel like if we're going to get a photon and a Higgs

Boson particle that we can work with here, it's going to have to not be a vengeful god but also a benign one that understands, that, you know…

Ben: So, the idea here is that the distance scale that you can use the weak force is much less then the distant scale that the electromagnetic force operates on. Pretty much if you get two particles far enough away from each other they no longer feel the weak force. And they came up with a really fun explanation, are you familiar with Heisenberg's uncertainty principle Greg?

Greg: I'm modestly familiar with it. It's just to me that when you describe it as a, what is it a fun explanation, that perhaps fun is a subjective term?

Ben: Fun is always a subjective term.

Greg: And that one person's fun is another person's, you know, water torture. But I'm willing to hear you out. So remind me of the uncertainty principle.

Ben: Fundamentally everybody describes the uncertainty principle as saying that you can't know a particle's momentum and location at the same time and so there are limits on how much information you can extract from a particle. But there is another way to look at Heisenberg's uncertainty principle. One of them involves looking at energy. So you can tell how much energy a particle has but not the timescale that it is living at. And so, what happens is, essentially, you can say, hey what if you make a particle and it's really, really heavy? The consequence of that might be that the particle ends up being really, really short lived. So, the explanation for why the weak force is so weak, in essence, is that the particles that mediate the force, the little messengers going back between two nucleons, are really heavy and so they're short-lived. Because we want them to be short-lived because then they can't go very far in a short amount of time. So this was the brilliant deduction that they made.

[12:35]

Greg: Have we come to the fun part yet? Or, are we idling before we get to the fun solution…

Ben: Alright, yeah okay, here's the fun part. I want you to imagine these force mediating particles as messengers between my house and various other houses around town. So, the photon is like a little kid on a bike, right. They've got so much energy you just say hey ride across town and tell the Johnsons that their dog sucks. And they will, it's really easy they can just go and go and go.

Greg: Don't you think it's a little ethnocentric to presume it's the Johnson's, I mean..

Ben: I don't you know, what ethnicity…

Greg: It could be the Gonzales, the eau Claire's, the Washington's… I mean..

Ben: So, then I want to talk with…

Greg: You live in like this white people town with picket fences, your photons are Romney supporters is what I'm getting at here, your photons are… go on, go on.

Ben: Alright, so I want to talk to my friends, the Chans…

Greg: So, you're going to send one of your messengers over…

Ben: But, my messenger is one of these weak force messengers…

Greg: Therefore a heavy one and short-lived so it can't get very far.

Ben: Yeah, really heavy. He gets halfway down the block and collapses so they never get the message. So that is the fun description of essentially why the week force is so weak, essentially all of its force mediators are really heavy so they die off too quickly to exchange the messages whereas I can send these little kids on bikes pretty much anywhere in town and the message will still get through.

Greg: I don't know about the fun aspect of it is a little, for me, I understand why kids on bikes are fun.

Ben: They're fun…

Greg: It was the Johnson thing that really tripped me out I guess. I just, it turned into a Shirley Jackson story all of a sudden. I'd prefer that messengers from another universe break through the fabric of space and time and intervene in man's machinations because of their own evil guiding principles that we are not privy to.

Ben: Are you talking about Romney again?

Tia: I looked for those at CMS and we didn't find them.

Greg: I'm not saying mine is based on any hard facts or research or even a fun theory. It's just something that I like to think about. I mean it's not as pertinent as it might be to this conversation but since kids on bikes are going to be fun I thought I'd take fun into a kind of H.P. Lovecraft area here, anyway… so now we've got the slow heavy particles, and we've got the children sending photon messages on bikes, how does my Higgs Boson God particle entering into the mix here.

Ben: Yeah good question. So here's the deal. Nobody knew why the fat, heavy particles were so fat and heavy. When they wrote out of the equations they saw that the equations only made sense if this weak mediator was massless. So all of these weak messages should be delivered by kids on bikes just like the other one. And so the mystery was, how did it get so heavy? And the answer is these guys came up with a theory that said there is this field called the Higgs Field, in essence. Higgs field sticking to the heavy guy is what makes him so heavy.

Greg: Alright.

Ben: So that's how it all comes together, now we are talking about the Higgs Field.

Greg: Well is it called the god particle because it's a part of the last piece of the puzzle of the fabric of the universe that was hitherto to unexplained or is it called the god particle because now you found something that actually integral to…

Matt: It’s called the god damn particle.
Ben: Yeah, it's called the god damn particle.

Matt: Because Leon Lederman at Fermi Lab was really annoyed at how hard it was to find but the press wouldn't print the full name.

Greg: Is that what was? Oh that's funny how come that wasn't in the paper that's much funnier. God particle makes it sound like it's going to come to your house and make some decisions or whatever.

Ben: No.

Greg: Like smote you with rain and ants and fire like in ancient Egypt or what not, like that musical… Joseph and the Amazing Technicolor Dreamboat or whatever … my god is an angry god and a vengeful god I mean if you're that kind of person. But then I'm from San Francisco so my god is a Filipino lesbian girl with piercings. It's much different and more fun.

Matt: Well I'm sure we can come up with some way to destroy the universe with the Higgs but you know…

Greg: I remember cold fusion years ago and what a disappointment it was that it actually never really happened and that it just basically just turned into cold filtering and made beer kind of watery.

Tia: Give us another century, we’ll see what we can do about that.

Greg: Oh okay, you can have as much time as you'd like. Just understand that time is a concept invented by corporations to make people feel bad about themselves.

Ben: That’s unphysical Greg Proops. I liked all of the stuff from another universe but you can't go saying that time doesn't exist around me. That don't cut it.

Matt: You know all the news that came out for the Higgs said that the Higgs gives everything mass, right. To describe any of this you have to, kind of, have a picture of what mass means, right? I mean we talk about it but for physicists it kind of, a specific meaning that doesn't necessarily translate into what … thinks about it. Mass is the thing that prevents you from going at the speed of light. Einstein, way back in some decade that…

Greg: 1905.

[17:43]

Ben: Nice

Tia: Wow

Ben: He is the smartest man in the world.

Matt: In 1905 Einstein understood that nothing could travel faster than light. Anything that has mass can't travel at the speed of light. Anything that's massless can never travel at anything other than the speed of light. And so one thing about mass it is the property that we have that prevents us from zipping around always at the same speed it allows us to kind of take a rest and not to move at the speed of light and so that's one way to think about mass. And that’s actually kind of the way that, when we are talking about this Higgs particle giving mass to particles that's what we mean. It's allowing things to travel slower than light and kind of weirdly, this always gets overlooked in the newspapers, it doesn't give all of the mass in the universe. You and I are, and the things around us, are made out of atoms and those atoms, most of their mass comes from a completely different mechanism. But the fundamental particles, things like electrons, all of their mass comes from this Higgs mechanism and so without them the electrons would be massless and if we had massless electrons we would all dissolve into a sea of charged particles and it would be a very boring universe. So Higgs is very important in that sense it gives us the ability to be around and if we want to explain what does it mean when it gives mass we are saying how does the Higgs prevent us from moving at the speed of light. So the analogy that people often use, and it's not the most perfect analogy but I guess it's a place to start, is that there is this field in the universe, it's the Higgs Field and every particle, you know photons and electrons and quarks has a field alright. And a particle is just kind of an a excitation of this field, you put enough energy into a little area and quantum mechanics means that a lump of energy moves around like a particle.

Tia: Another way to think about that is sound. The air around you is a field and then when you clap your hands you create this disturbance in the air and you get this wave that's very short and that is like a particle. So it is a quantum of air.

Matt: Yeah, so there is this kind of fundamental objects, fields you could just make little excitations out of them and those are particles that are just wandering around and there are many different types and one of them is this particular field, the Higgs Field. And it just has this property that as other particles move around they feel the presence of the Higgs Field and it prevents them from moving as fast as they would. And the analogy that people would use is a cocktail party. The background, in this case the Higgs Field, is everyone sitting at the cocktail party and they're just kind of evenly distributed around the room and they're talking to each other and then a very famous physicist walks in, Albert Einstein, walks in and they are all very surprised that he is back from the dead.

Greg: This is where my theory about the ectoplasm from another universe coming in and manifesting itself by re-animating people who are necessary. But go on, so Albert Einstein walks into a cocktail party, it wouldn't be Newton because I don't think he drank…

Matt: If the cocktail party was just an empty room then Albert Einstein could move from the left side to the right side very very quickly he would just walk across, right nothing would interrupt him. But because it's filled with this background field of physicists, when he walks in everyone around him kind of rushes up towards him.

Greg: I should hope so.

Matt: Most of the people would go up to talk to him and that's he tries to move to the room this field is kind of surrounding him, right, this excitation prevents him from moving as fast as he would. So we would see him moving slower then we might expect if the room was empty. To make the analogy, he is a particle that has just walked into this Higgs field and he is moving slower then he should be and so we say that he has mass. So that's one way to think of what the interaction between the Higgs and another field is. It's kind of preventing things from moving as fast as they would. If I walk into a cocktail party I am nowhere near Albert Einstein so not as many people would come over to talk to me so I would be able to move around the room faster. So I was seem to be lighter than Albert Einstein by this analogy.

Greg: But what if I was a child on the bike.

Matt: You'd probably cause a lot of damage.

Greg: Alright, go on.

Matt: You know if you throw little kid in and tell him to go from point a to point b in this room he can zip around everyone and get through. And there are particles that don't see the field, they're massless, things like photons, they just zip through the room from point a to point b.

Greg: Really though, are there any particles so blind that they will not see the field.

Matt: The ones that we see with actually.

Greg: I see.

Ben: Are you understanding everything that Matt is saying, do you have any questions?

Greg: I'm giving it the old college try, now mind you I went to a junior college and you guys are you no doctors. But my best friend in England is a doctor in physics so I think that ought to count for something.

Ben: It does, it counts for a lot. Physicists only talk to people that other physicists know.

Greg: I see.

Tia: That's true.

Greg: So, we are at a cocktail party and everybody's rushing toward a dead Albert Einstein and your analogy is that some particles are rushing towards him and some particles are away, we're still trying to gather mass here.

[22:42]

Matt: Yeah, so the analogy here is that the physicists in the cocktail party just are there and their presence…

Greg: There's drinks, there's a reason to be there probably, maybe some music.

Matt: And as we've established physicists apparently only either talk to other physicists or who else are we going to…

Greg: Or people who know physicists.

Matt: Rarely. It's scary. The analogy is just that the particle here is the famous physicist who walks into the room and the presence of this background field makes it harder for them to walk around and we see that as mass. And then the last part of the analogy would be we actually found something that we call the Higgs boson which is distinct from the Higgs field. And the analogy here is that if I leaned my head into the room and whispered a rumor about physics. A very interesting rumor that will tell everyone what papers to write and or some salacious gossip, then in this cocktail party, if you were sitting and watching this, you would see little groups of people moving through the crowd having this conversation. And so the field itself, the background, just kind of clumped together spontaneously and that sort of excitation of the field.

Ben: So, let me rewind try to take another tack at mass. Okay so you've heard of Einstein's famous formula $E=MC^2$, right Greg?

Greg: I have, yes.

Ben: Essentially, it's saying anytime you have any energy at all it's going to have some mass. Some gravitational mass, so it exerts gravity on things nearby it. It also has inertial mass, so inertia mass just says like, that the heavier an object is the slower it will accelerate so if Satchel Paige could throw a fastball right, how fast could he throw a shotput? The shotput is so heavy that he whips it, it ends up going much slower in the end because of its higher mass. Okay?

Greg: Mhmmm.

Ben: Einstein's big idea that energy equals mass it's pretty crazy. What it means is that any type of energy you make has its own mass so if you took a Spring, you take a spring I'll your mattress because you're a sociopath you squish it so that it's almost flat, so it's almost fully compressed. And then you tape it up with tape, you have given that spring a whole bunch of potential energy. That potential energy will have mass, suddenly the spring minus the tape is going to have more mass than it did before you squished it.

Greg: Yes, so, now you've got a squishy spring.

Ben: So, in essence, if my spring had zero mass to start with and I squished it, suddenly the spring would end up with mass because I've given it energy, the energy is stuck inside the spring system, suddenly you have a massive spring. So, this is another way of looking at how the Higgs field is giving mass to particles. So, in essence, most of the things in the universe that have mass are stuck in someway to this Higgs field. We say the word coupled in physics but one thing to imagine is say, say you have a cymbal and you want to hit it with the drumstick, essential you give the cymbal some energy, it's vibrating but there's air around it. And the air around it carries off the vibrations, it carries off the noise that the cymbal makes, okay. So then we can describe this is two different systems that are coupled together. First there is the cymbal head which is its own system. It has its own physics describing how waves travel across it and then there is the air which has its own physics describing how waves move through it. And because the cymbal is touching the air all the time, because if you make waves in the cymbal this is going to, in turn, make waves that are going to move through the air. So the idea here is that the Higgs field is stuck to everything that has mass and what it means is that anytime we want to do anything to field that has mass, anytime we want to excite one of these weak field interaction particles, because it’s stuck to the Higgs field, creating any kind of excitation in it will in turn compress the Higgs field. It will give the Higgs field a little bit of energy and that Energy is going to follow the person of around and act like a mass. In essence, the Higgs field is kind of like a spring in their pocket that they're squishing down and giving mass it mass.

Greg: Okay.

Ben: Does that makes sense?

Greg: Yes. I wonder if there is a light at the end of this tunnel?

Matt: In what way.

Greg: Are we getting near the explanation of… we've discussed the fields, which is different from the particle and now we've discussed why mass matters.

Tia: So I think we described why the Higgs has mass but why do we care. I think we should talk about that. Ultimately being able to see the Higgs at CERN gives as a tool to study more about the theory.

Matt: Are you asking like metaphysically why do we care about the Higgs having mass?

[27:34]

Tia: I’m saying that we should say why it's important that our governments spend all this money. I think we should address that. Ultimately what basic knowledge we find out now about physics we may not see the results in technology for another hundred years or something because that happened with the electron. I mean J.J .Thompson discovered it in 1897 and now we have iPods and iPhones, I mean come on, that's pretty amazing. So who knows what will be able to do with what we find out now about the Higgs.

Matt: I'm a theorist, my job is to sit around and think about this stuff and often it’s hard to come up with a specific thing of what finding out about this will tell you. Will this help me build a better iPod or you know a weapon of mass destruction or anything like that. And the serious answer is nothing that we know of right now but as I said theories that we have worked on a century ago or decades ago we're now finding why they're useful. Quantum mechanics was totally, you know, some crazy theory that no one saw, ever, any reason for, or that it would do anything in the 1920’s. And it's the fundamental basis of computers and we wouldn't be able to build a computer without our understanding of quantum mechanics. But going back to this whole thing that we started off with, we were talking about heavy particles and light particles. You know things that were very long range like photons make it somewhat easy to build devices that we find useful. Whereas things like the W and the Z and The Higgs are really heavy and so we need a lot of energy concentrated in the very small region to manipulate them so it's unclear right now what that will do but if you stop learning you'll never figure out what the answer is. And it my turn out to be something really amazing down the road and that sort of always the promise of working on this kind of thing.

Ben: Oh yeah, well, that was fun. Thanks Matt, thanks Tia, you have pleased me. Your efforts have born fruit and the fruit is sweet. Here is some fruit, Mathew you get seedless watermelon.

And Tia, you get a bunch of seedless grapes. Alright I would like to think my guest, Greg Proops.

Greg: Thanks everybody.

Ben: You can listen to the Proopscast, it's call The Smartest Man in the World and it's lots of fun.

Ben: Okay, suppose you interact with the titanium physicist, a little bit more if you would like to keep track of us why not follow us on Twitter at @titaniumphysics or on our Facebook group. If you would like to hang out with us and socialize why not join our online forum or if you would like to send me an email directly or to ask a question or propose a topic you can email me at barn@titaniumphysics.com. Let's suppose you want to listen to us more conveniently if you've got and iPod or an iPad you can try subscribing to our show using the iTunes store or the iPod podcast app. While you're there write us a review. Your reviews determine our ranking within the podcast app in the iTunes Store which in turn determines how many new listeners discover our show. If you have a Zune or a BlackBerry you can subscribe to our show on those doodads as well using their respective podcast apps or you can download the Stitcher radio app which 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. For all of this information and more visit hour website at www.titaniumphysics.com. 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 so 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.

[32:07]

Ben: And so in the 1950s, was it was 50s right, either of you, no, yeah?

Tia: 50s or 60s.

Ben: Yeah, right, so somewhere in the 1950s or 60s they were trying to describe.

Greg: So my understanding is that physics is you're very inexact to science it's not important to know what decade that anything occurred. You really ball park everything.

Tia: Well it's not about history and dates like in world history.

Greg: Oh, I see.

Ben: Thats right. We have trouble remembering who did what in fact.

Greg: Evidently only old people watch my show, and even I know when the 50s were.

Ben: Well, yeah, that's okay.

Greg: Alright, go on with your discovery here of the 50s.

Laughter.

Ben: So back in the caveman days they were trying to…

Greg: When phones didn't talk and stuff.

Ben: They we're trying to qualify why some…

Greg: When someone called your house and you weren't home, tough cheese.

Tia: And people wore bell bottoms.

Ben: That wasn't so long ago.

Greg: And you had to get up and turned the channel.

Ben: Ah, alright so people were wondering why this weak force…

Greg: And no one bothered you and no one Facebooked you about something that happened in their life or put a picture of their dog up that you had to look at all of the sudden. You had to go to someone's house to see their dog picture.

Laughter

Greg: It was good in a lot of ways, trust me. And records were just as fun as downloading, you just had to play the same one over and over.

Laughter

Ben: So…

Laughter

[34:04]

Greg: We even had the theory of relativity which hasn't even been called the theory of relativity by anybody here and I am the only non-physicist on this program. I believe you called it a famous formula at one point, like famous Amos.

Ben: Yeah well there's more to the theory… that's called, that's called… calling that the theory of relativity is kind of like calling the shiny gold letters on the front of the Bible the essence of the Bible.

Greg: Well, let's be honest about that, it is the essence of the Bible.

Laughter

Greg: Without the sizzle there is no steak.

Ben: What a subtle thing to say. Yes, you're right. Anyway, um, yeah, there's more to the theory of relativity. So, actually, one of the consequences…

Greg: Of course there is, he went to party where he is dead and all these people rushed him, I remember.

Ben: Yeah.

[35:04]

Greg: Since I represent the public in this, I'm lost. From the cynical point of view these discoveries in physics don't seem like as much a waste of money as just another step in the military industrial machine. We're often told that NASA is very important because we're discovering other products and stuff and it seems kind of evident that the Defense Department has a giant stake in NASA. And to take it even more cynically it is amazing that we have iPhones and iPads. But the bitter truth about iPhones and iPad's is that they're often made by people who are almost slaves if not technically slaves. And that really the First world abuses the Third World at the expense of all of this luxurious technology that we have. To take this out even further not only does the technology enable us to communicate with each other instantaneously, for those who can afford it and those who have it, which isn't a majority of people in the world. But it also alienates us in the sense that people don't really phone each other as much anymore, they text more. People text while they drive which has created an insane danger on the streets of LA where I live where no one is watching the road anymore. So there is kind of a, as you say, what will happen with the elements of discovery that will be applied in some sort of practical science that we all deal with it's a double edged sword. On the one hand yeah maybe it will be something benign, if you think an iPhone is benign. Or it will be something evil which since the United States is the number one supplier of guns to the entire world, and armaments, and is way ahead of every other country right now. And yeah we keep hearing that, on these debates and everything that somehow we are going to cut the military and it's going to hurt us. So I think it's conjectural, at best, to try to estimate the application of the Higgs boson theory is. I think it's more of a celebration for you guys because something is revealed the, goddamn particle and what not, that you've been trying to find for a long time, and by saying you of course I mean, you, but for the rest of us it's a bit confusing. And like I say, from a cynical point of view, I'd like to believe that all science is benign and helpful because there's so many people that deny science right now and that's the other, talking about the glitter on the holy Bible, there seem to be so many people in the world who don't want to believe that there is such a thing as climate change or that stem cell research is valuable or that people determine their own homosexuality or things like that. And there seems to be a giant refutation of science so I think it's important to embrace it but it's also, I'm sure you understand, scary to a lot of people, not just because they don't understand it but because of what can end up happening. Boy that was a long description but I feel like I didn't use any analogies like what's the sound of eating a pancake riding down a hill on a Big Wheel…

Tia: So I mean I can…

Greg: And the microwave went off and I was wearing a hat and Abraham Lincoln walked in… he would represent the speed of the photon. Go on, I'm sorry.

Tia: So I think that science is actually benign. It's information, it's information that we know. The problem is what happens when you get greedy people and you give them that information. They exploit it, so…

Greg: Aren't those scientists working for those people?

Tia: What people need to do is, what everyone needs to do is, wake up see what knowledge is out there and see how selfish people are exploiting that and using them.

Ben: I have another tack on why it's valuable. We are going to speak metaphysically here. So think about things that we knew in about 1950, back in the Stone Age. We knew that there was something call gravity, people have known that since Newton. We knew that there is light and this is a electromagnetic force we've known that since the 1600s, 1700s, right. In the early 20th century we discovered radioactivity and we started firing electrons and protons together to see what was inside of nuclei but those discoveries in terms of the forces that were involved in them we're fairly specific. You can't talk about the strong force or the weak force outside of an atom because usually they don't really matter, right. So in essence our day-to-day lives, we say there is light, there is gravity there's not really anything else between us. On the other hand, the Higgs means that there is this weird field it's like the electromagnetic field, and it's everywhere in the universe and we had no obvious interaction with it prior to this discovery. Imagine going up to a fish you can communicate with a fish, and say look fish there's this thing called water and you're sitting in it and you're surrounded with it all the time. And the fish would say, who cares what's the use but one could argue that there is metaphysical beauty in finding out that you're actually surrounded with this ubiquitous field. For the fish it's called water, for everything in the universe it's called this Higgs field. It somehow the fact that we're stuck to it in various ways, like a kid trying to run over tarpaper, it's sticking to their shoes, anytime we try to move we are interacting with this ubiquitous field. It's aesthetically very wonderful. I mean it's too bad that they called it god particle but there are a lot of dumber things that they could've stuck the word god on to that makes even less sense.

[40:26]

Greg: Uhhuh.

Ben: So, you should like it because it's wonderful.

Greg: Alright. I promise to like it because it's wonderful.

Ben: You should like it because it's mind blowing. Everywhere.

Greg: I appreciate that it's a giant leap forward in knowledge. I just, as I said, sometimes science is there for several reasons and that I don't believe that people just operate in a vacuum. I think in the cynical world that we live and there's always a political reason for everything including science, especially science. And that I think the electromagnetic field that you spoke of and radiation that were known well before the Middle Ages. I think the ancient Greeks and ancient Egyptians would have something to say about that if they can walk into a party eating a pancake being a spring riding a bike.

Ben: Ah, they knew about electromagnetism, they did, in various ways. I don't think they knew too much about radioactivity though.

Greg: Hmmm, possibly not but they certainly knew the movement of the planets and the heavens to a degree.

Ben: They certainly did.

Greg: And I'll also say that the American Indians of this continent did as well.

Ben: Yes. It's true. Gravity was arguably well understood by the Greeks and the ancients, so was electromagnetism. But here is something new, here some field connecting all of us, it's like a tarp that we're all standing on that were all completely unaware that we're standing on.

Greg: It’s what Iain M. Banks would call the grid, if you've ever read any of his books. He writes sci-fi and he's Scottish. I think he kind of anticipated that with a book called Excession where people, where ships are powered by the power of the grid, they don’t even have an engine anymore. They just use, basically the Higgs Boson field, and they tap into it.

Ben: Awesome. I would have also accepted the force from Star Wars.

Matt: The grid’s better.

Greg: The Force from Star Wars it's like going to a bad Northern California spa for the weekend.

Laughter

Greg: The philosophy’s really not that… now on the matter of Mynocks on the power cable that could be a situation