AstronomyCast: Live at Dragon*Con 2011

Pamela: It's seven o'clock on a Saturday night, and I'm not James Marston, and this room is packed, and I'm watching them turn people away at the door and this is kind of awesome, so thank you all for turning out. This has been a great experience, and I hope that you enjoy what we're about to do. This is my co-host, Fraser Cain from AstronomyCast.

Fraser: Yeah, so we decided because we're actually both here to kind of give you also an impromptu episode of AstronomyCast.

Pamela: So this is going to go into our feed. For those of you who didn't know you're attending AstronomyCast live, you're attending AstronomyCast live. The lights are completely fine…so we just came from the Parsec Awards where we did not win, but the person who won actually was very deserving -- it was Matt Kaplan of Planetary Radio. And after last year, having run from this building to that building in the opposite direction and getting there all hot and sweaty and discombobulated, I decided this year not to bother with slides because that's one more object to like run in heels with, so we're just going to talk you because we're audio-podcasters -- so we can do that. Now, we're going to talk to you about weird stuff.

Fraser: Alright, so now did you want to take questions first, or did you just want to cover some of the recent interesting stuff?

Pamela: Let's cover some weird stuff to begin with.

Fraser: Who here has heard of…actually who here has heard of AstronomyCast, and who here has never heard of AstronomyCast? OK, good, good. Alright, so AstronomyCast (since half of you don't know who we are), AstronomyCast is a weekly space and astronomy, yeah, podcast…

Pamela: Eric's smarting in the corner.

Fraser: … that Pamela and I do. She is a PhD. Astrophysics, and I am the publisher of Universe Today, and once a week we pick a different topic in space and astronomy, and we cover it front to back, top to bottom, explain it in a way that we hope will be very accessible, and then you can then lecture your friends at your next cocktail party about super-massive black holes and

Relativity, and, you know, symmetry, and homogeneity, and all that kind of stuff.

Pamela: And super-symmetric particles do not exist; the Large Hadron Collider has not found them enough times that we're pretty sure they're not there.

Fraser: So we've done about 231 episodes, plus question shows on every single topic you can possibly imagine about space and astronomy, so if you want to check that out, if you like what Pamela has to say, I highly recommend you check out AstronomyCast, but enough pimping our stuff… So one of the things that we like to do is cover some of the mysteries of the Universe because, a lot of the time, some of the greatest parts of astronomy is where we're right on the cutting edge. We're finding out the latest stuff that we just didn't know yesterday, and now we do know, the stuff that's really weird, the stuff that's like, "I don't know what that is," and there's been a bunch of stuff that's released very recently which perhaps some of you have heard in the news. Has anyone heard about the "diamond planet?" Have you heard about this? Yeah, so this was a binary object consisting of a big star and a less big star. The big star died, became a millisecond pulsar, so, you know, a dead star spinning very rapidly, orbiting what was the white dwarf remnant of the other star, which has now cooled down and become a "diamond" (that's actually from what I understand) roughly cool enough that you could actually touch it. They are calling it a diamond planet, but I don't know if that's really appropriate.

Pamela: Well, we do know there are giant (it's not after 10 p.m. yet)…there are giant "expletive" planets in the Universe. We tend to call them white dwarf stars. So our sun someday will become a very different object. As it grows older, it's going to stop burning hydrogen in its core; a lot of weird reactions are going to happen as it starts burning heavier and heavier fuels. Eventually, it runs on stuff it's able to burn, and when that happens, it loses its atmosphere and what's left behind is just a nucleus of carbon that has configured itself into a crystalline structure -- that's a diamond -- that has all sorts of nifty occlusions in it, so it won't be flawless. But imagine something a fraction of the size of the Sun that's a diamond – and that's our sun's future. So there's kind of diamonds everywhere, and supernovae actually create diamonds fragments, or at least little tiny diamond chips, diamond dust…all these different things, different…asteroid impacts can do this. The Universe likes to kill humans and create diamonds. I'm not sure what it's saying, but it's kind of cool.

Fraser: So why don't we take a bit of a tour through the Universe? Let's start with our solar system and talk about some of the weirdest things in our solar system. Where do you want to start?

Pamela: Mimas! Where else do you start?

Fraser: Sure, "the Death Star moon." Has anyone seen a picture of Mimas? Mimas looks like a death star. It really does! It's a moon with a huge, big crater carved out of it. So what happened to that?

Pamela: Well, our universe is filled…not our universe, our solar system is filled up with leftover rocks that are careening around in orbits that… it's like watching windshield wipers that aren't quite lined up. Most of the time, they're not doing the exact same thing, but occasionally you'll get that one swipe where they're exactly in sync. Well, most of the time bits of rock happily orbit around not hitting things, but occasionally things line up, and you end up with smaller rock hitting larger moon, creating something that looks just like the Death Star, and it's always nice when you get these moments because I wouldn't have got to talk to you about craters if it wasn't for our solar system creating a look-alike for the Death Star. So this is what we call a teachable moment.

Fraser: Now, did that impact…was that big enough to have destroyed Mimas? Was it pretty close?

Pamela: No, no. We've seen much bigger collisions. In fact our own moon…we're now starting to learn we've been baffled for a while by our moon because its center of gravity isn't in the center of the mostly spherical moon, and that's kind of disturbing. The front side has these beautiful lava seas, big pretty craters, backside – beat the tar out of it, completely different coloration, completely different texture, and we're now starting to think that at some point in our past, something whacked the backside of the Moon (which may not have been on the back side at that moment in time), knocked the center, changed the shape of the Moon (because it was probably something very, very large that did this), and then glommed on and became part of the Moon, so the off-center center of mass is due to this massive collision, the change in texture and surface composition. That's the stuff that hit it, and that is a large collision, but the Moon stayed in one piece.

Fraser: But another Saturnian moon is Iapetus.

Pamela: That's fabulous!

Fraser: …which is very strange. It's got two sides: one is black, one is white, and it has a very bizarre ridge that's 10 km high that looks like a…

Pamela: And the reason that this happens is just black stuff absorbs heat more effectively than white stuff, so at some point in its history, it got a thin splattering of darker material, and that darker material caused that side of the moon to melt a little bit more. And the ice isn't pure; all through the ice there's these organic materials, and as those organic materials end up coming to the surface, they're black. So the one side just keeps getting blacker and blacker and blacker. Now the other side, the way that works is its melting, too, but in a very different way, and so you're ending up with the white ice is forming on the white side, and the black stuff just building up on the other side, and the difference in heating is causing the cliff between the two sides. And if you've ever seen nasty, covered-in-pollution snow in the winter, that black sludge in the snow is very similar to the surface of Iapetus.

Fraser: And I hate to stay with Saturn, but then there's Enceladus.

Pamela: True.

Fraser: Right, and so Enceladus has these bizarre tiger stripes at the bottom of the moon, and pouring out of these tiger stripes, these, you know, these kilometer-long, kilometer-wide cracks, fissures on the southern pole are geysers of snow and ice pouring out of Enceladus into space.

Pamela: And our solar system creates these geyser-y planets, and we have a volcano-y world: Io orbiting Jupiter…all of this is created by taking a moon and squishing it over, and over, and over like a squishy ball. Now, if you took a stress ball and you constantly squeezed it, it would slowly heat up, or a faster way to do this is to take a super ball and just bounce it manically, and if you act like a small bored child, you're going to heat up the super ball. Now, the planets…this doesn't happen because they're getting squished back and forth by someone bouncing them on a table, but gravity is doing this for us. As these moons… Your eyelashes are amazing! For our listeners, Minnie Mouse just walked in and her eyelashes are at least 3 cm long, and she's in the front row blinking very nicely at me. So, all of these different moons that have volcanism, whether it be water geysers or lava, this is caused by gravity. When the Moon is a little further from the planet it's orbiting, being a little less, when the moon is closer, it's a little bit more, and this causes a constant contracting and releasing, contracting and releasing that creates volcanoes that creates ice geysers, that creates amazing rich thermal stuff in the outer Solar System that's supposed to be cold, but since it's not cold due to volcanism, there could be life out there, but that's for a different topic. So, come back next year.

Fraser: I hate to stay on Saturn, but Titan has liquid hydrocarbons on the surface. There's lakefront property on Titan.

Pamela: Titan is a moon that exists at the triple point of methane. This is the temperature and pressure regime where methane -- that stuff emitted by cows that causes people to say that cows cause more global warming than cars…not quite sure. Methane, though, on Titan is capable of being a liquid, it's capable of raining from clouds, its capable of being a solid ice, and it's capable of having gaseous form -- that's these clouds that just rain, so it's just like Earth where we have the triple point of water where we have liquid ice, oceans, frozen ice -- Antarctica while it's there; both worlds have this amazing thing, and the thing is Titan's a little tiny gravitationally, and methane -- it's not as noxious as cutting through things there as water is here, but it's enough fluidity, enough flowing across the surface that you see river deltas, you see lakes, you see all of the types of geology created by water here on the planet Earth. And what's neat is methane is a carbon molecule, and it has many other very complex carbon molecules on Titan as well, and there's some work that was written about by Chris McKay that talked about if there's methanogens: bacteria that function utilizing methane on Titan, there'd be certain chemical signatures, certain things that existed out of chemical equilibrium. Those are those equations you did in high school that made you hate yourself and cry. So Titan balanced those equations the way I did when I got a C in chemistry: they're not in balance, and they're out of balance the way you'd expect if there is life on Titan, it's not conclusive, it's not proof…

Fraser: Did you just say there was life on Titan?

Pamela: No, but it's interesting, so we want to go there, but we need to figure out how to sterilize things a whole lot better before we go looking for life on a planet that could have it…or a moon.

Fraser: Big Astronomy told us not to announce that. [missing audio] OK, so we can leave Saturn. So one last place in the Solar System and that's Europa, which is the place we're not supposed to go to, but... So again, if you've seen pictures of Europa, it's quite amazing. It is this smooth, glassy ball orbiting Jupiter as a moon. When you get really close, you can actually see these strange cracks, striations on the surface of it. So what's going on there?

Pamela: So this is another case of a moon getting heated up by constant squishing – in this case as it goes around and around Jupiter, its in orbital resonance with some of the other moons, and is affected by Jupiter itself, and this is causing it to have internal heat. We think that it probably has down deep a rocky, potentially molten core a lot like Earth's, built small. And above that is a vast ocean, and on top of the ocean is varying depths of ice, and in some places you'll have a heat vent in the bottom, and this is work that was presented by Britney Schmidt recently, and the idea that she put forward is you have hot vents in the bottom, like the hot vents we have in the mid-ocean rift here on Earth -- but on Europa, and that hot water rises, thinning the ice at the surface, and that ice is moving like the tectonic plates here on the planet Earth. And those plates, as they shift, as that ice shifts, cracks appear, and the water oozes out constantly re-coating the surface. This is why there's so few craters. The craters keep getting filled in with new water the same way craters here on Earth keep getting eroded away by all the different weathering we have on our planet. Now one of the things we desperately want to do (and people keep proposing missions to do this) is to go there and ice fish, basically, to dig through the ice and drop in a robot, and leave a radio signal sender on the surface of the ice and go exploring. And what's awesome is in NASA science images, scientists images on view screens, when they're talking about wanting to go do this, they always show the same life forms that you see at the mid-ocean vents. Now, the thing is, we used to learn, when I was in school at least, it takes three things for life: you need sunlight, you need food, and…um, I forgot the third one, so it must not matter that much.

Fraser: Water?

Pamela: Water! Thank you.

Fraser: I don't know. I have no idea what it could be.

Pamela: Yeah, yeah…what's this water thing people keep talking about? So you have water on Europa, you have liquid methane, fluid on Titan, you have food -- there's carbons on both planets. We now know because of the mid-ocean vents on Earth, though, you don't need sunlight. You need a thermal gradient; you need a difference in temperature between two points that drives chemical reactions. It's a thermal gradient, that change in temperature, that drives the chemistry that drives life, so you can have life on Earth deep beneath the soil, deep in the bottom of the ocean where there is no sunlight, but where Earth's own heat creates the temperature gradient that creates the possibility of life. We'll get to questions later.

Fraser: Actually can you let us know about halfway through? We can switch over to questions. We're about half-way through?

Pamela: Can you wait 30 minutes? Thank you.

Fraser: Caves on Mars, caves on the Moon, Pluto has an atmosphere…can I keep going? The 11-year solar cycle…it's all really weird, but I will let you talk a bit about going out of… You can hear my Canadian accent, can't you? He's Canadian. We go out of the Solar System…

Pamela: My husband's Canadian too.

Fraser: …and now we're starting to find really strange things in the Universe because now we're not just dependent on what's weird in our solar system, but what's actually weird in the whole Universe. One really weird thing (and this is partly because this is all we've been able to see) are Hot Jupiters, which is something really interesting. So people have probably heard of Hot Jupiters, but the extremes just keep getting pushed and pushed and pushed on what's awesome. So, do you want to talk about Hot Jupiters?

Pamela: So the idea is that solar systems do not form the way you learned in school. When we were kids, those of you who are…those of you who went to school before 1995 -- most of the room, not all of the room -- we learned that when solar systems form, you have a cloud of gas and dust that collapses down, forms a disk, rocky planets form next to the Sun, gassy planets form next, icy things that we no longer know what to call form in the outer parts, and this was the model, and then the very first planetary system we found had something way bigger than Jupiter on an orbit way smaller than Mercury's, and then we found more like that, and we realized we have no clue how planets form and end up where they end up in solar systems. And as we start learning about more and more planets, we've now found roughly 700 potential planets orbiting alien stars, and they're not anything that we see in our solar system yet. We have Jupiters on top of their Suns, we have planets bigger than the Earth that are primarily made of ice, we have all of these crazy systems, but it's the Jupiters that disturb us the most because, in some cases, they orbit so close to the star they're going around, that they create tides, like ocean tides, but on the surface of that sun. In some cases, the Jupiters are so close that their atmosphere is being blasted off by the light from the star. The starlight exerts so much pressure it strips the planet and makes it smaller.

Fraser: Yeah, you have incredible winds that pull the heat from the hot side of the planet to the cool side and actually balance out the temperature around the whole planet, even though they're tidally-locked -- so one side of the planet is facing the star, the other side is facing away, but the winds can be thousands of km an hour as the temperature of the planet tries to equalize around itself.

Pamela: And we keep finding planets around stars that we never thought planets would belong to: little, tiny red dwarf stars, stars that will live for 30 trillion years, but for the first billion or so are extremely violent and give off x-rays and ultra-violet light. We've found planets close enough to these little, tiny dark red stars that the planets could have water if only they weren't, just like Fraser is explaining tidally-locked, such that one face always faced the star and other face didn't. So they go through this double death: first they get blasted with x-rays and ultra-violet light (bad for life), and then they get locked into place and one side gets all the light and the other side gets none, and we're not quite sure what that does, but we're pretty sure it's not habitable.

Fraser: Well, you keep saying that, but you've got 30 trillion years to hang out beside one of these stars, so …

Pamela: It depends where your volatiles come back from.

Fraser: They get blasted away, but we're not going to have an argument here. So we'll move on, does everyone know there is a supermassive black hole at the heart of every…?

Pamela: You skipped the coolest star though. You skipped suddenly to black holes! Have you guys heard…there's a star out there 15 times the size of Jupiter that on its surface is 100 degrees Celsius? The surface of the star is the boiling point of water. There's clouds in the atmosphere of this star… and that's just kinda cool.

Fraser: Is that really a star?

Pamela: It's a brown dwarf. It burns a special kind of hydrogen that has extra neutrons -- when it was young, very briefly, then it ceased nuclear burning, but the way we define stars is something that once upon a time burned something in its core. That was and remains called a star.

Fraser: Oh, that's right, you want to talk about amino acids, formaldehyde and alcohol.

Pamela: So space is filled with clouds of stuff that haven't yet become, well, stars, and planets, and that material in these giant clouds has time to do very slow, very cold chemistry. Now it used to be that we didn't think a lot of things happened in these cold, low-density environments because, basically, the molecules are kind of sitting there moving very slowly, very far a part from each other. It's the opposite of "Con." Imagine this place 6:00 a.m. Tuesday and you have a better picture. But even though these atoms and molecules are moving very slowly, given enough time, the 13.7 billion years of our universe, they'll collide and they'll bond and molecules will form, and in these cold clouds, there's nothing to start breaking up the molecules, so when we start looking at these dark, cold molecular clouds, we start finding weird "insert word of choice," there's formaldehyde, so if you want to preserve your aliens, you can. There's all sorts of amino acids, and this is where some of the ideas that the building blocks of life came from the stars comes from, there are things called polycyclic hydrocarbons, which are stinky if you ever made them in high school chemistry lab and accidentally set them on fire like I did, getting a C in that course. We find all of these complex molecules in space, including Buckyballs, and basically, if you can think of something complex involving carbon, it's out there lurking between the stars waiting to become a star or a planet someday in the future.

Fraser: Oh, Cepheid variables, let's talk about that cause they're really weird.

Pamela: Cepheids?

Fraser: Aren't they the ones that go…?

Pamela: Well, there's a lot of pulsating variable stars.

Fraser: A star that expands to several times its own size, and then contracts back down over the matter of a few hours…you don't think that's kind of weird?

Pamela: Fine. Fine. It was my topic of research, so I think that no one else is interested in it. Keats, the poet, said he wanted a love as constant as the stars. Yeah, those of you who laughed, you're right -- stars explode! I don't want that relationship! So the reality is that when you look at the stars, if you look at any star with a fine enough detail, you're going to find that it changes and brightens at some level, that there's some variability to everything, but there are special kinds of stars that enter this place where their temperature and their pressure and their radiance and everything else comes together just right. Most importantly, their temperature and luminosity come together just right that they become unstable. Stars are held together with the light being produced in their core -- that energy, light and energy are really the same thing. That light, as it pushes its way out from the center of the star where its created to the atmosphere where it radiates for us to see, as it pushes its way out, it actually has a pressure, and that pressure supports the star from gravitational collapse. When stars stop producing light, and they're big enough, they collapse violently into a black hole. So that light pressure's kind of important. Now, most of the time as stars age, their temperature's changing ever so slightly, and the star is able to compensate, it gets a little bit bigger, it gets a little bit smaller, rebalancing itself into a stable configuration, but there's this one place where -- I believe it's helium -- acts in an evil way. So you have a star and it has helium in its atmosphere, and as the star changes temperature, it reaches the point where the helium suddenly goes, "I'm going to ionize," and all of the energy that would normally go into supporting the outer layers of the star, instead goes into ionizing the helium, and so the star collapses back down, and as it collapses it heats up. As it heats up (and add to this you have so it collapses down and heats up), the heat causes it to expand back out, it expands past the point where the helium decided to ionize, keeps expanding, as it keeps expanding it cools off. The energy that had been stored from the helium ionizing now goes back into the helium, starts to collapse again, helium re-ionizes -- this is a complex process, where basically the helium is like a person pushing a swing. Every time the person starts to slow down, just add the push back in. And so for millions of years, different types of stars: Cepheids, RR Lyrae -- many stars that we actually use as standard candles to tell us how big the universe is -- they pulsate and change radically in size and brightness. And the reason we can use them to measure distance is with the RR Lyrae in particular, they're all the exact same brightness. Stars vary by factors of 1000s in how bright they are, so when you look at a star and you go, "that's pretty bright," it could be something very faint very close to us, or something amazingly bright at the edge of the galaxy. You can't tell, but because these things blink for us…imagine if all 40-watt light bulbs beat 40 times a minute, and all 100 watt light bulbs beat at a 100 times a minute -- you could tell the wattage of a light bulb by getting annoyed by the strobe effect. We can tell the brightness of a star by rejoicing in the pulsation, and once you know how bright something is, it's sort of like if you see a motorcycle light, and it's really bright, and you're standing in the road. You know you're going to die, but if it's really faint, you're fine. And so when we see these r-alaris, we know bright they should be, we see how bright they appear, and we can calculate how far away they are and use them to measure the Universe.

Fraser: So just stop me when you want to…are we half way?

Pamela: Let's do five more minutes?

Fraser: Sure. Sure. Blue stragglers?

Pamela: Blue stragglers, we're still figuring them out. We sometimes think that they're binary stars that combine into a single star, which is kind of cool.

Fraser: Stars that are moving so fast they're escaping the Milky Way…?

Pamela: Binary stars do evil things. This is also, in many cases, either binary stars or triple systems, where gravitational interactions usually (triple systems actually), where the interactions cause you to have a binary at the end, and one of the stars gets flung away. This can also happen if you have a regular binary system where one of them opts to explode as a supernova and pushes the other one out. So you can fling stars about by either exploding near them, or flinging them with gravity. Both are good things.

Fraser: Great Attractor?

Pamela: Giant blob of mass at the edge of the disk of the galaxy…so if you go outside and look tonight in the dark side of the sky, you can see a band of bright light and that band of light -- it's called the Milky Way because if you go somewhere sufficiently dark, it really looks like an astronaut poured milk over the atmosphere, and it just sort of spread in an arc, and that band of light is the stars that are in the disk that we live in. So if you imagine looking out across a plate where all of the bits of the plate emit light, this becomes opaque; you look above the plate, you're looking through nothing -- the band is the Milky Way. Now, we know because we're watching galaxies above the band and below the band that there's something straight through the band if you just keep going out of our galaxy, and keep going for a lot of light years, there's something out there (that we can't see because the stupid galaxy's opaque) that's sucking all of these other galaxy clusters towards it.

Fraser: Whoa!

Pamela: So we call this invisible sucking thing the "Great Attractor." The reality is it's probably just a super cluster of galaxies that we just can't see, and it annoys us that we can't see it.

Fraser: And all the nearby galaxies are being accelerated toward this thing...so you know that's pretty weird.

Pamela: The Universe is kind of weird.

Fraser: We could do this all day long, but you guys probably have some questions about space and astronomy for us.

Pamela: And we might have answers. Microphone, please, we are recording this, and if you speak into the microphone, be aware that your voice might end up used in our podcast.

Questioner: OK, sorry, I'm horrible with names, but you mentioned one of the moons basically has water over a rocky core that might have life in it, and sometimes the water erupts into its surface. And you mentioned one of the other moons that has the methane seas, and you did the chemical comparisons to see if there might be life there. Has anyone ever done the chemical comparisons on the water coming out on the icy moon to see if that also has the imbalances, which might indicate life?

Pamela: We don't have the right instruments there. So the problem is to get the really good results that tell us what is the exact ratio of this chemical to that chemical. We have to send something there that has the detectors we need onboard. Right now we have Cassini orbiting around Saturn, and it has all of those instruments; it's a modern spacecraft. Well, the last thing that we sent to explore Jupiter, which is where Europa the ice planet with liquid on its surface is…the last time we sent Europa there (not Europa), the last time we sent a spacecraft there, it was the Galileo spacecraft, which I believe we pitched into Jupiter to make sure we didn't accidentally leave bacteria on a moon because that would be bad. We took Galileo and we plunged it into the atmosphere of Jupiter in either 2002 or 2003. It was built a decade or so before that using flight-ready designs, which means the designs were even older than that, and the technology just wasn't up to measuring that fine a gradient in the chemical compositions. We also didn't know that's what we wanted to go looking for yet. When you make new discoveries and you don't have the spacecraft in place, it's really frustrating, but if you love this sort of stuff, call your congressman and representatives because NASA's budget is getting slaughtered right now, and all our dreams for spacecrafts to answer these questions are in the process of getting canceled, and you can change that! And to be entirely honest, if they keep slashing these programs, I'm no longer an astronomer because I'm going to run out of funding, so you're protecting jobs. So if you're worried about "Oh, we're just throwing money away on science!" well, we're also throwing money away on funding human beings who give back to society -- who teach, who educate, who talk about science at Dragon*Con. So anyway, stepping off of my soapbox, we'll want to build those missions.

Fraser: If you have questions, you'll want the mike.

Questioner: I have my lab coat on. I've heard about a proto-planet that is spewing water…do you know that one?

Pamela: OK, I have to admit I travel roughly 70% of the time, which means I have random gaps located where airplanes were taking off and landing. I will look that one up and get back to you. I'm sorry.

Questioner: You were talking about the big things that are going to become planets and stars at some point. What are the oldest things that have been tossed around? Are they basically the clouds of alcohol?

Pamela: Yeah, so the beautiful thing about the galaxy is it provides everything you need for a good margarita except for the lime. There is tons of alcohol, ethyl alcohol, just about everywhere, and because there's alcohol everywhere, that's another one of these neat organic compounds that just starts making it easy to talk about the Universe because who doesn't want to talk about alcohols?

Questioner: Yeah, I heard a little while back and I was hoping you guys could tell me if it was true or not, I heard that when galaxies collide, like if Andromeda collides with us, that the gaps between the stars is so great that it's actually possible that like nothing will actually even collide.

Pamela: It's entirely true. They've already named this future merged system -- it is "Milkdromeda."

Fraser: You know what? They call it Milkomedia, and my name was Milkdromeda, and Milkomedia is the one that was taken.

Pamela: I've seen Milkdromeda on some NASA press releases, too. So it's true -- the space between stars is huge, often measured in light years, and so if you try and collide these two systems, the best way to think of it is if you have a room with chairs and no feet on the ground, and you sit in the back of the room and just start rolling marbles across the room randomly, most of those marbles are going to make it all the way across the room without touching any chair legs. This room is 1000s of times denser than the galaxy, so now imagine rolling those marbles -- they're pretty much not going to touch anything.

Fraser: That was a good example. If you have a marble about that big here…

Pamela: He's holding his fingers an inch apart.

Fraser: About a centimeter apart for us Canadians, you could…the closest star to the Sun would be around St. Louis, so consider how…what are the chances of marbles colliding with those kinds of distances? But you will get crazy tidal gravitational merging, so I mean, the gravity…

Pamela: Dust clouds will have a bad day.

Fraser: Yeah, yeah, so I mean the two galaxies will never look proper again, they will be mushed up and sprayed out, but the actual individual stars won't collide…probably.

Questioner: You were talking about RR Lyrae being standard candles because they always have the same amount of light, but how do you know that there aren't RR Lyrae that have other kinds of light?

Pamela: OK, so I over simplified, as one does occasionally. There are what are called globular clusters: clusters of thousands of stars pocketed together orbiting together in our galaxy. All of the stars in a given globular cluster formed at the exact same time out of the exact same material. When we look at globular clusters, the RR Lyrae in them are the same brightness with minor corrections occasionally needed. You make a plot with any normal telescope that isn't hyper-sensitive, they're all…they just line up beautifully as having the exact same apparent brightness. Now, different globular clusters will have slightly different chemicals in them. Astronomers say that we live in a universe with hydrogen, helium and all the other atoms we call metals 'cause...well, why not? And so, what we say, some of these globular clusters have a higher "metallicity," a higher metal content than others, and all of the RR Lyrae, once you correct for the differences in metal content, have the same brightness in these clusters, and while all of the stars in a cluster might not be the exact same distance from us -- compared to Earth, they are. It's sort of like everyone in this room, for all intents and purposes, is the exact same distance from Beijing. Yes, one of you slightly closer than another – it doesn't matter. So when you can look at this cluster that are all made the same way at the same time and they're all the same brightness, this cluster all made the same way at the same time same brightness, that's when we can assume all RR Lyrae are, once you correct for metallicity, the same brightness.

Questioner: You mentioned all the complex organic chemicals that we find floating around, and with the huge variety do we have any evidence of nucleic acids in there, along with the alcohol, formaldehydes and other things?

Pamela: There's a lot of amino acids. I don't remember finding nucleic acids, but not my specialty, so I know there's amino, I don't know about nucleic, and that's simply an "I don't know". Again -- got a C in chemistry.

Questioner: All of us have heard or seen pictures even of the geysers on Enceladus, and I was wondering…you spoke about Europa earlier. I was wondering if you could maybe contrast those two. Which one has a better chance of having life there…?

Pamela: So Europa's a whole lot bigger than Enceladus. Enceladus is going around Saturn; Europa's going around Jupiter. Jupiter's a whole lot bigger as well, and with the orbital resonance that Europa has with Io and Callisto, and Ganymede -- all of these factors are causing Europa to have this constant squishing going on. It's bigger, so it can store more water under its surface. It has a higher chance of having volcanism down in its core. For all we know with Enceladus is it's pure ice all the way through, and its melting is also caused by the squishing, but it probably doesn't have these vast oceans that are interconnected, it probably has pockets of water that are being forced through the surface. So it's the difference between the pockets of lava you see at Yellowstone, or rather pockets of hot springs you see at Yellowstone, with the geysers coming up. We really don't have lava under Yellowstone coming up vs. the vast oceans that we have, well, Atlantic and Pacific come to mind. So Europa: Atlantic and Pacific interconnected quite nicely; Enceladus: geysers at Yellowstone.

Fraser: Yeah, I mean astronomers still…this is where we need more missions, right? Because there could be 10 km of ice, there could be 100 km of ice, you know? There's definitely going to be liquid water, but it could be slushy, so it might not be the kind of place life is going to be in. This is one of those things where more information is needed. We need to send some probes, we need to drill down and have a little submarine that zips around under the ice and searches for life. You know, there could be black smokers like we've found here on Earth. So, both are really exciting. I would go for Europa, personally.

Pamela: So we are going to take a few more questions, but I wanted to say before people start fleeing too dramatically -- my staff just finished packing up my booth of merchandise and are bringing it to this room, so if you'd like to get AstronomyCast t-shirts, bumper stickers that I can sign, we have posters, we have all sorts of stuff. All of the proceeds go to supporting science education. The money that we're earning at this conference is going to get science curriculum into schools, and the reason we're doing this is because we developed a really great curriculum, went to the schools with it in digital form, and they said, "we can't afford paper." So I've printed it all out, and take the kits, take the experiments, take the plastics they need in Rubbermaid kits, in Rubbermaid tubs to the schools so the teachers can do hands-on science with their kids. So everything you buy…

[applause]

Pamela: Everything you buy helps "science-ify" children. Go ahead.

Questioner: You spoke earlier about the thing that we couldn't quite see that was causing gravitational…

Pamela: The Great Attractor…

Questioner: Yeah, the Great Attractor. I recently read about a theoretical physicist that was attempting to explain that with a flavor of M- theory, as another dimension that has stuff rolling toward the…I was just wondering what you thought about that as a possible explanation for unaccountable forces.

Pamela: So I have to admit that we live in a universe that works really well, and any time you have to start invoking things in extra dimensions to explain something you can explain by saying there's a large cluster of galaxies we can't see hidden behind the gas and dust, well, probability says, there should be a giant cluster hidden because we know how randomly they are distributed across the sky -- easy explanation, works beautifully, allows us to have a great name for a hidden object. Now, when you have to start changing rules of gravity, which we keep finding to new ways to prove exists, um, it starts to make me feel uncomfortable. Now, I'm not going to "dis" all of M-theory, all of String theory today [laughter], but…

Fraser: Yeah, that's another podcast.

Pamela: But the issue is we have to take Occam's razor, and you have to look for what real proof is there for this that allows that theory to exist as something more than just an explanation for a special case. If you have to come up with a huge theory to explain an example of one, you either haven't looked around hard enough, and here I think we have…or you're just making stuff up because it's fun mathematically, and a lot of theorists do brilliant fun stuff mathematically, but that doesn't mean -- even though the math works -- that it actually describes reality. I like reality.

Questioner: So my question goes back, I guess, to Europa with the tidal currents that are going through the…with the water. Is there any evidence that the convection currents are starting to form a magnetosphere that we would have, and that the geysers are contributing to a thicker atmosphere on Europa, or…?

Pamela: So Europa doesn't have any atmosphere at all, but what it does have, we think, according to some of the really neat models… Again, I'm quoting stuff that I saw Brittany Schmidt present; she was showing how you can end with the rising heat. So you can think this is a basically convective process: you have hot water rising, thinning the surface of the ice, cooling off as it radiates heat, and sinking back down. So this works a lot like a lava lamp does, except it's an ocean capped with ice instead of, well, something not capped with ice with a light bulb on the bottom. Volcano capped in ice – much more interesting.

Fraser: Yeah, but one of the great reasons to have an atmosphere, here on Earth for example, is that it protects us from a universe that's trying to kill us, and Europa has this thick ice, and water is one of the best protectors you can have from cosmic rays, and radiation, and solar flares, and all that kind of stuff. So, in fact, any life that is underneath the ice is going to be perfectly protected from whatever the Universe is going to try and throw at it, and again, is another great reason to explore Europa for life.

Pamela: And we have no evidence positive or negative about a magnetic field there, so I just can't address that.

Questioner: Briefly, you had mentioned the 11-year sunspot cycle, and I know that currently you are finished…we are in one of the longer versions of said cycle, and I believe I've read elsewhere…I can't remember the name of the theory, but there's a theory that the sunspots are getting dimmer, not exactly necessarily, and harder to see, which is part of the reason that we're seeing less of them.

Pamela: OK, I'm going to take that one. I was going to give it to Fraser…

Fraser: Well, except that just to remind you that the Solar Maximum is going to show up in 2012.

Pamela: I know, I know, that pesky Solar Maximum and its big old solar flares that shake our atmosphere and generate currents… So sunspots – these are when you look at the surface of the Sun and it looks like it has acne; that's actually places where there's magnetic field lines coming out through the surface of the Sun. So if you've ever played with one of those magnetic toys where it's the face with the filings that you move around to give the dude a beard using a magnet when you play with them just right… Go to a dime store -- they have them there; they're quite silly. They date back to like my parents' childhood. OK, yes, that's awesome. Those are sunspots, so those are places where if you saw the arcs made by the filings – those were magnetic field lines. So with the Sun, these are magnetic field lines that are coiling out filled with plasma, so this is filled with like the type of stuff…it's all ionized gas. Now, where these come out – that surface place of the Sun is a little bit cooler in temperature, and it's because it's cooler in temperature that it appears darker. So as long as there's the same difference in temperature between where the magnetic field comes out and the surface, they're going to have the same difference in how they appear to us, the same apparent difference in brightness. The physics of magnetic fields haven't changed, but what we are seeing is, for reasons no one can explain, our Sun is refusing to give us the large number of sunspots it should be right now. And this is actually really starting to annoy some planetary scientists because when you see those big ole sunspots with the big ole magnetic field loops associated with them – those field loops periodically let loose and stream high energy particles towards us, the Moon, Mars and all of the other planets, and if you hit the surface of a planet that doesn't have an atmosphere -- the surface of the Moon -- with these high energy x-rays, you can get reflected high-energy particles that allow you to start looking at what is the compositions of the soils. You can only make these measurements if the Sun fires off high energy, which it's refusing to do, and we've sent spacecraft to the Moon, assuming Solar Maximum would come on time – and it's refusing, and so there's a lot of people who…they just can't do the science they want because the Sun isn't being, well, abusive toward the moons and planets.

Fraser: That's pretty hilarious that one of the most predictable things we know of in the Solar System is this…

Pamela: Didn't happen.

Fraser: …is this eleven-year cycle of maximum/minimum, and all the people who put together they did their research papers, and they got their missions up, and they got their telescopes ready…and it didn't happen – yet.

Pamela: So we have eight more minutes. One more question, lucky sir, go ahead.

Fraser: Well, I was actually curious to know what each of you find the most neat, weird – however you want to define it – thing in the Universe.

Fraser: My problem is I suggested my whole list to Pamela, so I gotta pick one. I would say the thing that I like best is Iapetus, which again if you take a look at Iapetus, there's this amazing two-color shape – one side is black, one side is white, looks like kind of a ying-yang, and yet it has this amazing walnut shape to it as well, like it's been squished, and it's got this ridge that runs along it. It's one of the most fascinating things in the Solar System -- and that's my favorite. It's the one that I just keep going, "What made that?!"

Pamela: I'm going to give you a somewhat lame answer. I'm a volcano junkie. I don't study volcanoes, although I kind of stalk the Iceland website because I fly a lot, but we keep…did you know there's volcanoes on the Moon? They've been dormant for a while, but there's shield volcanoes on the Moon that are identical to the volcanoes that we have here in America and in Hawaii. And so you're looking through these high resolution pictures from the Reconnaissance, which if any of you are around 6-feet tall and you lie down and assume the make a snow angel position, you'll appear in these images as a few pixels in size. These are really high-resolution images that allow us to look at volcanoes, and we see them on Mars, and we see them on Io, and they all have the exact same physics, and they have such an ability to randomly, and without warning, just destroy planets that I…it's like watching "Shark Week." [laughter] So that's my thing. Now if any of you want to be astronomers or planetary scientists, you can right now without having to go back to school because there are a series of projects that are citizen science projects that take this amazing NASA imagery and place it online, and I'm going to plug one where we really need your help right now. It's called Icehunters.org. There is a spacecraft called New Horizons -- it's on its way to the once and future planet, Pluto, [laughter] and it will fly by in 2015, and it has just enough fuel to change its trajectory to visit one and possibly two more objects that haven't been discovered yet, and so we've taken all of the images that those objects should be in, and we've put them online for you to help us search through. They're really ugly. They're difference images, which is where you take two images and you subtract them, and if you imagine the stars are like this in image one, and one moves – that's not a star, that's a Kuiper Belt object that orbited between the two images, so when you subtract this image, and this image, these go away and you end up with a bright spot, and a dark spot in the subtraction. So you can look at these really ugly images that occasionally have bright blobs in them that could be the object you discovered that we send a NASA mission to. So go out it's Icehunters.org, and my staff is hiding out there with all of our merchandise, and you can mob us for questions, but he's going to make a final announcement.

Fraser: I've got one more thing, which is that we are doing our final actual official AstronomyCast live tomorrow at 4:00 with Dr. Kevin Grazier, Dr. Phil Plait, and Dr. Pamela Gay, and me, and…is he a doctor as well now? No…

Pamela: And the wonderful engineer, Les Johnson.

Fraser: The wonderful engineer, Les Johnson, yeah…so that's going to be tomorrow at 4, we're going to be doing that, I think over there, in the podcasting room, which is the same size.

Pamela: And our booth will be set up the rest of the time next to the "Her Universe" shirts booth -- we got liberated from the Sheraton dungeon. So we're here for the rest of the weekend, so come find us and talk to us. Thanks for being a great audience. [applause]