Astronomy Cast Episode 273 for Monday, September 24, 2012:
Solutions to the Fermi Paradox

Fraser: Welcome to Astronomy Cast, our weekly facts-based journey through the Cosmos, where we help you understand not only what we know, but how we know what we know. My name is Fraser Cain; I'm the publisher of Universe Today, and with me as always is Dr. Pamela Gay, a professor at Southern Illinois University – Edwardsville. Hola, Pamela!

Pamela: Hello. How are you?

Fraser: Good. You're in Spain. You're in Madrid.

Pamela: I am in Madrid. I am here for the European Planetary Sciences Conference and realizing I don't speak any Spanish. Sesame Street did not prepare me.

Fraser: Really? Aww… What is the conference about then?

Pamela: It's basically a review of planetary science all across Europe, results from all of the missions that are shared between NASA and the European space agency, so I'll be hearing about Vesta, about Mars, about plans that the Russian Space Agency has for going back to Mars. It's a small, nice little international conference in the biggest conference center I have ever been in in my entire life. You could like fit most of the conference centers I've ever been to into this one conference center. It's huge.

Fraser: Yeah, there's some really big conference centers in Europe. So hopefully you'll be reporting at some point on this down the road or in StarStryder, or we can reference it in a future episode, so that'll be great! So take notes and convince people to launch more spacecraft if you can.

Pamela: We're trying. We're trying.

Fraser: OK, so let's get rolling then.

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Fraser: So in episode 24 we presented the concept of the Fermi Paradox, in short: where are all the aliens? And today we're going to examine the theoretical solutions to this problem. Maybe they're out there and they just don't want to talk to us, maybe it's too hard to communicate, maybe there are no other civilizations, maybe civilizations wipe themselves out before they reach a certain point…so many solutions, and none of them very satisfactory. So Pamela, so this really leads to…actually, last week during our recording of Astronomy Cast, we actually wrapped up our episode on abiogenesis, and somehow…and we do this as a live Google plus hang-out and we had a lot of people watching, and some people asked some questions, and somehow led to a conversation about various parts of the Fermi Paradox, and some of the possible solutions to the Fermi Paradox, and we were having a great time, everyone was talking and I realized, "OK, this should be a show," so we tabled the conversation and posted it on the schedule, and now we've brought it back for this week, so before we sort of get into the solutions, can we get a refresher again on what the Fermi paradox is?

Pamela: Well, it's basically the idea the Enrico Fermi, an Italian physicist working at the University of Chicago, one day at lunch basically said, "Where are they?" and this of course confused everyone who he was eating lunch with, but what it turned out that he meant was, "Where are all the aliens?" It should only take, depending on how you run your calculations, a few tens of thousands of years to a few millions years to largely populate our galaxy, and if that's the case, why haven't they populated where we are? Why haven't we seen the aliens? Why aren't they regularly visiting in a way that is scientifically provable and everyone can agree upon? Where are they? And so this became Fermi's Paradox.

Fraser: And it really is a devastating paradox when you think about it, I mean, think about situations like a little bit of bacteria making it to a sandwich. I mean within a few hours, or within a few days that bacteria has made it to the entire sandwich. And so it's the same situation that if, you know the Milky Way, for example, is only, whatever, a hundred thousand, a hundred and thirty thousand light years across (I say "only"), but if you're moving at one tenth the speed of light, and you're moving from world to world, then you know, conservatively, it would take you about a million years to move across the entire galaxy, and if you've sent some self-replicating probes or colonies, you know, and give them a little time to catch their breath, it's still only going to take a couple of million years for these

people to, at speeds that are fully within the laws of physics so there's no reason to believe…and when you think about how the universe has been around for 14 and a half billion years, all it took was one span of about a million years…

Pamela: 13 and a half billion years.

Fraser: 13 and a half billion years. Sorry.

Pamela: 13.7 plus or minus.

Fraser: 13.7…yes. Sorry. 13.7 billion years, so you think the universe has been around for that long, just one moment on one civilization on, whatever, 200 billion years, 200 billion stars in our Milky Way, you know, one intelligent civilization had to arrive and then just take one million years, and boom! -- colonize the entire milky way, and I mean, we're on our way to doing this right now, and we will absolutely do this. I mean, this is a drive that, you know, that humans have had to explore and colonize every portion of the Earth, and we'll absolutely take it out into the stars, so give us a million years and we'll have populated every planet in the Milky Way.

Pamela: But this is assuming that we don't kill ourselves off.

Fraser: So, right, so then…so if with all those assumptions, really, why do we not see any aliens? So what are some of the really, sort of, the…what is the first real powerful meta argument that we see?

Pamela: Well, I think the easiest way to look at it is, well, what are the things that would prevent us from doing this? And so first thing that comes to mind is disease. There's always the fear that there's going to be such a horrifying disease that it crushes civilization and civilization isn't able to rebuild itself. If it's not a disease, what about war? And if it's not disease or war, asteroid impact, comet impact, otherwise some form of natural catastrophe, and one of the truly terrifying things about a civilization as advanced as the one that we have now is we've used up all our planet's easily accessible natural resources, so were civilization to have to rebuild itself from scratch, there's no easily accessible oil, there's no easily accessible coal, there's very few easily accessible minerals and metals left short of mining up the superstructures of buildings in cities that have been bombed out, so the idea of civilization being able to recover and rebuild to

the point of being a space faring civilization again, it's very hard to imagine given the planet that we have now. So disease…?

Fraser: Sure, but every one of 200 billion stars that potentially could have supported life, was it disease 200 billion times? Who knows how many intelligent civilizations came about…you just need one, right? You just need one to not die of disease and not kill itself, and then, boom! -- it's colonized the entire milky way.

Pamela: Those are not the only things, those are the things we worry about as those are most likely to stop us short term – finance. We have a global economic crisis going on where due to lack of funding. We canceled our Mars sample return mission. The plans that we had between the United States and Europe to jointly go land one robot on Mars, scoop up rocks, go land a second spacecraft next to it on Mars, bring back the rocks -- that was an extremely high-risk mission that we had, a rather a scary flight plan, but it's a former scary mission that we're not going to attempt. There isn't going to be another "Seven Minutes of Terror" movie describing how we're going to back to get the rocks. That mission is dead.

Fraser: Yeah, but ever? 200 billion worlds, every one always cancels their spaceflight plans?

Pamela: You can imagine that it's just never financial priority, and as civilizations advance, as they run out of resources, they simply never choose to make their priority be space exploration.

Fraser: So this is really sort of like you're saying...this is the Doomsday argument, right? That all intelligent life will always destroy itself before it becomes a space-faring civilization.

Pamela: Or up until this point in history, any of the civilizations that have thus far reached that stage have found some reason not to leave their planet, and then there's also the stupid things that you have to worry about, such as, if civilizations grew up on a planet where they evolved under water, would they ever develop spaceflight?

Fraser: But I gotta go back to always 200 billion worlds in the Milky Way? We're an example of…

Pamela: Thus far.

Fraser: Sure, we're an example of a race that has shown up on land and not on sea, so yeah, maybe 50% of them are on the land, and 50% of them are on the sea?

Pamela: No. So the other thing is you have to pre-suppose that our civilization, which it doesn't have this capacity yet, is a baby civilization and so there's always the potential that…imagine we're the most advanced civilization currently existing in the galaxy.

Fraser: Right. So we're first; we are the most advanced civilization in the galaxy.

Pamela: Or we're one of only a handful, and the other few handfuls all destroyed themselves.

Fraser: So not only are we first, but this capability is also very rare.

Pamela: Yes.

Fraser: Yeah.

Pamela: So there are so many different things that have to go right, and then there's also the matter of having resources capable of allowing you to do this. What if you developed civilization on a planet that doesn't have enough natural resources that are accessible in order to build the types of spacecraft that you need? You're running short of nuclear supplies, you're running short on easily accessible metals…and so you can develop an advanced civilization, but not an advanced space-faring civilization.

Right, OK, so just to kind of break this down for people, really, you know, either life is very rare, or intelligent life is very rare -- we're first, right? And we're in sort of a relatively intelligent…and we're first, or life destroys itself. Well, it really kind of depends on it, but there's something else as well, right, which is that life destroys each other, that we aren't first, that in fact, there is a civilization that has already colonized the Milky Way and has made sure that the life doesn't expand, so that's the…

Pamela: This is basically the idea that there is a angry protector civilization out there, and as soon as your society reaches a certain level of technological advancement, they come in and say, "No more!" and so you don't hear about them until they're basically enslaving you, and so we're right now the equivalent of bunny rabbits that are cute and fuzzy, but will cause no harm and thus don't need to be imprisoned and things like that, so they have no need to interact.

Fraser: Right you can imagine an analogy here on earth, right? Where we don't really treat, say, viruses that seriously until one comes around like smallpox and then we go, "OK we need to wipe that one completely out of existence because that one is very dangerous," and so you can imagine the same situation -- that aliens treat us sort of like smallpox or like a virus. Right now we're like the common cold, but if we get space-faring ability, then they'll treat that like smallpox. There was a great series a great science fiction series, "The Berserkers…?"

Pamela: I don't know that one.

Fraser: Yeah, oh man, someone in the comments is going to mention it in a second here, but it's this concept that you can expand, as I said, you can expand at one-tenth the speed of light, and so instead of colonizing you just send killer spacecraft out, and you have these spacecraft show up at every possible world, and then the spacecraft just stops and waits and watches for any evidence of a space-faring civilization and when it finds it, it…I don't know, blows up the Sun or something.

Pamela: It's kind of the plot of "Prometheus," although I have to admit, the full plot of "Prometheus" was always kind of mysterious to me.

Fraser: Don't try to think about the plot of "Prometheus," you'll only go mad. It's kind of like "2001," but that was different because that was kind of an uplift. So that really kind of collects all these together, so let's kind of lump these into one pile, which is sort of…

Pamela: So the civilizations never get to the capacity, so they either they're under water, they don't have the natural resources, they live under clouds and the idea just never occurs to them, so civilizations can't get there.

Fraser: Yeah, so there's another whole classification, I think, which is that they are there, but we can't find them or communicate with or really connect with them.

Pamela: And so this is the idea of we would never recognize the communications from a life form that communicated extraordinarily quickly, or extraordinarily slowly. The passage of time, in some ways, very much matters, and it's not necessarily only the passage of time, but that's the one we think of.

Fraser: Right, but space is big, right? Douglas Adams has a great line about how mind-bogglingly big space is, that the intelligent civilizations are all just too far away from each other and communication with them is just impossible.

Pamela: Yeah, but that's still doesn't fix the Fermi Paradox, which says that they can go out and spread out in a million-ish years or more. That implies that they've chosen to keep themselves far away, that they've held back their exploration tendencies, and in a way you can understand a civilization making the choice not to exert the resources necessary to have self-replicating robots that go out and colonize the entire galaxy, knowing that they'll never get the signals back, knowing that there's…what is the point of sending out self-replicating robots to take over the galaxy when you can't be there to experience it? We abandoned Voyager to go flying through space, but we didn't make it self-replicating, and I don't think anyone would have argued for that.

Fraser: I would have. Seriously, I would have. That would have been awesome! Fire it up on another planet, build another Voyager, communicate with us…I absolutely would have argued with that, then I would have come back and I would have tried to kill the Enterprise…

Pamela: Exactly.

Fraser: Then you can imagine, then, that humans, for some reason (and we haven't figured this out yet), at some point, someone will kind of go, "Oh, here's the math. It doesn't make sense to explore the galaxy. Let's not bother." And everyone saying, 'Yeah, OK, yeah, that makes total sense. I don't know why we never thought of that."

Pamela: And that's kind of where I'm at is: it's expensive, you won't get the information back, and so until we figure out how to colonize everything, which requires a whole new level of resources, that's harder to do in a million years.

Fraser: Right, and as you said, economically it's entirely possible that it's just not feasible under the laws of physics to do it in any kind of reasonable way.

Pamela: Well, I'm not sure about the laws of physics so much as we're pretty good at building spacecraft that are good at powering themselves for a few decades, using various radiothermal generators, but in order to be able to self-replicate, you have to somehow get to another planet, dig up and mine more nuclear resources, and so you have to be prepared to check multiple worlds before you can find what you need, finding uranium, or plutonium or whatever you want is difficult enough on the planet Earth where we can explore the whole planet at will, so just the idea of: how do you get the power sources necessary to replicate and spread out? That raises all sorts of complications.

Fraser: Yeah, yeah. Now, you could imagine a situation where, for example, humans…I mean, we think that we should be listening to radio signals, or beamed laser transmissions, or neutrino emissions, but maybe there's a communications problem.

Pamela: No one's listening for neutrino emissions.

Fraser: But, maybe. Right – nobody is. That's what you're saying, that currently no one's listening. Yeah! That's right, yeah! So it might be that aliens communicate through neutrinos, which would actually be a pretty great way to communicate since they can pass through light years of solid lead, and we're just not listening. So maybe in ten years we're going to realize that, "Oh! Neutrinos are way better ways to communicate with than radio!"

Pamela: They're just kind of hard to detect. It's that whole passing through light years of lead thing.

Fraser: What else? I mean, sort of, in this same thing -- they're too alien?

Pamela: That brings up the cultural difficulties of: their culture doesn't have the desire to explore. And that's something we've seen a variety of human races as well, or human cultures rather, where there's certain cultures that simply don't have the must-go-out-and-take-over-every-ounce-of-lead-on-the-planet, we are quite happy where we are, thank you very much. So you can imagine an entire world of cultures that just don't have the wanderlust that the people who founded America, Canada, Australia and those countries had to get there.

Fraser: They…so I think this is a great one, right, which is that they really have chosen, and I think a lot of people buy this one, that they have chosen not to interact with us, that there's some kind of galactic federation…

Pamela: The Prime Directive.

Fraser: The Prime Directive right, which says, "Don't talk to them until they can fly their spaceships." What do you think about that one?

Pamela: I think that one's pretty interesting, except there's the, "Well, how do they know we're here?" You would have thought that maybe they're somehow monitoring us if that existed, and there's enough telescopes out there that you know we're pretty good at catching random rocks falling into Jupiter right now, you'd think we would have in all of our images man age to intercept something flying through the field, and even if they're good at building stealth spacecraft, they would have occulted a star now and then, I mean, who knows if we would have seen it as anything more than a wink in and out that we ignored, but…

Fraser: That's them ignoring. And then there's this further concept of the Galactic Zoo, where we're actually…they've created a very elaborate zoo for us, and they're hiding evidence of the universe from us. Sort of the grand conspiracy…

Pamela: I think that one's just a little crazy, but…

Fraser: Oh, unlike all the others…

Pamela: Well, so the whole idea that the civilizations didn't leave their planet – that one doesn't require suspension of belief. The idea that we basically are in a solar system-sized version of the Truman Show – that one

seems a little bit more difficult because you'd have to forge the cosmic microwave background.

Fraser: Yes, but they're super space aliens, and any civilization…what is it -- technology, sufficient technology, would appear as magic right?

Pamela: Yeah but we don't see it as magic, we see it as the Big Bang.

Fraser: Right. OK. And then, of course …I think another one is that the aliens are here all around us.

Pamela: Yeah, no.

Fraser: We just don't know. They're disguised as us.

Pamela: See, that's just like "Battlestar Galactica" 1984…

Fraser: Or "V."

Pamela: Yeah, or "V," no "V" we knew about.

Fraser: "They Live"…there's lots of great examples of aliens. There's a lot of pretty wing-nut theories on the internet.

Pamela: "Alf."

Fraser: "Alf?" [laughing] There you go. "Alf" as a solution…

Pamela: The ultimate alien living among us…

Fraser: "Alf" as the solution to the Fermi Paradox -- they're in people's living rooms, watching television and eating cats.

Pamela: [laughing] Yes.

Fraser: So then, of all, you know, we've sort of gone through a bunch, but we've only gone through a fraction of possible solutions to the Fermi Paradox, so which one do you really feel is…which one feels right to you?

Pamela: I think that (and this is going to be me being the more depressive one of the two of us)…I think the idea that civilizations consistently, before they reach the stage of interstellar travel, suffer from either disease or natural disaster that crushes their civilization to the point that they can't return. I can see that as being fairly likely because there's just a certain point where you've used up easily accessed resources, and you can't return from…imagine a global outbreak of ebola, imagine a global outbreak of any number of the horrible diseases.

Fraser: So…or not necessarily something so negative, I mean, something positive as well where they do the math, and they realize that it's just not feasible, and instead stay back on the planet and create a utopia…or you still think it's the negative side?

Pamela: I'm much more tempted to go with, by and large, it's the negative side.

Fraser: Right.

Pamela: Simply because we see in our own civilization, there's always that one rich dude who's willing to expend the energy to figure it out. Today it looks like Elon Musk is going to be the one to figure out how to get us to Mars, and so there's always that one person willing to expend the resources, but interstellar travel requires your civilization being much more advanced than we are currently, and we've come so close to…whether it be war, whether it be Spanish influenza, we could have lost our society many times. All it takes is one asteroid. Now, I'm sure that in the grand scheme of things, there are going to be in the tail end of the probability distribution the societies that don't care, the societies that run out of money, the societies that are simply too young.

Fraser: So for me (and I'm glad you asked), I like the Rare Earth hypothesis. So I think, for me, it's that either we are sadly alone in the universe, or in the Milky Way, or we're first, or there's no sort of…or we're very first, or we're close to first because…I don't know, it just feels always to me like when we get these exponential…everything's exponential in this idea that any one world would then colonize the entire Milky Way. And so, you know, in each one of those arguments that you posed, you would have to say, "Well, but every time for 200 billion stars it didn't work out?" And

that's all, it just feels like all you need is one, and then you get the whole galaxy.

Pamela: You have to be careful with the 200 billion number because that's…

Fraser: Of course. You need to go to the Drake equation to really do the math. I understand. Sure, so 10 thousand stars, you know? One in ten thousand? All it took was one in 10 thousand to make it through the disease, the technology, the whatever, and then -- boom! You're off to the races, and then I think you would see evidence, and then the other thing, I think, is that we would see evidence not only of other stars that were under the effect of a highly advanced civilization, we would see them dismantling their stars, creating disonspheres, organizing stars together into weird patterns and shapes…

Pamela: You just love the idea of taking apart stars!

Fraser: I do! But I think we would even see evidence of galaxies being dismantled and reconstructed in various ways, and so we can see out into the universe, and we don't see any galaxies that have been turned into big smiley faces, you know?

Pamela: And the energy requirements of something like that…I just can't imagine something like that being considered as worthwhile to do, and it's… yeah, 14 billion-ish, 13.7 plus or minus billion years seems like a long time, but our sun is only 4 and half billion years old, and it's one of the mainstream metal-rich types of planets that support life, or support planets rather, and we've found lots and lots of different types of planets that support stars, but what I haven't seen yet is just how far back can you go and still be finding stars that had planets.

Fraser: Well, and we see again we see 200 billion galaxies around us, so…

Pamela: Right, but most of those we're looking back in time, so as we look back in time, we're not going to see the civilizations.

Fraser: For sure…so that's all. I just feel like there's just such huge numbers, and that it's not about you seeing the fractions, it's that in any one of those galaxies or in any one of those systems, you would have this

exponential expansion that would come from any intelligent civilization that was attempting to actually colonize its home galaxy, so that's all. And I just feel like if you looked out, you would see that evidence somewhere, so for me the most compelling one is the fact that sadly or unfortunately we're either alone, super rare, or first, so…but I…your option, as well, is pretty terrifying, so both kind of haunt…both haunt me. And that's why I love the idea so much. This is like a horror story for space nerds, I think.

Pamela: No, the Fermi Paradox definitely does say there's something wrong here.

Fraser: Yeah. I personally find the Fermi Paradox really chilling actually…very cool, and so exciting. Well, that was great Pamela! Thank you very much. I'm really glad that this turned into a conversation from what happened last week. So hopefully, that will happen again. So enjoy your time in Madrid and soak up the sun, and maybe pick up a little of the language.

Pamela: I have to! It's…when you start with zero, it's easy to learn.

Fraser: Awesome! Alright, well have a great time. We'll talk to you later.

Pamela: Thanks! Bye-bye.