Astronomy Cast Episode 271 for Monday, September 10, 2012: Who Does What in Space & Astronomy

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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 is Dr. Pamela Gay, a professor at Southern Illinois University – Edwardsville. Hi, Pamela. How are you doing?

Pamela: Hey, Fraser. I'm doing well. It's Fall here; we're back with the new season, and we're back with…well, it's not hay fever, but corn fever, so forgive the scratchy voice.

Fraser: But this is the start of our seventh season? Seventh year of doing this?

Pamela: Yes, that was an amazing realization I had earlier today.

Fraser: Our six-year anniversary of recording. We were just mentioning this. We started…our first show was about how Pluto lost its planethood, and that was two meetings of the International Astronomical Union ago.

Pamela: So the next meeting's in Hawaii. That's going to mark that we've been doing this going into our tenth year, so I think we need to plan to be in Hawaii for the next meeting.

Fraser: Oh, that would be great! Yeah! Hawaii's pretty close to me, so that sounds good. China, where you just came back from, was pretty far. So thanks to everybody who put up with us not recording shows over the summer break. We really needed to take that hiatus, and clearly, I think, this is going to be the trend in the future, so let's just keep that in mind. A little bit of an announcement: 1) I just want to remind everyone that we are recording these episodes of Astronomy Cast as a live Google plus hang-out on air, so you can actually watch us recording. We've got about 50 people watching us right now actually, so if you want to join us, you can just come to Google-plus, search for me or Pamela, and we'll create an event in advance. You can actually sign up for the event. It will go into your

calendar…it's pretty cool. The other thing we're doing, of course, is that every Sunday night we do our virtual star party, where we hook up a bunch of telescopes live on the internet and broadcast our view, and last night was pretty cool. We had Uranus and Neptune for the first time live.

Pamela: Yay! You pronounced it the way I pronounce it this time!

Fraser: I know, I'm caving to your politically correct pronunciation of Uranus. Yeah, so we had that – that was amazing! Live! You know, Neptune was sort of the plan, then Mike Philips brought in Uranus by accident.

Pamela: And we had moons galore. It was really, really fabulous.

Fraser: We had moons…it was, yeah, pretty amazing, so we do that. And then, the last thing, just to remind everyone (we actually have mountains of announcements and stuff, but I won't sort of overwhelm you this time), we're going to get back with the weekly space hang-outs starting on Thursdays at 10 a.m. Pacific, you do the math, and then…

Pamela: Don't forget we also have the Wednesday Science Hours at 4 p.m. Pacific.

Fraser: Yeah, we do have about four kinds of programs every week, so if you want space and astronomy -- lots of opportunity. So the other thing, just to remind everyone, is that we're going to be doing the Not-the-End-of-the-World cruise at the end of the year, and I think the time for registration for that is starting to close down in a couple of weeks, so if you have any interest in joining us on a cruise to celebrate the fact that the world isn't going to end…and we're actually going to go to the Mayan ruins and stand at the point of apocalypse, and watch other people's faces.

Pamela: And it's not that expensive as far cruises go, and it's completely family-friendly. Fraser's kids are going to be there, and I plan to try and kidnap them to go to Disneyland at one point.

Fraser: Perfect. Wait a minute, that's not family-friendly! Kidnapping children to go to Disneyland! Cool…so I think that's going to be a lot of fun, so I really hope people…if you're interested in doing that, and you want to join us, that would be great fun. So you can go to, I guess,

Astrosphere.org, yeah, and there's a link there for the Not-the-End-of-the-World cruise, and you can find out more information about it there. Is that it?

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Fraser: So in the past, if you looked up into the sky, you were an astronomer, or I guess maybe an astrologer, but everything has gotten so complicated. Now we have astrophysicists, and cosmologists, planetary geologists and even exobiologists. So who does what, and how do they all interact with one another? And if you want to go into space research as a career, which one should you choose? So what are you, Pamela?

Pamela: I'm an astronomer.

Fraser: You're an astronomer.

Pamela: Technically, I have an undergraduate degree in astrophysics, and a PhD. in astronomy.

Fraser: Not an astrologer.

Pamela: But most of what I do…no, I'm not an astrologer. Although I did take a class on astrology so that I could more effectively understand why they are not science.

Fraser: Did you really?

Pamela: Yeah, actually…I kid you not. When I was at the University of Texas, the barn that I kept my horses at, our Dressage instructor hired a high-level local astrology person to come in and give…I want to say it was an eight-week course on astrology out of her home. It was taken very seriously -- there was homework, the whole nine yards. It was just like any university course you might sign up for, except it was astrology. So yeah, that was an interesting take on: they don't actually understand what it means when Mercury's in retrograde.

Fraser: But it wasn't a skeptical view of astrology, right? It was…

Pamela: No, no, no, no! This was for people who were seriously trying to learn how to cast horoscopes and understand…it was fascinating to get an inside view on "not the science."

Fraser: That's amazing. OK. Specifically, though, you're an astronomer.

Pamela: I'm an astronomer.

Fraser: What does an astronomer do?

Pamela: Well, so the first breakdown that we hit is astronomer vs. astrophysicist. Astronomers are at the most basic level: people who go out, look up, and their way of doing science is based on an observational view of the Universe. So as an astronomer, perfectly valid for me to say, we see all these following trends, we still need to define the physics that makes these trends happen in the Universe. An astrophysicist comes at it from the mathematical side, where you're working up from the basic equations to try and match what the astronomers are observing, and then there's this mix in between where you're doing both.

Fraser: So an astronomer, for example then, would be the one who's actually looking through the telescope night after night, or looking through the data.

Pamela: Looking through the data, we don't look through scopes…

Fraser: Right, looking through the data sent back from the Hubble space telescope, and I guess, their catchword would be something like, "Huh, that's interesting," or "I wonder what this is?" or "Can we zoom in on this?" Right?

Pamela: And questions get answered using data. And with an astrophysicist, questions get answered with mathematics to explain, well hopefully explain, but astrophysicists can make predictions that…so astronomers you look for trends and stuff, but an astrophysicist is where you build a theoretical model that then can often make predictions. So for instance, the solar neutrino problem, which has now been solved, was astronomers noting what the flux coming off the Sun was, we had a general understanding of how old the Sun is, and it was the astrophysicists who built a model explaining, well, there's nuclear generation going on in the core of

the Sun. These are the reactions that are likely taking place; this should be producing neutrinos. And then, to add a new word, particle cosmologists started looking for, or in this case, particle astrophysicists started looking for those neutrinos coming off the Sun, found 1/3 of what they expected. Astrophysicists have to go back and try and figure out what's going on, but then it was the high-energy physicists that actually figured out what was going on using new data, and they…so it's an interactive process where you have the data gatherers, the modelers, and people who look up, people who look in machines -- it all works together.

Fraser: Right, and so just to…I guess that's that interesting distinction, right, where you have an astrophysicist will make a prediction. They'd say, "I wonder if the Universe works like this."

Pamela: Yes.

Fraser: …and then they'll sit down, they'll take the math that they already know, and they say to themselves, "If the Universe works like this, then the math would look like that, and then you would see things in space that matched the predictions that I'm making right now, and then they hand that off to, say, an astronomer as a collaborator to say, "Next time you're in front of a telescope, check to see if you notice some dark area over there, or these galaxies moving toward those galaxies," or whatever it is they're looking for. Is that sort of an accurate way to describe it?

Pamela: Yeah, sometimes you get people who do both. I'm pretty much strictly an astronomer, but I work with people who… Bill Keel, down at the University of Alabama, he recently did a whole series of observations of overlapping galaxies, and as light from the background galaxy passes through the foreground galaxy, you can start to see where dust in that foreground galaxy is obscuring the light from the background galaxy, and you can do mathematical models of the distribution of material within the foreground galaxy that match the observed dimming of the background galaxy, so that's combining our physical understanding with mathematical models to match the observations. And in this case, it's one person who's taking both the astronomical side and astrophysical side of the problem in hand.

Fraser: Right, and I mean, so I think in science you've got probably a similar structure between almost all the sciences. I'm sure you have with

chemistry. You have theoretical chemists match up with production chemists, and so on, but it's the same idea where you've got someone pushing the boundaries and the frontiers and making predictions, and other people doing a lot of the observations, and like you said, sometimes it's the same person. So then what's a cosmologist?

Pamela: A cosmologist is someone who's looking at the Universe as a whole. So this is where we start taking into consideration the entirety of the Universe formed in the moment of the Big Bang. This produced the cosmic microwave background, this produced the initial ratios of hydrogen and helium and trace elements that we see in the most chemically unenriched gas clouds the universe, so cosmologists are trying to build that big picture understanding. Astronomers are typically looking at stars, galaxies as smaller systems, so that the cosmologist is trying to take everything and look at it together, and you end up with gray areas where you have observational cosmologists, who are measuring the expansion and acceleration of our Universe by doing supernovae studies. You have particle cosmologists, who are trying to understand the origins of the Universe, and how particle physics works using some of the world's accelerators, and then you have theoretical cosmologists…well, they're the people who are predicting, when they look at the cosmic microwave background, we're going to see this distribution of the hot and cold spots.

Fraser: So cosmologists are really just astronomers, but they're looking at one specific subset of the science? I'm sure they wouldn't like me to say that to them to their faces, but…

Pamela: Well, so what's interesting…

Fraser: Highly specialized astronomers?

Pamela: [laughing] It's…when you consider your subset of data as we're looking at the entire forest rather than the trees and animals living in the trees – that's probably the best way to look at it is the cosmologists are the ones flying in the helicopter above the forest trying to get the big picture view, while the astronomers are the ones in the forest taking core samples of the trees, catching squirrels and seeing what type of squirrel they are, and so the astronomers are the ones looking at the smaller properties, and the cosmologists are the ones looking at the big picture.

Fraser: OK, so what's a space scientist?

Pamela: So…I love looking at business cards at conferences and seeing what bin people have chosen to put themselves in.

Fraser: Yeah! Why have you chosen this specific title for yourself?

Pamela: Right, so space scientists are people who often work more in space flight, space exploration. They're the ones who are looking at not a planet, not a star, but how do we survive in that place between the planets, between the stars, so space scientists are often people who are working with NASA in manned, unmanned space flight to try and define things like, well, how do we deal with heating and cooling properties in space? How do we build solar sails? So there's…it's a lot more of literally dealing with "space" rather than with a thing.

Fraser: But they're not engineers…

Pamela: They can be engineers. So space scientists can be someone who does a lot of engineering, but consider someone who studied, for instance, the Van Allen radiation belts. That's hard-core science. Understanding the thermodynamics of moving back and forth between being in sunlight and being in shadow, exposure to the vacuum of space – all of the these different things, and then you add in people who study orbits. That's now celestial mechanics and orbital mechanics.

Fraser: So would you be a "celestial mechanic?" Would that be your title? I've never seen that one before.

Pamela: No, I'd be astronomer. No, a celestial mechanic…

Fraser: No, no, no. Would a person who does that be a celestial mechanic, or an orbital mechanic? **B**ecause that would be an awesome title…

Pamela: An orbital mechanic is the poor schmoe who's tasked with calculating: how do you get from Earth to Mars in a low-energy orbit and where do you…?

Fraser: But will a person actually put that on their business card?

Pamela: Yeah, yeah…totally.

Fraser: Really?

Pamela: Yeah.

Fraser: Orbital mechanic…I've never…cause that's got to just get the craziest questions, right? Like, "Can you fix my car in space?"

Pamela: Yeah, so there's actually a lot of complexity to orbital mechanics, and one of the members of my original dissertation committee, but unfortunately he passed away before I finished my degree, was Victor Szebehely. His daughter and I were friends, and she told the story of how he basically figured out how to solve the one special case of the three-body problem that is solvable. Basically, while sitting at dinner…and he suddenly starts playing with the salt and pepper and ketchup on the table.

Fraser: Right, and making a mashed potato Devil's Tower in the middle of the table?

Pamela: Not quite. He was much more of the moving objects, so yeah.

Fraser: Right. OK.

Pamela: But yeah, so orbital mechanics, they're the folks who figure out: How do you get things in stable orbits? How do you get them from point A to B? How do you prevent things from colliding? How do you figure out globular clusters? That's one of the most complicated orbital mechanics problems because you have all these stars that end up interacting with one another, and over time, mathematical models show that globular clusters, due to orbital mechanics, beat like a beating heart, and celestial mechanics, people who figure out: Well, how are the stars passing one another? How do you take into consideration proper motions? They do a lot of astronometry and stuff, but then you also have astrometrists, who are the ones measuring everything. I'm just going to keep throwing titles at you.

Fraser: Please do! I'll stop you every time I hear a new one. Astrometrist? Is that right?

Pamela: Yes.

Fraser: So if I say that I am an astrometer…?

Pamela: Yes. "I do astrometry" is the way it would be…

Fraser: Astrometer? I do astrometry. I am an astrometer.

Pamela: Yes.

Fraser: And that means I measure space.

Pamela: You are the person who very precisely measures the location of things and helps define coordinate systems. So someone who does astronomy, for instance, figures out what are the precise stars that Hubble uses to maintain its guiding, how do we take two different catalogs in the radio and the optical and line them up precisely so that…it's a very important field to do because we don't always have objects that give off light across all the different wavelengths. We use quasars for a lot of different things because many quasars, not all, but many quasars you can see them in the optical, you can see them in the radio, but then you have to get the x-ray stuff on the same system, and there's so many different wavelengths and trying to line everything up is a challenge.

Fraser: Alright, so there's a few titles. We've got people who are various kinds of geologists.

Pamela: Yes.

Fraser: Right? And so you've got a regular geologist…

Pamela: Rocks on Earth…

Fraser: …and then you've got a planetary geologist, and so what's the distinction there?

Pamela: Well...

Fraser: Isn't Earth a planet?

Pamela: [laughing] Earth is a planet.

Fraser: Did that get decided at the IAU while you were in China that Earth is no longer a planet?

Pamela: Earth is still a planet. They did redefine the AU in ways that I'm still trying to figure out.

Fraser: The astrometers would be interested in that, I think.

Pamela: So, yeah. The geology, if you go to the American Geophysics Union out in San Francisco, it's this amazing meeting of people whose jobs vary from how to efficiently figure out where is there oil under the ground, to how are the plates on the planet moving. A volcanologist is a very specific type of geologist to what are the comparative characteristics between plate tectonics on Earth vs. something like Venus, where it seems like the entire surface doesn't move, but rather just reshuffles every once in a while. So at its core, a geologist is someone who studies the surface and internal characteristics of a gravitationally-bound solid body, so Earth…

Fraser: Not necessarily a planet…

Pamela: Right. Now, gas giants aren't as much the purview of a geologist, but planetary scientists start getting involved when you start looking at gas giants, ice giants, and things like that, so that's its own field.

Fraser: Asteroids, comets, Kuiper belts, they're fine with all that.

Pamela: [laughing] Well, then so then icy bodies -- those are completely different again. So everything's complicated. Planetary scientists…

Fraser: OK. Alright. Let's go back to…so a planetary geologist, not a planetary scientist because that's different...

Pamela: Planetary geologist is someone who's dealing with bodies that you can model using geological models, so plate tectonics, volcanology, you end up using hydrodynamics to understand ice processes, water processes… Planetary scientist broadens that, so it's planetary geologist can…it's like the Venn diagram overlap between geologist and planetary scientist, so planetary scientist moves on to take on things like Jupiter and Saturn, Neptune Uranus, all these gas bodies that you can't model the same way, but

meteorology starts to creep in matter…gas dynamics matters, so there's so much to learn, and when you start trying to figure out what you need to know to do a given theory, what it takes to understand how Jupiter's atmosphere works is radically different from what it takes to understand how is it that Vesta is shaped in this crazy Dr. Seuss way that it's shaped. And so it takes two different types of degrees, two different kinds of science to model and understand these two objects that we've thrown into the same book when we teach in 8th grade.

Fraser: So then, I guess, the last step is the biologist.

Right. So now we're starting to add in things like astrobiology, which is the study of trying to understand: How do you determine if there is life out there among the stars? What chemical signatures do you look for in the atmosphere? How would life throw a planet's atmosphere out of chemical equilibrium?

Fraser: But isn't that like the strangest career to have if you think about it because an astrobiologist has no access to actual astrobiology yet, and so they can't study aliens, right? Because so far none have been discovered, and so they can only make predictions. I mean, I'd say they're astrophysicists.

Pamela: No, no, they're theoretical biologists is what I would call them.

Fraser: That's what I mean. They're the equivalent. They're theoretical biologists. They say, "Here's what life might look like out in space. Go look for that." And then they hand that off.

Pamela: And that's cool!

Fraser: Absolutely! No…

Pamela: Their entire job is "What if…?"

Fraser: …I'm not saying they shouldn't exist, I'm just saying it must be a very strange job to have trained in biology, and then not have any examples to look at the thing you've been trained in.

Pamela: Well, they do do a lot of work studying extremophiles here on the planet Earth and saying, "OK, where on the Earth do we have this totally insane chemical composition set of conditions? Let's go look there for life, and see if life can exist." And this is where we had Mono Lake, which is extremely rich in arsenic, was searched for life. This is where a lot of people go and look in hot springs. There's all of the work to look at underground lakes in Antarctica. There's lots of places that we see as models for trying to understand what life could potentially look like on other worlds, and hopefully, within our lifetime, we'll be able to start going out and exploring Titan, and Europa, and Mars, and looking for…we don't expect to find major life, but we might find bacterial life out there in our own solar system.

Fraser: So then, I want to give you a couple of examples of things that people do and you can kind of tell me what kind of a job title you would want to be able to do that. So what if you are studying the atmosphere of Jupiter?

Pamela: Planetary scientist or meteorologist.

Fraser: Is there a planetary meteorologist?

Pamela: It's a specialty in planetary science, just like studying variable stars is a specialty in astronomy.

Fraser: What if you are examining the effects of long-term radiation on astronauts?

Pamela: That is straight-up biology, or space scientist.

Fraser: Not space medicine?

Pamela: Space medicine, yeah, that's true. Space medicine is a field. I forgot about that one.

Fraser: You're like an astro-doctor?

Pamela: You know, NASA needs doctors, too.

Fraser: Astrophysicist?

Pamela: No.

Fraser: Astrophysician -- I've decided it's an astrophysician.

Pamela: That would be a great title.

Fraser: Exactly. What about examining the environments right around black holes?

Pamela: That's probably a cosmologist.

Fraser: Cosmologist? But isn't that like big picture stuff?

Pamela: They tend to throw black hole studying in with cosmology.

Fraser: Alright. And what about predicting what kind of a life people will have based on the year they were born, and what constellation the Sun was in?

Pamela: That's not a science, but that's called astrology.

Fraser: Oh! I almost had you, but you took a course on it so you know an awful lot about it. Cool! So I guess the last question is that if you want to go into space and astronomy as a career, how early do you have to actually decide? I mean, do you become a…which of them are real, that you do really need to hunker down and start to learn, say, astrophysics early on and decide, or which can you just change your business card and go, "Now I'm an astrophysician?"

Pamela: Well, so none of them can you really just change your business card. If you want to make a career change, it's possible to get into any of these fields later in life, but it gets harder the more theoretical and mathematically driven the field you're going into is. I've seen lots of people go back to college in their 30s and 40s and go on to have good careers in astronomy as people who dance on that line between astronomy and astrophysics, but when it comes to theoretical work, there's actually a lot of research that most people have their major breakthroughs before they're 30, and so that means you really have to get started in that field as a teenager, and that sounds kind of weird to say, but going into astronomy and getting into the top theoretical programs is such a highly competitive field that

nowadays, they're looking for people who have been publishing research papers as undergraduates, and when you start looking at that level of competition…I'm not top of our field; I'm a perfectly generic, American-bred astronomer, but my high school job was reducing VLA data working at Haystack observatory, and measuring Stokes parameters of T Tauri stars using Haystack data. My college job -- I was publishing papers working at Michigan State University in variable stars. It's this sort of starting-very-early background that, unfortunately, is necessary when there might only be ten jobs in the United States for what you want to do once you get your PhD.

Fraser: Right. And so, for example, if you want to be a planetary geologist, you've got to focus on geology, and then start incorporating that planetary geology pretty early on.

Pamela: Yeah, and so…

Fraser: And go to the right school…

Pamela: And go to the right school.

Fraser: Where they teach it.

Pamela: So while you can, for the non-theoretical in here, planetary does count. You can go back to college in your 30s and 40s, you can get a job working in the field. The observational stuff is much easier to get into. When you start getting into the theoretical modeling, there's so much to learn because you have to know all the observational science, you have to know all the mathematics, you have to be able to do the computer models -- that's a lifetime of work to get there. And so it depends on what you want to do, but there are ways, later in life, to become a professional in these fields as long as you're not trying to become Albert Einstein in these fields later in life.

Fraser: And which one would you say is the hardest of all of them? Like which is the one that all…?

Pamela: People who do theoretical magneto hydrodynamics.

Fraser: So that would be a…?

Pamela: People who study magnetic fields

Fraser: No, no, no. What's their name? Like if they had business card…

Pamela: Theoretical astrophysicist.

Fraser: Not a theoretical hydro-magneto…

Pamela: No. Magneto hydrodynamics is a subfield of astrophysics.

Fraser: Right, but the one if you showed them the person's business card, they would just like, "Whooooa!"

Pamela: People, I think, are most "Whoooaa!" as you put it, involving theoretical cosmology because that's kind of the sexiest one, but the thing about theoretical cosmology is you're allowed to make stuff up because not all of the theories are testable.

Fraser: That's your job.

Pamela: Yeah, it's your job to make up stuff that can't be proven, but what I do love about theoretical astrophysics is it does generally lead to provable theories.

Fraser: Yeah, yeah…they're forced to make predictions that can be tested.

Pamela: Yeah. Cosmology you can make stuff up – it just has to be based in math.

Fraser: Well, thank you very much, Pamela. It is great to be back recording with you again, and I look forward to a whole new and exciting season of Astronomy Cast, and all the other stuff we've been working on. So thanks again, and we'll see you next week.

Pamela: Sounds great, Fraser! Talk to you later.