Astronomy Cast Live from Dragon*Con 2012: Space Money

Fraser: Welcome to Astronomy Cast, our weekly facts-based journey through the Cosmos, where we tell you not only what we know, but also how we know what we know. My name is Fraser Cain; I'm the publisher of Universe Today, and with me as always, in person…

Pamela: Yay!

Fraser: …is Dr. Pamela Gay. So this week, so we're doing a live show from Dragon*Con, so we've got our regular show part planned, which we're going to do for the first 20 minutes or so, 25 minutes, and then we'll go into your insane questions, where you try to break Pamela, and I will help you by making the questions even more complicated. So please, if you've got some zingers, start formulating them now and then together, we'll work together to really ruin Pamela's brain.

Pamela: I thought you liked me.

Fraser: That was what the hug was for. We're done with that.

Pamela: [laughing]

Fraser: So we've probed the deepest recesses of the Universe, landed spacecraft and humans on other planets and moons, but face it: all of this exploration is expensive. Just a single spacecraft can cost billions, so who pays for all this stuff? So Pamela…and this has been one of the big issues that we've been dealing with in the last couple of years, and in fact, it feels like all we're writing about on Universe Today is Curiositiy and then how there's no money for things as awesome as Curiosity, so you've been dealing with that as well. You just came back from China [missing audio] from the IAU in China, and dealing with all the recent horrible budget cuts that have been happening, and so we'd like to talk about how all this stuff gets paid for and maybe where we stand right now, and what's going to happen in the future because the news is kind of bleak, isn't it? So let's go back in time and sort of go back to where did…how did people pay for science when it first got started?

Pamela: So the truth is that astronomy has always been sort of a rich man's toy. So when you look back through history, you find that the earliest astronomers were either very wealthy individuals who were highly educated, or they were people who were basically the pets of very wealthy individuals. So Galileo had people who gave him money, Ptolemy came from a rich heritage, Kepler-- again a favorite of the King, even William Herschel ended up being the royal court astronomer, so you have all these different people who have basically found wealthy individuals who dropped them money that allowed them to do science.

Fraser: And didn't a lot of them have like a day job that somehow related to the science they were doing? So, you know, they'd be doing their day job, and maybe they're going to be maybe working with glass or metals or things like that, and then they're building all this laboratory equipment in their house, and taking it over bit by bit. Came at a great personal cost.

Pamela: It often did. They very best have always been able to figure out how to make it their full-time job eventually, but what's interesting is even up until recent times, we've had examples of individuals who used their personal income to afford their astronomy. There was Grote Reber, who was the father of radio astronomy here in the United States, where he was an individual whose day job was a commercial radio engineer. And he built a giant radio dish in his backyard because he could, and proceeded to map the sky in radio waves, and professional astronomers went out to his house to verify that what he was doing was scientifically valid. Lo and behold: the very first radio map we had came from a guy that worked in a radio station, and that's kind of awesome.

Fraser: But science is expensive so you get to a certain point where you can no longer can afford to do it just, you know, out of what you can scrounge around, and time you can take off, and maybe you can ask somebody to pay you, so once we move to that next phase, where it's bigger amounts of science, more work getting done, things are expensive, the equipment is expensive, you have to send ships. But how do they start to fund that?

Pamela: Well, eventually it became a matter of governments funding universities. Over time we started establishing research centers. It's tended to be rich men for a long time. Some of you may have heard of Percival Lowell, who funded Flagstaff observatory because he was going to find life

on Mars, and so he funded a major research facility. But as we've moved into the modern era, what we've seen is things like the National Science Foundation being facilitated by the U. S. government, we've seen the military sink more and more money into it, so it's starting to become more and more often, the U. S. government uses a fraction of your tax dollars to fund science.

Fraser: So, then what? How would, sort of, in the olden days, if they had some…remember when they were going to first observe the transit of Venus and they sent these gigantic missions across the planet, lots of astronomers sending up ships? How would they fund that kind of thing?

Pamela: By a King or a Queen.

Fraser: Right, who was like interested in space, or interested in answering those questions, or wanted their name in the history books.

Pamela: Catherine the Great actually funded a bunch of stuff like this. She was going to work on figuring out, well -- what's the various geometries? And so she sent expeditions all over the place…a Russian queen funding science. The observatory outside of Leningrad is one of the most beautiful observatories I've ever visited.

Fraser: So how much would some of those old missions cost? Or…I call them missions, but expeditions is the right word. Like how much would that cost?

Pamela: The way to think of it is it wasn't too different than sending Christopher Columbus to America, but instead of discovering a new continent they were discovering a new way of measuring our solar system.

Fraser: But it was still all very ad hoc, right? So they would go and bring their proposal to the King or Queen, or bring it to the government and say, "Here is what I want to discover. Here's how it's going to put your name in the history books. Here's how much money I need."

Pamela: It's very much like selling a Hollywood movie.

Fraser: Yeah, totally.

Pamela: This is really the right way to think about it…is you come up with an idea, you write a business plan, or a vision, you then go to that person that you've, like, a friend of a friend of a friend has helped you go get to meet, and you grovel before them, and you say, "This is why what I want you to fund will make you famous forever, so fund my project," and you hope -- and it's not fully logical, it's partially emotional, and so you just sort of hope that this rich person gives in to your dream, and makes it become reality and you usually name it after them.

Fraser: So when did things start to turn into our more modern understanding of the way funding is done? Now we've got funding institutions, government grants, all that kind of stuff. How did that all sort of come about?

Pamela: Wars.

Fraser: What?!

Pamela: [Laughing] So our modern way of doing science, the idea of big science was really perfected during the Manhattan Project during World War II, and over in World War II in Germany, and then also in Russia, so a variety of different countries during WWII. And this started during WWI when we started gassing people. When you need more and more effective ways to utilize science to destroy things, you build scientific facilities and you fund them using military dollars. The Manhattan Project was perhaps the first truly large science project where they basically took all the best scientists in the entire United States, gathered them in Los Alamos, NM, fragmented out the project that they were working on so that not everyone had a big picture understanding of what they were doing (and no one had the complete picture in their head except for some of the higher level people in the project)... Everything was paid by the U. S. government, and in the end, they ended up creating the nuclear bomb. Well, since then, we've gone on to come up with new large ways of doing science. Prior to that, we'd seen major observatories built, but it was usually someone went out and fundraised. So we saw the 200-inch telescope out in California was fundraised by rich dudes, Yerkes fundraised rich dudes, McDonnell observatory fundraised rich dudes, Manhattan Project -- U.S. government, different form of rich dudes. I was expecting more laughter.

[Laughing]

Fraser: It's sad, yeah, "Let's figure out very efficient ways to kill people on a large scale."

Pamela: And one of the things as an astronomer that I found really…. Discovering there's that one moment in grad school where you're flipping through…and I did stellar spectroscopy for a while, which means I looked at charts of lines and tried to identify the lines, and I learned that titanium atoms have a whole lot of different electron transitions because when you look at a solar spectrum, it looks like someone has just been throwing titanium at the Sun…all these lines, but then there's all this other stuff that you have to identify, and there's tables of books that you look through and you're like, "OK, this wavelength is this line, OK, identified. This line, this wavelength," and you start to realize the atoms we understand most are carbon and oxygen, and you are carbon and oxygen, and there's a correlation between these two things. Now, in modern day Astronomy, we still end up seeing the military having somewhat of an impact on us. Laser guide stars, that was in part developed out at White Sands missile arsenal, where they were working with the Angel Fire to try and develop ways to have higher resolution imagery. Now we use it to take some of the highest-resolution images of the stars. We see that the large synoptic survey telescope that's being built in Chile, part of its funding is justification of protecting the human race from oncoming asteroids because it will be able to discover them more effectively. So the military's still there as a motivating factor that helps fund some things, but then we luckily also have the National Science Foundation and NASA, which work hard to try and fund basic research and exploration.

Fraser: So how does that work? We've got, you know, we've come up with efficient government systems to fund…

Pamela: I wouldn't say efficient.

Fraser: …killing of large…

Pamela: Large, I'll go with large, yeah, that I can live with.

Fraser: …large bureaucratic systems for organizing people with the one goal of killing as many human beings as possible. Then we move to another

sort of, but then phase after that where you're trying to fund the exploration of the Moon and putting humans on the Moon.

Pamela: Again, almost a war effort.

[Laughter]

Fraser: But, I mean, so how did we transition to more modern kinds of funding because still there's…it's still fairly complicated. I mean you explain to me how the hoops you have to jump through to be able to fund some projects that you're working on, and there's a lot of really interesting parts to it that you have to navigate to prove that you know how to do it. So how does it all work today?

Pamela: So today we're in a situation where different agencies of the U. S. government, NASA is an agency, National Science Foundation is an agency, different agencies of the government put out calls for proposals requests for proposals, and each proposal will detail, "We want to fund X," we want to fund Arctic research, we want to fund cyber-infrastructure, we want to fund basic research in astronomy," there's all of these different categories and there are very specific categories for people to do research in different areas. You find a proposal that hopefully fairly closely matches the type of thing that you want to do. You then read and you find the line that tells you how much money you're allowed to ask for, and you don't ask for more than that or they give you zero.

Fraser: You don't ask for less than that either, right?

Pamela: Well, actually there are a lot of times…one of the frustrating things is there are so many people proposing. It gets highly competitive, and one of the criteria that they look at is how much bang is there for the buck, and this can work against you. I've been in situations where we've been reviewing these grants, and you see the grant come in from a high-level person, which means they have a high-level salary at an institution that's fairly expensive, and they're asking you to do something in a location that's fairly expensive, and you say they're going to affect sixty people -- and how much does it cost? Then you look over here at this other proposal where they're planning to use graduate student labor, and you're working in a cheaper part of the country, and they're affecting 600 people for the same

cost, and you make choices. And so one of the problems I faced is some of the grant calls they say you can go up to $200,000, but the reality is if you go over $90,000, you're not getting funded, and so sometimes there's guesswork involved, and you have to…it's almost black magic trying to figure out how to get a proposal funded nowadays. And we use what's called a jury of our peers to decide what is fundable, and different agencies select this jury in different ways. NASA – they look for people who are already fairly experienced, look for people who have already been there, done that, and can put a critical eye to reading proposals based on personal experience. So you generally get mid-career to senior level people reviewing your grants, at least in the proposal panels that I've been in. At the National Science Foundation, they're required that a certain number of the people reviewing the proposals are early-career people who have never done this before, so they're reviewing proposals in part to learn how to write proposals. This means that you occasionally get some of the screwiest reviews you can imagine. I've had proposals rejected where the program officer called me and apologized because, unfortunately, because it's a jury of our peers just like juries in the U. S. court system, sometimes you get weird verdicts. My favorite failed proposal of all time is back in the days when I was doing Slacker Astronomy…[laughing] back in the days when I was doing Slacker Astronomy, we put in a proposal to the National Science Foundation in order to do some research into podcasting, extend what we were doing, make it more friendly for schools to use it, and we submitted this proposal that had a half-page screenshot from iTunes. We were so proud because the day we caught this screenshot, under "new and noteworthy" was Astronomy Cast, not Astronomy Cast -- Slacker Astronomy, under the top 10 was Slacker Astronomy, and like in the top row of the science and medicine was Slacker Astronomy. We were three pages on this half-page screenshot of iTunes. One of our most critiquing referees, the one that slammed us the most and made it unredeemable and unfundable said, "Why is it you're doing this podcast when you're not in iTunes?" Did you read our proposal? Apparently not, but because that overworked, overly-tired, not necessarily experienced person did not read our proposal in detail, we did not get the funding we wanted to fund us for doing 3 years of research. And the problem is if you don't get funded, you have to wait another year, and the cycle of research funding is exhausting.

Fraser: Well, that's what I was going to ask you is how much of your time, I don't think people even realize, how much of your time is spent asking for money?

Pamela: Every proposal I write takes me about three weeks full-time effort, unfounded, in my spare time. You're not allowed to get paid off of grants to write grants. My salary comes from grants, which means that to write the grants to pay myself, I have to work overtime that is unpaid. Now, I'm pretty good at getting grants, which means I get about 3 out of 5 I apply for, so that's six weeks of effort per year for naught.

Fraser: Yeah, she goes into these times when she's in writing proposals and she's just unreachable, and just all she's thinking about is trying to get through that process, but still it takes weeks and weeks and weeks it's amazing.

Pamela: And this is all across academia – this is your cancer researchers, this is your, you name it, your biomass researchers, your computational researchers. So all across the nation there are all of these man hours going into just writing grants, and one of the things that happens in the United States that doesn't happen in other countries, is in other countries you can write a grant and say, "Look, I've done this awesome stuff in the past I'm going to keep doing basically what I'm doing now. Will you please fund me?" and they'll fund you to keep doing awesome things. Here in the United States, you have to come up with a novel idea, propose the idea and it's the idea that gets judged, which means if your group of reviewers just doesn't like your idea – no funding for you. If your idea isn't new and novel enough – no funding for you. If you have a new and novel idea, but they think it's too new and novel, and thus risky – no funding for you. It's black magic.

Fraser: It's really about writing as much as you can and seeing what sticks.

Pamela: Yeah, that's exactly what it is.

Fraser: Now, this was all kind of interesting, and now it's pretty much history because both in Congress and with the National Science Foundation, they've gone at both the space exploration budget, and the science budget, the astronomy budget with a chainsaw in the last couple of years. So what's happened in the last couple of years with funding?

Pamela: So what we've been seeing is there has been a strong reaction I think is probably an understatement within the U. S. Congress to seeing

some of NASA's programs ending up running severely over budget, so Morris Science Observatory was extremely over budget, James Webb space telescope, or Jim the Space Telescope as I like to call it by accident occasionally…

Fraser: We blame the Curiosity rover. How could it do that to us?

Pamela: So these projects have had significant cost overruns, and as a result, NASA has essentially been told by some Congressmen, "You are irresponsible with your money, so we're giving you a smaller allowance." That's what it means when they cut NASA's budget. It's like telling your teen-age kid because you can't use your allowance wisely, we're going to restrict your money until you prove you're responsible again."

Fraser: So what's gotten axed? What's gotten cut in just the last couple of months?

Pamela: Well, the thing that I've seen that's been the largest cut is the science mission directorate at NASA has seen a lot of its planetary funding go away, and this means that we lost the next major planned mission to go to Mars. There's a smaller mission called Maven, but there was going to be a much larger mission that was a sample-return mission. It was going to return rocks from Mars to Earth. It was a meeting we were supposed to be doing jointly with the Europeans, and no longer. We canceled our treatise to do it; the program was axed. This is going to have significant repercussions in our ability to get to Mars as human beings instead of just as cute rovers.

Fraser: The Europeans might still just pull that mission off on their own.

Pamela: They don't have the money.

Fraser: They don't have the money?

Pamela: That's the problem right now is no one has money right now in the Western world, and as a result, in order for us to do big-dollar science, we have to join forces with other nations.

Fraser: We saw how that worked out…

Pamela: Yeah.

Fraser: …with the International Space Station.

Pamela: Sometimes things go south. When you design things for politics instead of for science, you end up with the International Space Station, but one of the other things that we have to take into consideration is how we are funding science also radically changes not just in the dollars that are going into science, but the type of science that we're funding. When we funded projects like the Hubble Space Telescope – this is a telescope that can do all sorts of different types of science; it gets used by a whole variety of different scientists who are looking at looking at planets, looking at stars, looking at galaxies. Tonight, Bill Keel, who's been very successful at getting Hubble space telescope time, we're actually at the very end of the Space Geeks panel at 10 p.m. presenting a collection of short stories based on the new science coming from the Hubble space telescope, so if you like Scott Sigler, he wrote us a zombie story based on new science from Hubble. That's kind of cool. Now, today, instead of building more of these highly versatile instruments, what we're instead moving to doing is building extremely expensive very, very large instruments, so there's Mars Curiosity -- extremely expensive, admittedly SUV-sized instrument roving the surface of Mars.

Fraser: Totally worth it.

Pamela: Totally worth it, but by itself it's 5% of the science mission directorate mission budget.

Fraser: I don't care. I don't care. It's totally worth it -- so much.

Pamela: So then we have the large synoptic survey telescope, which is another billion-ish dollar telescope being built in Chile, that is simply going to be scrolling across the sky night after night after night surveying the things that go flare, that go boom, that go whoosh as they race across the sky. It's a very specific type of instrument. James Webb space telescope works in the infrared. It is a much broader instrument, but again, stupidly expensive. By building these stupidly expensive, very powerful instruments, we have to close down all the small and moderate-sized instruments.

Fraser: We could have had a boat on Titan.

Pamela: We could have, yes.

Fraser: Wouldn't it be cool?

Pamela: It was one of the plans. We canceled it.

Fraser: Yeah, but you know all is not lost. We've got some really interesting stuff that is starting to happen now. For example, have you been watching the kinds of stuff that's coming up on Kickstarter?

Pamela: Yes, so what we're starting to see is things like satellites. So there was a satellite called "Ardwinosat," (which is just fun to say), where they're building a satellite that's going to have, and it's possibly two satellites because the Kickstarter went really well, where they're going to be building a satellite that is a number of ardwino-driven (these are little tiny circuit boards that anyone can program, you give them to middle schoolers and they can program them), these ardwino circuit boards with a whole bunch of sensors and they're going to let individuals like you competitively suggest we should do "foo," we should measure "foo," we should try "foo." If your "foo" is better than somebody else's "foobar," then your "foo"…we will get set ardwinos to test all of your "foo" on. If the ardwinos continue to function well after you've tried your "foo," it will then upload your "foo" to the satellite and you will get to do the data you want to do, get to do the experiments you want to do using the ardwinosat. You get to do your "foo."

Fraser: [laughing] So right, we've got that. I saw just a couple of days ago, there was a Kickstarter for a space elevator.

Pamela: That one I didn't see.

Fraser: Now it's from the Liftboard Association. I think they only need like $20,000 to do a demonstration of like making a robot climb a tether. I think they have their money funded [missing audio] or something. Yeah and so now on Universe Today we're probably mentioning Kickstarters almost once a week now, so it feels now really to me like there's this whole other boom that's going on that there's this pent up…on the one hand, this real frustration with how all of the science and how all the commissions getting cut at this time when it feels like this "golden age" of planetary and space exploration, and then on the other hand, you've got the ability to organize

and come together on the internet, and to be able to raise these funds directly for the projects that seem to really capture people's imagination.

Pamela: And this is a really neat model. We're taking it from once upon a time, I would find an extremely rich person and kowtow and beg to instead I go to a whole lot of people and kowtow and beg, and the thing is where one rich person might give a million dollars to a project, something like a MacArthur grant, a whole lot of individuals can each give 10, 15, 100 dollars each and accomplish the exact same thing. Now, admittedly, it's a whole lot harder to find that large number of people, but what's amazing is with the internet, with things like Kickstarter and indiegogo, we're seeing that people have a passion to change the world by deciding what world they want to fund. In the United States, we complain about our taxes a lot, but they're actually fairy low compared to Europe.

Fraser: …or Canada.

Pamela: Sorry. So here…what I love is you occasionally hear the "Penny for NASA" idea. Well, I don't think we can convince the Congress to take a penny of every tax dollar and give it to NASA, but I think we can have the same ultimate effect by individuals who have the extra ten dollars and care about science and finding that science project that they believe in and giving it ten dollars.

Fraser: And I think the other thing that's been really interesting and fascinating is in the last couple of years, we're seeing a lot of private groups starting to look into exploring space. You've got the planetary resources that are going to be doing asteroid mining, and I don't know if you people have seen what Elon Musk is doing. He's got…

Pamela: SpaceX

Fraser: SpaceX, but he pretty much built SpaceX because he wants to send humans to Mars, and so he figured, "If I need to have a rocket, I might as well build a rocket company, make it profitable, then I'll have rockets," you know? Like, I love the way this guy thinks! I saw him do a presentation just a couple of months ago, I think, for the Mars Society he was like "I'm still on track, I'm going to send humans to Mars probably within the next 15 years." You know, and now he's got his rockets, he's got his contracts, he's got his funding, he's set, so I think there's what the planetary resources are

doing, there's what Elon Musk is doing that as this shift happens we're going to see it's both a very sad and depressing time for space funding, and at the same time, though, it's a really exciting time for all the new stuff that's going to be happening.

Pamela: And this is a complete change from the way space exploration works. We're going from the paradigm where NASA launches rockets, to the paradigm where a new generation of barnstormers, these are the internet billionaires, they realized we don't have our "jet car" future, so they're using the money they made from Amazon, from Paypal, from Intel, from Microsoft, from all of these different corporations, they're using their personal wealth to pull together the teams of engineers and scientists who are necessary to build that rocket car future that they want to see.

Fraser: Yeah, yeah, so now we're going to… we'll shift to the question show but I think one last thing we want to do is of promotion, which is Uwingu, right?

Pamela: Yeah, so there's an indiegogo campaign that some of you may have seen called Uwingu. The idea behind Uwingu is Alan Stern, the former deputy director, or science mission director rather, science mission directorate director of NASA, I think I got that right…

Fraser: So he…DAWN, New Horizons, SMART 1 …

Pamela: Yeah, you name the mission, he's probably touched it. He's been trying to figure out how do we change the paradigm because as NASA's budget gets cut, as missions end up costing more and more, the money for salaries for scientists, for educators is getting less and less. This year McDonald's will spend more money advertising Happy Meals than NASA will spend on education. That's disturbing. So Alan wanted to figure out how do we make a new way to fund space that is built into the economy on the commercial side instead of on the taxation side, so he pulled together a team of people and built a company called Uwingu, and unfortunately, I'm under NDA, so I'm about to become exceedingly vague, and it breaks my heart because I'm the "I want to share everything with everyone" kind of person, and the idea behind this corporation is it has a series of internet-based products that it plans to create and allow you to basically buy into space. It game-ifies space, and the people who are behind forming this

company are going to use the profits, not to make the stockholders rich, not to make themselves rich, but to fund research. So every dollar you spend at this company, 50 cents of that dollar is going to automatically go to funding research. The other fifty cents is going to go to paying internet costs, paying salary, paying business insurance, paying legal fees, paying a lot of things I didn't know you needed to worry about, and then what's leftover after that will also go to research. So it's guaranteed 50%, and then whatever's left after business costs as well going to research. This is a new model for doing it that required people to say, "We have a commercially viable idea. We could be rich, but instead we're going to change the Universe by changing how well we understand it as humans." You can help fund this by going to indiegogo.com and typing Uwingu in and helping to fund it, and what's awesome is we have a $75,000 goal for our start-up costs, and that's based on how much we have to expend on legal fees and things like that to get the company going. Every dollar we raise after that $75.000, 50 cents of it goes to the Allen Telescope Array in California to already start funding science, so…and also since this is Astronomy Cast and we're at Dragon*Con, we have a booth.

Fraser: Yeah, right, if you haven't seen it already.

Pamela: So we have posters from the booth up here that if you have pens we will sign (we forgot the pens), and if you go out to the booth, we have science you can do by getting engaged with Cosmoquest. We have t-shirts you can buy. Every t-shirt you buy pays one hour of a student's salary, and we hope that you'll help us find our own way to use selling products to fund doing science.

Fraser: So now, why don't we switch to the question part? And I hope you've been sort of ruminating and come up with some really killer questions for Pamela.

Pamela: And I'm going to go to the guy who had his hand up earlier in the show.

[missing audio]

Pamela: No, it's fine. We have our normal show format, and so I knew we had the questions coming.

Fraser: But feel free to -- anything, please. Whatever you can do to stump her.

Pamela: I was in Beijing Friday morning. Not all of my brain has gotten off the planet yet, just to warn you.

Question: This is really a question…the idea of the balance between what we call bench research or basic research and outcome research, and that it seems as though the trend now to look toward outcome research that what we fund we must have an idea what's going to exactly come from that, as opposed to bench research, which is, I think, a more fundamental need overall in this country.

Pamela: It is a complicated balancing act. So when they write calls for proposals, requests for proposals, they specifically say, "We're looking for…" and they'll get as specific as "We're looking for grants that evaluate and do research into how best to educate people using informal science." So this is the type of grant where someone would research how well Astronomy Cast teaches astronomy. It gets that specific, and so when you're on the review panel, you…(I wish I could be specific but then I'd give away which panels I was on, which you're not allowed to do). So you look at the request and then you look at the proposals that came in and when you're at that stage, you don't have any say on bench vs. outcome research. That comes from the high level people well above my pay grade at NASA and the National Science Foundation, and at other places, other agencies that also fund research. DOE -- Department of Energy funds research, Department of Defense funds research, and we do see that a lot of today's calls for proposals are things that will help improve the economy. Lately we've been seeing a lot of calls for proposals on building cyber-infrastructure, on building programs that will increase the number of people that are moving into science, technology, engineering and mathematics careers. The idea of investing money in a way that will increase our cyber-infrastructure, how well we're able to maintain computing in the United States, increase the technological workforce that we have, and the scientifically trained workforce. That's very important today. This does mean that a lot of basic research we don't really know where it's going to go. We're trying something new that's much harder to get funding for. You have to be very specific and sometimes you have to do research for free in your spare time

or get money from your university through internal grants to trial something before you can go and get the sufficient money to do real solid, large studies.

Fraser: It feels like a shame though, right? Because it's like the basic research -- that's when the great, deep understandings come about of our universe, and so on, and then later on they can apply it, refine it and build the technology. It almost feels like it's a distrust. If you just give a good team of people funding and let them just start exploring…

Pamela: And this is one of the big differences with how the U. S. funds things, I remember a few years ago, Bryan Gaensler, who is a young astronomer from Australia, he and I were both working at Harvard, and he was offered his own research center in Australia, where they basically said, "We will give you money, hire whom you want, do good things." That's kind of awesome! The Max Planck centers over in Germany are very similar. You get really good at what you do, and they give you a research center. In Canada they quite often fund researchers, and say, "You've been doing good things, keep doing good things, here's money." It's here in the United States where we're in this horrible position of you're proposing, "I'm going to do X," which means when you fail to do X, your next grant doesn't come through, and this can be quite concerning. I know I have one grant now to try and do citizen science in Facebook. We haven't gotten anywhere because Facebook keeps changing their permissions as soon as we're done with our software, and so that's going to be a black mark on my record. And so you have to worry about these things, and it's our country, in trying to make sure no one wastes money…makes it hard for people to spend money to do creative things. Bruce...

Question: There are a lot of teams out there trying to get grant money, a lot of people writing proposals, and I believe that proposal writing is a very specific process. It's different from your core training science. So doesn't that play into the unfairness of grant awards based on those people who are just good at writing?

Fraser: So it's not about how good a scientist you are necessarily but how good a proposal writer you are. Do they break them up into teams?

Pamela: Well, you do often work in teams, but what you find is the very best researchers are also very good writers. In order to be a successful scientist, you're not allowed to be bad at anything, and this is actually

exhausting and intimidating, so the expectation is if I'm going to be excellent as a scientist, I have to know how to program computers to run my data, I have to know how to do high level math, I have to know how to work telescopes, I have to know how to write kick-ass proposals, and I have to know how to present my research in a clear and understandable manner in both professional journals and before audiences like you and audiences of my peers. It's intimidating, terrifying, and if you're bad at any one thing it means you nay not succeed.

Fraser: Yeah. I have a computer science degree and she's the "tech-ie" of the team. It's hilarious.

Pamela: It's true.

Fraser: She's into all the coding, all the PHP, all that kind of stuff.

Pamela: Yeah, when we merged the BOUT forum with the Cosmoquest forum and he's like "No." [laughing] Yeah. But it does put limitations because you either have to work in a team where there is that person who is a really good grant writer, and I've been that really good grant writer for other people occasionally, but the expectation that you can do it all is terrifying, but it's the reality that we deal with.

Fraser: And is that just a case of like so many people fighting for the same jobs that you really just have to be this jack-of-all-trades, master of all?

Pamela: Yeah, the number of jobs in astronomy is constantly going down and one of the things that I don't think a lot of people realize is as they reduce the funding from the National Science Foundation and from NASA, what we're actually doing is eating our young because when someone like me gets a funding cut, the first thing I do is say, "Well, I can't hire a student next semester. Well, when Nicole's done with her two years as my post-doc, I can't rehire her." So the first thing that happens is I start firing people until I don't have enough money to pay myself, in which case I fire myself. It's not so much firing at that point as going home and crying, but this is the reality and as the budget's tightening, we're finding that it's harder and harder for the people just coming out of college to find jobs because there just simply aren't jobs.

Fraser: And we get these inspirational letters from people like, "Oh, I love listening to your show. You guys have inspired me to go back to school," or "choose astronomy as my career. I'm so excited. Now I have about 12 years ahead of me to get to my post-doc. I look forward to working in astronomy," and unfortunately the conversation often will be "Wow, are you sure? Are you sure you really want to go?" Cause it's not about the school part. Anybody will take your money and let you go to their school and learn the astronomy part. It's that other part where there aren't a lot of jobs.

Pamela: One of the slides that went up when I was at the International Astronomical Union conference, we were talking about how many of the developing world's nations are using astronomy to increase the ability of their nations to move forward technologically and intellectually, and one of the women who was giving the presentation put up a slide that documented how many PhD research astronomers there are per country in the first column, and in the second column was how many millions of people there are in the country, and for the most part it's one PhD research astronomer per one million people globally. There's countries like Peru that have way, way, way, way less. There's countries like America that have more, but it balances out globally to one per one million people on the planet are astronomers. There are more people working for Coca-Cola than astronomers on the planet. There's not that much of us, and there's not that many jobs for new people coming into the system, and one of the things that Uwingu hopes to solve is they plan to change the model of funding in the U. S. to one where good people apply and get funded like the Canadian model of, "Oh, you've done good things. We'll give you money to continue to do good things." So we want to find a way to move away from the governmental model and change it to allow these people coming up to be able to do things to find new ways to fund telescopes, new ways to fund education. To try and end this on an inspirational note…I know this is a depressing topic, if you bought a t-shirt it, will fund one hour of a student's salary, but more than that, one of the things I heard when I was at the International Astronomical Union: South Africa is one of the up-and-comers in the astronomical society. They have extremely dark skies, they have a government that is trying to advance their country technologically and educationally. They know they have a long ways to go, but one of the ways they've found to improve their country is through astronomy. One of the men from there stood up and he said -- very, very impassioned -- he said, "Our country is a country that still has problems with starvation. People die every day because they can't get enough food, and it seems irresponsible

that we spend money on astronomy when people can't buy food, but the total South African budget for astronomy is only enough money to buy one meal for every single person in South Africa." But while, yes, they could buy one meal for every person in South Africa, by investing that money into building telescopes in remote locations, they're bringing water to places that didn't have clean water. They're bringing electricity to places that didn't have electricity, and they're also bringing the internet, and they're bringing an infrastructure, and they're bringing inspiration to the people in these remote areas (and you build telescopes in very remote areas), they're bringing inspiration to a new generation of people to grow up, become more inspired, to have a better infrastructure in their own lives, to go on and build a better South Africa. Now, imagine if our country took that sort of a perspective -- that by going places and building research centers, we're bringing an intellectual inspiration to a community, that we're raising our nation up by inspiring people to want to learn. It's a completely different way of looking at it. Instead of wasting money on research when we could be spending it on…corn.

Fraser: What is it? "Why don't we…how can we send people into space until we fix all the problems here on earth first?"

Pamela: And the answer is: we can fix all the problems on Earth by throwing certain people into space.

Fraser: I think we have time for one more question. Does anyone else have a question? Yeah.

Question: How can we as normal, everyday [missing audio]?

Fraser: Well, like I said, there's, you know…you can vote better people, right, for starters, make sure that the, you know, your politicians are equally aware of how important science is. Like I said, how much we all love the Curiosity rover, and how exciting it was to see it land, and then there are all these really interesting Kickstarters. I mean, I think there's going to be some really neat projects that are getting funded. It's a way for you to not only give your feedback directly, but also to help support them with some money. It's not huge, but in many cases, it's this first stepping stone to let people take a few discrete steps to get to the next step where they can get deeper funding.

Pamela: And there's certain things you can do that are mostly a change of looking at the world. It used to be that people would tithe a certain percent of their income to the Church. Well, what if you set aside a certain amount of your income to fund the indiegogo programs that help to reshape the world into that world that you want to live in? What if you took a moment, not for silent prayer, you're welcome to do that, but make sure you also take a moment for science. Find citizen science projects that you believe in. We have Cosmoquest, we'll introduce you to the Moon. Take a moment for science and spend some time in your day doing science, and talk to the people around you about it. Change the paradigm into one where if you don't pay attention to science, there's something wrong with you. It used to be that people felt that it was OK to say, "I hate math. I'm afraid of math." Make it so that it's not OK to say, "I'm scared of science." Make it so that people understand that science is for everyone and this is how we advance ourselves as a society, and you can change society one Kickstarter project and one moment of science at a time.

Fraser: So I think we're out of time now. [missing audio] is going to give us the eye in a second, but just a couple of quick announcements, which I don't know if anyone's aware, but one of the problems we've had with Astronomy Cast is that because it's all audio -- we're talking about such a visual subject, but every Sunday night we hook up a bunch of telescopes into a live Google plus hangout and broadcast the night sky, so if you've never seen that, you know, you can sort of follow us on Google plus, and see when we're doing that, but every Sunday night, you know, the Moon, Jupiter, we had Pluto one week, so pretty cool. And then the other thing that we're doing as well is we're actually recording Astronomy Cast live as a Google plus hangout. So you can actually watch us record live, give us your questions, both about the show…and also fix our mistakes during the show, and then also sort of interact with us after the show and, you know, we're glad to do that. And then the last thing we're doing as well is a lot of people want us to bring news, so we're doing that, and we put this into the feed, which is this weekly space hang-out where we're actually doing a round-up of all the big space news that's breaking. So with Astronomy Cast we try to make it sort of timeless, but we know there's a lot of really neat stuff that's going on. And the last thing is did anyone catch our coverage of the Curiosity landing?

[applause]

Fraser: Yeah? Yeah, so that's the third thing we've done now. We did the transit of Venus, we did the solar eclipse, we've done the Curiosity landing, so I think… what, the international Observe the Moon day is coming up?

Pamela: International Observe the Moon night is coming up on September 22nd. We have postcards advertising it out at the Cosmoquest booth, and we will be doing a hang-out for that, and if you're near Edwardsville, Illinois, we're probably going to be doing a moon party at Annie's custard stand.

[laughing]

Fraser: Yeah…so but anyway, we're going to try to do a lot more of that stuff, so it's great. And when we're experimenting, and we're trying to figure out how all this is going to work, but it's great to get all your feedback. You know, let us know what you think, and what you like and what you don't like because it feels like it's the future. It feels like finally we've got a way that we can turn this very audio medium and do something with video and make it interactive, and…very complicated to bring it all together, but it was a lot of fun, so thanks a lot for all your support.

Pamela: And as we move forward we're going to keep doing new things and keep perfecting things, and the only thing we know for certain is telescopes are awesome, custard is awesome -- the two shouldn't be mixed in the same container.

Fraser: Cool! Well, thanks a lot, Pamela.