Astronomy Cast Episode 188
The Future of Astronomy

Fraser: Astronomy Cast Episode 188 for Monday May 3, 2010, The Future of Astronomy. 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're you doing?
Pamela: I'm doing well. How are you doing, Fraser?
Fraser: Good, but summer doesn't seem to have arrived yet here on the west coast... it's just been cold and wet and rainy, and we're in June...
Pamela: Oh, I'll trade! We're hot and muggy, without air conditioning, and daily thunderstorms...
Fraser: Well, I was wondering if somehow the volcano would... the European volcano might have had some impact by darkening the skies and causing the summer... the year without a summer...
Pamela: No... they're saying that it was the wrong part of the atmosphere for it to have an effect... it wasn't Krakatoa or Pinatubo... I think was how you pronounce it... No, Katla... no not Katla... we're waiting for Katla... the E--unpronounceable Icelandic volcano... no it just spit on the air industry, not on the air conditioning industry.
Fraser: Right. Oh well, I guess I can't blame it on volcanism.
Pamela: Well, if Katla goes, you can blame Katla.
Fraser: Ok. Alright, well, we spent 5 episodes telling the story of astronomy so far... how we got from the work of the Babylonians to the modern discoveries made in just the last decade. But now we want to look forward... setting the current science missions and experiments to uncover the mysteries that astronomers are hoping to solve. So, with this episode, it's going to be another one of those jumping all over the place episodes and obviously there is no way that we can accurately predict what discoveries are going to be made in astronomy to any great extent. No one could have predicted dark energy. Those happy, random... oh, that's interesting... discoveries that astronomers make. But at the same time, there are broad themes, there are missions going up, there are mysteries, there are better experiments being developed which should then turn around and give better results, and maybe solve some of the open problems. And so... we've kind of broadly classified this... so let's start by staying close to home... and talk about some of the stuff that's going to be happening in the solar system and use that as a way to know what we're looking for.
Pamela: Well, I think closest to home are the series of missions that are going to be looking at Mars and the moon and trying to figure out where should we go next... what should we build next... what should we do next... so we have GRAIL and LATTES getting ready to go that are going to work to better understand the moon, to better understand its composition, its atmosphere, we're going to be looking at Venus and its chemistry and dynamics. We're going to be hopefully going and landing a laboratory on the surface of Mars and having it be a laboratory that can move itself around a bit. The Viking missions were awesome because they sat there on Mars' surface, scooped up what

was in reach, and very carefully looked for signs of life, signs of chemistry, and actually got inconclusive results because we realized that there were things that we forgot to take into consideration about the Martian climate.

Fraser: Well, I mean up until now, NASA's take on Mars has been very conservative. Was there evidence of past water on Mars? Yes. Is there currently water on Mars? Yes... frozen. Is there ice water underneath the polar ice caps of Mars near the surface? Yes. But come on... let's get to the question... is there life on Mars? That's the question, and that's the one that they need to solve.

Pamela: And this gets to... the problem of getting Congress to sign off on things of... hi, we're going to look for little green microbes... not little green men, just little green microbes... and that's a complicated task. But if all you're doing is looking for water, looking for things that human beings would need if we went and took over Mars, that's easier to sell. It's also very controversial... how do you say if there's life or not? We had the funding with the early landers... we had the question, is there life? We had the experiment, and the experiment was inconclusive... that's a failure to many people. It's not in science. Inconclusive means you have new questions, new things you need to answer. Inconclusive is awesome and cool and leads you to new directions of discovery. But it's hard to explain that.

Fraser: So, there are plans in the works to develop a mission just to analyze the methane in the atmosphere of Mars. And as you said, there's the Curiosity rover that's going to be down over the surface of Mars. It's a nuclear powered, SUV-sized, rover with arms and laboratories inside it, and it is going to be looking for life. It's going to be looking for the chemistry of life on the surface of Mars. Maybe within the decade we should be able to come up with a pretty good answer...

Pamela: That's what we're hoping. We're hoping that the next big launch window, it will be what goes up. And then beyond that, we're also looking at the Mars sample return mission because by sending a lab to Mars, we're limited in what we can do. If any of you have ever worked in a lab, you know there's always the day where you go... dang it, I need... and you go borrow something from a friend... you go grab a tool, you order something online, you get a new reagent. If you're on Mars, you can't do that. But, if instead we go out and we grab a bunch of rocks like we did with the moon... with the Apollo missions and the lunar sample return missions... if we go to Mars, grab a bunch of rocks, bring them back to Earth, then you have that ability to run unimagined experiments. Now there isn't a secure timeline on the Mars sample return mission. We're hoping sometime end of this decade... beginning of the next decade... somewhere in the 20 year plus or minus... that maybe we'll be able to get our rocks.

Fraser: So, when we're making our big list of mysteries we were talking about that... is there life on Mars... we will either find results inconclusive--which means that if there is life on Mars, there isn't much. It's pretty well hidden, and isn't pooping and isn't breathing. And if there is life on Mars, the more interesting question is going to be is it related to us... and how? Are our two planets connected? And when?

Pamela: Panspermia...

Fraser: Yeah, so even if we do find life on Mars, once again, if the planets are connected then it means that life moves from planet to planet... maybe from solar system to solar system around the whole Milky Way. If we find life on another planet or orbiting on another star, maybe we're related to that life as well. So Mars is just one place... we're

going to look at other places in the solar system, as well. Although there's less definitive plans for that.
Pamela: Right. Juno is one of the next big missions we're looking at... to go and explore the Jupiter system. I say Jupiter system because even though Jupiter's not a star, it is in many ways a model of a solar system. You have this almost-star orbited by moons that it is able to keep warm, it's just not warming them radiatively like the way our sun warms the earth... instead warming them gravitationally by squishing them like little squishy balls until they heat up.
Fraser: Exactly... grab a squishy ball or grab some Silly Putty and just smoosh it back and forth and you'll be warming it up in the same way.
Pamela: And so here we have this system with... well, I think that Europa is perhaps one of the greatest mysteries in our solar system. Clarke, in his 2010 Space Odyssey books... that was the moon that the aliens were from, or at least the big black monoliths... and you're supposed to leave it alone. Well, we're not going to leave it alone. We're not only not going to leave it alone, but we're going to burrow through the ice and again, look for life. That's one of the amazing things... we are now entering the period in our space explorations where looking for life is one of the everyday questions. We're going to go to Mars--we're going to look for microbes. We're going to go to Europa--we're going to dig through the ice and see... is there life in the liquid ice beneath the surface.
Fraser: And we're not going to stop in looking at the planets here in our solar system. I mean, now we're at the point where every month, every week, the total number of planets that have been discovered is in the 100s, but the final goals haven't been reached yet. All we've been discovering so far are hot Jupiters and mega-Neptunes, and super-Earths. But the goal, of course, is Earth-sized worlds with life, orbiting other stars.
Pamela: Right. And with the Corot mission... the European Space Agency mission to basically look for things that pass in front of the stars that they're orbiting.
Fraser: You said that very quickly... Corot... C-O-R-O-T...
Pamela: Yes, it's French... which is not one of my best languages to pronounce. This is a mission that is starting to turn up things that are fractions of Jupiter's mass. It actually has found one object that is 0.015 times the mass of Jupiter. It's about a tenth of the radius, so it's still not an Earth-sized body, but we're getting smaller. And it's again very close in to its star... pretty much on top of its star... its semi-major axis in astronomical units is 0.02, so it's on top of its sun. But it's still tiny. So we are finally finding tiny things. We also have the Kepler mission up, and between Corot and Kepler the rocky worlds are going to be found. That will hopefully allow us to once and for all have an understanding of the diversity of what solar systems look like. When you and I were kids, what was the solar system model that we both learned? It was rocky worlds next to the star, gas giants out at the edge. We now know that it's wrong. But, what else is there?
Fraser: Right. And so with Kepler and Corot, we're not going to get much more than rocky worlds orbiting other stars. It's going to be a whole other generation of telescopes that need to show up to take things to the next level.
Pamela: And this is where we start getting into the weird stuff, with missions like James Webb, you have the ability to start studying planetary atmospheres if only you don't have to get blinded by that silly star that planets are orbiting. And so we're looking at how do we build giant orbiting shields that can move into a position such that they block out the light of that offending star allowing you to resolve the planet nicely. So we're starting to

try to figure out what are the ways that we can start imaging planets, start looking at atmospheres, start... well, maybe finding life by the signature it leaves in planetary atmospheres as observed with our next generation of space telescopes.
Fraser: So, when do you think that will be done... if you were just to guess, would you say... Kepler and Corot won't be able to do it... James Webb might be able to hint at it... but we're looking at something after James Webb... so we're looking at an as of yet unnamed oh, terrestrial planet finding mission, for example.
Pamela: Right, right. This is where we start getting into the... we know how to solve this problem if only NASA or ESA or JAXA or one of the other space agencies just had enough money to build all the cool science toys we need. This starts to become a question of economics more than of technology. If we can get a good solid global economic recovery, within the next ten years. But I think unfortunately a lot of money is going into solving problems other than what is the atmosphere of alien worlds. I want to know what the atmosphere is of alien worlds!
Fraser: So we'll probably get an answer for the solar system within about ten years... and maybe other worlds within 20. Ok, so that's life... very important...
Pamela: Very cool...
Fraser: But there are more concepts in astronomy which we're going to want to get some answers to... there's two big ones, of course. We've talked about dark matter and dark energy. Dark matter.... we're starting to really narrow in on that one right now. Some big discoveries happened in the last couple of months. I think we're actually thinking of doing another episode on dark matter at some point to finally update a concept that we presented back at the beginning of the show, which now there's enough news now that we can take another spin at it.
Pamela: Right.
Fraser: But, there's some wonderful tools that are going to help us figure out what dark matter is.
Pamela: And what's really interesting is that this isn't a matter of strictly looking up anymore... now we're also digging into the ground, and just as we used giant tanks of fluid to detect neutrinos, it looks like very similar technologies are going to be used to detect dark matter particles as they go through the earth system. It also looks like with the Large Hadron Collider, just as we're hopefully creating Higgs... Higgs bosons, which we also did a show on.... maybe, just maybe if we're lucky, the lightest weight of the super-symmetric particles, if that theory is correct, will also be detected and those would also be another form of dark matter. So we're getting to the point where through ground-based experiments with the Large Hadron Collider and ground-based detectors with these giant underground tanks that they have in Japan and the States and Canada... usually in coal mines or other mines, we're going to start directly detecting particles... particles of dark matter one by one.
Fraser: Particles... perfect. And then and you can see how we've traced that lineage. We've gone from maybe we don't understand gravity, or maybe there's a bunch of particles that we can't see that are the majority of the matter in the universe to... it's pretty clear that it's the particles, and now we just aren't really sure what those particles are and where they came from and why they're there and what their characteristics are and how they interact with other things or don't and so that's what the work of the astronomers are going to be. I wonder if they're ever going to come up with a new name and then so we

can stop calling dark matter, which bugs everybody, and just give it the new name... I don't know...
Pamela: We kept big bang, and it was meant as an insult...
Fraser: Black holes...
Pamela: Yeah... so we keep keeping these insults and clinging on to them.
Fraser: So the more mysterious one is dark energy, which is... not really connected to dark matter at all.
Pamela: No... utterly unrelated.
Fraser: But still in people's minds because of the "dark" and the "dark" it's connected, but... yeah it's a whole separate thing. It's this mysterious force accelerating the expansion of the universe, discovered in 1998, and astronomers still have no idea what we're looking at...
Pamela: Right. And just trying to figure out... well, how do we best figure out what it is. That itself is even in debate. This is one of those great cases of watching science try and figure out a mystery in the public realm. There was a committee convened to try to figure out how do we figure out dark energy... and one of the debates that came out of it... and this is Rocky Kolb and Simon White... was do we do like we did with the cosmic microwave background and start building very specialized, very dedicated instruments like we did with the Wilkinson Microwave Anisotropy Probe - WMAP- the really great satellite that got us a final definition of the universe is 13.7 plus or minus 0.2 billion years old and nailed the expansion rates... and just so much really great science has come out of this mission, and now we have Planck, another narrowly-focused mission working to study the cosmic microwave background in even greater detail, do we take that approach?
Fraser: And just really narrow down and confine dark energy... at this age of the universe this is how fast it was pushing, and now... to the left and to the right... and to really understand its characteristics?
Pamela: Not quite. No, it's more do we build missions like that... because the other alternative is... well the Hubble Space Telescope was built to figure out what is the expansion rate of the universe. But that's not the only thing that Hubble does. WMAP was built to study the cosmic microwave background, and yes... some ancillary science has come out, too, but it studies the cosmic microwave background. Hubble... heck we're using it to study light echoes from quasars, we're using it to study planets, we're using it to...
Fraser: ...discover rings around Neptune...
Pamela: Right. So it's focus is not just one thing. It's a mission that was built that individual scientists can put in for time to do individual research questions. And it's an observing tool. It isn't a one-use experiment. And so this is the debate... in trying to solve dark energy, do we focus our dollars on building one-trick ponies... instruments that can only be used to study dark energy. Or, do we take the Hubble Space Telescope approach and so we're right now so far away from an answer that we're not even sure what sort of tools to bring to the question.
Fraser: And so that is what.... it might go down one the way which is very similar to WMAP... there'll be the Dark Energy Explorer and its only job will be to carefully analyze just the supernova in all directions to really calculate the expansion of the

universe in the past and now, or a nice big generic tool like Hubble that can... one of the things it can do is analyze supernovae.

Pamela: Yeah. And the thing that comes out of this is this is also a change in how we do astronomy. Because if you look at the author lists of projects of WMAP, like Planck, and even like Kepler in many cases, you have teams of hundreds and sometimes thousands working to solve one question... each person dealing with their one specific part of the data pipeline. But you look at Hubble, and you still have the occasional two author papers, where it's individuals solving the personal question of their lifetime.

Fraser: Yeah, in many ways it's very difficult to really predict what people are going to be... what questions are going to be answered... because as you said, it's not like... think of the Apollo mission, right? What was the goal of the Apollo mission? To land humans on the moon and return them safely to Earth. And you know that the whole mission profile, and all of the people and all of the tools and all of the software is all being developed for that purpose. But in many cases now, it's people who are going to be... I'm going to use this to study pulsars and try to get a better sense of some mystery of pulsars, or I'm going to use it to study gas clouds. But, is the emphasis... I mean there's the large telescopes... the Overwhelmingly Large Telescope and the Very Large Telescope and the various arrays of telescopes and the different... so would you say that the tools are more general tools? Like, let's have some good tools in the radio. Let's have some good tools in the infrared... Or are there some specific-purpose tools being built?

Pamela: I think one of the things that's happening now is a really neat compromise where we see things like the Large Synoptic Survey Telescope that is getting built with the core mission of finding any rock out there capabable of destroying the planet Earth and figuring out its orbit well in advance. That's its core mission. But it's also going to image the part of the sky available to it every three nights, and in the process of doing that it's going to turn up types of variable stars we can't even imagine. It's going to increase the number of novae and supernovae that are getting detected on a regular basis. It's not just going to find the Earth-endangering objects, it's going to find Kuiper Belt objects, it's going to give us a solid and statistically significant understanding of how our sky is changing at the cadence of every three nights of a new picture of what's changed. That is pretty amazing, and there are communities of astronomers trying to sort out what can we do with this wealth of information that's coming our way? So there's one scientific central goal that the telescope has to be able to solve--where are the rocks that are going to destroy the planet Earth? But they're building the system using sets of filters and other characteristics are being done to be sure that other science can be done, as well. I think it's a dual-purpose model that we're going to be seeing in the future.

Fraser: Right, and one mission that should change everything or should push things out to the next level is going to be the James Webb.

Pamela: Right. And this telescope that's going to go out beyond the moon... it's going to hang out in the LaGrange point in the shadow of the moon, observing the infrared sky... and it will allow us with its core mission to see the first galaxies, to see our universe clear itself out as it reionizes. That will tell us exactly how it is that galaxies formed.... top down? bottom up? both? We think we know the answer is both. James Webb will answer that question... it won't be "I think," it will be "I know."

Fraser: Right. And right now we see press releases--most distant galaxy observed... where Hubble has used gravitational lensing to spot some galaxy that's 500 million years

after the universe formed, or 700 million years... but with James Webb, we should get right out to the edge, to the wall, to the limit... and that's going to be really neat.
Pamela: And it won't just be the supergiant, weirdo, huge galaxies... it will be a wealth of different galaxies. So we'll be able to see not just how the giants formed, but... we won't see the dwarfs, but we'll see the normal things. We'll see the small smudges coming together. What we know from Hubble, and from other deep ground-based surveys, is the further back you look, the more chaotic galaxies appear. They start to go from nice pretty spirals and boring puffballs to "dead bug" in appearance. Well, it's true..
Fraser: Yeah, no, no... I know...
Pamela: And we're just going to be able to see how is it that galaxies evolve by seeing them piecemeal in all their different sizes across all the different eons of evolution.
Fraser: What about the more exotic stuff, like gravitational waves?
Pamela: So, there's a few missions that just keep falling off the funding list and LISA is one of them, and that's an interferometry mission. A mission with multiple spacecraft that keep each other co-orbiting, but are connected through lasers and as the distance between the individual spacecraft varies, you can pick that up through interference in the laser beams and nominally that would allow you, if you have a really good gravitational model for the planet they're orbiting, to start detecting gravitational waves from supernovae, from merging black holes, from merging neutron stars. There's a whole variety of different events that should cause gravitational waves, and we've seen evidence of gravitational radiation in black hole binary systems and neutron star binary systems, but we haven't seen any of these stupid waves! We can do it in math, but we can't see them! If LISA can just get funded, and we can get all the calibration data we need, maybe we can see them and someone can get a Nobel prize.
Fraser: And then what about some of the really weird stuff, like other dimensions... string theory... worm holes...
Pamela: Yeah, we don't have any...
Fraser: ...white holes... oscillating universes... and branes....
Pamela: No, no, no... string theory, we don't have any...
Fraser: Probably not... you can't say no because there's a famous quote, right? When a scientist tells you that something could be possible, then it probably is. And if it's impossible, then they're most certainly wrong...
Pamela: What I was going to say is that with string theory, we just don't have any solid experiments that only say string theory is the possible answer. We have ones that would say "not string theory," but we don't have anything that says "string theory and only string theory." So with that one, the theorists need to catch up more. But with brains and oscillating universes and all those sorts of things, those aren't on anyone's radar right now, so...
Fraser: ...no experiments.
Pamela: Not in the near future.
Fraser: But someone could.... once again, you could have some discovery that comes out of nowhere and somebody... some alien shows up and says take a look through my universo-scope...
Pamela: I want my aliens in microbial form, please.
Fraser: Alright, with laser beams...
Pamela: That's like sharks with lasers, except now we have microbes with lasers...

Fraser: Well, let's meet back in 20 years, Pamela, and find out how much of this stuff came true.
Pamela: Sounds like a plan.
Fraser: Alright, we'll talk to you next week.
Pamela: Ok, bye-bye.