Astronomy Cast Episode 187

History of Astronomy, Part 5 - The 20th Century

Fraser: Astronomy Cast Episode 187 for Monday April 26, 2010, History of Astronomy, Part 5 - The 20th Century. 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: Good. I get uninterrupted Pamela time for like the better part of a month before you're travelling, so we've got a lot of shows that are going to be coming out hopefully very quickly, so I hope this will show our commitment to you, the listener, as you get buried in audio. So, I think this is going to be the last part of the history of astronomy. So, let's go into it. So many of the modern ideas in astronomy happened right in the 20th century... dark matter, the big bang, inflation, quasars, black holes, neutron stars, pulsars, and even dark energy. So, with so many discoveries in one important century, let's get started. Alright, in episode 4 we wrapped up right with Hubble's discovery that those blurry spots that he thought might be nebulae, were actually whole other galaxies... which means that the universe is much bigger and the Milky Way is just another galaxy in a gigantic universe. And you mentioned that you've met astronomers who remember that...
Pamela: Right...
Fraser: Which is quite amazing to think... I mean you look at all the books and you think about all of our modern concepts of astronomy, and the sort of size and scale of the universe, that really plays a big role in that. And yet, all of the stuff just came in the last 70... 80 years. So, let's proceed from Hubble's discovery of our place in the universe and what would you say is the next big discovery that was made?
Pamela: Well, I think it was figuring out our place in our own galaxy in 1927 with Oort. Up until that point, we still didn't know where in the Milky Way we were. There were people who put us in the center, there were people who just didn't know. But the problem is, you look out in the disk and because of dust, because of the density of stars, you can see within the disk the same distance in all directions.
Fraser: Right, I remember that it was Herschel who first took a shot at that, right? Tried to do a... tried to figure out our place and try to map out the size and shape of the Milky Way... but it was hopeless because he didn't realize that the gas and dust would be obscuring our view towards the core of the galaxy, and so he had no idea what the real true shape is.
Pamela: And it's really frustrating because star counts can't get you there, and so we had to come up with something new, and this is where globular clusters come into the picture. They're rich with pulsating variable stars and pulsating stars are distance indicators, so we can tell where they are. And Oort went out and he started measuring the distance to the globular clusters and plotting them out, and figured pretty accurately where we are within the Milky Way... and we're still figuring out "accurate"... but that we're off to the side... and he was able to finally say the center of the Milky Way is in the constellation Sagittarius. We didn't even know that amount of information until 1927.

Fraser: And so it was more of like looking for spots that were missing where there weren't globular clusters and to realize that those were blocked.
Pamela: Well, and not only that, but the thing with globular clusters is they form a sphere... a nice friendly round distribution around the Milky Way galaxy. And so he was able to plot the distances to the ones that we can see. And we can't see the ones that are on either side of the disk... but by plotting out the distances to the ones that he could see, and knowing what parts of the sky were obscured, he was able to say... Ah, this is a sphere! And I see where we are within the sphere, and I can see where the center of the sphere should be... and that's towards Sagittarius.
Fraser: Right, and of course we know the name because the Oort Cloud was named after him.
Pamela: He was the one that... theoretically he didn't have observations... we still haven't observed the Oort Cloud. He was the one who theorized that the Oort Cloud is out there serving, perhaps, as part of the source of comets.... that there should be this spherical distribution of material around our own solar system just like there's this spherical distribution of material around our Milky Way.
Fraser: So now we know our place in the Milky Way. And... surprise, surprise... it's not the center of the Milky Way.
Pamela: Right, right.
Fraser: So, what was next?
Pamela: Well, now we're in an age of just filling in pieces. And that's a nice, comfortable place to be. We know where we are, we know where we are in the Milky Way, we know where we are roughly in the universe... which is just somewhere... everything is the same everywhere... it's all expanding. In 1930 Clyde Tombaugh discovered Pluto, growing our solar system a little bit more... expanding the walls and filling in the details.
Fraser: Poor Pluto.
Pamela: Yeah. Well... Ceres had the same fate and no one ever says, "Poor Ceres."
Fraser: Poor Ceres... That's true. Planeted... unplaneted... dwarf planeted.
Pamela: Right.
Fraser: Same as Pluto... right. Poor Ceres. We should do that. We should really pay our respects to Ceres. And, you know, it was important because it pushed out our observations and found a very large object in the Kuiper Belt, and began the discovery of many more objects in the Kuiper Belt. And at the time... oh we got a new planet... but as the observations came in, it kept getting smaller and smaller and more like everything else in that region.
Pamela: Right. Well, they didn't know that there was other stuff in the region at the time. That's the interesting thing, and that's part of why it got to stay a planet is they knew almost immediately that this sucker was tiny and not like Uranus or Neptune and not at all like what they were expecting. But, they wanted a new planet, so dang it... it was going to be a new planet.
Fraser: Right, but also I think it was the methodology that was used to discover that was quite... I don't know if it was revolutionary... but very efficient. I mean they used these photographic plates and they switched them back and forth, and that's a method that's still used now to find asteroids and comets and Kuiper Belt objects... to go at it in such a systematic way really proved a gold mine for finding new objects out there. It's almost

like finding Pluto was part of it, but also just... and I'm sure you turn up all kinds of other stuff by having a really powerful way of seeking objects in the sky.
Pamela: Right, so there were asteroids, there were novae, there were variable stars. But, it sure would have been nice if it could have been another Neptune-like discovery where it was just done mathematically... but that didn't quite work out.
Fraser: Who's next?
Pamela: So next is... well, now we start adding colors of light. We have Karl Jansky discovering that radio waves come from the sky just as much as they come from, well, radio transmitters. So he was the first person to realize that if you look upwards, you can start getting signals. Jupiter is an easy culprit. You can detect Jupiter with a good ham radio, if you want to.
Fraser: And I guess fortunately, the earth's atmosphere doesn't block radio waves.
Pamela: Not most of them... and so that made it easy. So we have Jansky filling out the radio spectrum. Then we start finding stuff that's invisible. We had Zwicky in '33 was looking at clusters of galaxies and realized that they're moving faster than they should. The orbits within the clusters aren't what they should be, and he put forward the idea of dark matter and no one listened to him... nobody listened to him at all.
Fraser: People aren't entirely listening to him today, still...
Pamela: Well, no... that's true.
Fraser: Yeah, you still get a lot of people that still don't like that dark matter idea...
Pamela: Well, and beyond that, Zwicky is the first case of... if you're a cranky person, no one listens to you. Zwicky is famous for being a cranky person at Cal Tech and traumatized many generations of graduate students. So, if you're going to discover something, be non-cranky and don't be a crank. Two different rules, but both apply.
Fraser: But this was one of those mysteries that was opened up back in the 30s, and we're still waiting to close it up now. We're getting tantalizingly close with a lot of the evidence that's been brought back by Hubble, but we're still not there yet. We still can't definitively say what it is.
Pamela: And the thing is, so at least we've gone from Zwicky saying something weird is going on... things are moving too fast... these galaxies should be escaping... they surpass the gravitational binding energy... to... skipping ahead, we'll go back... in the '70s we had Vera Rubin looking at galaxies and finding that the orbits within galaxies made no sense... to... there was a long period--decades-long period--of people not knowing if it was a problem with our understanding of gravity or if there was just stuff that we couldn't see. Now we can say with confidence that the majority of dark matter is nonbaryonic matter that doesn't interact via the electromagnetic force and is collisionless for all intents and purposes. And while most of those words don't make sense without many years of physics, that's much better than "there's stuff out there." And that's where we started.
Fraser: Yeah, small stuff that we can't see... that doesn't bump into each other. What was next?
Pamela: So this is going to be the point, point, point type of ...
Fraser: Yeah, I like when we can tell these kind of weaving narratives, but in this case it's just like... discovery after discovery...
Pamela: There's so much stuff...
Fraser: Like, oh yeah, you know... pulsars... quasars...

Pamela: So according to the timelines I've found, nothing interesting happened in the '40s. I think this probably has a lot more to do with the fact that there was a world war going on, and most energies were put into other things, unfortunately.
Fraser: But there was some work in rocketry, right? There was the V-2 rockets...
Pamela: Right.
Fraser: So, not necessarily astronomy, but some of the space flight...
Pamela: Right, so we can go back and we can look at... in 1926 there was Robert Goddard who started using liquid-fuel rockets. And the nice thing about liquid fuel is that you can turn your engine off. If you have a solid rocket booster, once she's fired... it just keeps going. With Goddard's invention of the liquid-fueled rocket, it changed how we can build rockets and made steering a lot easier as well. And Werner Von Braun in Germany continued this work and then carried it over to America when we ruthlessly stole him. And in the 1950s, this brings us into the space age where in '57 Sputnik was launched...
Fraser: Beep... beep...
Pamela: Yeah, fully detectable. If you haven't seen the movie October Skies go watch it, or read Rocket Boys. It's a fabulous story. And in America... not to be competitive or anything... in 1958 had to launch their own rocket, the Explorer I satellite went into orbit. Suddenly, new things were possible. We were able to start thinking about the idea of space telescopes, and as soon as we had satellites that was one of the first things that astronomers started dreaming of was space telescopes.
Fraser: So, what about... I mean there was one big question that still hadn't quite gotten answered yet, which was like "where did the universe come from?" Or, the shape and expansion of the big bang... so where did that come from?
Pamela: Well, so big bang is one of those things that... it actually is a rather derisive term that Fred Hoyle came up with in a 1949 radio broadcast. He is one of those people who is both amazingly brilliant and also wrong periodically. So while Fred Hoyle has done many, many amazing things, he's also the person who warned that maybe landing on the moon wasn't such a good idea because maybe the dust was so deep it would eat the spacecraft. He really, really didn't like the big bang. He preferred the idea that we live in a universe where every cubic meter of space just sort of magically has stuff come into it... this is a steady-state model and it turns out to be wrong. So in a 1949 radio broadcast, people were debating is this right, is this wrong... it was Fred Hoyle that said the big bang is hooey... basically. So that was when they started debating the existence... then we had problems like the cosmic microwave background radiation getting discovered. So here in 1964... Penzias and Wilson... they're working at Bell Labs... there's noise in their horn... they can't figure out what the noise is... they scrub it, they check the electronics... we did a whole show on this--go listen to the show. And they find this strange hum that is the universe. This was finally the lynchpin that ended decades of debate about what is it that's causing our universe to accelerate, well not accelerate but expand. But throughout the '30s, '40s, '50s, all the way up until their discovery in '64. All we knew was that our universe was expanding... we can't point to any key moment and say that... that's the moment that we understood the big bang. We have to wait for the observations and the technology in the '60s.
Fraser: Right, and then inflation didn't come around until the '70s?

Pamela: So inflation didn't actually come out until the '80s. This is the type of thing where we were old enough to be reading when these ideas originated. And the problem with inflation is as we got better... well, the problem that was solved by inflation is Penzias and Wilson made their observations of the cosmic microwave background but their detectors weren't great. And as our technology got better and better, and as we better figured out that the cosmic microwave background isn't just in all directions and fairly uniform... it's in all directions and very, very uniform. And the only way to get that extremely uniform background is if somehow there is this epic of rapid inflation that stretched everything out and hid the lumpy, bumpy parts... like stretching out Silly Putty and destroying a comic that you've picked up on the Silly Putty. Or that stretched things out from a point where once upon a time they were able to communicate with one another... they were thoroughly mixed at some point in the past. So in 1980, Allen Guth came up with the idea of inflation and people have been working throughout the '80s and '90s and even today to try to figure out what could inflation be? What could have triggered it... what are the different ways that it might have been caused to end? It's an ongoing problem. Here we live in the point where we're filling in details, and that's hard and it's hard to look for key moments in theory in the same way you look for key moments in observation.
Fraser: Yeah, and key people, right? You know, we talked a bit about the space age... I'm sorry, we're going to be jumping around... I hate to do this, but there's so many trails to follow... and with Sputnik going up... but that's when planetary astronomy... and in many cases deep sky astronomy really got going. There were missions sent to the moon, missions sent to other planets...
Pamela: Right, so we had in the '60s the first successful landing in '66 of the Luna probe and Surveyor I by the USA, and in '69 we had Armstrong and Aldrin walking on the moon. Then in the '70s it was Venus, and Jupiter has Pioneer missions sent towards it. We're exploring Mercury with the Mariner probes, and Mars with Viking, and all of these different missions... the Voyagers get sent out and in the early '80s start sending back pictures from the gas giants. All of these different missions... they made it possible to see planetary surfaces as more than just fuzzy blurs. This was particularly important with Mars where we were finally able to squash the stories of there being canals and potentially life... It was a bit depressing up until we actually got things orbiting Mars. Well, we could see from Earth that the poles got bigger and smaller, we could see the dust storms, you could still hope that maybe there was vegetation, that maybe there was life... and if you read old sci-fi you can suddenly see... well, the Mariner missions got there and the sci-fi community changed because Martians no longer played a role in sci-fi.
Fraser: And Venus was no longer a wet world... it changed to a hellscape.
Pamela: It was an acid planet...
Fraser: But they landed... in the 1970s they landed spacecraft on the surface of Venus and sent back pictures of the surface of Venus. They landed the Viking probes on Mars and sent back pictures. So, we're just getting back images from the surfaces of other worlds. There's nothing like getting up close and taking a good look to build your scientific knowledge, and that really is what a lot of the last half... even the last few decades of the 20th century was just dominated by all these planetary discoveries.

Pamela: And we're still continuing to make them. Just this week there's further understanding of Saturn's moon Titan and its atmosphere and the abundances of chemicals in that atmosphere that are pretty odd and leading to some really interesting questions about... is there some new chemistry that we're still trying to understand on Titan. Or more interestingly, is there maybe methanogen-based life on Titan. Mars... we're finally proving there was water on Mars... and we're finding water on the moon... admittedly not in useful form... it's embedded in the geology and you'd have to tear apart rocks to get at it. But still... that's cool.
Fraser: In 1990, probably the most important scientific instrument ever made...
Pamela: Hubble launched with bad vision...
Fraser: With bad vision, and was fixed in a few years... and then maybe the last great discovery of the 20th century... in 1998...
Pamela: In 1998 was the discovery of dark energy by two different supernova teams... And that in itself is just sort of the final piece of changing our perspective to the modern perspective where we know the universe is accelerating apart. And what's amazing, though, is even today we're still filling in details. When I was an undergraduate, we hadn't yet with certainty detected any black holes, and black holes were first theorized back in the late '30s and we're only now starting to say with certainty... yes, that system contains a black hole. It was only in the mid-90s that we were able to say that galaxies had black holes in the center and that quasars and active galactic nuclei and Seyfert 1s and Seyfert 2s and blazars... they're all the exact same thing.
Fraser: The discovery of extra-solar planets...
Pamela: Yeah....
Fraser: First around pulsars in the '90s... in the early 90s... and then around... and then mega-Jupiters orbiting other stars at the end of the '90s. But now we have 100s of planets under our belt, and more every month. Some are narrowing in towards Earths and Earth-sized planets. It's quite amazing.
Pamela: And it's one of these things where I have to keep throwing out books. Or at least throwing them into storage. Our picture of the universe is changing very rapidly, but how it changes is I think in some ways is more interesting. If you look at our past 4 episodes, the "how our understanding has changed" has almost consistently been driven by technology... Galileo gets the telescope and we're able to see phases of Venus that forced the sun out of the orbital place it had been and put it into the center of the solar system. We get really good recordkeeping by the Babylonians and it's possible to start to understand the eclipse cycle. You get instruments that Tycho Brahe and observers in the Persian empire used to very carefully plot out the positions of the stars and suddenly you're able to see... oh, our planetary models don't work... we need better planetary models. It was consistently observation technology forcing us to change our perspective. We now live in a time where instead it's filling in the details of the theory. And in some cases, our observations are ahead of us... we don't know what this dark energy stuff is... dark matter--we're halfway there, but we're not all of the way there. So now our theory needs to catch up with our understanding from observational astronomy. And that's a really awesome thing.
Fraser: One thing that's quite neat to do is to go watch Cosmos again... and you'll see there'll be artists' rendering of things... like... oh, I wish we could see what this would look like... Well, now we know. Even quasars... he described quasars and wasn't quite

sure what they were yet... and now we know. So, it's quite interesting to see... and Cosmos came out in the late '70s... early '80s... so even stuff that's maybe 30 years ago... big chunks of it are out of date, so it's quite interesting to watch... and yet it's still fantastic! I mean you watch Cosmos and it's amazing! Interesting to see how things are changing even from then to now. And it's all available on You Tube... you can find all the Cosmos episodes on You Tube. I've recently been watching them with the kids, and they're bored... but I just love it. Yep... planetary nebulae... supernovae... so, there's so many things that have just come out within this last century. But now, we've kind of caught up to now... and so the next episode we thought we'd look forward and talk about some big missions that are coming up... and some lines in science, some theories that the technology, we're hoping, is going to fill in all the holes. What are some of the big discoveries that might be made in the next 50 to 100 years? So, stay tuned for that and we'll talk to you next week, Pamela.
Pamela: Sounds great Fraser. I'll talk to you later.