Astronomy Cast Episode 185

History of Astronomy, Part 3 - The Renaissance

Fraser: Astronomy Cast Episode 185 for Monday April 12, 2010, History of Astronomy, Part 3 - The Renaissance. 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: Very well. I wanted to sort of just remind the listeners... we get a couple of complaints.... how come you guys haven't been recording in a month? Well, the reality is we are recording... we're just a month delayed. The month delay is this constant, non-stop reminder of our debt to you, the listener...
Pamela: We're trying...
Fraser: ...that we owe you about four shows, and if you'll see, we've been dragging this four show delay over the course of a year, but that's just to remind us day in and day out that that's what's coming to you. So the show is still coming on a very regular basis, sometimes we make up a little ground, sometimes we lose a little ground... it all depends on how much traveling Pamela is doing. So, that is why we endure a delay. So, that's why... that's our gift to you... our solemn promise to you that these episodes will catch up to you.
Pamela: And if you'd like to see me in person so that I can apologize in person, I'll be at Convergence in Minneapolis, Balticon in Baltimore, TAM in Las Vegas, and DragonCon in Atlanta... and you're welcome at any of those. I'm sorry... if you remind us of this I'll give you a button! I'll bribe you...
Fraser: And a half-hour discourse on any of your astronomical theories. She'd be more than happy to spend a couple hours... maybe even take you out for dinner.
Pamela: No, I work for a state university... I'll give you a button.
Fraser: Fine... alright, alright, alright... ok... well, then let's move on to the Renaissance. So now we reach the time with the names with which many of you will be familiar. Galileo... Kepler... Copernicus... this is an age when the biggest names in astronomy use the best tools of their time to completely rearrange their understanding of the universe... putting the earth where it belonged--merely orbiting the sun--and not the center of everything. Alright Pamela, so when last we saw our heroes... and I do mean that... our heroes... we had Ptolemy who was a Greek--actually who was a Roman--very careful, very accurate, and completely wrong.
Pamela: That would be true.
Fraser: Then it was a long time that anyone figured out that he was wrong. So when should we pick up our story again?
Pamela: Well, picking up the story really doesn't fully happen until the Renaissance. But we can't forget what the non-western world was successfully doing during the Crusades. So, in the 1300s, Europe decided it was going to war on religion, basically, and it wasn't pretty. Not a lot of science was accomplished, as anyone knows during war time science is one of the first things to go, unless you're building weapons. While Europe wasn't

focused on learning, Babylonia was. So we had the formation of astronomy schools, we had the translation of scientific documents from Latin and Greek into Arabic. We had people continuing to work on carefully studying the sky, on carefully writing down the passage of the planets and trying to understand all the changes in the sky from night to night and year to year. For instance we had in the late 1390s... early 1400s... Ulugh Beg a noted astronomer. He built an observatory... Samarkand... and with it he made it possible to very, very accurately map the sky. This was one of the first times an actual observatory was built with instruments permanently set in place specifically to make sure that our notes, our measurements are accurate of the planetary and stellar positions.
Fraser: Right. And I think a lot of information was maintained and disseminated by Arab astronomers. During that time I know that a lot of information was coming into... was being passed around and being used in Central Asia. So although not much was happening in Europe, a lot of stuff was happening around the rest of Asia and in the East... but the time we really want to talk about is the Renaissance. So when, from an astronomical standpoint, did that really get going?
Pamela: Probably in the 1540s when we had Copernicus working on his theories. So Copernicus... he was Polish... he was professionally an astronomer... a mathematician... and in his day people were still using the Ptolemaic models of the solar system, which, incidentally, were in many ways preserved by the Arabic cultures that transcribed and translated and built on his books. But looking at this, though, he realized that this didn't work. So he decided to try to put the sun in the center. Again, it still didn't work because Copernicus was building on the Aristotelian idea still that everything had to be a perfect circle. So, he introduced mathematical models that still had crazy circles upon circles. By only having circles upon circles he was able to philosophically open new doors, but not mathematically make better predictions. It's a bit troubling, but at least it was a start in the right direction.
Fraser: So, it brought a bit of a simpler model, but it was less accurate than the Ptolemaic model.
Pamela: And eventually he did end up with epicycles on his model as well to try to explain retrograde motion, to try to explain the fact that the planets appear to move faster and slower at different points in their orbits. So his theory, while it started out nice and simple, as they desperately tried to figure out how to make it predictive actually grew as cumbersome and awkward as Ptolemy's before it.
Fraser: How was that received?
Pamela: With controversy. The Catholic Church, as well, got involved, didn't like it so much... umm... human beings... philosophically aren't we supposed to be the center of the universe? And Copernicus was going against that idea. Luckily, though, observations were the word of the day. They were the trendy topic. So in the 1540s we had Copernicus publishing his heliocentric theory of the universe. Then in the 1570s we had Tycho Brahe building a new observatory and working very carefully to mark positions, to map the sky, to study planetary motions with greater precision than had previously ever been done. And through his work, people had the data they needed to forever say... no, Copernicus, you're wrong... no, Ptolemy, you're dead, but you're still wrong as well... and start building the accurate models. That was perhaps the most important thing to happen-- Tycho Brahe making the needed observations.

Fraser: But he also... he's got a supernova discovery that he made, and that helped astronomers understand that the sky isn't static.
Pamela: Right, so in 1572, Tycho Brahe was not the first person to note a supernova. We had supernovas identified in Babylon in 1006 and in China in 1054, but the 1572 one... Tycho Brahe was able to look at it and say, look... sky changing.... Ok, we need to set aside our philosophical way of understanding this and base what we do on our observations. Another thing that Tycho Brahe did was he, for instance, looked at comets and realized from their parallaxes... or actually their lack of parallaxes... that they couldn't be atmospheric objects. So, there were many different things that through careful observation he was able to say our current theories can't be right. Now, he wasn't a theorist... he didn't come up with the answers, but he provided the data that said this, this, this, and this are entirely wrong.
Fraser: Right... but he still didn't have a telescope yet...
Pamela: No, and that's what's amazing...
Fraser: And neither did Copernicus... right? They just worked out the math... looked up at the sky... did the best they could with tools... but they didn't have a telescope.
Pamela: It wasn't until about 30... 40 years later in 1608 that Hans Lippershe, a glasses maker, a spectacles maker realized that you can combine lenses to make bright, magnified images of distant objects. So he was the first person to make a telescope. Now he usually doesn't get credit in popular science. All the credit goes to Galileo. Perhaps because Galileo knew how to get himself in trouble, and people who get in trouble generally get all the attention.
Fraser: But this original telescope solved more daylight concerns, right? It was the kind of thing you could use on a ship to look for the port, or something you could use on the field of battle to see where your enemies were lining up in their formations.
Pamela: These were spy glasses. These were devices that were awesome for ports. That was actually part of how they got sold to Italy. Italy's a peninsula with lots of vulnerabilities from the sea. So, Galileo worked to develop the better spy glass for that sort of work... watching ships come up over the horizon actually helped prove the planet was round... because if you have a telescope and you're watching the horizon, you see the top of the ship before you see the rest of the ship. It literally comes up over the horizon. So, in 1609, Galileo took spy glasses and pointed them upwards. Who knows if he was actually the first person to do this. I can't imagine that no one else got the idea to look at the moon. He was the first person to document what he saw. He discovered the four brightest moons of Jupiter. By looking at the moon's terminator, he was able to realize that this variation of color on the surface of the moon was craters, mountains. He was also the first person to realize that the band of white across the sky... that's our Milky Way... isn't milk spilled across the sky, isn't even a solid shade of white or cream across the sky, but rather simply thousands and thousands of closely-packed individual stars that are so close that our eye translates them as a solid shade of light.
Fraser: He realized that Saturn has ears.
Pamela: ...that come and go with time, yes. The sugar bowl approach to Saturn.
Fraser: And he also recognized Venus and realized that it went through phases similar to the moon.
Pamela: And it was these phases of Venus that meant that our sun had to sit at the center of the solar system. The issue is that if Venus goes around the earth, and the sun is

beyond Venus, you end up with a full Venus... a Venus that has a full phase only if it can be on the opposite side of the earth as the sun... and you can never quite end up with that. But we can look at Venus and see an almost full phase when it's on the backside of the sun relative to the earth. So the distribution of phases of Venus that we're able to see from the planet are only possible with Venus circling and circling and circling the sun.
Fraser: And how did that work out for Galileo?
Pamela: Not so well, but part of Galileo's problem was he didn't know how to play nice with others. He knew he was right... and we all know this person.... the really smart brat who doesn't know how to close their mouth... and I know I've resembled that brat now and then in my life... And you just want to go nyah nyah nyah nyah nyah nyah--you're wrong. Well, he did that to the Pope.
Fraser: The most powerful person in Europe...
Pamela: Right, and he messed with the de Medici family... these are the people who basically defined how to stab one another in the back. So, yeah... Galileo messed with the wrong people. By not playing nice... it wasn't so much that the church was out to decree his science was wrong, because in fact when he first started his work, the Pope--who was a different pope than the one who eventually sent him to his house forever under house arrest--he was originally supported by the church, but he just played politically badly and this is detailed beautifully in the book, *Galileo's Daughter*. And if you haven't read the book, I highly recommend getting it. He played politically wrong. And he paid for it... and science paid for it...
Fraser: Yeah, and I've heard differing descriptions of it. I think... we'll talk about Newton in a second... he was a jerk. No one really disputes whether Newton was a pain to be around. I think with Galileo there's a lot more controversy about what was he like personality-wise. I think he was the same kind of thing... he didn't know when to let it be. Even when he had gotten a pretty good situation out of the church and things were, you know... he wasn't having his feet branded by pokers, and he was able to continue doing his work... he kept pushing. He tried... even though I think the church knew they would have to take on a lot of his discoveries and recommendations, they didn't want to proceed as quickly as he wanted to. That's great... that's great that he held true to his beliefs, and at the same time, it unfortunately personally for him, he did it in house arrest with a lot of very powerful enemies.
Pamela: The difference as I understand it was... Newton was probably simply your standard socially-inept scientist. There are people who say he had Asberger's... yes, he was a jerk. But with Galileo, he was pompous as well. The final thing that sealed his future in a lot of ways was when he wrote his dialogues. He put the arguments of the Pope in the mouth of the Idiot in the dialogues. And so he basically mocked and parodied the most powerful man on earth as an idiot. And Saturday Night Live can get away with that, but they're about the only ones and they didn't exist for a few hundred more years.
Fraser: And that's why it's great to have free speech now, when we can say that kind of stuff, and make parody and say what we think and not worry that someone is going to lock us up and torture us for our beliefs. Unfortunately back then that wasn't the case, so now... when a person stands up and says what they believe, you congratulate them and know that it's great to hear them standing up for rationality and things like that. Back then, you had to be a little more careful. I think I probably would have told Galileo... be a little more careful... slow it down a bit.

Pamela: At about the same time, though, on the other side of the religious curtain on the Protestant side of Europe, we had Kepler doing much safer work. So while Galileo was out making his observations, making the sun the center of the solar system and mocking the Pope, Kepler was being his mathematical self working a less politically dangerous life where he took Tycho Brahe's work... and while he occasionally had problems after Tycho died with getting permission from the estate to continue to use the observations... Kepler's work plugged on to mathematically show that the planets have to go around the sun if you want accurate predictions.... that if you want to be able to say with certainty where Mars will be tomorrow, where Jupiter will be tomorrow... you put the sun in the center and you place all of the planets--or at least out to Mars... Kepler only calculated out through Mars because he didn't have assistants to help him with his calculations--you have to put the planets on ellipses. But if you put the planets on ellipses, it all works.
Fraser: Right, and that was it... that was the big discovery... that solved the whole problem. Instead of looking at everything as a circle, you just make everything an ellipse and suddenly, problem solved.
Pamela: And one of the things I love about Kepler's work is he initially tried all sorts of bizzaro-land egg shapes... because he figured that somebody in the course of history had to have tried the ellipse... it was such a straightforward, simple thing.
Fraser: Duh! And nobody did...
Pamela: Nobody did, because they were all a little bit too Aristotelian in their thinking.
Fraser: Yeah, it has to be circles... God would want it that way.
Pamela: Exactly... exactly. So, in the same year that Galileo used his telescope to look at Jupiter and the moons, that Kepler came out with the orbits are ellipses... that they sweep out equal areas in equal times as they orbit about the sun or orbit about Jupiter, in the case of moons. It would take him another ten years to get to the point of realizing the relationship between orbital period and the distance of a planet from the sun. By 1619, without even knowing the existence of gravity, we had empirical equations that matched the observations that told us how to predict where things are located in the solar system. And that's pretty cool.
Fraser: That is a beautiful thing... yeah. And he created his three planetary laws of motion which, when you go through astronomy class, you'll learn them... and physics class. But, it's great that you had observation... you had calculations... calculations matching observations... that's it... that's the whole thing.
Pamela: And it wasn't until 1609 that we could actually make these predictions. But suddenly, because of Tycho's careful observations and Kepler's careful mathematics, we could say where the planets are. And because Galileo was loud and obnoxious, everyone knew the possibility of the sun being in the center of the solar system, even if only the Protestants bothered to believe it at that moment.
Fraser: Right, that's fabulous. Ok, who's next?
Pamela: The next astronomy person is probably Christiaan Huygens and I just love saying his name... it's just fun to say.
Fraser: Huygens... Huygens, Huygens, Huygens... although I'm sure we're saying it wrong... and someone from the Netherlands is going to tell us that it's got more of a...
Pamela: Well, it's still fun to say... however you're supposed to pronounce it...
Fraser: Huygens...

Pamela: Yeah... he was working in the 1650s and he was almost what I'd call a polymath. This is someone who worked on probability theory, who figured out how to make pendulum clocks, who worked on things like internal combustion engines... although he never built one... it would have been awesome if he did... He might have actually had a Steam Punk reality... But he also worked on astronomy. He watched the transit of Mercury that took place in 1661, and he also observed Saturn's rings and four of Saturn's moons. What's cool about Huygens is he had better optics than Galileo. There had been 50 years of telescope design going into Huygens work. He was able to realize that those teacup handles that Galileo saw were actually a ring of material... what he wrote down was a thin, flat ring no where touching and inclined to the ecliptic. So, it was inclined to the planet's orbit around the sun. That's pretty amazing. Now, admittedly, he thought it was a solid object... take a hula hoop and turn it into a flat disk, and belt it around Saturn. It's still pretty amazing. He was just using a 50 power refracting telescope. If you've bought--and if you haven't, you should--if you've bought a Galileo telescope from the International Year of Astronomy project, that's a 50 power telescope. So using something no more complicated than the $30 Galileoscope, Huygens was able to find 4 moons and define the ring orbiting Saturn. He also went on to look at the Orion Nebula...
Fraser: He saw stuff on Mars...
Pamela: Right, and what was interesting about Huygens was he was someone who felt that extraterrestrial life existed everywhere. Now, he's not the first. The Arabs and their cosmology thought that the earth was just one of many worlds orbiting many suns. But Huygens was the first westerner to observe planets and basically believed that there had to be extraterrestrial life out there. He had the idea that there should be other life just like what we have here on earth. Maybe there's different types of waters on Jupiter and Venus... he assumed that there had to be life on Mars and Jupiter, it's an interesting standpoint to have back in such a religion-dominated universe... or a religion-dominated culture, rather.
Fraser: And so, next....
Pamela: Next, we have.... we're in the period of people who've had missions named after them... so following on the coattails of Christiaan Huygens we have Cassini, who in the 1660s was working in many different nations. He was an astronomer for hire, in some ways. He worked in Italy, he worked in France, and he realized that there's a divide in the rings of Saturn, he realized that Mars has ice caps, and so he took our understanding and he worked to add details to it. I like this advancement of details that begins happening during this period of time.
Fraser: It's interesting... you're right, you're beyond the big discoveries. I mean like, oh... the universe is completely different than what we thought it was before. But, you get these oh... they found a moon around Mars, and they were able to see additional moons around Jupiter, and then they find bands on the planet of Jupiter, and then they see the Cassini division, right? They see breaks in the rings... and it's back to incremental discoveries, but built on such a solid foundation. The correct one, as opposed to the incorrect one. So, I think that's great.... And that's, until we get to the 1900s, there's a couple more big discoveries which I think we'll get to next, is Newton. Newton made a big discovery about the nature of why things did what they did. He wasn't necessarily an observationalist...

Pamela: Right, he did do his own observations... he was actually the one who figured out... one of the modern ways of using the telescope--the Newtonian telescope... he was the first one to use a mirror instead of a lens. But he was much more of a theorist. He was one of the people influential in developing calculus, he figured out that the moon is actually falling around the earth and just missing the surface... for which we're all quite grateful, and that it's way of falling around the earth is mathematically identical to the perhaps apocryphal apple falling from a tree. So Newton was the person who started to figure out the "whys." Kepler figured out the "hows." Here's a mathematical equation describing how Mars orbits the sun. Newton took that one step further and said, this is why. It's gravity. And look... these errors that we still see in planetary motion is because the planets pull on each other gravitationally and this causes measurable variations from what you'd expect if they didn't pull on each other. Newton was able to start building models that took into account if Jupiter's here, this is what happens to Mars. What's amazing is he ran the calculations in a day prior to computers.
Fraser: Yes. And once again, another polymath. He was interested in optics, he was interested in astronomy and physics and alchemy, and had his.... he was working on... and mathematics... He... I'm going to say invented calculus... with error quotes.... because other people were inventing calculus at the same time, their battles with Leibniz are great books in their own. But, this was somebody who was all about research, all about study, all about pushing scientific investigation forward, and damn the consequences and damn the relationships... Didn't he at one point stick a... I'm trying to remember the story... he pushed the back of his eye with a pencil or some kind of...
Pamela: Yeah... ok you're starting to turn my stomach...
Fraser: I know... to see how it affected his vision... I mean he was relentless for science, and made... I think this is the start.... this is modern astronomy. At that point, I think we can put that dividing line down, and say ok, we had the Renaissance and then we had Newton.
Pamela: He and Huygens and several others actually were--and this is a topic for an entirely different show--were on the pursuit of the wave-particle duality of light, and were building science as an experimental process. Even the theorists had to say, ok... somebody go build the following thing for me to test this idea.
Fraser: Yeah, absolutely. Ok, so well I think we've kind of gotten to Newton and really covered the Renaissance. So we'll draw another line right here and call this show to an end. But there's more coming.
Pamela: There's more coming.
Fraser: Next we'll move through a whole bunch of influential and incremental astronomers taking us to the big guns of the 20th century. Thanks a lot Pamela, again. This has been really interesting. We'll talk to you next week.
Pamela: Sounds good Fraser. I'll talk to you later.