Astronomy Cast Episode 228 for Monday, April 11, 2011:

Giovanni Cassini

Fraser: Welcome to Astronomy Cast, our weekly facts-based journey through the Cosmos, where we help you understand not only what we know, but how we know what we know. My name is Fraser Cain; I'm the publisher of *Universe Today*, and with me is Dr. Pamela Gay, a professor at Southern Illinois University – Edwardsville. Hi, Pamela. How are you doing?

Pamela: I'm doing well. How are you doing, Fraser?

Fraser: I'm doing really well. This is kind of cool – we are doing our first-ever, live, hang out version of recording Astronomy Cast, so while we're doing our Astronomy Cast recording, we've actually got eight of our good astronomy friends listening in and watching us on video as we do the recording, so no pressure.

Pamela: Please, please be kind to us -- that's all we ask.

Fraser: [laughing] Now, we've got a bunch of announcements. We'll get through them as quickly as we can; we know you don't like them. So first, I was a guest on the Caustic Soda podcast, so my good friend Toren Atkinson and [missing audio] because of weird time dilation, the episode that I recorded is going to be showing up in July, but we're saying this is April 11, but in fact, time is all wiggledy-timey-wimey.

Pamela: Time is just relative, that's all.

Fraser: Time is just relative, so we're moving at a faster velocity, or is it a slower? Anyway, could you do the math, please?

Pamela: No.

Fraser: The next thing that is important to note is that Pamela and I are going to be doing a live episode of Astronomy Cast at Dragon*Con, which

is the Labor Day weekend, 2011, and that's going to be really fun. The…oh! Go to astrogear.org; buy our stuff.

Pamela: It's summer…you can look sexy in an astronomy t-shirt. Go show off your non-geocentricity.

Fraser: Perfect! I'm not wearing one today; I'm usually wearing them. That's all I wear actually. And then finally, you've got an announcement about a lunar phases calendar.

Pamela: Right, so Astronomy Cast is a joint production of SIUE/*Universe Today*, and a little non-profit that Fraser and I formed along with our friend, Phil Plait along with a couple of other people, and we're trying to raise money for our non-profit so we can keep on doing cool things like this show and 365 Days, and so one thing that we're going to do is a lunar phases data visualization contest. All of the rules are up at astrosphere.org, and the winning poster design could get turned into a poster we sell in our store.

Fraser: Very cool! And so people can get the lunar phases organized.

Pamela: Yes.

Fraser: Awesome! Alright, let's get on with the show then. So another two-parter coming at you. This week we talk about the Italian astronomer Giovanni Domenico Cassini, best known for discovering Saturn's moons, and the biggest division in Saturn's rings. Cassini made many other important discoveries in the solar system, and in the fields of physics and astronomy. And next week, we'll talk about Cassini: the mission, but now let's talk about Cassini: the man.

Pamela: He was an amazing, well, he was an amazing person -- I won't say amazing man. This is someone who was working in the days when we were still trying to figure out where the heck we were in space. He grew up thinking that the Earth was the center of the universe, and had to re-find his place in the universe as an adult. He grew up believing in astrology, and as an adult became a hard-core, science-focused astrophysicist in the earliest days of that field.

Fraser: Where would we place him on the timeline of all the famous astronomers, you know, the Galileo and the Copernicus?

Pamela: So, he was after Galileo, he was after Kepler and Brahe, but they all kind of overlapped at various points of their life. So he was born in 1625, and so he was growing up learning about all these things going on, but he got to follow far enough behind them that he had much better optics to play with.

Fraser: Right, I mean, Galileo was one of the first people or the first person to point a telescope up, so he discovered everything that was worth looking at with a telescope…but he saw the moons of Jupiter and Saturn's ears, but then Cassini and all these other people got their hands on much better instruments and got to take the science a lot further.

Pamela: Right, and he got to be around for interesting things like the discovery of gravity, which he actually didn't believe in initially -- and I just love the concept of not believing in gravity.

Fraser: [laughing] What! Not believing in gravity? That's easy to prove, you know?

Pamela: But it was something where the whole idea of gravity being a force that kept the planets in orbit around the Sun -- that was revolutionary! It forced you to change how you view the entire Solar System, how you view the entire Universe. To go from being a kid with a geocentric view of the Universe, and a belief in astrology to an adult who had to believe in a heliocentric with gravity -- that's an amazing change to go through in your lifetime.

Fraser: He was an early adopter.

Pamela: He was truly an early adopter, but he wasn't the first. He was the one who waited for his buddy -- he found all the bugs, and then bought it after his buddy did.

Fraser: Right…of course…yeah. OK, so then why don't we start with his early history, then? I guess the astrology side…

Pamela: It was just one of those things. When we're kids, we're all into strange stuff; some people pick up all the frogs in their backyard, he picked up all the learning he could on astrology, and that's really all anyone ever

says about it. It's only after he went and he got a what was then an excellent Jesuit education that people really start looking at his life, and the thing that I just sort of look at and go "wow, things were different back then. He was a professor at the age of 25, and I didn't have my PhD yet.

Fraser: Well, not long after, Pamela.

Pamela: Well, still – I'm not full professor yet, and here he was…

Fraser: But you got your PhD pretty quick, though.

Pamela: So he got his PhD at age 25, and he had this interesting joint career where he was working in Bologna, and he was both a fortress builder, and an astronomer, and I love the juxtaposition of walls and sky. He was both grounded and had his head in the clouds.

Fraser: But the math is the key.

Pamela: Right, it's all physics -- it's all stress, strain, motions, kinematics…

Fraser: Yeah, yeah, and you could see it was a natural fit for him. And you know he loved astrology as a kid. How did he move into the astronomy side of it?

Pamela: Well, I think it was a matter that he just kept discovering amazing things with the observations he made. He worked with some of the craziest telescope configurations, where he actually built a tower at Paris Observatory and would put lenses up at the top of the tower, and then have the eyepiece, in some cases, hand-held, in other cases, mounted separately. So can you imagine building an open-air telescope that is two non-connected pieces of glass?

Fraser: So you would hold a piece of glass and just sort of move it around and look at it?

Pamela: And line it up with the one up at the top of the tower.

Fraser: Right, but you can imagine that might have been the best, fastest way to get images, right? I mean, it was an open frontier back then, so there's all kinds of different ideas that people are trying out. That's neat just

to hear about that kind of experimentation. You can imagine the connection with this fortress-building experience, right? Where he's kind of like, "Oh, we could easily buttress up that telescope over there, and support it with that, and hold the eyepiece over here and get some images." Yeah.

Pamela: He was definitely the nuts and bolts kind of physics guy. I have to admit this is the type of physics I like [missing audio] not so much my thing, I can do it but the whole "if you do this, you get this reaction, nuts and bolts, gravity, kinematics, stress strain, this is how you build a building that doesn't fall down, this is how you build a solar system that doesn't fall in on itself" – he was that kind of a scientist, and he made discoveries so along those lines too, so just straightforward, linear thinking, so in 1665 he was using his amazing telescopes to look at the planets because they're kind of the coolest thing to look at, and he was making out markings about the sides of the planets for the first time, write down and determine the rotation rates, and so he was able to look out and go "Wow! Jupiter – it's orbiting faster than we are! Oh, Wow! Look at Mars" (not orbiting, it's rotating faster than we are). He was able to look at Mars and accurately figure out "Wow, its day is just a little bit more than 24 hours." That's really impressive.

Fraser: But I mean most people who are listening to this podcast recognize the name from the mission, which we'll get to next week, so he clearly makes an impact in the research on Saturn.

Pamela: So he was someone who was out there determining moons. He was the person who discovered Iapetus, the little white and black, completely funky-colored moon that kind of looks like it ran head-first into something. He was the one who while observing the [missing audio] Saturn's rings, realized "wait, there's a gap in those rings," and that gap now bears his name. It's the Cassini Division.

Fraser: Right. And what is that gap?

Pamela: It's where there's a moon located, and then the moon shepherds the rings and clears out the gap.

Fraser: But he had no idea that's what he was looking at.

Pamela: No. It's taken us a long time and, well, it's taken the Mission Cassini to really help us understand these rings.

Fraser: Right. OK, so he discovered…what he ended up discovering, what four of them, right? Four of Saturn's moons, the Cassini Division…

Pamela: Right, and he determined the rotation rate of Jupiter, which has features unlike Saturn -- which is kind of beige -- and I think one of the neatest things he did was he was a very careful observer, and he was tied up in trying to understand how to measure time, he was tied up into trying to accurately measure longitude. And he followed the recommendations of Galileo in terms of realizing you can use Jupiter's moons to keep time, except while recognizing that, he realized "wait, there's this weird lag that keeps cropping up," so you're watching Jupiter, you're watching Jupiter, you know how long it takes its moons to orbit. You go away for a couple of weeks, you come back, and there's this either acceleration in when you see the moon complete an orbit, or a lag. It can be many, many, many minutes – tens of minutes, and this was confusing, and it was actually one of his colleagues that figured out "wait, this is just the speed of light." So it was his observations that got us to the speed of light.

Fraser: Really? So is it because the moon is further away, or further away on its orbit, so it's taking longer to get to us?

Pamela: It's the whole system is moving further away, so if you look at Jupiter when it's at closest approach, and you measure when Io passes directly in front of it, and then you wait a few weeks and you come back expecting to see that transitive of Io in front of Jupiter again, well, if Jupiter's now further away, that transit is going to lag behind when you expect to see it. And that lag is because Jupiter is now in a different place.

Fraser: Right. Right. Right. OK, yeah. That's crazy. It's crazy, but they had no idea. I mean did they interpret it correctly? Or did they interpret it…

Pamela: They interpreted it correctly, and the reason they were able to make this light/travel time discovery is because of earlier work that Cassini had done with a Frenchman named Ritchey and …

Fraser: Sorry to interject -- is that where the telescope name comes from? There's a Ritchey–Chrétien …

Pamela: Yeah, I'm pretty sure that's…it's…they were all working on optics back then; they were all working to figure out the best telescopes, but in this case, poor Ritchey got stuck on a boat and got sent far south, and the reason he did this, the reason they did this was Cassini and Ritchey both looked at Mars at the exact same time because they were working on determining accurate ways of measuring time with new clocks and watches. They looked at Mars at the exact same time, measured its location relative to the stars very accurately…

Fraser: But from different places on Earth.

Pamela: But from different places on Earth. They knew their separation on the planets, they knew the distance between them, they could measure the angle that Mars moved on the sky, and this allowed them for the first time to accurately measure the distance to another planet, and using geometry and using Kepler's Laws, once we knew where one planet was located, we could figure out where all the planets were located.

Fraser: I mean, that was one of the times when they finally understood the scale of the Solar System.

Pamela: And so they were able to then go from "OK, I know exactly where Mars is" to "OK, I now know where Jupiter is…OK, I now know how much the distance to Jupiter has changed between now and three weeks ago…OK, I now know how much the predicted time of Io transiting in front of Jupiter has changed…I now know the speed of light," and that's just an amazing train of logic, and you can see in this how Cassini went from astrologer to astrophysicist in one lifetime.

Fraser: But that's a completely independent method of measuring the speed of light. Then I know they did another experiment. Didn't they do an experiment where they were on mountaintops and rotating mirrors…?

Pamela: Yeah, that's the much more difficult way to do it, where, basically, you're trying to get the rotation rates just right, and the flashing just right so that it passes through things as they rotate, and it's very complicated and we'll link to it because that requires photos.

Fraser: But that was a completely different method of independently determining the speed of light. I wonder how accurate they were. How

accurate Cassini was. So we've got these really cool, you know, discoveries…helping measure the speed of light, understanding the scale of the Solar System, discovering the moons of Saturn…

He also did a Zodiacal light. So in 1683, he was…basically he did what we've all done at some point. He stayed up all night; he looked at the sky and went "Huh! Why is it suddenly getting brighter in the direction opposite the sunrise?" And he correctly figured it out that's there's just particulates out there, and that was sunlight shining off of stuff that wasn't in the shadow of the Earth, but was behind the Earth, so you can actually as it's getting ready to be sunrise, you can see the sunlight in the opposite direction of the sunrise illuminating particles that are not quite on a straight line, but almost on a straight line from the Sun to the Earth and out to the space behind us, and that space behind us is just filled with stuff left over from comets, stuff left over from asteroid collisions, stuff that makes the Zodiacal light that was interesting to Cassini and Brian May used to write his PhD.

Fraser: I've actually never seen it. Have you?

Pamela: I've only seen it once. I saw it from Southerland Observatory in South Africa, and it was surreal because the Zodiacal light got to be as bright as the Milky Way, and that's just kind of creepy.

Fraser: Wow! So you need a really dark place to observe, and then when would you be able to see it?

Pamela: It's brightest before the sun comes up, so wait before astronomical twilight starts and that's an excellent time to take a look at it, and it's the opposite direction of sunrise.

Fraser: Now, he didn't stay in Italy the whole time, did he? He moved to France.

Pamela: Yeah, he ended up being the director of the Paris Observatory. He was the astronomer for the Academie Royale of Sciences. He actually escaped being one of the Pope's minions because the Pope tried very hard to lure down into the Vatican territory, but he just wanted to be a scientist, and what was amazing is the Paris Observatory actually sort of became a family legacy. He was the first director ever of the observatory, but then his son, his grandson and his great-grandson went on to run the observatory after

him, and his poor great-grandson was director of the observatory when the French Revolution hit and got thrown in jail for many months for his ties to the royal house. Basically, if you're the "astronomer royale," and it's the French Revolution, you're as bad as anyone else, but well, that was the end of the astronomical dynasty. It's just neat to look back over Cassini, after Cassini, after Cassini having this scientific legacy.

Fraser: Hmm. Yeah, there's a lot of those stories where you've got the father, and then you've got the sister…you've got the…right? And then the son…

Pamela: Uh…you wouldn't be talking about the Herschels, now would you?

Fraser: The Herschels…yeah, yeah, so there's the Herschels right? Where it's like him and his sister, and then his son did some work with them as well.

Pamela: The Struve family had a couple of observatory directors across a couple of different continents. We just see this, and then there's husband and wife teams galore through astronomy.

Fraser: So then how long was he working in Paris, then?

Pamela: He ended up spending the entire latter half of his life there. He actually stayed at the Paris Observatory even after his son took over. I think the sad part was, in 1711, he went blind and it was another year before he actually passed away at a fairly old age, but still to be an optical astronomer in a day when you could only observe with your eyeballs, and to go blind. That was pretty bad, but he left a really good legacy behind him.

Fraser: So it was still, like,100 years before any photographic observing was done, right?

Pamela: Yeah, so he was essentially there from 1669 onwards, and he became a French citizen, and what's neat is that poor, imprisoned great-grandson actually had the French version of his name, and so his great grandson was Jean Dominique, instead of Giovanni Domenico.

Fraser: Right, right, but still Cassini…

Pamela: Exactly.

Fraser: So I should…there's one thing I think that you didn't touch on yet, which was that he did a lot of work with Jupiter's Red Spot, right?

Pamela: Right, so he along with Hook were the co-discoverers of the Red Spot, and they were able to determine this is a lasting structure; this is something that is tied to the rotation rate of Jupiter, and it was part of how they started to realize the different rotation of the bands on Jupiter. So it was through his careful observation, his high quality optics for the time that they were able to start realizing that it wasn't just the planets weren't on perfect circles, the planets themselves have ever-changing surfaces, so this was more of that revolution in how we view the Solar System.

Fraser: But again, did they have any inkling about what they were looking at? I mean it was a blotch on the surface of the planet that helped determine the rotation rate, but…did they know what they were dealing with?

Pamela: We really didn't know what Jupiter's Red Spot was until we sent the Pioneer and Voyager missions out; it was just this weird artifact on the surface. I think the place where he was able to start making wild guesses was he was also one of the first ones to look at Mars and see its polar caps. So there you see the ice forming and going away and forming and going away, and you could sort of start to guess what that is, but Jupiter's Spot -- how you get from being a European to understanding it's a giant hurricane back in the days without satellites, I mean, could they even imaging what a hurricane looked like from above?

Fraser: Yeah, I don't know…you're right, but it's also a testimony to how long that storm has been raging on the surface of Jupiter, I mean, the fact that they made those observations in what the late 1600s, and here we are four centuries later and, you know, it's still going.

Pamela: Still going…so he just watched everything change in terms of our conceptual understanding, and he also is responsible for making France smaller than any war ever made it larger, and it was simply through science that he shrunk France.

Fraser: Uh, you're going to have to explain that one.

Pamela: So he was a mapper. He was one of the first ones to understand how to accurately measure longitude and so in mapping France, in determining accurately where its borders were, he inadvertently shrunk the country. Prior maps had France much bigger than his map that was determined using triangulation.

Fraser: That's the kind of geography mistake that gets your head chopped off.

Pamela: He actually apparently was able to make the king laugh, and the king joked that he had shrunk the country more than any prior war.

Fraser: And then killed him?

Pamela: No, no, he was able to live to a ripe old age, but none-the-less what was interesting is that it was his sons who carried on the mapping as well, and went on to map other countries, and his grandsons and great-grandsons… So he created not just an astronomical dynasty (and I mean that in the literal and not the figurative sense), but he also created a map-making, geographer dynasty as well.

Fraser: That's really cool. Alright, well that's great, Pamela. Thanks a lot! I really appreciate it and we're going to continue on with next week's episode where we actually talk about the cool mission.

Pamela: That sounds great and we might sneak in a little bit of Huygens as well.

Fraser: Oh, that'd be cool!

Pamela: Make this is three-parter?

Fraser: A three-parter, yeah, that's a good idea…or a four-parter.

Pamela: Four?

Fraser: Cause there's so much that Huygens did with Titan, right?

Pamela: So, Cassini/Cassini/Huygens/Huygens…we may have a plan.

Fraser: That sounds good. Alright, we'll talk to you next week, Pamela.

Pamela: OK, sounds great, Fraser!