Astronomy Cast Episode 175
Mysteries of the Solar System, Part 2

Fraser: Astronomy Cast Episode 175 for Monday February 1, 2010, Mysteries of the Solar System, Part 2. 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's it going?
Pamela: It's going well. How's it going with you, Fraser?
Fraser: Good... ready for more mysteries. So apparently, this is at least a two-part series. We have no idea how many there's going to be. But this week, we continue examining some of the baffling mysteries of the solar system... where we fill your head with more questions than answers. Sometimes we've just got to share the enjoyment of not knowing the answers. Alright Pamela, so we... when last we saw our heroes they'd covered Pioneer, Uranus, Europa's seas, methane on Mars, strange atmosphere on Titan... so, mystery number six: How does the sun's corona work? Why is it so hot? So what's a corona?
Pamela: It's the highest level where you start seeing the beautiful loops, the beautiful flares, all of the amazing activity that missions like STERO and... well, our new little SDO is going to be imaging these as well.
Fraser: Right, so these are all these crazy plumes and prominences coming out of the sun... that's the corona. And it's hot.
Pamela: It's too hot. It's pretty much the same temperature--like 15 million degrees-ish--as, well, the core of the sun.
Fraser: Right, so the corona--the outside of the sun--is the same temperature as the core of the sun... which is hotter than the surface of the sun, which is only like 5800 Kelvin.
Pamela: Yeah.
Fraser: So, how is it possible that you can have... I understand that the core of the sun is 15 million degrees Kelvin, the surface is only 5800 degrees Kelvin, and it keeps getting cooler from there... but, no, the corona is back to 15 million degrees.
Pamela: Yeah.
Fraser: Now it's not like, you know... go out and roast in the 15 million degree temperature... I mean the pressure... there's so little material out there that it's not like fusion is taking place.
Pamela: So, here's what's happening. The material... it's really, really thin. But when you start looking at it with missions with ever-so-boring names like the NASA-funded X-ray Telescope... very blandly named instrument, or the Extreme Ultraviolet Imaging Spectrometer, also very blandly named instrument, both of these on the Henoday spacecraft, you start seeing that there's plasma that's 10 million degrees Kelvin, there's plasma in other places that's 5 million degrees Kelvin... we're looking at all the different loops and measuring the temperature... so the material tied up in the loops... and we can't really explain what's happening, and that's never a good thing. It was originally thought... and Ian O'Neill who writes for Universe Today is one of the people who worked on this model... that perhaps there's some sort of steady state heating where you have these giant

loops and they're able to conduct heat up, and it's this conducted heat that's steadily, steadily increasing the temperature, increasing the temperature, increasing the temperature. But the models that make those predictions predict that the loops are going to have a certain density, and they don't. And that's a bit problematic.
Fraser: So some process is boosting the temperature of this material back up again, and there's no real good answer yet.
Pamela: So, the other thing that we blame it on is nanoflares, but we're just starting to be able to observe nanoflares. So, we're not sure if that's right either. So this is one of those cases where we have more models than we have evidence. Hopefully soon we'll know.
Fraser: So you just mentioned that the SDO has just launched...
Pamela: Yes.
Fraser: Is that going to help?
Pamela: Well, the one thing that it will be able to do is constantly monitor the sun's activities at a cadence, a rate, that we've never seen before. It's going to be taking image after image after image after image, firing them back to the planet Earth... tidal wave of data coming back at us in a resolution that we haven't seen before. And hopefully, by getting flooded in data, somewhere in all this new information, the solution is going to be found.
Fraser: Question number seven: What is the cause of the Kuiper Belt cliff? So the Kuiper Belt is an area of icy objects surrounding the sun... starting from the orbit of Neptune and out... large objects in this group are Pluto and Eris... so, why does it start and why does it end?
Pamela: Well, the starting is a little bit easier. It couldn't really have formed anywhere earlier in the solar system.. it was either too warm, and you ended up with an asteroid belt instead... too cleared out by Jupiter, which is very good at herding things into little pockets of Trojan objects, Saturn's another object that's pretty good at clearing up the space around it. So, where the Kuiper Belt starts is pretty much where you'd expect a belt of icy bodies to maybe start being able to exist. But the problem is, is that it's thought that they should just keep going, and they don't. We know that we don't have them further in because of resonances, we know that there's empty holes where the objects would be in resonances with some of the other planets that are emptied out. Then, suddenly, about 50 astronomical units away from the sun, they just drop off in number. And they shouldn't... they should actually be increasing in number according to models. So, the idea of a planet being out there really isn't one that we're all embracing quickly, but it is one that's been mathematically worked out by a researcher named Patryk Lykawka and if he's right, then there could be another planet out there... something the size of Earth or Mars that's responsible for clearing out this area of the Kuiper Belt.
Fraser: Where's the planet?
Pamela: We don't know...
Fraser: We would see it, right? If we've discovered Eris... it would be further out than Eris, right?
Pamela: It would be further out... so we're looking for something that would be further out. We don't know how dark it is, if you have something that big it's probably... well, we don't know... we can't say anything about it, but it could be covered in substances that make it non-highly-reflective. It could just be we haven't managed to stumble across it yet.

Fraser: But it would be... it would be pretty big.
Pamela: It would be the size of roughly Earth or Mars. But if you have something out there that's slow-moving, and this would be slow-moving, that's extremely faint because it's not very reflective, it could've gone missed at this stage. So this is where the Large Synoptic Survey Telescope potentially will be able to start finding some of these really faint, really slow-moving objects that are out on the edge of the solar system while it's turning up everything else.
Fraser: So, is it possible that the Kuiper Cliff is actually more of a divot, that we see the end of the cliff and there could be some great big planet orbiting in that spot, and then on the other side of that planet's gravitational influence, there's more icy objects.
Pamela: It's entirely possible.
Fraser: And then we just can't see them, we're already working at the very limits of Hubble to even see some of these Kuiper Belt objects at all.
Pamela: Right. Right. And so the confusing thing that we're in right now is, yeah... there could be a divot out there, and in fact, all of our theories suggested that the number of objects should increase by as much as a factor of two beyond 50 AU instead of dropping to zero. So, it could be that there is an object out there that's dark and orbiting slowly that we just haven't seen, and that there's more objects hiding behind it.
Fraser: Hmmm... it's a mystery. Who knows the answer? We don't! Alright, number eight... Why do long-period comets come into the solar system?
Pamela: Yeah, we don't know that one either.
Fraser: No... we have the short-period comets that are really just Kuiper Belt objects that have been shoved into a more... a different orbit where they come in, but they don't go out too far. They come in to the sun and they don't go in too far. But there's this whole class of objects that come in almost like they're coming in on a straight line... the size of their orbit is so big, and they can take tens of thousands of years, millions of years to make a trip around the sun. What on Earth... or what on space... where are they coming from? Why are they coming towards us?
Pamela: Well, we're pretty sure we know where they are coming from. They seem to be originating from somewhere... probably between 20,000 and 100,000 astronomical units away from the sun. They're starting really, really, really far away. But, what we don't know is what sent them our direction. So, there's this cloud of material that we call the Oort Cloud that we believe... and there's some evidence based on looking at alterations to the cosmic microwave background that we can actually see what in some ways might be regarded as the shadow of the Oort Cloud... We're pretty sure the Oort Cloud's out there. We don't have direct evidence, but we're pretty sure it's out there. Something is causing objects to get knocked out of the Oort Cloud and sent our direction, and it could be that we periodically pass close enough to other stars that objects get knocked in. It could be objects interact with one other periodically and something gets sent in, it could be there's a giant planet on an elliptical orbit or a... maybe we have a brown dwarf or a red dwarf companion star that just hasn't been found. And any of these additional bodies could knock things up in the Oort Cloud and send a rain of icy material into the inner solar system.
Fraser: And one of the theories is that it's these rains... these periodic rains of comets that have caused some of the big devastation on Earth in the past, that seem to come

every 65 million years or so, right? With the last one occurring about 65 million years ago...
Pamela: Exactly. But, even ignoring these giant infalls of material, we still get 5 to 10 fairly significant cometary bodies coming in to the solar system each year. So, yeah, we get giant influxes on a regular basis, but we're also getting things on a steady lower level all the time.
Fraser: So the question is, what is the thing that kicks them out of their nice stable Oort Cloud. Why did they choose now... out of the 4.5... 4.6 billion years they've been orbiting the sun, why did they pick now or 10,000 years ago to fall into the inner solar system?
Pamela: And all different possibilities we have are ones that... if you generally see an article that says "Giant planet suspected to be orbiting edge of solar system," you'd call the person a crazy... "Sun thought to have binary companion," you'd think the person a crazy. But, the only way we can start to explain this is to invoke these theories, and it starts to get kind of uncomfortable. It's almost like an angry gremlin kicking them into the inner solar system is just as valid a theory, but you can't mathematically justify that. So, it looks at one level really like there could be something out there.
Fraser: But... it has nothing to do with this Nibiru nonsense... Planet X...
Pamela: No. Nothing. Nothing at all to do with any of that.
Fraser: So, mystery number nine: Why does Enceladus have geysers? And this is amazing. This is one of the big discoveries of the last 5 years... which is that Cassini has discovered these geysers of water-ice blasting out of the southern pole of Saturn's moon Enceladus. So if there's a geyser of water-ice, then does that mean that there is a hot bubbling water pool that's spewing out water that's turning into ice as it reaches space? So, what's going on here?
Pamela: Well, what we know for certain... because we can image it... is that Enceladus has geysers, that they're shooting sprays of water out of the surface with escape velocity. This is actually helping to feed into some of Saturn's rings and to keep replenishing them with new material. And then trying to understand it, there are competing theories. There are groups saying that there are underground oceans that perhaps the pressure from the oceans... the water's mist is coming up through the surface and sending out this high-powered mist in some ways.
Fraser: Right, but it's the same situation... it's a tidal flexing going on... an interaction between Saturn and Enceladus that is causing it to remain liquid inside and heating up the liquid, and then that liquid is being spewed out of these geysers. Sorry to derail you, but I think it's kind of funny that one mystery about Saturn has been solved by this, and yet it creates a brand new mystery.
Pamela: I know, I love it!
Fraser: What is one of the possible sources replenishing Saturn's rings? Oh, well it's the geysers on Enceladus... the wha?! The geysers on Enceladus? Yeah, I know... that's what it is. Sorry, so what's the other... you said maybe it's bubbling water?
Pamela: Maybe it's underground oceans... there's other groups that are claiming--well maybe there's caverns where this is taking place... all sorts of crazy geometries of the underground geophysics are being invoked... and they're not really crazy. They're all geophysics that exist here on earth.

Fraser: And I've seen some dry... some not-water... not-liquid solutions for it as well. Which are just ice being rubbed together... sublimated... and it's just coming out as geysers. So it's not actually liquid, it's just ice, because Enceladus is almost entirely ice.
Pamela: Right, so you basically have cryovolcanism. But the real question starts to be that Enceladus, as far as we know, isn't all that different from the other icy moons. Why don't all of them have geysers? So this is really a two-sided problem. Not only why does it have geysers, but why don't the others as well? And we don't know.
Fraser: But they might... I know they've found like hints of some similar process going on with Rhea and Dione as well. So, they haven't ruled it out yet. They've found particles. I forget what it is... like hydrogen atoms surrounding those moons, but not in the same way that you see it around Enceladus.
Pamela: So, we need to just keep looking, and keep trying to understand it. And maybe send another robot.
Fraser: But as I said, that is a classic example of like... one problem solved... ten! ten mysteries open up...
Pamela: And throw out one problem and get back ten theories.
Fraser: Yeah, exactly. Ok, mystery number ten: the hexagon on Saturn... hexagon on Saturn? What's that?
Pamela: Right, oh... if you haven't seen a video... any of you out there listening to my voice right now... if you haven't seen a video of Saturn's hexagon in motion...
Fraser: Google it!
Pamela: Yes, there's examples of it on Wikipedia... easy to find. It's this amazing structure that's a perfect hexagon. It's not something where you're eye is tricking you into thinking... well, maybe there's something vaguely stop-sign-shaped... but, no, it's a perfect hexagon.
Fraser: There's a bolt... there's a great big bolt on the bottom of Saturn that you could take a great big wrench and crank it. That's what it looks like.
Pamela: And the straight sides on this thing... they're basically 14,000 kilometers long.
Fraser: That's a big wrench.
Pamela: Yeah, you'd need a really big wrench... really big handle to turn it, as well. This entire thing is being turned by an invisible wrench at the same rate that the planet seems to be rotating... a little over ten hours. So, lots of people have been trying to figure out exactly what this is. It has basically a clearly-defined hurricane-like eye wall that's a hexagon rather than the perfect circle that you get with a hurricane.
Fraser: It should be a circle... by every piece of physics that we know, and atmospherics, that should be a circle.
Pamela: Yeah. But it's not. And so when you see things that you don't understand that are waves that are not changing, you call them standing waves. So, it's been possible in the laboratory to spin buckets of just the right fluids in just the right ways to get polygons. There's all sorts of really cool experiments where they spin things under different conditions and sometimes they actually take giant globe... put giant globe over it and fill the space between the two giant globes with different fluids that mix in different ways, and they try and create planetary atmospheres this way, or at least the motions of planetary atmospheres. And we can get polygons, by spinning things in just the right way... but not hexagons... and we haven't seen exactly this shape. There are some people

that think this might actually be tied in somehow with Saturn's aurora. So, time will tell... more observations are needed.
Fraser: Does it have one on the other hemisphere?
Pamela: No... at least not that we've imaged yet. So far in all the images--and this has been seen by both Cassini and by the earlier Voyager mission--there's a northern pole hexagon.
Fraser: Do we see this on any of the other gas giant planets?
Pamela: There's something similar on Venus, but it's not identical. It's another giant hole through the atmosphere generated by the spinning winds.
Fraser: Right. But we don't see an even bigger one on Jupiter...
Pamela: No.
Fraser: Jupiter provides the circle that we crave.
Pamela: Or at least behaves more rationally.
Fraser: Yeah, exactly. So, who knows why it's there? We don't know. It's a mystery. Sorry... Well, I think we got through another set of five and who knows... to leave you with one more mystery... next week, will we continue on with mysteries 11-15? Or start our first set of mysteries about the Milky Way? Who knows?
Pamela: This is our mystery to you...
Fraser: Or to us... 'cause we haven't figured it out yet...
Pamela: And one final announcement, though. We forgot to tell you at the beginning of the show... we have new toys for you in the Apple store.
Fraser: Oh, right! Yes... yes....
Pamela: Wizard Libsyn Systems... our hosting provider... put together for us an iPhone app. So, if you're an iPhone owner, you can go out and buy an app that will bring to your phone the latest shows, and we're going to be getting all of our transcripts into it. It's $1.99 and we do get proceeds from this, so there's yet another cool way for you to get and consume all of the Astronomy Cast content.
Fraser: Right. So this is like a separate app, apart from what you would download in iTunes. So, check it out, and if you want... yeah.... $1.99. Well, thanks a lot Pamela, and we'll talk to you next week.
Pamela: Sounds great Fraser... talk to you later.