Astronomy Cast Episode 64:
Pluto and the Icy Outer Solar System

Fraser Cain: It's been a long journey – 64 episodes – and now we're back where we started: Pluto. Last time, we talked about how Pluto lots it's planethood status, so we won't go over that again. Just listen to episode 1 and you'll understand how it all went down.

This time we're going to talk about Pluto, it's neighbourhood, its moons, the Kuiper Belt, and the other icy objects that inhabit the outer solar system.

First Pamela, let's get the pronunciation down. K-oy-per? K-eye-per?

Dr. Pamela Gay: I've heard it pronounced both ways by people who've discovered K-oy-per or K-eye-per Belt objects, and I figure the people who find them are allowed to pronounce them however they want.

Fraser: Okay, so let's talk about the Kuiper Belt in general. Pluto's just one object of that, so let's talk about the overall environment.

Pamela: It's basically a land of icy chunks. This is the part of the solar system where a lot of the short period comets are thought to come from.

Fraser: Hold on – what's a short period comet, then?

Pamela: Something with a period that's under about 200 years.

Fraser: So would that include Halley's Comet?

Pamela: For reasons I'm not sure of, I've seen websites that say Halley's Comet probably came from the Oort Cloud (which we'll talk about at the end of this episode). So this includes other short period comets like Comet Enke for example.

Fraser: Right, so comets that show up every 200ish years are thought to come from the Kuiper Belt.

Pamela: The objects that live out there are all different sizes. They range from your random snowball to things the size of a Volkswagen, to things a couple thousand kilometres in radius. There's nothing really big out there.

Neptune sort of rides herd over the entire group. The main part of the Kuiper Belt extends from roughly 2:3 resonance with Neptune (that's what Pluto's in) out to a 1:2 resonance with Neptune – these are objects that go around the Sun once for every time Neptune goes around the Sun.

Fraser: So you won't find any objects closer in than Neptune? They start at Neptune and then go out from there.

Pamela: There are rogue ones that come further in, just like there are asteroids that come further in than the asteroid belt, but the main Kuiper Belt itself is considered to come from the 2:3 resonance out to the 1:2 resonance. In terms of AUs, that's from somewhere around 30AU's out to about 55AU's.

Fraser: Right – AUs being Astronomical Units, the distance from the Earth to the Sun.

Pamela: Exactly.

Fraser: So 30 times the distance from the Earth to the Sun. Okay. And as you said – it's from snowballs to… small planets.

If you could get up close and look at one, what would you be seeing?

Pamela: Basically the same thing as the core of a comet. If you take a look at one of the really cool space probe or Hubble pictures of the cores of comets, that's the exact same stuff these Kuiper (or K-oy-per) Belt objects are made out of.

I once heard Mario Livio say something that really struck me as kinda clever. He said if you took Pluto and brought it in on a comet's orbit, it would behave just like a comet and grow a tail – which is no way for a planet to behave. These are really objects that are just waiting to get sent into the inner solar system and act like comets.

Fraser: Right, so with the Stardust mission, they got pretty close to a comet. If you were to get really close to one of the Kuiper belt objects, you'd see essentially the same thing, but it wouldn't have the tail.

Pamela: Exactly. These are pockmarked, icy chunks. Take the stuff on the side of the road after a really bad snowstorm in a city, where you end up with dirty snow, and that's what these things are. They're made up of water ice, of ammonia, of dry ice. They have a little bit of rock and gravel and dust chunked in with them. They're made of what we call volatiles or ices. There's also methane mixed in with them. They're really dirty snowballs – they just happen to be really large dirty snowballs.

Fraser: So where do astronomers think they came from?

Pamela: They formed on the outer part of the solar system. Our solar system, during its formation, had different regions with different temperatures. In, close to the Sun, everything was getting blasted with heat. Water and other volatiles couldn't exist; it was too hot and they got blown off of the planets when they were forming. Our own planet Earth didn't have water initially, we had to wait until we got bombarded by comets to get our water back.

Partway through the asteroid belt, we get to the snow zone where you started to be able to have water. Beyond the gassy planets is where pretty much all you could have is frozen volatiles.

So it's just leftover stuff from the formation of the solar system that was allowed to be in this place where it's gravitationally safe. Things that end up in the wrong places, Neptune/Jupiter/Saturn tend to gravitationally fling them into the inner part of the solar system where they become comets, or just fling them out of the solar system entirely.

So this one band is a safe place for icy things to exist without getting thrown around the solar system by the other planets.

Fraser: So all of the water, then, that we have here on Earth, was probably transported form the Kuiper belt inward through comets? None actually formed with the Earth to begin with?

Pamela: Our planet could've formed with water, but then the Sun blasted it all off. We had no water for a period of time, and then everything we have – all the water, all the rain, all the snow, all the oceans, came from objects that probably originated in the Kuiper belt – or perhaps even in the Oort Cloud, but we don't have a lot of observational evidence for the Oort Cloud, so it's kind of hard to make predictions.

Fraser: Well thank you to the Kuiper Belt, then!

Pamela: It's what allows life to exist here on our planet.

Fraser: Okay, so then let's talk about one of the most prominent objects, which is Pluto. How did we find out about Pluto?

Pamela: Math isn't always the strong point of people who think they know what they're doing. After Neptune was discovered by looking at irregularities in the orbit of Uranus, people looked at the orbit of Neptune and said, "wait, it has irregularities too!" and started predicting there had to be another planet out beyond Neptune just waiting to be discovered.

Fraser: People still do that!

Pamela: People still do that, yeah.

Fraser: People have been predicting that for a hundred years now – that there are more and more planets, planet X…

Pamela: And they also predict that we're perhaps in a binary solar system – but we'll get there.

Perceval Lowell was the one who was really spearheading these predictions. He set Clyde Tombaugh with the challenge of finding this missing planet X. Poor Clyde Tombaugh out at Lowell observatory in Flagstaff, Arizona (which is an absolutely beautiful facility), was tasked with the job of basically looking all around the ecliptic, trying to find this missing planet.

He'd take glass plate after glass plate and then blink them. He'd take one image one night and then a few nights later he'd take a second image and then he'd blink them and look for objects that had moved from one image to the next. One night he finally got lucky. He finally found this missing object… and it was way smaller than anyone predicted. It didn't reflect nearly as much light as anyone predicted, but they were looking for a planet so it was going to be a planet.

They argued over the names for a while, and eventually a little girl in England suggested the name Pluto. Since the first two letters, P-L matched the initials of Perceval Lowell (P-L), they named it Pluto. We ended up with this planet that really was way too small – but we're going to go with it.

People kept looking and we started finding things that made us question whether it was really appropriate to call Pluto a planet. Triton, one of the moons of Neptune, is bigger than Pluto and it's compositionally identical. It's clearly a captured object, not an object that formed with Neptune – it goes the wrong direction around Neptune, we talked about that last week.

So first we have that hint that there's this moon that used to be a free-roaming object, and it's bigger than Pluto. Then we started, in 1992, finding other objects that are out in the area around Neptune and a little bit further out. The first of these, QB1, was found out in the classical Kuiper belt, out 42-48AU's. (A lot of people who like to use cutesy names call objects out in the classical Kuiper Belt QB1s and they even spell it out and it looks like some Star Wars alien creature when they spell it out.)

Once we start finding other objects out there, people started wondering if we'd eventually find something bigger than Pluto. It was pretty much understood this was likely to happen, it was just a matter of time, a matter of looking. Low and behold, we started finding objects bigger than Pluto.

We found Eris, that has both a bigger mass and a bigger radius. We're still looking, and it's quite possible that we're going to find other things that are bigger and just waiting to be found.

Fraser: I don't want to leave Pluto right yet – we'll talk about Eris in a second. With Pluto, is it somewhat different than a Kuiper belt object? Because of its size, do more interesting things happen? It has an atmosphere, right?

Pamela: It has an atmosphere. What we don't know is if other Kuiper belt objects have these same characteristics as well. We've been watching Pluto a little bit longer, so we know more about it. In fact, we've been watching it a lot longer.

Pluto, when it's closer to the Sun, has an atmosphere. When it's further from the Sun, the atmosphere actually freezes out and snows down to its surface, which is kind of cool to think about.

Fraser: How would they find an atmosphere like that? I know in almost every telescope it's just a dot.

Pamela: You look to see what happens when a star passes behind Pluto, and how the starlight changes as the star passes behind Pluto you can start to see hints of atmosphere. This is how we find atmospheres on most of the planets – we look to see what happens when a star passes behind. We look to see how its starlight changes as it first passes behind the atmosphere and then flicks out completely as it goes behind the planet and then comes back out through the atmosphere in a different place.

Fraser: I see, so moments before the star actually goes behind the planet, it's passing through the atmosphere and they can just measure the changes in the starlight and determine what they're looking through.

Pamela: It's a really neat way to do it. You can actually even measure the composition of the planet's atmosphere just by looking to see what spectral lines appear and disappear as the star passes behind and then back out from behind the atmosphere.

Fraser: All right, and then Pluto has a moon – or moons.

Pamela: It has a large moon, Charon, which is very close to it in size. It's about ten times smaller. Pluto has a diameter of about 2300km, and Charon has a diameter of about 1200km. they're best described, perhaps, as a binary system. They actually orbit a point outside of Pluto's surface. So they're going around a point between the two of them, instead of Charon going around Pluto.

Fraser: Right. I remember from my science classes that when you have two objects orbiting one another, they're actually orbiting a common point of gravity. It's not actually one sitting still in the universe with the other going around it, and that's how astronomers can find the pull of extrasolar planets, because it's actually yanking the star back and forth. In the case of the Earth, the point of gravity the moon and Earth are orbiting is actually inside the Earth, so it really is the moon going around the Earth. But in Pluto and Charon's case, they orbit a point out in space, together.

Does Charon fit the qualifications as a dwarf planet too?

Pamela: Currently we don't see Charon as being a dwarf planet, although when the IAU was trying to resolve the whole planet/not a planet/dwarf planet paradigm shift, they had for a while a list that would've included Charon as a dwarf planet. Today the only dwarf planets we have are Pluto, the asteroid Ceres, and the other Kuiper Belt Object, Eris.

Fraser: Okay, so now Pluto has other moons too, right?

Pamela: It also has Hydra and Nix, these two little spuds that also orbit it. But it's not unusual for non-planet objects to have moons. There are asteroids that have been observed to have moons. It's something we find all the time.

Fraser: I think as we mentioned last episode, it's that having these objects be binary objects, or having moons, allows those 3-body captures, right? That's one of the ways that a planet like Neptune or Uranus can capture one of these objects and fling away its binary partner and it has a new moon.

Pamela: Things just tend to form in pairs. It's something we find all over the universe. We find galaxies in pairs and groups. We find stars more often in binaries than not. It just seems to be one of the natural ways in which things are able to form dynamically. So finding these two little extra moons going around this binary system of icy chunks is just part of what we expect to find nowadays.

Fraser: Are there any other interesting Kuiper Belt Objects?

Pamela: There's a whole slew of them. It's been a really wild ride watching these things get discovered over the past several years. Like I said – we found the first one back in 1992. Then in 2003, we found this new large object that for a brief time they thought maybe, maybe was almost as big as Pluto. It's not quite.

This object was Sedna, originally 2003VB12. It's one of the objects we think might actually be an Oort Cloud object. It's at a distance of 90AU's, one of the most distant objects we know of. It's 1800km across, whereas Pluto is 2200/2300km across. So, it's another large, frozen object, and it's on this really odd, highly inclined orbit. It's not really following along with the rest of the planets and asteroids. It's extremely inclined.

If you look at the orbits of the majority of the asteroids, the orbits of the planets… it's pretty much all like a bunch of hula-hoops fitting inside of one another set on the floor. Some of them are a little bit tilted, but more or less they're lying pretty flat.

Sedna's at this huge incline. Pluto's a little bit inclined, but Sedna has this huge incline. Dynamically it's something completely different. They only way to explain it that we really believe is to think of it as perhaps being one of the first Oort Cloud objects.

Fraser: So it just takes this long journey – it has what, a 10 thousand year orbit?

Pamela: It's something ridiculous like that.

Fraser: It just happens to be on the closer side of its long orbit. It's just a fluke – a one in 10 thousand year chance for us to be able to see it.

There's one other object that I think is really interesting before we get to Eris, and that is called 2003EL61.

Pamela: Oh yeah, that one's called Santa. It's really cool because not only is it really bizarrely shaped, but we've also found moons going in orbit around it. One of them has been called Rudolph, actually, which is kind of cutesy.

These are scattered Kuiper Belt objects. They're objects that Neptune's gravitational pull has flung into a bizarre orbit, again more inclined than we'd expect, at an average distance of about 43AU, but more inclined. Again, it was really lucky we were able to find these things.

Originally when Michael Brown and others were looking for these, they were looking right around the ecliptic. They looked out, straight along where all the other planets are in the sky, right along the zodiac. Now they're learning they can look pretty much anywhere in the sky and have a chance to find one of these Kuiper Belt objects.

Fraser: I remember with the discovery of this object, there was a bit of a political problem. The discovering team from Caltech had found the object and were keeping it under wraps, but some information leaked out on the internet and a competing team made an announcement at close to the same time. So it's quite an interesting story.

Pamela: David Tytel at Sky & Tel wrote a really neat article on this that I believe can be found online. It was one of these things where our own, as scientists, temptation to be open and honest about everything we do perhaps got the better of these scientists.

It's somewhat normal for many observatories to put out a list of what's being observed when. Sometimes things can be downloaded online. It's possible to go through these and get a sense of where in the sky something interesting might be going on.

Then also there's things like abstracts from conferences. We have to put in our abstracts sometimes six months ahead of when the actual paper is being released. Information gets embargoed, but it still gets seen by some people. In this case they'd been following an object for a long time and other people realised, "wait, there's something cool here" and did their own follow-up with a different telescope and perhaps scooped the story.

Fraser: Right. Oops.

Pamela: Yeah. It happens. Even among scientists there's a lot of competition in who got what first, and while there's not a patent at stake for finding an object, there are things like naming rights and pride and press releases.

Fraser: I've seen some really interesting things on the internet. There's one – it's a Twitter feed that updates whenever the, I think it's the Jodrell Bank telescope changes targets.

Pamela: Yeah, Jodrell Bank.

Fraser: Yeah, so every time they switch to a new observing direction the Twitter update goes off and you can see what they switched to. I'm sure there's a lot of people that watch Hubble and so on. Especially if you're "in the biz" of astronomy reporting, we have all kinds of ways of finding out what people are working on, much ahead of when press releases are going to come out.

I don't think the astronomers ever predicted or thought this kind of scrutiny would happen with them. What Britney Spears is up to sure, but what astronomers are working on? Come on! And it's all just getting faster and faster – I can go on for hours about how the whole embargo system is broken.

Let's move on to Eris, which is larger than Pluto.

Pamela: It's larger than Pluto, it's in not that different an orbit than Pluto, it's right there sitting in the Kuiper Belt. Again, Eris is a scattered-disk object. It's not in the main belt, but it is part of the Kuiper Belt.

The thing about Eris that's kind of neat is it's highly reflective, which is part of why we were able to find it. You have this highly reflective, distant object, hanging out scattered in the Kuiper Belt just waiting to be found. It was just a matter of Michael Brown looking long enough.

This object had neat history. It was originally nicknamed Xena. It has a little moon that was originally nicknamed Gabrielle, it ended up officially as Eris and Dysnomia. It was originally spotted using the Mount Palomar-based team led by Michael Brown. They followed it and they knew they were on to something particularly interesting and held on to their results until they could be completely certain that yes, this was an object bigger than Pluto.

When you find something controversial, you triple, quadruple check all of your results. This is an object that gets out pretty far. It goes all the way out to 90AU, and comes as close in as 38AU.

It has a really neat orbit, and we were lucky enough to find it when it was on one of its closer passes. It's going to slowly walk its way out to the outer edges. With an orbital period of 557 years, if it was currently out at that 90AU it can get out to, we wouldn't have been able to see it.

The interesting question this raises though is what is there currently out there at 90AU, at 100AU that's on its way back in? That, like Eris, is also bigger than Pluto, also waiting to be discovered.

Fraser: It's almost inevitable that astronomers are going to turn up objects that are even larger. I guess that's why they jumped on making the decision about what's a planet and what's not – just sort of end the controversy for now and forever.

Pamela: It's just like Ceres was originally thought to be a planet. Ceres is the largest of the asteroids – then when we started finding other asteroids we realised we needed to classify it differently.

Fraser: Let's talk about the last part of the outer solar system, which is the Oort Cloud.

Pamela: The Oort Cloud, at this point, is still just theoretical. It's thought that perhaps out, at the very edge of where the Sun formed, there may have been a cloud of icy chunks. We think that Sedna and another object called 2000CR105 might be Oort Cloud objects, but we're not sure.

This cloud of objects should have a spherical distribution around the solar system, it should consist of objects with a whole range of different sizes, and because it's so far away, it's hard to figure out how to find it.

There's a lot of people doing a lot of neat thinking about it. One of the perhaps most interesting ways I've seen to potentially try and find it is to look at the cosmic microwave background and look for very small asymmetries in it that could be caused by the Oort Cloud not having a uniform distribution in all directions. Because of that, you'd end up seeing the cosmic microwave background being a little bit brighter in some places and a little bit darker in others. Just like if you were looking through a window screen that had a different density at different parts of the window screen.

Fraser: But the evidence we have are these comets that come in and might take a hundred thousand years, right? To go around the Sun.

Pamela: They have to come from somewhere.

Fraser: They have to come from somewhere, yeah.

Pamela: We think this Oort Cloud is maybe as far away as 50 thousand AUs from the Sun, and at this distance maybe occasionally the solar system gets knocked by other stars in the galaxy.

There's even the idea that we have a very loosely bound, very, very faint companion star that hasn't been discovered yet, that every 26 million years or so, knocks the Oort Cloud and sends a new rain of comets into the inner part of the solar system. But we haven't found it.

Fraser: That hasn't been found.

Pamela: Right.

Fraser: All right. I think we've got one last part of our tour of the solar system, and that will be next week, where we'll talk about essentially the end of the solar system – where we interact with the rest of the galaxy.

Pamela: That's the heliopause.

Fraser: So that'll be next week.

This transcript is not an exact match to the audio file. It has been edited for clarity.