Astronomy Cast Episode 1:
Pluto's Planetary Identity Crisis

Fraser Cain: If we talked to any astronomer, anyone in the space industry this last couple of months and said, "what's the hot story?" They'll all tell us it's Pluto. Pluto, Pluto, Pluto. In fact, every question I got is about Pluto, is Pluto a planet, is it not a planet, what does that mean? What is a planet?

We got a lot of that, so we thought we would cover that story a little bit, but also try and explain a little more deeply what the controversy is.

So, let's talk about planets. What's the story so far with Pluto?

Dr. Pamela Gay: So Pluto was discovered a while back by a guy by the name of Claude Tombaugh working out at Lowell Observatory. Little tiny spud, hanging out on the edge of the universe, and for a while it was the biggest thing out there.

Then came the announcement of this critter called 2003 UB313 which is bigger than Pluto. Everyone in the media went, "oo, do we have a 10th planet?" The astronomers went, "oh no." If there's one bigger, there's probably a lot that are bigger. People had been wondering for a while is Pluto a Kuiper Belt Object, is it a planet, is it both? Do we need to rethink how we name things?

So, we had to come up with a definition for a planet. Defining things is really hard, and there's a lot of history involved in this.

So, what is a Kuiper Belt Object is probably a good place to start. Out on the edge of our solar system that we can see with our regular telescopes, we can look out there and there's this big planet, Neptune, hanging out in a slightly elliptical orbit. All around it are these proto-comet objects, Kuiper Belt objects, that occasionally get knocked into the inner solar system and become our short-period comets.

Hanging out in the midst of all of these proto-short period comet objects are bigger objects like Pluto and its moon or some people said its binary object, Charon. Their orbit is no different than all these other proto-comet objects. It cuts across Neptune, it's highly elliptical, it goes on this weird diagonal through the plane of the solar system. It's not like any of the other planets. Seeing just how odd it is, you have to question. It's just like Sesame Street; which of these objects belong? Is Pluto a planet or not?

Fraser: If I recall, the controversy's been happening for quite a few years now, it's not like with the discovery of UB313 that people said, "now it really calls it into question." I know even in the last four or five years people have been wondering whether Pluto should be removed.

Pamela: Ever since we started finding these Kuiper Belt Objects, this question has been around. The smaller Kuiper Belt Objects started to show up in the early 90s. They all had these similar orbits. Kuiper Belt Objects were originally suggested back in (I believe) the 60s.

Short-period comets had to come from somewhere. Where they came from appeared to be coincident with Pluto. If Pluto shares its orbit with a whole bunch of other objects, how is it any different from the really big asteroid Ceres that shares its orbit with a whole bunch of asteroids?

The debate's been around for a long time. The International Astronomical Union, which is the naming organization, the definition-making organization of the entire astronomical community, put together a working group. That working group has been trying for a long time to figure out how to define a planet and it all came to a head this summer.

The debate's been around for a while: what do we do, do we call Ceres a planet? How do we lump everything together? It all starts to come down to what makes one object different from another object, and how do the orbits play into all of this, and where do we put the cutting off point for a planet?

Fraser: I guess the discovery of UB313, something larger than Pluto, that kind of brings the discussion to a head. How did it all go down this summer?

Pamela: There was a lot of debates. There was initially the suggestion that we call all these big objects planets, why don't we make UB313 a planet, why don't we make Pluto and its moon/co-object Charon a planet, why don't we make Ceres a planet.

Fraser: How could you make Pluto and Charon a planet? Isn't one a moon of the other?

Pamela: They both orbit a point that's between them. Pluto goes in a small circle around a point outside of its body, and Charon also goes around the same point, but at a larger distance. So it's more of a binary system. Just like we have binary stars, we also have Pluto and Charon which are binary to one another. They co-orbit a central point that is outside of Pluto.

Fraser: Oh okay, so the central point between, say, the Earth and the Moon, is actually inside the Earth?

Pamela: Inside the Earth. The Moon is clearly going around and around the Earth, whereas Charon and Pluto go around a point external to both of them. It's a binary system – so they can be binary planets. But are they planets?

There's this initial talk… do we make all these things planets? Do we suddenly make the solar system much bigger?

Fraser: And anything new that fits that criteria as well.

Pamela: And anything new that fits that criteria also becomes a planet.

Fraser: We could have a hundred planets, a thousand planets, just going on and on and on.

Pamela: Exactly.

Fraser: That went over well.

Pamela: Not really. It was sort of decided that doesn't work. Let's come up with something different.

Let's start thinking about what are the common traits of our definite planets, the things we know for certain we want to call a planet – like Earth, Mars, Jupiter, Saturn – these nice, fairly large objects. Things that basically… no question.

We started looking: what are the general traits of a planet? Well, they're spheres. This eliminates Ceres from being a planet: it's not round. Its self-gravity is such that it can be lumpy and bumpy and as the gravity of the entire asteroid pulls all the pieces together, it's not strong enough to smooth everything into a nice, round, sphere. Scientifically, what we say is its self-gravity can't overcome rigid body forces. Big mountains, big lumps, they stay there, such that it doesn't assume a nearly round shape because it's in hydrostatic equilibrium. So we tossed Ceres.

Fraser: Right, I've heard that Mount Everest here on Earth for example, is the maximum size you can have a mountain, and that any larger and its just getting smashed or squished at the bottom as fast as it's growing on top.

Pamela: Exactly, and this is because we have a large planet. It squishes large mountains and makes them just not get any bigger. IF you go to Mars, which is a smaller planet, you can get bigger mountains. Olympus Mons, on Mars, is much bigger than Mount Everest, because the self-gravity of Mars is lower than the self-gravity of Earth.

Ceres, the self-gravity isn't enough to make it a sphere. So, not a planet.

Fraser: Okay, I have a wrench for you: isn't Saturn a kind of squished ball?

Pamela: Well… there's a difference between a squished ball and a potato. All the planets are squished balls: you take something that's spherical, spin it, and it's going to flatten. If you spin it too fast, it becomes a pancake. None of our planets are spinning that fast, which is good because they'd probably fall apart. Saturn, Jupiter – even our Sun is a slightly squished ball because they're rotating and this causes the centre to bow out. It's the same principle that when you're on a merry-go-round that's going way too fast you want to fly off the edge. The equators of the planet want to fly out but gravity holds them in.

Fraser: Okay, so smooth – we've got a smooth ball.

Pamela: Smooth ball

Fraser: That's our first one.

Pamela: The next characteristic we look at is: is it orbiting something else?

We have these giant moons that are in fact much bigger than Pluto. Why don't we call the giant moons of Jupiter planets? Some of them have all the characteristics we're used to seeing in planets: volcanism, they in some cases appear to have liquid water, they have atmospheres, but they're satellites of another object.

So a planet cannot be the satellite of another object; it has to be orbiting the Sun as its primary thing that it's orbiting. Planets are things that orbit stars.

Fraser: So even though Titan is large and smooth, it's out

Pamela: It is totally out

Fraser: because it goes around Saturn.

Pamela: It is a moon.

Fraser: Or in this case, when we talked about "going around" it means that the centre point that the two are orbiting is inside Saturn, so it doesn't count.

Pamela: Exactly

Fraser: But it must be just a tiny bit away from the centre of Saturn.

Pamela: Yeah. Whenever you get more than one body they end up not orbiting the true centre of the object, but some point that is the gravitational centre of the two objects. This is how we're able to find extrasolar planets. Planets pull on stars, so stars are actually orbiting some point that's inside of them.

Fraser: Okay, so we've got smooth balls, we've got only orbiting the star, not some other object, and then what's the third?

Pamela: Next we look around and see what's hanging out around the object in question. Big planets – even some of the smaller ones like, say, Earth – we have our orbits pretty much to ourselves. As the earth swings around the Sun every year, we do cross things in our paths: comets that go through the orbit of the Earth tend to leave dirt behind, and when we collide with this we get meteor showers. More or less, the orbit of the Earth is a nice, big, empty area that occasionally gets crossed by the orbits of asteroids or comets, but nothing lives in our orbit. We have our orbit to ourselves. Other things pass through, but they don't stay there. If they do stay there, we eat them (hopefully without too much destruction to our planet). It's an empty orbit.

Fraser: Or veer them off into space, right? Clear them out?

Pamela: We're not quite sure how to do that yet, but it's a good goal.

Fraser: Yeah.

Pamela: So when you look around the orbit of an object, you look to see if the orbit is empty of other stuff. This implies that while the planet was forming, it ate up all the material in its orbital path, made it part of itself, or through interactions, flung it into other parts of the solar system. Thus the planet lives in an area of the solar system that has been cleared out. This is where Pluto gets itself into trouble.

Pluto is in a 3:2 orbital resonance with Neptune. This means that for every three times Neptune goes around the Sun, it goes around twice. There's a whole lot of things that do that. A whole class of objects that do that.

Fraser: But Pluto and Neptune aren't actually in the same orbit, right? Pluto has this elliptical orbit that's inclined off the plane and zooms in past Neptune and then back out again, right?

Pamela: Exactly, but Pluto crosses through that orbit, and it's not the only thing crossing through that orbit. There are a whole lot of different objects that are all crossing back and forth through Neptune's orbit. These are trans-Neptunian objects, and the ones that share Pluto's type of orbit are called Plutinos.

So, Pluto isn't orbiting by itself. It's sharing its orbit with a whole bunch of little objects – and in some cases bigger objects.

Fraser: So are these objects that are also locked into that same orbital resonance with Neptune?

Pamela: Yes, these are all objects that have a 3:2 resonance with Neptune. These are called Plutinos. So Pluto is not unique, it's in a class of orbits with a whole bunch of other objects, it's just the biggest one we've found so far. It's a fairly reflective object, so it reflects lots of light from the Sun back to where we can observe it here on Earth, we've detected it, but who's to say there isn't a really dirty Pluto out there that we just haven't detected yet? There's lots of smaller stuff that we've already found in that orbit.

So here's where the IAU kicks Pluto out of planet classification. The definition now says it has to have cleared its orbital neighbourhood of other stuff, and Pluto's orbit is jam-packed with other stuff.

Fraser: Obviously this didn't go well for a lot of Pluto fans, and I've heard a lot of people saying it's the third definition that's the kicker. There are a lot of planets that do have other objects in their same orbit. There's a series of asteroids that go before and after Jupiter, for example, in its orbit.

Pamela: Yeah, these are the Trojan asteroids. What happens is as things go flying through the Universe, and specifically flying through our solar system, they interact with other bodies. Over time, where they started isn't necessarily where they ended up. Jupiter has a lot of gravity. Other than the Sun, it's the largest thing in our solar system, and it tends to capture asteroids and comets in what are called Lagrange points. These are places where objects can get trapped so they're gravitationally balanced between Jupiter and the Sun and basically co-orbit with Jupiter, either leading it or trailing it.

These objects didn't necessarily form in those orbits. They probably got captured and got stuck there. We tend to stick satellites in the Lagrange points of the Earth. It's a nice, happy place to stick objects, and they're fairly stable, depending on which Lagrange points you stick them in.

So when you look at Jupiter, you're not looking at stuff that hasn't been cleared out of Jupiter's orbit, you're looking at stuff that has been trapped in Jupiter's orbit. There's a difference between not clearing your orbit and clearing your orbit and then deciding you're going to gravitationally grab some junk and trap it there. That's what we're looking at when we look at the Trojan asteroids.

Fraser: So with this definition of planethood, if we do find a large planet further out past UB313, that fulfills that requirement, then they would necessarily have to call it a planet again. So we might get nine planets again.

Pamela: It's possible to have nine planets, yeah.

Fraser: I'm wondering… is this just for the solar system, or does this definition work for extrasolar planetary systems as well?

Pamela: Well, it should work with extrasolar planetary systems. The catch is going to be being flexible. As we look at other stars, currently we can't see everything that is orbiting a particular star. We're able to pick up the giant planets, the things that are Jupiter-mass, fairly consistently.

There's over 2 hundred known extrasolar planets at this point, and we're slowly starting to find the small stuff. As we look at other stars, we're seeing disks around them when they're young and still forming, and in several cases we can actually see cleared out regions in these dust disks that we believe are places where a planet is forming and has already cleared out its orbital path. When we find that object in that cleared out area of the dust disk, that's a planet

When we start finding things using, perhaps gravitational microlensing, a technique where a star will pass in front of a background star and its gravity will cause light that would otherwise shoot off to some other part of the galaxy to get bent back toward us, thus increasing the amount of light in total that we're able to see here on Earth. When this happens and there's a planet involved, that planet's gravity also gets in on the bending light activity, and we're able to detect smaller planets this way through their gravitational interactions with objects further off in the galaxy.

Fraser: Yeah, with the traditional methods we can only find things a few hundred light years away. I know with this someone found a planet using gravitational microlensing ten thousand light years away.

Pamela: Yeah, it's one of these fascinating new techniques that gravity's a powerful thing and it's allowing us to make powerful measurements of little tiny planets (or at least, 14 Earth-mass planets) further out in the galaxy. The only problem is we can't confirm these discoveries. Gravitational lensing events… you see them, then they're over and you don't get a second shot. It will help us determine the frequency at which these planets are out there, but since we only get one shot, and we can't go back and look for additional objects in the same orbits… who's to say there aren't a bunch of 14 (I don't think this is rational, but) who's to say there aren't a bunch of 14 Earth-mass planets in the exact same orbit, in which case they're no longer planets – because they haven't cleared their orbit.

We have to be flexible. We have to be willing to say "we think it's a planet, but we haven't fully explored that extrasolar solar system to see what all is in it" The definition should stand, but we need to recognize that what may be a planet today, tomorrow we may realise is not really a planet.

Fraser: I don't know whether the Pluto fans are going to take this lying down. I know that already there are petitions in the works to try and get the IAU to overturn the decision soon, or at least by the time of its next meeting. I know there was a very low turnout at the meeting, and I think something like 5% of the people in the IAU voted for this book-changing definition.

Pamela: Yeah. Part of the problem was the final vote ended up happening on the last day. Anyone who's gone to a big conference knows the last day is often the day during which a lot of people have had to catch planes and they're just not there anymore.

There's also a vested interest in this for every elementary school teacher who doesn't have the budget to buy new textbooks. There's a vested interest in all the poster-makers who've already made 10 thousand posters showing Pluto as a planet.

Fraser: Walt Disney's going to be mad…

Pamela: That poor pseudo-dog!

Fraser: Yeah

Pamela: He's never been given any respect, and now he's not even named after a planet, he's named after a dwarf planet.

Fraser: Perfect. Great, well that was all we needed to know about Pluto and its un-planeting, re-planeting and then its un-planeting. If Pluto becomes a planet again, or if there's anything new in the dwarf planet news, we'll bring that back up.

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