Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *The outer limits.*

This podcast is about various objects which are out past Neptune's orbit – and which are sometimes called Trans-Neptunian Objects – but that definition becomes a bit uninformative when we are trying to describe the increasing diversity of stuff that we keep finding out there.

'Out there' means everything out to the edge of the hypothesised Oort cloud, which may be as much as one light year out from the Sun, but is really just one of those things in astronomy we have never observed and there's really only circumstantial evidence for its existence – but until more data comes in, everyone feels more comfortable if we give it a name and make computer models about it.

Anyway, the first collection of stuff past Neptune's orbit is the Kuiper belt – which starts from around 4.5 billion kilometres from the Sun out to around 8.25 billion kilometres. Kuiper Belt objects – of which over one thousand are known and up to seventy thousand are hypothesised – are thought to be largely composed of frozen volatiles, chiefly water, ammonia or methane – and include Pluto and Makemake.

Interestingly, the Kuiper Belt is considered to be dynamically stable - meaning there's hardly any interaction between objects that might perturb their otherwise steady orbits – and hence the Kuiper Belt is not thought to be a source of comets. The reason for this strange stability is all about Neptune.

Some Kuiper Belt objects are resonant – meaning they have orbital resonance with Neptune's orbit. For example, some objects do two solar obits for every three of Neptune's. The most famous example is Pluto – and hence objects of this resonance type are sometimes called Plutinos. Other objects that have a resonance of one solar orbit for every two of Neptune's are called two-tinos. Yet other objects which are not in orbital resonance with Neptune are called cubewanos – after the first known example, 1992 QB1.

It's out beyond the Kuiper belt that we find things becoming a bit more chaotic. This region is called the scattered disk – and in contrast to the Kuiper Belt – these objects can be perturbed by Neptune's passing orbit. Known objects in this region, including the largest known trans-Neptunian object Eris, often have very elliptic orbits – and orbits that are highly inclined to the relatively flat orbital plane of the major planets, which may be the result of gravitational scattering by Neptune or the other ice and gas giants.

It's thought that if a scattered disk object's orbit is sufficiently perturbed it may get flung outwards – potentially to join the Oort cloud – which is thought to be a diffuse collection of such lonely solar system outcasts. Alternatively, scattered disk objects may be dragged inwards – becoming Centaurs – so called because they are half comet, half asteroid. Well, not really – but to all intensive purposes they initially look like asteroids, but because they actually frozen volatiles from trans-Neptunian space, they are sometimes observed to develop a comet like tail if they get close enough to the Sun.

Centaurs orbit the Sun anywhere between Jupiter and Neptune, but in relatively unstable orbits and have only a transient existence of a few million years. Any gas giant mediated perturbation of their orbit will either see them flung back out to the Kuiper Belt, the scattered disk, or even the Oort cloud – or they may be flung inwards at which point they probably do become comets.

Such comets generally have highly elliptical orbits – so that one might become briefly visible from Earth and then disappear off into the distant outer regions to return again only periodically – a classic example being Halley's comet with its 76 year orbital period.

But Halley's comet may be the exception rather than the rule that guides the final outcome of all those Centaurs. In recent times and with improved technologies we have seen two objects crash into Jupiter in 1994 and 2009 and its certainly conceivable that other objects could get past Jupiter and crash into an inner planet like Earth, such as the hypothesised Tunguska object in 1908. The largest known Centaur is 10199 Chariklo at 260 km in diameter. The object that wiped the dinosaurs was about 10 km in diameter.

Moving on, way out past the Kuiper Belt and the scattered disk is the beginnings of the Oort cloud, at least the hypothesised Oort cloud. It's thought that the space-time curvature exerted by the Sun's mass finally peters out at almost 2 light years from the Sun – so the existence of a dispersed cloud of outcast objects hovering in a spherical shell between 1 and 1.6 light years away is at least plausible.

However, as long as we've been looking we haven't seen any object with an orbital apoapsis (being the most distant part of its solar orbit) approaching anything like one light year – but let's remember we've only been looking for 400 years through telescopes.

Some commentators discuss some known objects with widely outflung orbits as being members of the inner Oort cloud – which is also referred to as the Hill's cloud – and which is proposed to be extend out to around 5% of a light year from the Sun. Sedna is one such Hill's cloud candidate with an apoapsis of about 1.5% of a light year and an orbital period of over 12,000 years. The only reason we even know it exists is that is currently still near its periapsis – albeit even that's three times as distant as Neptune.

Since we know we would have no hope of seeing Sedna at apoapsis with our current technology, it's reasonable to assume it may be part of a population of outflung bodies from the Hill's cloud and beyond. An example of a body in the process of being outflung to those sort of distances is Comet Hyakutake, which moved through its periapsis around the Sun in 1996 – and although it probably started its life as a scattered disk object – due to perturbation of its orbit by the gas giants, it is now not expected to return to the inner solar system for 100,000 years as its new perturbed orbit extends out to almost 7% of a light year.

And look, as long as everyone's comfortable talking about the Oort cloud as though it's a given quantity, we might as well also mention Nemesis – the hypothesised dark companion of the Sun. Given that stars are more often binary than singular, it's conceivable that a difficult to detect red or brown dwarf star could be the Sun's binary companion. If it exists, Nemesis would be out beyond the edge of the Oort cloud, but less than 2 light years away so that it's still within a faint gravitational handshake of the Sun.

Being so far out, its orbital period would be extremely long perhaps in the order of millions of years. Some palaeontologists have proposed that mass extinctions events occur on Earth, on a periodic basis, in the order of every 26 million years plus or minus some very generous error bars – and some astronomers and physicists have proposed that this might be linked with the orbit of Nemesis periodically perturbing the Oort Cloud and sending a rain of comets down into the inner solar system.

The evidence for all this is highly circumstantial, but that's never stopped us theorising before – and if Nemesis really is there, its likely our increasing astronomical coverage of the sky, both from the ground and from our robot spacecraft, will pick it up sometime in the next fifty years or so. Visualising even darker objects in the Oort cloud could take a bit longer, but we'll see.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where time might be money, but space doesn't have to cost you. No ads, no profit, just good science. Bye.