Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this *The 'other' Lagrange points*

The topic for this episode was chosen by Martin Kammann and family – one member of whom also provided the intro bit.

So, first there's Lagrange point 1 or L1. It's a point about 1.5 million kilometers away on a direct line between the Earth and the Sun, representing the point where the Earth's and the Sun's gravitational fields kind of balance – so you can park a spacecraft there and it will experience a gravitational pull towards the Sun, but be balanced by an equal gravitational pull back the other way towards the Earth.

Although, you can't exactly park a spacecraft – because L1 isn't completely stable, for reasons we'll get to later. So really, spacecraft do a little orbit of L1. And when I say spacecraft, we are talking about the venerable 15 year old Solar and Heliospheric Observatory (SOHO) and two spacecraft monitoring the solar wind – the 13 year old Advanced Composite Explorer, better known as ACE – and the 16 year old WIND, which actually isn't an acronym, it's just WIND. All these old spacecraft have orbited L1 for years expending hardly any fuel. This is why mission planners love Lagrange points.

And there's Lagrange point 2 or L2. It's directly on the other side of Earth away from the Sun and is also about 1.5 million kilometres from Earth – and let's pause for a moment to think about the planets. Mercury has to move really fast in its orbit to stay so close to the Sun, while distant Neptune can orbit at a much slower speed. So, you'd think an object 1.5 million kilometers further out from Earth should naturally orbit the Sun at a slower speed than Earth – which is true, but if your spacecraft is right on L2 it's going to get a gravitational assist from the lined-up Earth and Sun. In fact, exactly enough 'assist' so that its speed will match Earth's.

This all means that if you park a spacecraft at L2 - or at least put it in orbit around L2, its velocity will match that of Earth's and it will stay on a station-keeping orbit 1.5 million kilometres from Earth, almost indefinitely. WMAP, the Wilkinson Microwave Anisotropy Probe, has been at L2 since 2001 and now shares it with the Herschel and Planck space observatories - and will be joined by the James Webb space telescope in 2018.

Next is Lagrange point 3 or L3. It's on the opposite side of the Sun from Earth - and again a bit further out than Earth's orbit, but the combined pull of the Sun and the Earth in line gives it a gravity assist to keep it moving at the same speed as Earth. This might sound like yet another opportunity to park a spacecraft, but being so far from Earth such a spacecraft would be easily perturbed from its position by another planet, particularly Venus which is orbiting the Sun faster than Earth and comes within about 45 million kilometers of Earth's L3 on each of its orbits.

And then, there's Lagrange point 4 and Lagrange point 5 or L4 and L5 - the really non-intuitive Lagrange points. If you draw a line between the Earth and the Sun - and think of the Earth and the Sun as two points of an equilateral triangle - the third point of that triangle, looking ahead along Earth's orbit is L4 - and if you draw another triangle behind Earth that third point is L5.

Essentially, L4 moves ahead of Earth at 60 degrees along its 360 degree orbit and L5 follows Earth – at 60 degrees behind it.

Now bear with me while we think about why planets clear their orbits - which according to the International Astronomical Union, is one of their defining characteristics. Even though the Sun is a lot bigger than the Earth - it is still influenced by the Earth's mass - so we tend to say the Sun and the Earth both orbit a common centre of mass - the barycentre - which is inside the body of the Sun, but not at the Sun’s centre. So as the Earth orbits the Sun - the Sun kind of wobbles a bit too.

This means that any smaller objects that are also moving around different parts of Earth's orbit are going to experience some loss of gravity when the Earth pulls the Sun off centre and away from those objects. That loss of solar gravity will mean those objects will drift outwards off Earth's orbit. And anything that has drifted out off Earth's orbit is going to slow down - because Mercury moves fast and Neptune moves slow – it’s Kepler's 3rd law.

Anyway, with that object having drifted off Earth’s orbit – and moving slower – the Earth is going to catch up with it eventually – either capturing and eating it or giving it an additional nudge of velocity that will fling it even further away.

On the other hand, because the Earth does very slightly pull the Sun towards itself anything in Earth's orbit that is less than 60 degrees from Earth will be dragged into that bulge of Sun.

So to summarise all that, if you are somewhere around Earth's orbital path – if you’re more than 60 degrees away from the Earth, you'll either get eaten by the Earth or flung out – and if you are less than 60 degrees from Earth, you'll definitely get eaten by the Sun. But if you’ re right smack on the 60 degrees point, on either side, the Sun and the Earth's competing pulls balance out and objects can just sit there, either leading or following behind the Earth as it orbits the Sun

Now as we've mentioned already, L1, L2 and L3 aren't stable. L3 because of Venus and L1 and L2 because they both involve trying to balance on a knife's edge - one slip and you either fall towards the Earth or you fall towards the Sun.

L4 and L5 are different though – they’re stable. So rather than balancing on a knife’s edge – it’s more like you are sitting in a bowl. If you try and shift towards the Sun, the Earth pulls you back - if you try and shift towards the Earth, the Sun pulls you back - if you try and shift outwards from your current orbit - they both pull you back.

Nonetheless, the effect is not very strong and potentially other planets can still perturb things out of L4 and L5. Around Earth we know there are noticeably higher concentrations of interstellar dust at its L4 and L5 points - so that's something. A big planet like Jupiter though, can hang onto asteroids at its L4 and L5 (which are called the Trojan asteroids). So can Neptune, which isn't as big as Jupiter, but is so isolated there's little chance of its L4 and L5 being perturbed by other planets.

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Most importantly, Earth's L4 and L5 represent potential sites for space colonies. Obviously if you want a space colony, it makes sense to have it on or near Earth's orbit – because, you know, it's the habitable zone. So, if you're at L4 or L5, you are in a nice stable location where the Earth won't try to clear you out of its orbit.

I mean seriously… there's these two perfect locations just sitting there, only 150 million kilometres away on either side of the Earth. So come on - let's do it.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where you won't be perturbed and never cleared out. No ads, no profit, just good science. Bye.