Orbit in the Lagrangian Point

The Herschel and the Planck satellites are placed in Lagrangian point L2. But where is this point and why it is so attractive for these types of satellites?

Both Herschel and Planck are supposed to explore the far universe, and their instruments will not be influenced by the sun and the planets to any great extent. The best position is therefore furthest away from the sun and the earth. Luckily the gravitation of the sun and the earth make some points in space where these forces neutralise each other and create several points where an object will have a nearly steady position.

This point was discovered by the French mathematician Louise Lagrange in 1772 in his gravitational studies of the "Three body problems", how a third, small body would orbit around two orbiting large ones.

This phenomenon is most known in the Sun-Earth system, but the same points also exist in the Earth -Moon system. There are five such points in the system, named L1 to L5.

Kepler's laws require that the closer a planet is to the sun the faster it will move and over time the body will move away in relation to the earth. But there is a loophole – in the point where the sun's and the earth's gravitational forces neutralise each other the body will have a stable point. If the distance is just right – about a hundredth of the distance to the sun – the spacecraft, too, will keep its position between the sun and the earth and will need just a year to go around the sun. This is the L1 point.

L1 is a very good position for monitoring the sun, and several solar observatories are placed here. The first satellite was the Sun-Earth Explorer (ISEE-3) in 1978. Today the European SOHO solar observatory is one of placed there.

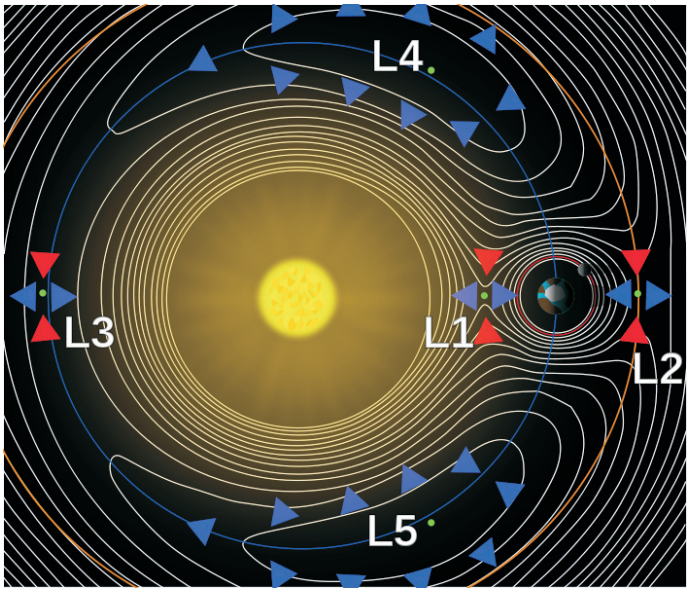
Baard Kringen, NordicSpace

However, the point is not completely stable. The satellites will slowly be drifting away, thus, their own propulsion systems and regular corrections are necessary. In comparison, think of a little ball placed next to a large ball. With a push the small ball will roll away to another position.

Herschel and Planck are supposed to explore and investigate the universe, thus the best point for them is the **L2** point. The L2 is localized to a point outside the earth's orbit in direction from the sun. This point is 1.5 million kilometres from earth directly behind the Earth as viewed from the Sun. It is about four times further away from the Earth than the Moon. L2 is a great place from which to observe the larger universe. A spacecraft to orbits the earth passes in and out of the earth's shadow causing it to heat up and cool down, distorting its view. Free from these restrictions and far away from the heat radiation by earth, L2 provides a much more stable viewpoint. After Herschel and Planck, satellites at Eddington, Darvin, Gaia and the James Webb telescope will be moved to this point. However, the satellites have not completely stable positions.

Both Herschel and Planck will enter a large Lissajous orbit around the Lagrange point. Lissajous orbits are the natural motion of a satellite around a collinear libration point in a two-body system and require less momentum change (i.e. thruster firings) to be expended for station keeping than halo orbits, where the satellite follows a simple circular or elliptical path about the libration point.

Planck will operate from a Lissajous orbit around L2, with an amplitude of 400 000 km.



The five Lagrangiaan points. Figure: Wikipedia

Louis Lagrange

Louis Lagrange was born in Turin in 1736. He moved to Paris in 1787, where he remained, until his death in 1813. During his life, his greatest contribution to mathematical astronomy was his theoretical investigation of the way in which gravitational forces act on small mass when placed in the vicinity of two larger ones. Thus, he discovered the five points that are very important for placing space observatories.

The **L3** point is situated on the opposite side of the sun and a satellite here could not be observed from earth. Today, this position has not been found suitable for a mission.

The **L4** and L5 positions lie at 60 degrees ahead of and behind earth in his orbit as seen from the sun. Unlike the other Lagrange points, L4 and L5 are resistant to gravitational perturbations. Because of this stability, objects tend to accumulate in these points, such as dust and some asteroid-type objects.

Bodies, like satellites, in these points will be stable like a ball in a bowl; they will always return to their original position if they have been pushed away.