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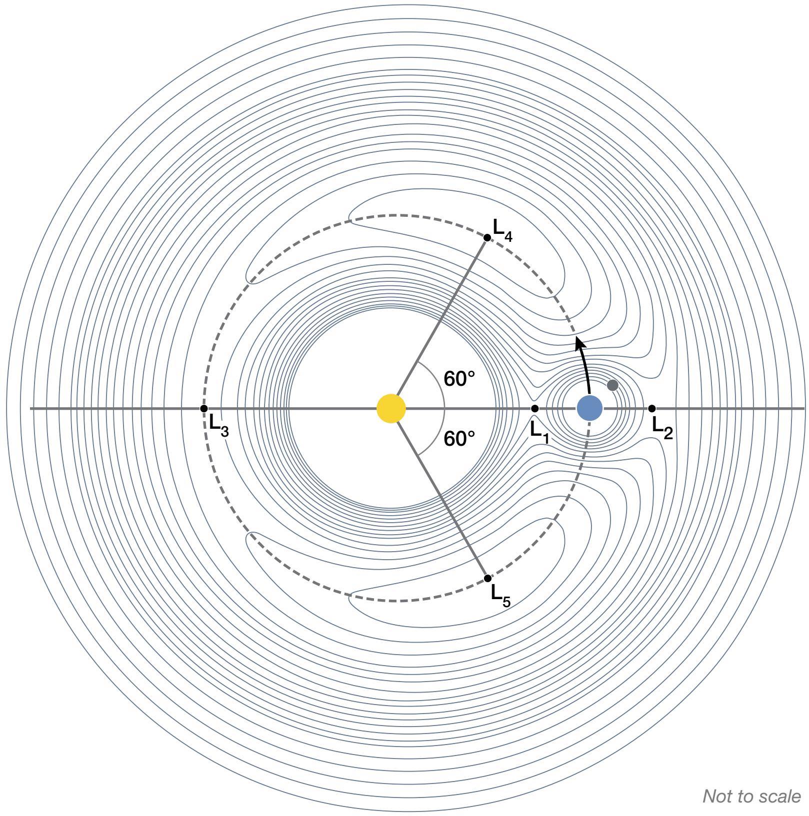
What are Lagrangian points?



▲ **LAGRANGIAN POINTS** Five gravitational equilibrium points exist in the Sun-Earth system, where a much smaller body can orbit the Sun while maintaining a fixed location with respect to both our star (yellow dot) and Earth (blue dot). Closer contour lines correspond to stronger forces.

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IMAGINE SETTING two bowling balls on a waterbed. Each makes a divot in the mattress. You also place a marble on the bed, near the bowling balls.

Then you roll the bowling balls around each other on the bed. As the balls move, the mattress's contours change. The marble will have a hard time staying put — it'll likely be flung away or crash into one of the balls.

Something similar happens in the solar system. When two massive bodies in space — such as Earth and the Sun — orbit each other, they create an ever-changing gravitational landscape. (That's the waterbed.) Each of the two bodies warps space around itself. As the two bodies move, the gravitational effects they exert on their surroundings combine in different ways.

There are, however, five safe zones on the space mattress. Here, a third, much smaller body (say, an asteroid or a spacecraft) can travel with the two larger bodies, maintaining a constant distance from them both. These are the Lagrangian points. For the technically minded among you: At these points, the gravitational pull exerted by the two large bodies equals the centripetal force needed for the third, smaller body to keep its place in the orbital dance.

Parking Spots

Let's call the three bodies m_1, m_2, and m_3, in descending order of mass.

The first three Lagrangian points lie along a line that passes through m_1 and m_2. L_1 lies between m_1 and m_2 (order: m_1-m_3-m_2), and L_2 lies on m_2's other side (m_1-m_2-m_3). L_3 lies approximately on m_2's orbit but 180° away, on the other side of m_1 (m_3-m_1-m_2).

In the Sun-Earth system, we use L_1 and L_2 as spacecraft parking spots. L_1, which lies between the Sun and Earth, is a great location for Sun-studying craft, since they have an uninterrupted view of our star. A telescope at L_2, conversely, can keep its back to the Sun, Earth, and the Moon and stare into deep space. The James Webb Space Telescope is at L_2. We don't use L_3.

These three points are only safe for so long. They are saddle-shaped ridges bordering the mattress divots, oriented with the stirrups along the line connecting m_1 and m_2. If little m_3 comes too close to a stirrup side, it'll slide off and out of the safe zone.

Both L_1 and L_2 are only stable for 23 days or so. To stay put, spacecraft adjust course and attitude regularly.

L_3 is stable a bit longer, about 150 years. Perpetually hidden from Earth's view behind the Sun, L_3 would be a bad place to park a spacecraft that needed to communicate with Earth. But as astrophysicist Neil Cornish wrote in 1998, the 150-year time scale makes L_3 "a good place to park your invasion force while final preparations are made."

Stable Orbits

Unlike the first three Lagrangian points, L_4 and L_5 each lie at the vertex of an equilateral triangle, with m_1 and m_2 at the other two vertices. L_4 leads m_2 in its orbit about m_1; L_5 trails it.

L_4 and L_5 are stable, so long as the ratio between m_1 and m_2's masses is greater than 24.96. (Yes, that's very specific — blame Joseph-Louis Lagrange, the Italian-French mathematician who discovered these two points' existence in 1772.) The ratio holds true for the Sun-Earth system and several other pairings in the solar system.

L_4 and L_5 are shaped like hilltops, not saddles. When an object — such as a speck of dust or an asteroid — rolls down the hill, it picks up speed. The same force that spins up hurricanes on Earth then swings the object into a stable orbit around the hill. But other factors can boot little m_3 out over time.

Asteroids collected in a planet's L_4 and L_5 points are called Trojans. We've found Trojans shadowing several of the planets. Jupiter takes the prize, with more than 15,000 so far. We've found two for Earth, both at L_4. ■

Read more about the Lagrangian Points at this link...