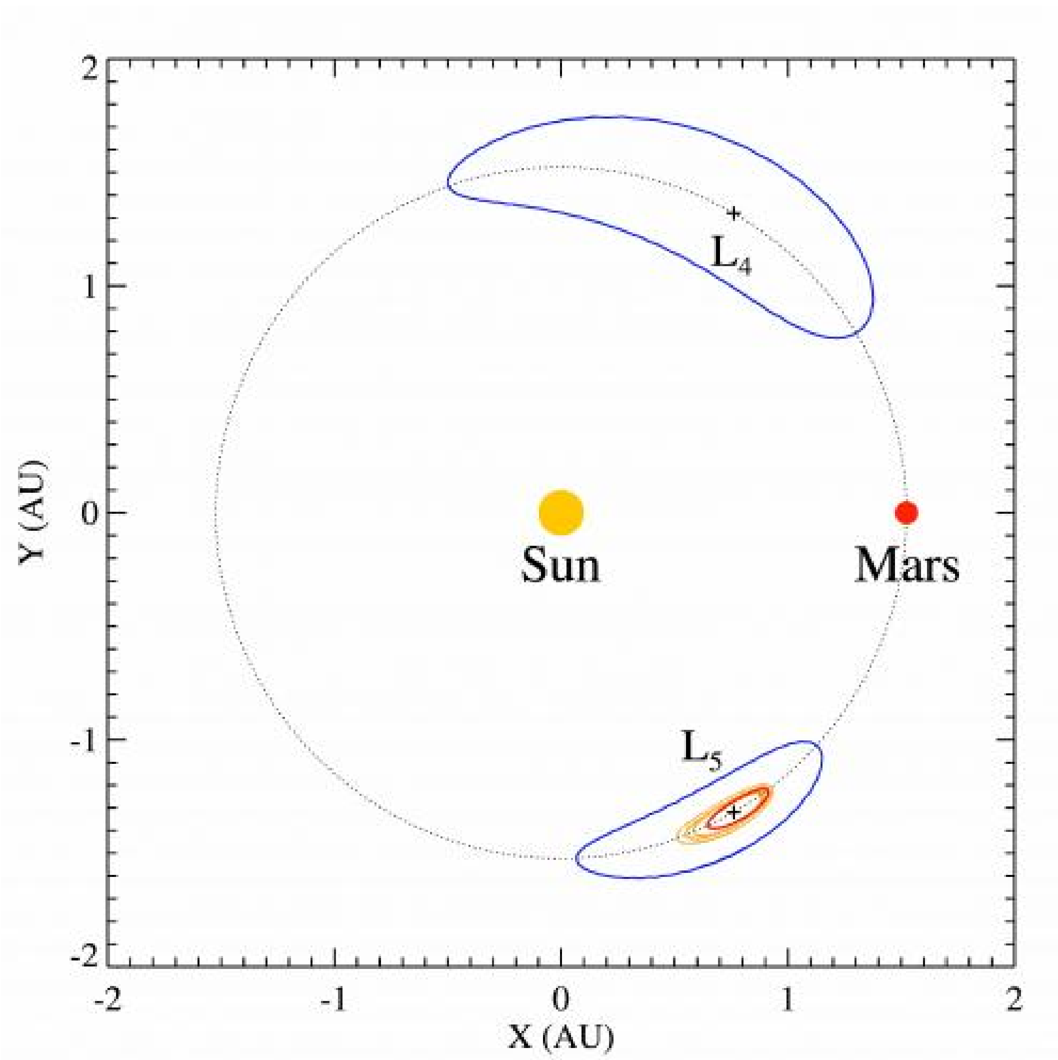
# An asteroid pile-up in the orbit of Mars

October 11 2013




The paths traced by all seven Martian Trojans around L4 or L5 (crosses) in a frame rotating with the average angular speed of Mars (red disk) around the Sun (yellow disk). A full revolution around the corresponding Lagrange point takes approximately 1,400 years to complete. The dotted circle indicates the average distance of Mars from the Sun.

The orbit of the planet Mars is host to the remains of an ancient collision that created many of its Trojan asteroids, a new study has concluded. It paints a new picture of how these objects came to be and may even hold important lessons for deflecting asteroids on a collision course with our own planet. The findings were presented at the annual Meeting of the Division for Planetary Sciences of the American Astronomical Society in Denver last week, by Dr. Apostolos Christou, a Research Astronomer at the Armagh Observatory in Northern Ireland, United Kingdom.

Trojan asteroids, or "Trojans," move in orbits with the same average distance from the Sun as a planet. This may seem as a precarious state to be in, as eventually the asteroid either hits the planets or is flung, by the planet's gravity, on an entirely different orbit.

But solar and planetary gravity combine in such a way as to create dynamical "safe havens" 60 degrees in front and behind the planet's orbital phase. The special significance of these, as well as three other similar locations in the so-called three-body problem, was worked out by

18th century French Mathematician Joseph-Louis Lagrange. In his honor, they are nowadays referred to as the Lagrange points. The point leading the planet is referred to as L4; that trailing the planet as L5.

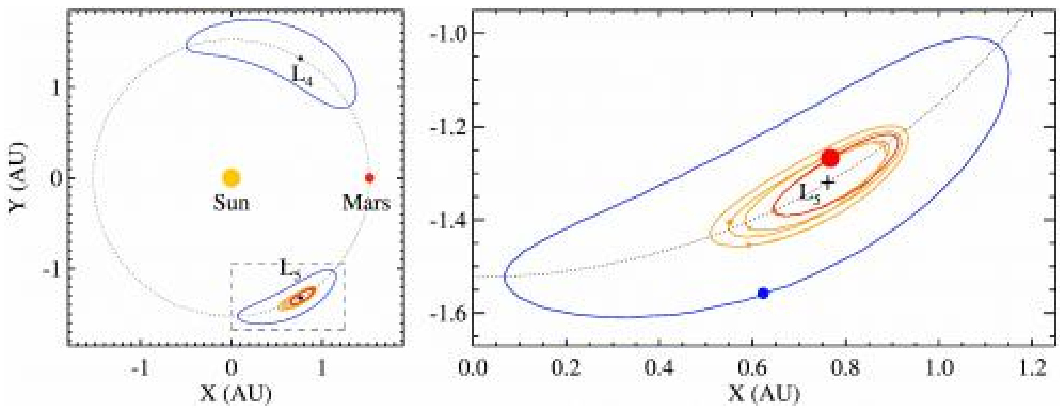
Although not all Trojans are stable for long periods of time, almost 6,000 such objects have been found at the orbit of Jupiter and about 10 at Neptune's. Those are believed to date from the solar system's earliest times when the planets were not yet at their present orbits and the distribution of small bodies across the solar system was very different than observed today.

Of the inner planets, only Mars is known to have stable, long-lived, Trojan companions. The first, discovered back in 1990 near L5 and now named Eureka, was later joined by two more asteroids, 1998 VF31 also at L5 and 1999 UJ7 at L4. In the first decade of the 21st century, observations revealed them to be a few km across and compositionally diverse. A 2005 study led by Hans Scholl of the Observatoire de Cote d'Azur (Nice, France) demonstrated that all three objects persist as Mars Trojans for the age of the solar system, putting them on a par with

the Trojans of Jupiter. In that same decade, however, no new stable Trojans were discovered, which is curious if one considers the ever-improving sky coverage and sensitivity of asteroid surveys.

Christou decided to investigate. Sifting through the Minor Planet Center database of asteroids, he flagged six additional objects as potential Martian Trojans and simulated the evolution of their orbits in the computer for one hundred million years. He found that at least three of the new objects are also stable. He also confirmed the stability of an object originally looked at by Scholl et al., 2001 DH47, using a much better starting orbit that was available at the time. The result: the size of the known population has now more than doubled, from 3 to 7.

But the story does not end there. All these Trojans, save one, are trailing Mars at its L5 Lagrange point [see Fig. 1 & left panel of Fig. 2]. What's more, the orbits of all but one of the six L5 Trojans group up around Eureka itself [see right panel of Fig. 2]. "It is not what one would expect by chance," Christou says. "There is some process responsible for the picture we see today."




Left (same as Figure 1): The paths traced by all seven Martian Trojans around L4 or L5 (crosses) in a frame rotating with the average angular speed of Mars (red disk) around the Sun (yellow disk). A full revolution around the corresponding Lagrange point takes approximately 1,400 years to complete. The dotted circle indicates the average distance of Mars from the Sun. Right: Detail of left panel (demarcated by the dashed rectangle) showing the motion, over 1,400 years, of the six L5 Trojans: 1998 VF31 (blue), Eureka (red), and the objects identified in the new work (amber). Note the latter's similarity to the path of Eureka. The disks indicate the estimated relative sizes of the asteroids.

**One possibility put forward by Christou is that the original Martian**

Trojans were several tens of km across, a great deal larger than those we see today. In that scenario, described in a paper published in the May 2013 issue of *Icarus*, a series of collisions kept breaking those up into ever smaller fragments.

This "Eureka cluster"—in reference to its largest member—is the result of the most recent collision. This hypothesis not only accounts for the observed distribution of orbits but also explains why the new objects are relatively small, some hundreds of meters across. As

Christou explains: "In the earlier collisions, km-sized objects would be among the smallest fragments produced and thus moving at tens to hundreds of meters per second, too fast to be retained as Trojans of Mars." In the event that formed the Eureka cluster, the energy of the collision would only allow the sub-km fragments to fly apart at a meter per second or less, so not only do they stay on as Trojans but their orbits end up being quite similar as well.

Christou points out that, although there are alternative ways of making the Eureka cluster, collisions are generally accepted as being responsible for many other similar groupings or "families" of asteroids in the Main Belt, "so why not Martian Trojans as well? Collisions are like taxes; all asteroids must suffer them." He hopes that his findings will motivate the modelers to work out the plausible impact scenarios and the observers to look for telltale signs that the members known so far share a common origin.

Assuming the collisional hypothesis stands the test of time, we are left with the closest example yet of a collisionally derived group of asteroids still in their original locations. Christou predicts that further study of the cluster and Mars Trojans in general will tell us a great deal about how small asteroids behave when they collide with each other.

Scientists trying to simulate collisions of large—tens to hundreds of km across—asteroids in the Main Belt have a lot of data to compare their models against. This is not true for impacts on km-sized asteroids and their even smaller fragments; these are simply too faint to be efficiently picked up by surveys either now or in the near future.

Understanding what happens under these conditions is important if we ever hope to deal with asteroids in a collision course with the Earth.

Deflecting such an object might be a trickier job than first meets the eye. As Christou explains, "Setting off explosives in its vicinity to push it away from its predicted path may instead break it apart. This will turn it into a cosmic 'cluster bomb,' capable of causing widespread destruction across our planet."

Martian Trojans are just the right size to serve as guinea pigs for such brute-force deflection strategies. In fact, our knowledge of the population is about to increase significantly thanks to new facilities and initiatives. These include Canada's Near-Earth Object Surveillance

Satellite, Europe's Gaia sky-mapper, and the US's recently reactivated Wide-field Infrared Survey Explorer satellites as well as the Panoramic Survey Telescope and Rapid Response System and Large Synoptic Survey Telescope ground-based surveys.

In concluding, Christou posits that "the future looks bright. Using the new data we should be able to determine what made these asteroids group up, even if the collisional model doesn't pan out in the end." For the time being, the work by Christou and the many others before him have

succeeded in highlighting the Martian Trojan regions as unique "natural laboratories," providing insight to evolutionary processes that even today are shaping our solar system's small body population.

Provided by Armagh Observatory

Citation: An asteroid pile-up in the orbit of Mars (2013, October 11) retrieved 27 April 2024 from https://phys.org/news/2013-10-asteroid-pile-up-orbit-mars.html