A population of asteroids of interstellar origin inhabits the Solar System

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Discovery by Brazilian researcher reported in Royal Astronomical Society's Monthly Notices provides clues for understanding the star nursery from which the Sun emerged. Credit: NASA

A study conducted by scientists at São Paulo State University's Institute of Geosciences and Exact Sciences (IGCE-UNESP) in Rio Claro, Brazil, has identified 19 asteroids of interstellar origin classified as Centaurs, outer Solar System objects that revolve around the Sun in the region between the orbits of Jupiter and Neptune.

An article on the study titled "An interstellar origin for high-inclination Centaurs" is published in the *Royal Astronomical Society's Monthly*

Notices. The study was supported by São Paulo Research Foundation (FAPESP) - FAPESP.

"The Solar System formed 4.5 billion years ago in a stellar nursery, with its systems of planets and asteroids. The stars were close enough to each other to foster strong gravitational interactions that led to an exchange of material among the systems. Some objects now in the Solar System must therefore have formed around other stars. Until recently, however, we couldn't distinguish between captured interstellar objects and objects that formed around the Sun. The first identification was made by us in 2018," said Maria Helena Moreira Morais, one of the two coauthors.

Morais graduated in physics and applied mathematics from the University of Porto (Portugal) and earned a Ph.D. in Solar System dynamics from the University of London (UK). She is currently a professor at IGCE-UNESP. The other coauthor is Fathi Namouni, a researcher at Côte d'Azur Observatory in Nice, France.

The first identification to which Morais referred was the asteroid 514107 Ka'epaoka'awela, as reported by Agência FAPESP in 2018.

The name Ka'epaoka'awela is Hawaiian and can be roughly translated to "mischievous opposite-moving companion of Jupiter". It has occupied the path corresponding to Jupiter's orbit for at least 4.5 billion years but revolves around the Sun in the direction opposite to that of the planets, i.e., it is a retrograde co-orbital asteroid of Jupiter.

"When we identified it as an object that came from outside the Solar System, we didn't know whether it was an isolated case or part of a vast population of immigrant asteroids," Morais said. "In this latest study, we recognized 19 Centaurs of interstellar origin."

Similar to Ka'epaoka'awela, the Centaurs identified in the study have

highly inclined orbits with respect to the orbital plane of the planets. "To investigate the origin of these objects, we built a computer simulation that works like a time machine, running their trajectories backwards by 4.5 billion years. The simulation enabled us to find out where these objects were at that time," Morais said.

The planets and asteroids that originated in the Solar System emerged from a thin disk of gas and dust that once orbited the Sun. For this reason, they all moved in the plane of the disk 4.5 billion years ago. If the Centaurs originated in the Solar System, they should also have moved in the plane of the disk at that time. "However, our simulation showed that 4.5 billion years ago, these objects revolved around the Sun in orbits perpendicular to the disk's plane. In addition, they did so in a region distant from the gravitational effects of the original disk," Morais said.

These two findings showed that the Centaurs did not originally belong to the Solar System and must have been captured from nearby stars during the period of planet formation.

Star nursery

The discovery in the Solar System of a population of asteroids of interstellar origin is a major step in the understanding of the differences and similarities between objects that formed in the Solar System and objects in the Solar System that were originally extrasolar. Future astronomic observations and possibly space missions will deepen this understanding. "Studies of this population will bring to light information about the star nursery from which the Sun emerged, the capture of interstellar objects in the primordial Solar System, and the importance of interstellar matter to the chemical enrichment of the Solar System," Morais said.

With regard to chemical enrichment, it is worth recalling that the primordial Universe mainly comprised hydrogen and helium. The lightest natural elements in the periodic table were created by nuclear fusion inside stars and were then spread out through space. The region in which the Solar System is located was chemically enriched by these elements, which contributed to the composition of the human body.

More information: F Namouni et al, An interstellar origin for high-inclination Centaurs, *Monthly Notices of the Royal Astronomical Society* (2020). DOI: 10.1093/mnras/staa712

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