The solar system follows the galactic standard—but it is a rare breed

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Illustration showing an artist's interpretation of what the TRAPPIST-1 solar system could look like. The seven planets of TRAPPIST-1 are all Earth-sized and terrestrial, and could potentially harbor liquid water, depending on their compositions. Credit: NASA/JPL-Caltech

Researchers at the Niels Bohr Institute, University of Copenhagen, have investigated more than 1000 planetary systems orbiting stars in our own galaxy, the Milky Way, and have discovered a series of connections

between planetary orbits, number of planets, occurrence and the distance to their stars. It turns out that our own solar system in some ways is very rare, and in others very ordinary.

It is rare to have eight planets, but the study shows that the solar system follows exactly the same, very basic rules for the formation of planets around a star that they all do. The question about what exactly makes it so special that it harbors life is still a good question. The study is now published in *MNRAS*

Eccentric planet orbits are the key to determining the number of planets

There is a very clear correlation between the eccentricity of the orbits and the number of planets in any given solar system. When the planets form, they begin in circular orbits in a cloud of gas and dust. But they are still relatively small in size, up to sizes comparable to the moon. On a slightly longer time scale they interact via gravitation and acquire more and more eccentric or elliptic orbits. This means they start colliding because elliptical orbits cross one another—and so the planets grow in size due to the collisions. If the end result of the collisions is that all the pieces become just one or a few planets, then they stay in elliptical orbits. But if they end up becoming many planets, the gravitational pull between them makes them lose energy—and so they form more and more circular orbits.

The researchers have found a very clear correlation between the number of planets and how circular the orbits are. "Actually, this is not really a surprise," professor Uffe Gråe Jørgensen explains. "But our solar system is unique in the sense that no other solar systems with as many planets as ours are known. So perhaps it could be expected that our solar system doesn't fit into the correlation. But it does—as a matter of fact, it is right

on."

The only solar systems that don't fit into this rule are systems with only one planet. In some cases, the reason is that in these single-planet systems, the planet is orbiting the star in very close proximity, but in others, the reason is that the systems may actually hold more planets that initially assumed. "In these cases, we believe that the deviation from the rule can help us reveal more planets that were hidden up until now," Nanna Bach-Møller, first author of the scientific article, explains. If we are able to see the extent of eccentricity of the planet orbit, then we know how many other planets must be in the system—and vice versa, if we have the number of planets, we now know their orbits. "This would be a very important tool for detecting planetary systems like our own solar system, because many exoplanets similar to the planets in our solar system would be difficult to detect directly, if we don't know where to look for them."

The Earth is among the lucky 1%

No matter which method is used in the search for exoplanets, one reaches the same result. So, there is basic, universal physics at play. The researchers can use this to say: How many systems possess the same eccentricity as our solar system? – which we can then use to assess how many systems have the same number of planets as our solar system. The answer is that there are only 1% of all solar systems with the same number of planets as our solar system or more. If there are approximately 100 billion stars in the Milky Way, this is, however, still no less than one billion solar systems. There are approximately 10 billion Earth-like planets in the habitable zone, i.e. in a distance from their star allowing for the existence of liquid water. But there is a huge difference between being in the habitable zone and being habitable or having developed a technological civilization, Uffe Gråe Jørgensen stresses. "Something is the cause of the fact that there aren't a huge amount of

UFOs out there. When the conquest of the planets in a solar system has begun, it goes pretty quickly. We can see that in our own civilization. We have been to the moon and on Mars we have several robots already. But there aren't a whole lot of UFOs from the billions of Earth-like exo-planets in the habitable zones of the stars, so life and technological civilizations in particular are probably still fairly scarce."

The Earth is not particularly special—the number of planets in the system is what it is all about

What more does it take to harbor life than being an Earth-size planet in the habitable zone? What is really special here on Earth and in our solar system? Earth is not special—there are plenty of Earth-like planets out there. But perhaps it could be the number of planets and the nature of them. There are many large gas planets in our solar system, half of all of them. Could it be that the existence of the large gas planets are the cause of our existence here on Earth? A part of that debate entails the question of whether the large gas planets, Saturn and Jupiter, redirected water-bearing comets to Earth when the planet was a half-billion years old, enabling the forming of life here.

This is the first time a study has shown how unique it is for a solar system to be home to eight planets, but at the same time, shows that our solar system is not entirely unique. Our solar system follows the same physical rules for forming planets as any other solar system, we just happen to be in the unusual end of the scale. And we are still left with the question of why, exactly, we are here to be able to wonder about it.

More information: Nanna Bach-Møller et al. Orbital eccentricity–multiplicity correlation for planetary systems and comparison to the Solar system, *Monthly Notices of the Royal Astronomical Society* (2020). DOI: 10.1093/mnras/staa3321

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