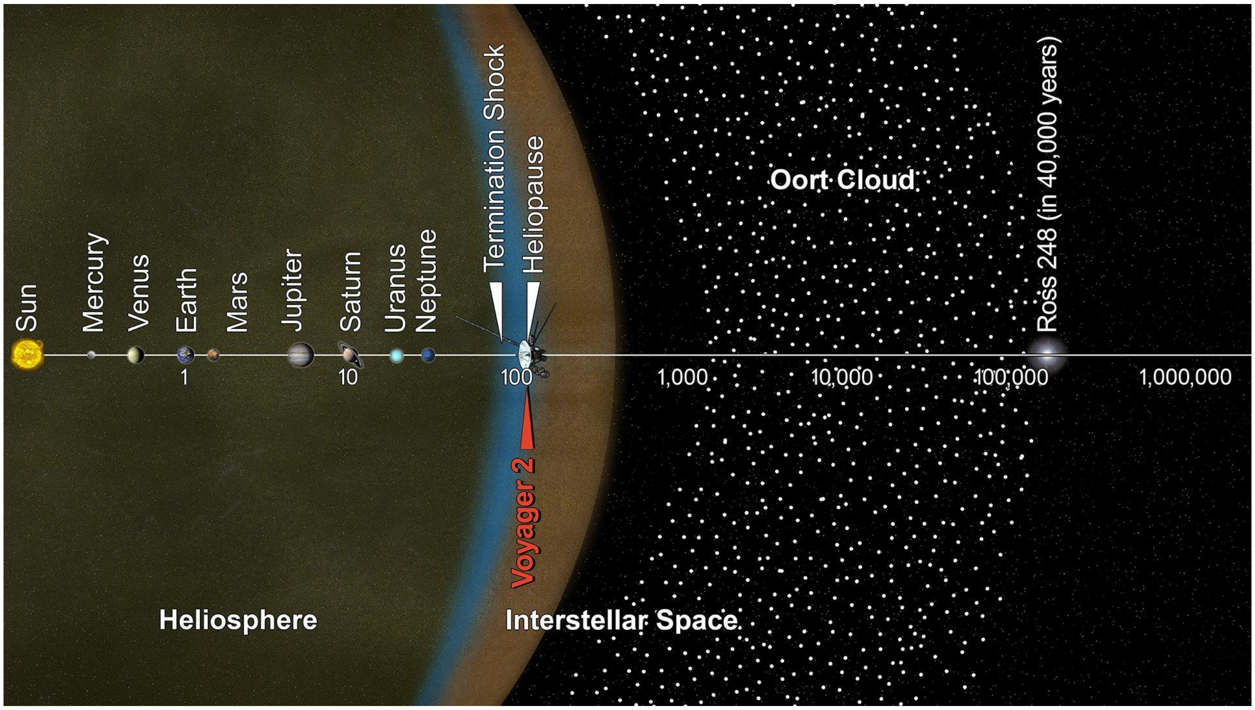
The Mystery Of The Oort Cloud



Ever wondered what's at the edge of our known solar system? Beyond Pluto and the Kuiper belt? According to scientists, if we were to travel into interstellar space, we'd need to pass through a gigantic cloud of planetesimal's called the Oort cloud. An immense cloud that encompasses the sun and all its surrounding planets, at distances up to 3.2 light years. A graveyard of icy comets and interstellar objects that have traveled billions of miles.

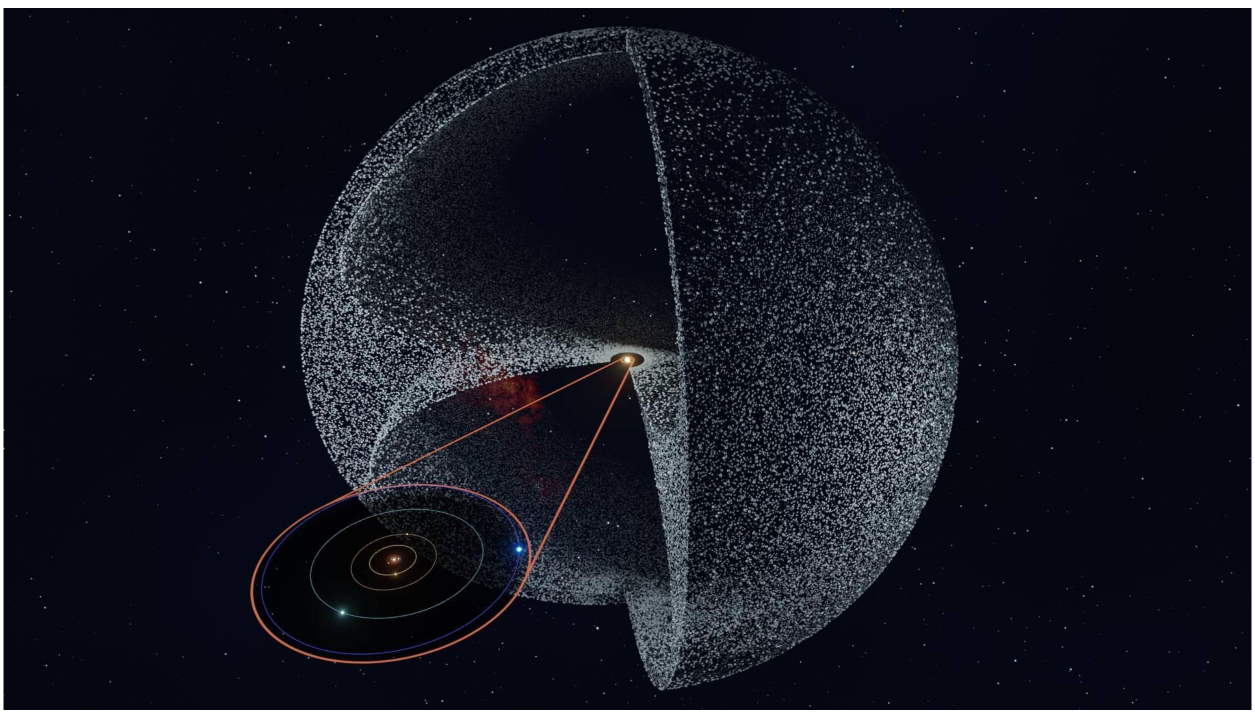
The Oort cloud is a mystery yet to be solved, primarily because of its astronomical distance from our home planet. As we speak, both voyager missions are currently exiting the solar system into interstellar space, and venturing towards the enigmatic Oort cloud. Estimates reveal that it'll take another 300 years for the Voyager 2 to reach the inner edge of the cloud and another 30,000 years to fly beyond its outer edge outside the bounds of our solar system.

But what lies within this icy periphery of the solar system? And will we ever get past it? Join us as we dive deep into the mysteries of the Oort cloud.

What Is The Oort Cloud?

In the farthest and coldest part of our Solar System, where no humans have ever gone before, lies a strange and frigid cloud. This remarkable cloud consists of materials derived from distant stars. Oort Cloud, also known as the Öpik–Oort Cloud, is a widely accepted theory that suggests the existence of an extensive collection of icy planetesimals encircling the Sun. This theoretical cloud is about 2,000 to 200,000 astronomical units or AU, which is about 0.03 to 3.2 light-years away from the sun.

In 1950, the Dutch astronomer Jan Oort proposed the concept of the Oort Cloud, which received its name in honor of him. Oorts proposition posited that the objects situated within this cloud play a pivotal role in sustaining a consistent influx of comets with extended periods into the inner Solar System. These comets ultimately meet their fate by being drawn closer to the Sun and eventually consumed.



The Oort Cloud is believed to consist of two primary regions: an inner, disk-shaped segment aligned with the plane of the solar ecliptic, often referred to as the Hills Cloud, and an outer, spherical portion that encompasses the entirety of our solar system. Both of these regions are positioned well beyond the boundaries of the heliosphere, and reside within interstellar space. The heliosphere is like a protective bubble made by the Sun's solar wind that protects our solar system from cosmic rays and interstellar space. It's a part of space where the Sun's influence is strongest and where our solar neighborhood ends.

In contrast to the Oort Cloud, the Kuiper Belt, the scattered disc, and the detached objects, three other reservoirs of trans-Neptunian objects are located much closer to the Sun, separated by a considerable distance of over a thousand times the proximity of the innermost part of the Oort Cloud.

[The Oort Cloud is between about 2,000 and 100,000 AU from the Sun. 1 AU is the Earth-Sun distance. - YouTube]

The limits of our Solar System are defined by the outermost extent of the Oort Cloud. The Sun’s Hill sphere marks the boundary where solar gravitational influence turns into the galaxy’s gravitational domain. The outer Oort Cloud is not very close to the Solar System, so it can be affected by passing stars and the Milky Way itself.

These influences have played a big part in changing the orbits of materials that came out of the inner solar system early on. As a result, the predominantly circular orbits of material within the Oort Cloud are significantly influenced by this galactic gravitational interaction.

Occasionally, comets within the Oort Cloud are disrupted by the gravitational interference from the Milky Way and passing stars, and they enter the inner Solar System. Many short-lived comets, but not all, are thought to have come from the Oort Cloud. It's worth noting that this massive spherical cloud could also be the source of other brief-period comets.

Astronomers think that the stuff in the Oort Cloud started out closer to the Sun, in a place called the protoplanetary disc. Then, the big planets pulled it away and made it move to a faraway place. Sadly, direct observation of the Oort Cloud is still impractical with current imaging methods.

It is thought to be the source of most long-period and Halley-type comets, which, when they enter the inner Solar System, eventually get closer to the Sun. The Oort Cloud may also serve a similar role for numerous centaurs and Jupiter-family comets.

Discovery Of The Cloud

As the 20th century began, astronomers sorted comets into two main groups: short-period, otherwise known as ecliptic comets and long-period or nearly isotropic comets. Ecliptic comets have relatively small orbits aligned with the ecliptic plane, typically not extending beyond 50 astronomical units from the sun. For reference, Neptune's orbit averages around 30 AU, and the infamous comet 177P/Barnard reaches an aphelion point of about 48 AU. An aphelion point is the point in the orbit of an object where it is farthest from the Sun,

Long-period comets, on the other hand, travel in extensive orbits, spanning thousands of AU from the Sun, and they appear from all directions in the sky, above and below the ecliptic plane. Understanding the origin of these comets was a challenge, as many were initially thought to be following spherical paths, implying that they were extraterrestrial visitors.

In 1907, A. O. Leuschner proposed that many comets thought to have parabolic orbits actually went on large elliptical orbits and came back to the inner Solar System after long periods of invisibility. In other words, a parabolic orbit is a one-time journey that objects take through space. They come from a very distant place, pass by the Sun, and then head back into deep space, never to return. Think of it like a curve that starts far away, gets close to the Sun, and then goes far away again. These objects don’t stick around in our solar system, they just pass by once and continue on their way.

Two Bodies' Parabolic Orbit - YouTube

Several years later, in 1932, Estonian astronomer Ernst Öpik introduced the notion of a comet reservoir with a long-period structure, namely an orbiting cloud, located at the outermost boundary of the Solar System. The Dutch astronomer Jan Oort revived this concept in 1950 to tackle the mystery surrounding the formation of celestial bodies.


Ernst Öpik

Questions were raised about the unique characteristics of long-period comets. Over time, their orbits change and could cause collisions with other stars, collisions with other planets, or ejections from the Solar System. The volatile compositions of comets gradually undergo vaporization upon each approach to the Sun, either leading to fragmentation or the formation of insulating crusts, thereby preventing further out-gassing.

During Oort's research, he considered that comets that were close to the Sun couldn't have kept these orbits since the Solar System was formed over 4.5 billion years ago. Therefore, long-period comets probably spent most of their time in an outer reservoir. He also observed a concentration of comets with aphelia around 20,000 AU.

Fundamentally, an Aphelion point is the farthest point in an object's orbit around the Sun. Imagine a planet or comet travelling around the Sun in an oval-shaped path. Aphelion is the point in that path where it’s the farthest away from the Sun. Like when a comet takes a brief trip to the outer edge of its orbit before returning closer to the Sun. The opposite of Aphelion is Perihelion.

Perihelion and aphelion

This indicated that the distribution was circular and identical in that region. He also thought that rarer comets with orbits around 10,000 AU might have traveled into the inner Solar System, where planetary gravitational forces pulled them in. Most of Oort's research has laid the foundation to our understanding of the Oort cloud and how it affects our surroundings.

What We Know So Far

During the summer of 2020, for a brief duration, sky gazers had the opportunity to observe an exceptional visitor to our region of the Solar System. If you had been looking up on a clear night, you might have seen something rare. Through binoculars, it looked like a typical comet with a bright nucleus and a long tail made of ice that was turned into gas by the Sun's intense heat. It was even visible to the naked eye in the Northern Hemisphere during early July.

However, this celestial traveler, given the moniker C/2002 F3 (Neowise), vanished from view. Anyone who had the opportunity to witness this comet will not see it again in their lifetime, nor will their descendants or several generations after that. This particular comet won't grace our skies for another 6,800 years.

C/2002 F3 (Neowise)

The significance of this brief flyby extends beyond its infrequent appearances (as many short-period comets return multiple times within a human lifetime). C/2002 F3 (Neowise) is believed to have originated from one of the least explored and most mysterious regions of our solar system – the expansive and frozen Oort Cloud.

This enigmatic cloud exists in the farthest reaches of our Solar System, surpassing the asteroid belt and the gas giants. It extends even beyond the icy realms of Uranus and Neptune, as well as the distant orbit of Pluto. It resides far outside the outer boundary of the heliosphere, a plasma bubble generated by our Sun that surrounds our Solar System, marking the transition into interstellar space.

The Oort Cloud can be visualized as an immense shell enveloping our Solar System, extending not only along the plane where the planets, asteroids, and dwarf planets orbit but in all directions. However, there is an intriguing challenge - the presence of this vast, icy dome remains a subject of uncertainty.

The Oort Cloud is believed to be comprised of countless ice and rock formations, numbering in the billions, if not trillions, all of which formed around the same period as our planets. It's a celestial feature that has eluded direct observation by astronomers, and even the farthest human-made spacecraft, Voyager 1, is not slated to reach it for another 300 years. However, ongoing research and upcoming space missions are gradually unveiling some of its mysteries. Additionally, visits from distant comets like C/2002 F3 (Neowise) are offering valuable insights.

Jan Oort

Jan Oort, in 1950, initially hypothesized the existence of the Oort Cloud to explain the presence of comets with extended orbits like Neowise. Unlike short-period comets, which complete orbits around the Sun in less than 200 years and originate from the Kuiper Belt, an icy disk beyond Neptune, the origin of long-period comets posed a more challenging question. It takes these comets between 200 and 1,000 years to complete a full orbit around the Sun, and they display off-centered orbits, which come close to the Sun before venturing far into space.

Oort’s theory suggested that these comets may have arisen from a distant shell of objects, primarily composed of rock and ice, situated far beyond the boundaries of our solar system. It is believed that this expansive shell begins at a distance ranging from roughly 190 billion miles or 306 billion kilometers, to 470 billion miles or 756 billion kilometers, from the Sun.

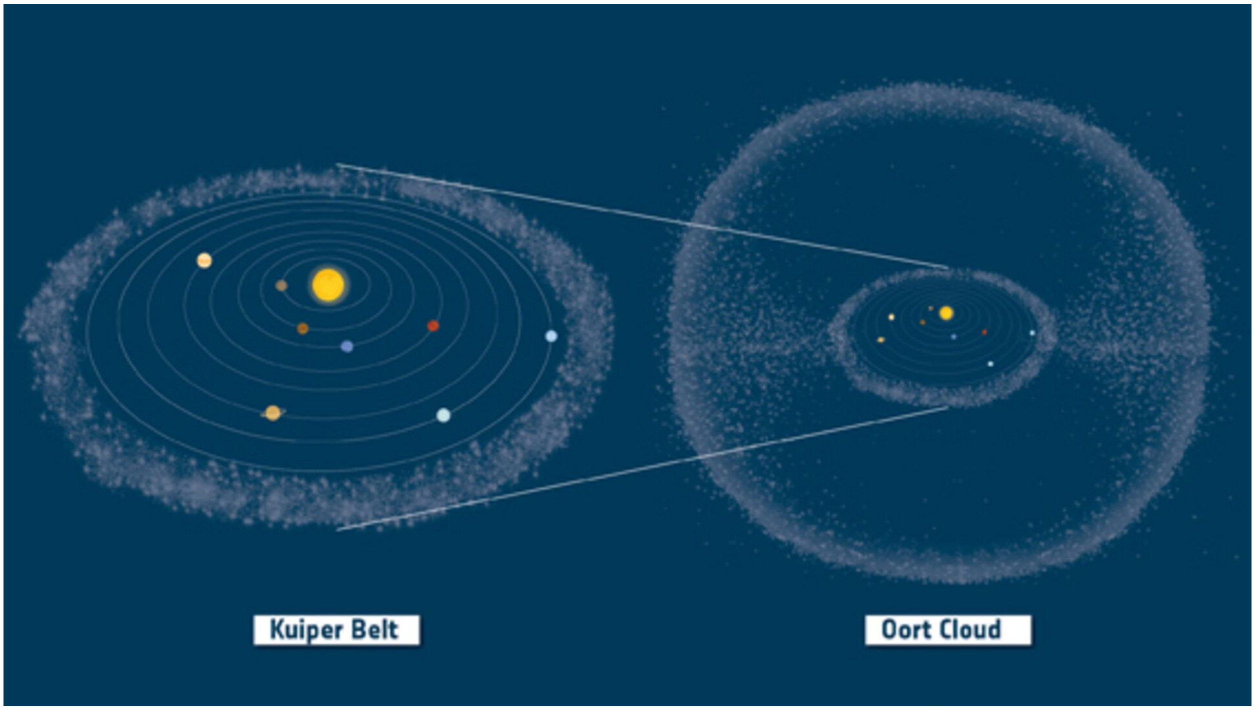
To put this into perspective, it’s roughly 2,000-5,000 times the distance between Earth and the Sun, or an astronomical unit, which is roughly 93 million miles or 150 million kilometers. Alternatively, this spans from 0.03 to 0.08 light-years. Some estimations extend the Oort Cloud further into space, reaching up to 100,000-200,000 astronomical units, translating to 9.3 trillion miles or 15 trillion km, to 18 trillion miles or 29 trillion km.

Cyrielle Opitom, a researcher with a specialization in comets and the Solar System at the University of Edinburgh, emphasizes the importance of observing comets saying, *“So far we don't have any other satisfactory explanation for the continued supply of long period comets we observe. When reconstructing their orbits, they seem to share an aphelion at around 20,000 times the distance from the Sun to the Earth, in what we call the Oort Cloud.”*

Origins And Further Investigation

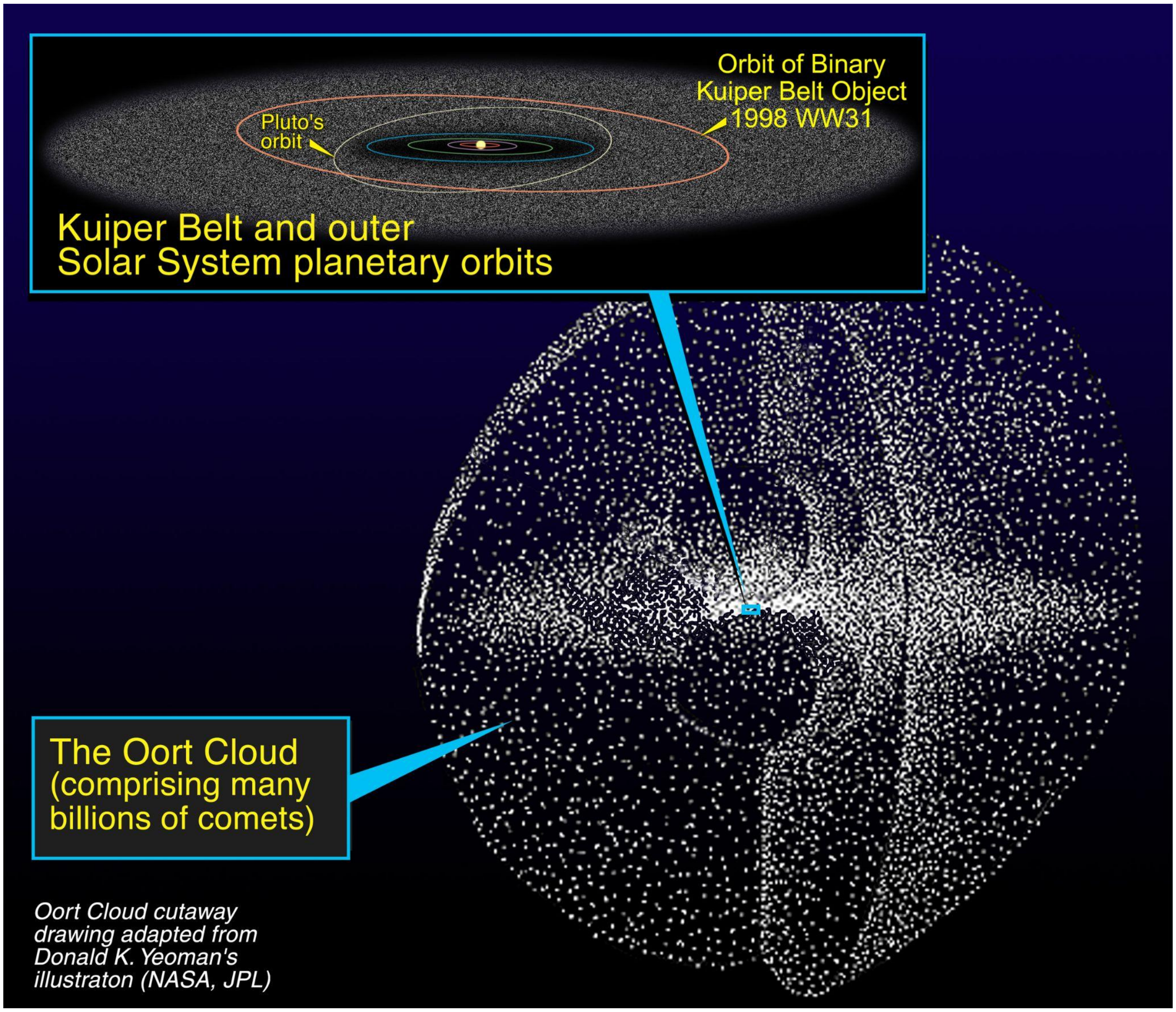
The Oort Cloud's origins are still a mystery. It’s believed to be home to numerous tiny rock fragments, ranging in size from a few kilometers to a few miles, resembling comets and possibly the foundations of celestial bodies. These objects are, however, too small to be seen directly from Earth, even with our most advanced telescopes.

A recent study by Simon Portegies Zwart and his team at Leiden University in the Netherlands has given us valuable insights into the potential formation of the Oort Cloud. They used computer simulations to figure out how the cloud came to be over a period of 100 million years. It is the first attempt to connect all the stages of the clouds' formation into a cohesive narrative, rather than examining them separately.



The researchers discovered that the Oort Clouds formation was not a straightforward process but rather a complex interplay of natural phenomena, involving planets, stars and the Milky Way. According to Portegies Zwart, *"The results show that the cloud did not form in a simple fashion, but by a sort of conspiracy of nature, where a number of processes have to follow suit"*

Portegies Zwart further revealed that these results show that our solar system might not be the only one with a big, icy cloud around it, saying, *"Once we had mapped out the various processes, they turned out to be a rather natural consequence of the evolution of the Solar System".* Their research provides predictions regarding the potential contents of the Oort Cloud. If their predictions are true, the Oort Cloud could harbor materials that originated from other stars, essentially *“stuff from other stars,”* as described by Portegies Zwart.



The idea that our Sun might have acquired material from elsewhere was initially proposed around a decade ago. Michele Bannister, a planetary astronomer at the University of Canterbury in New Zealand, explains that in the Sun's birth cluster of stars, the sibling stars would have been close enough for their comet clouds to intermingle.

As the cluster split up, these stars went their separate ways, possibly carrying comets from other stars with them. This means that similar to the possibility of the Oort Cloud containing comets from other stars, it is possible that some of our own comets may be orbiting around other stars as well.

One study from November 2020 says that objects from other stars outside our solar system could be more common than objects from our own Solar System. Another study, which released preliminary findings earlier this year, has found that three stars may have passed through the Oort Cloud.

It's not clear how much of the Oort Cloud's content comes from other stars, and even a close look at comets might not answer this question. Planetary scientists at the University of Arizona explain that it would be quite challenging to determine which comets were not formed within our Solar System. Real-time interstellar comet visitors may provide valuable insights in future research.

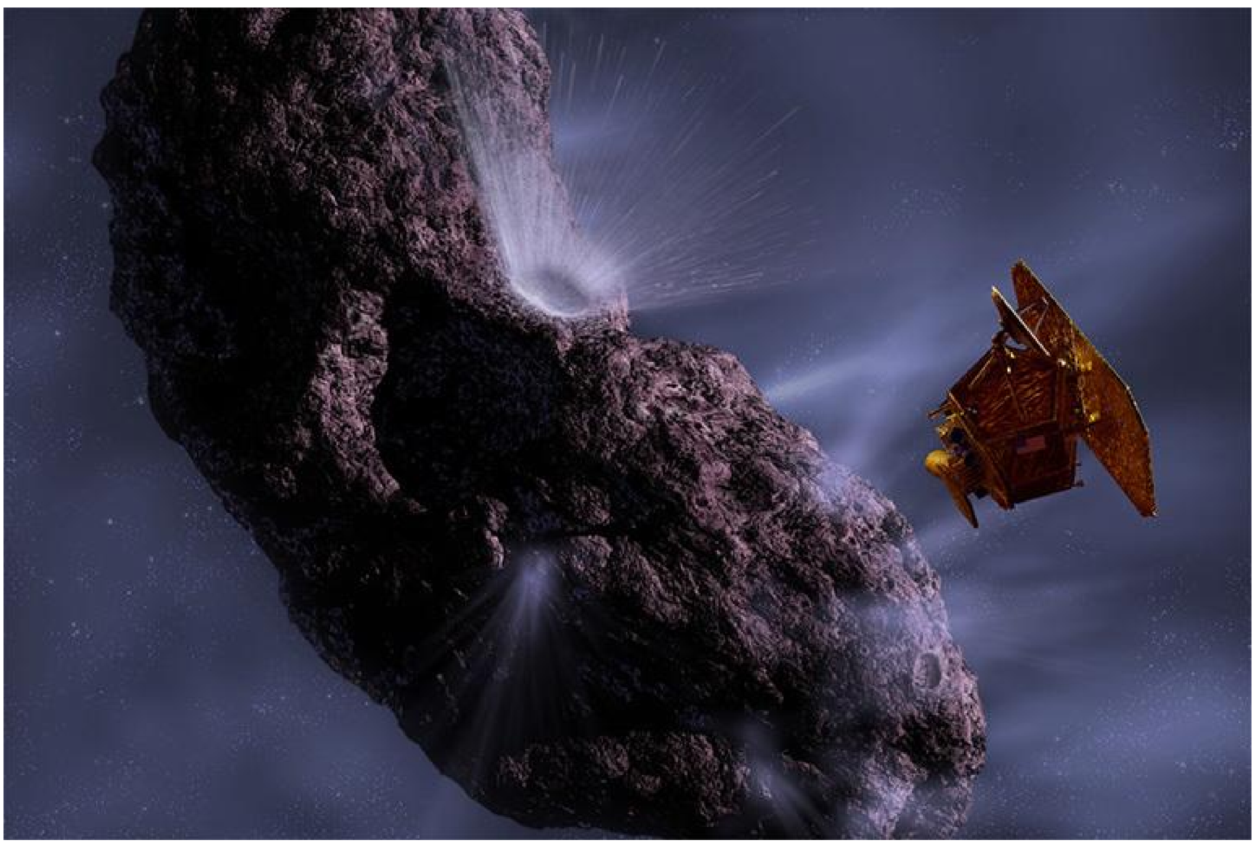
The results obtained by Portegies Zwart and his team suggest that about half of the material in the inner part of the Oort Cloud and a quarter of the outer part could have originated from outside sources. Understanding the Oort Cloud and the comets it creates could help us understand how our Solar System came to be. These objects are regarded as among the most pristine and ancient bodies within our reach, and it is believed that they were formed simultaneously with the formation of the planets.

Portegies Zwart expressed a desire to analyze the material from Oort Cloud objects. However, the prospect of obtaining samples is a long way off. Over 40 years after its launch, Voyager 1 is only a small fraction of the distance from the solar system to the Oort Cloud. Any direct contact with objects there is unlikely unless it encounters a collision. The Oort Cloud is a long way off, and four other spacecraft, including Voyager 2, New Horizons, and Pioneer 10 and 11, are expected to make it there eventually, but the lengthy journey means their power supplies are likely to run out long before they do. It is just too far.

Researchers have already discovered the presence of carbon monoxide, water, and various carbon and silicate materials in Oort Cloud comets. Scientists are obtaining valuable insights by studying data collected from observations of comets suspected to originate from the Oort Cloud instead of embarking on missions to reach these comets.

Examining the compositions of these comets does not require us to physically visit them. According to preliminary findings from various studies, carbon monoxide, water, and various types of carbon and silicate materials have been detected within Oort Cloud comets.

However, there is optimism that we might have the opportunity to closely examine one of these Oort Cloud comets through a space mission. Recently, European Rosetta orbiters, the Philae lander, and NASA's Deep Impact spacecraft have successfully visited passing comets. Other missions, like Japan's Hayabusa and Hayabusa2, and NASA's Osiris-Rex missions, have collected samples from asteroids and returned them to Earth.



However, studying comets from the Oort Cloud presents a unique challenge. The discovery of these comets usually takes place a few years after they begin to approach the Sun with great accuracy. As Opitom pointed out, this limited timeframe makes it challenging to plan and launch a mission to rendezvous with a comet.

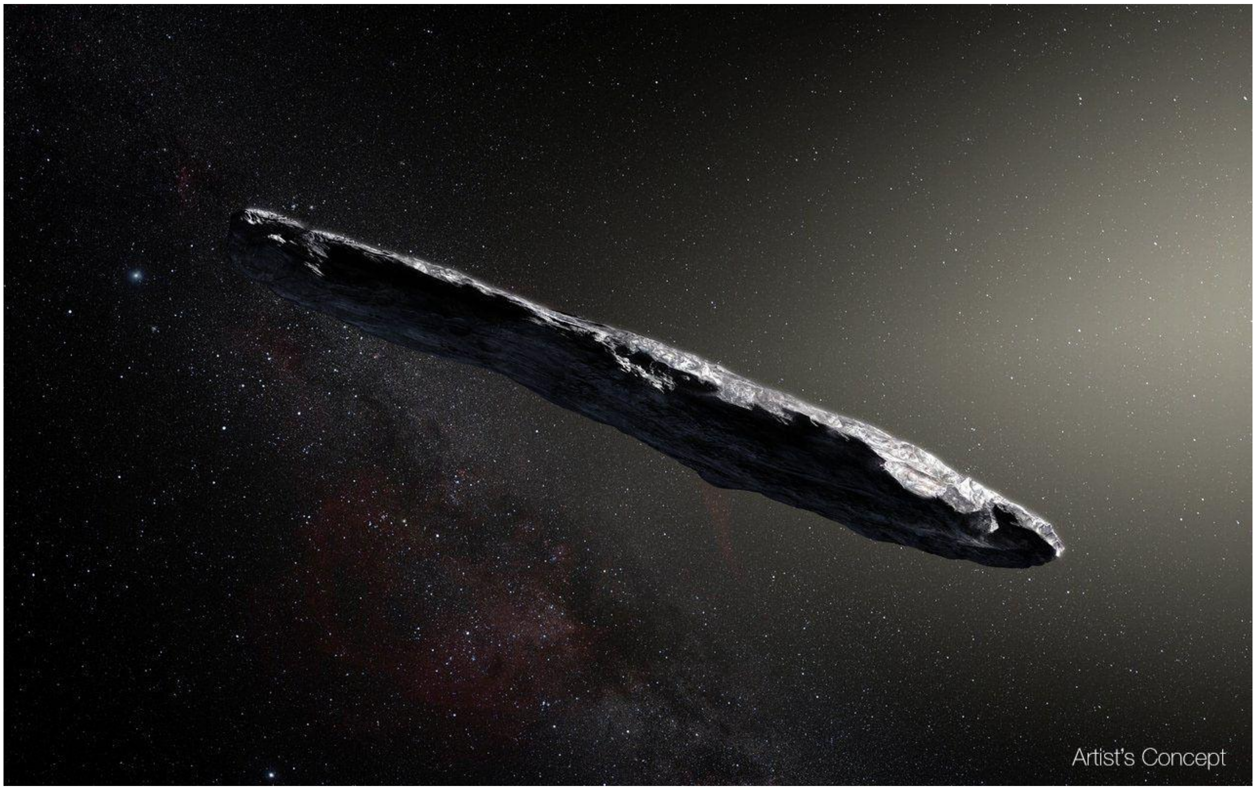
However, an upcoming mission is aiming to approach a comet directly from the Oort Cloud, rather than one that has made multiple orbits around the Sun. The Comet Interceptor mission, which has been recently selected by the European Space Agency, consists of many spacecraft that will identify and analyze a suitable target comet in close, after its launch and subsequent repositioning in a parking orbit.

Before Comet Interceptor is launched in 2029, the Vera Rubin Observatory, which is currently being built in Chile and will be finished in 2023, will start the search for long-period comets from the Oort Cloud. Opitom explains, *“This will allow us to send missions to comets coming from the Oort Cloud, and this is what the Comet Interceptor will do, even if it will not collect and bring back a sample.”*

Aforementioned Michele Bannister notes that, *“Studying comets up close offers a unique opportunity to monitor how they change as they're heated by the Sun when they come in close after eons in the deep freeze”*. Comets that are making their initial visits may possess valuable secrets. This approach could help address questions such as the size of the Oort Cloud and the extent of its connection to our solar system.

Numerous Interstellar Objects

'Oumuamua', the first interstellar object, posed more questions than answers when discovered near Earth. The mysterious nature of its appearance posed a challenge to understand, having been observed as it left the solar system. Oumuamua is neither a comet nor an asteroid, and remains a cosmic enigma, despite conventional explanations.



In contrast, Borisov, the second interstellar visitor, looked a lot like comets in our own solar system. Borisov, despite its hyperbolic orbit, displayed characteristics familiar to comets from the solar system. This encounter provided a rare chance to make direct comparisons between our solar system and its cosmic counterparts.

Research has revealed an intriguing reality, that our solar system's Oort cloud, an extensive reservoir of comets extending halfway to the nearest star, hosts more interstellar visitors than permanent residents. Comets from within the solar system dominate near Earth, and those from beyond our solar system are uncommon. This scarcity comes from observational biases that are influenced by our proximity to the sun. This gives us fresh insights into the solar system's relationship with its cosmic neighbors.

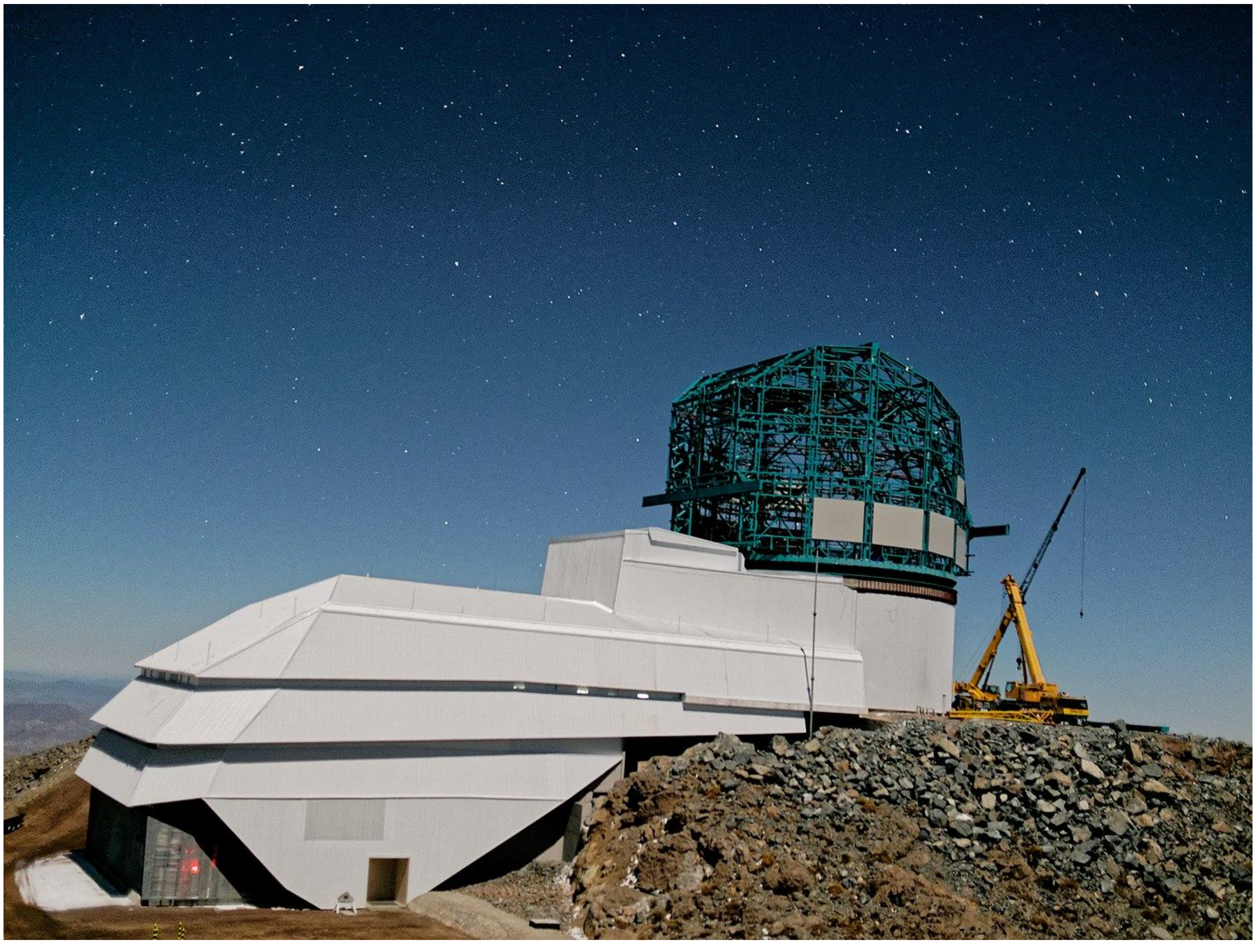

Borisov

Because of its gravitational pull, the Sun attracts local comets, while interstellar objects are rarely near it. Research indicates that there are more interstellar objects in the solar system's distant regions at any given time than local comets. This discovery will affect future observations and theories by encouraging searches for Oort cloud objects and challenging current theories about how planets form.

Starting in 2024, the Legacy Survey of Space and Time or LSST, on the Vera C. Rubin Observatory is expected to discover at least one interstellar object monthly, helping our understanding of their roots and planetary origins. The direct study of interstellar matter will provide exciting insights into the properties of these objects. The European Space Agency’s Comet Interceptor mission could sample interstellar objects like Borisov, provided the right conditions.

There is an interesting approach to searching for interstellar objects and even acquiring humanity's first samples of extraterrestrial matter directly from

Earth's surface. When objects enter the Earth’s atmosphere, they burn up because of air friction, which makes meteors. Finding these meteors is easier than searching in space, where you'd rely on reflected sunlight. Although the atmosphere provides a smaller search volume than space, the abundance of smaller interstellar objects makes hunting for interstellar meteors attractive.



Vera C. Rubin Observatory

Combining these findings with the LSSTs findings close to Earth, they could completely transform our perception of the solar system within its cosmic context. The ultimate goal is to find kilogram-sized or bigger meteorites, which could be the first pieces of interstellar matter that mankind has gotten. This could be achieved within a decade with a modest budget, by deploying a thousand globally distributed passive all-sky camera systems to patiently await these rare meteoroids.

Studying interstellar objects is a beautiful combination of various astrophysical fields, connecting planetary science with high-energy processes. It combines a variety of detection techniques, extending the scope of multi-messenger astronomy, as well as gravitational-wave and neutrino investigations. This approach could lead to new ideas about our place in the universe.

While researchers continue to piece together these intricate puzzle pieces to deepen our knowledge of the Oort Cloud and establish its existence, we can be certain of the truth when one of our spacecraft ventures into this mysterious, unexplored territory. If Voyager 1 can last another 300 years, humanity will have reached a new frontier.

So what do you think? What really is the Oort cloud? Is it as astronomically large as we think it is? Or is something else lurking in the shadows? Let us know in the comments below. If you like this video, a subscription to the channel and a like to this video would really help us. Thanks for watching!

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