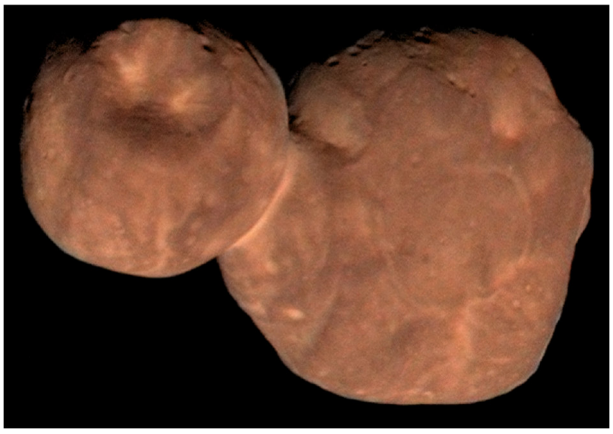
Trans-Neptunian Objects



Picture: Kuiper belt object 486958 Arrokoth, in images taken by the New Horizons spacecraft
Author: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute/Roman Tkachenko.
https://en.wikipedia.org/wiki/Trans-Neptunian_object#/media/File:UltimaThule_CA06_color_20190516.png

Transneptunian objects (abbreviated TNO) are all bodies that orbit the Sun outside the orbit of Neptune. For a long time Pluto was the only one of these objects that was known. With improved observation technology as well as by means of space probes always new objects were and are discovered. Most of these objects are located in the so-called Kuiper belt, named after the American astronomer Gerard Peter Kuiper. Kenneth Edgeworth and Kuiper predicted the existence of objects outside the orbit of Neptune. The discoveries of these new objects also led to the introduction of the new class of dwarf planets, because a lot of objects were found in this area which were very close to the size of Pluto and one did not want to introduce a flood of new planets. With this introduction, Pluto then lost its status as a planet. The dwarf planets, except Ceres, are all in orbits beyond Neptune. In addition, there are also many smaller objects that can be assigned to the minor planets or comets. This region is also called the outer astroid belt.
The Kuiper belt, which contains several tens of thousands of transneptunian objects, is an annular, relatively flat region extending near the ecliptic (plane of planetary orbits) at a distance of about 30 to 50 astronomical units (1 AU 150 mill. km). Objects in this region are called Kuiper belt objects (abbreviated KBO = kuiper belt object). A distinction is made as follows:

- Resonant KBOs (RKBOs) are objects moving on resonant orbits to Neptune (resonance = ratio of their orbital period to Neptune's orbital period). The best known objects are the Plutinos with a 2:3 resonance. Best known representative and eponym of these objects is Pluto. The Twotinos have, as their name already expresses, a 1:2 resonance. There are also 2:5, 3:5 and 4:7 resonances. One third of all Kuiper belt objects belong to this class. According to Kepler's third law, objects with the same orbital resonance have similarly sized semi-axes. However, other orbital elements, such as eccentricity,

may differ significantly. Their position parameters (inclination, length of the ascending node, and argument of the perihelion) are usually very different.

- Classical KBOs (cubewanos) are an even more numerous category. They have no orbital resonance and move in nearly circular orbits between 42 and 50 AU with orbital inclinations of up to 30°. The 1000 km objects Quaoar and Varuna belong to this group.
- Scattered KBOs have strongly elliptical orbits with perihelion distances (closest to the Sun) of close to 35 AU and aphelion distances (farthest from the Sun) of up to 100 AU. Up to now about 500 of these scattered KBOs are known.
- Detached objects have perihelion distances of more than 40 AU, which cannot be caused by Neptune's gravity alone. The cause of this special orbital shape could be passing stars or maybe a ninth planet orbiting the Sun outside the Kuiper belt.

Beside the objects of the Kuiper belt there are objects, which move their orbits around the sun far outside of the Kuiper belt. They are summarized under the term Sednoids. This group is named after the object Sedna, which is a candidate for the status of a dwarf planet. The Sednoids move on elongated ellipses, but are far from touching the hypotetic Oort Cloud. The origin of these orbits has not yet been determined. The similarity of their orbits may point to a larger, as yet undiscovered ninth planet. However, the exploration of the Sednoids is only at the beginning of the research. Probes to these objects will not be available in the next few years or decades because of the vast distance. A journey with a present-day rocket would take decades. Therefore, new propulsion systems leading to higher speeds would have to be developed first. One will have to rely on earth observation or telescopes in space.

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