= Makemake =

Makemake (minor @-@ planet designation 136472 Makemake) is a dwarf planet and perhaps the largest Kuiper belt object (KBO) in the classical population , with a diameter approximately two thirds that of Pluto . Makemake has one known satellite , S / 2015 (136472) 1 . Makemake ? s extremely low average temperature , about 30 K (? 243 @.@ 2 ° C) , means its surface is covered with methane , ethane , and possibly nitrogen ices .

Makemake was discovered on March 31 , 2005 , by a team led by Michael E. Brown , and announced on July 29 , 2005 . Initially , it was known as 2005 FY9 and later given the minor @-@ planet number 136472 . Makemake was recognized as a dwarf planet by the International Astronomical Union (IAU) in July 2008 . Its name derives from Makemake in the mythology of the Rapa Nui people of Easter Island .

= = History = =

= = = Discovery = = =

Makemake was discovered on March 31 , 2005 , by a team at the Palomar Observatory , led by Michael E. Brown , and was announced to the public on July 29 , 2005 . The team had planned to delay announcing their discoveries of the bright objects Makemake and Eris until further observations and calculations were complete , but announced them both on July 29 when the discovery of another large object they had been tracking , Haumea , was controversially announced on July 27 by a different team in Spain .

Despite its relative brightness (it is about a fifth as bright as Pluto) , Makemake was not discovered until well after many much fainter Kuiper belt objects . Most searches for minor planets are conducted relatively close to the ecliptic (the region of the sky that the Sun , Moon and planets appear to lie in , as seen from Earth) , due to the greater likelihood of finding objects there . It probably escaped detection during the earlier surveys due to its relatively high orbital inclination , and the fact that it was at its farthest distance from the ecliptic at the time of its discovery , in the northern constellation of Coma Berenices .

Besides Pluto , Makemake is the only other dwarf planet that was bright enough for Clyde Tombaugh to have possibly detected during his search for trans @-@ Neptunian planets around 1930 . At the time of Tombaugh 's survey , Makemake was only a few degrees from the ecliptic , near the border of Taurus and Auriga , at an apparent magnitude of 16 @.@ 0 . This position , however , was also very near the Milky Way , and Makemake would have been almost impossible to find against the dense background of stars . Tombaugh continued searching for some years after the discovery of Pluto , but he did not find Makemake or any other trans @-@ Neptunian objects .

= = = Name = = =

The provisional designation 2005 FY9 was given to Makemake when the discovery was made public . Before that , the discovery team used the codename " Easterbunny " for the object , because of its discovery shortly after Easter .

In July 2008 , in accordance with IAU rules for classical Kuiper belt objects , 2005 FY9 was given the name of a creator deity . The name of Makemake , the creator of humanity and god of fertility in the mythos of the Rapa Nui , the native people of Easter Island , was chosen in part to preserve the object 's connection with Easter .

= = Orbit and classification = =

As of December 2015 , Makemake is 52 @.@ 4 AU (7 @.@ 84 × 109 km) from the Sun , almost as far from the Sun as it ever reaches on its orbit . Makemake follows an orbit very similar to that of

Haumea : highly inclined at 29 ° and a moderate eccentricity of about 0 @.@ 16 . Nevertheless , Makemake 's orbit is slightly farther from the Sun in terms of both the semi @-@ major axis and perihelion . Its orbital period is nearly 310 years , more than Pluto 's 248 years and Haumea 's 283 years . Both Makemake and Haumea are currently far from the ecliptic ? the angular distance is almost 29 ° . Makemake is approaching its 2033 aphelion , whereas Haumea passed its aphelion in early 1992 .

Makemake is a classical Kuiper belt object , which means its orbit lies far enough from Neptune to remain stable over the age of the Solar System . Unlike plutinos , which can cross Neptune 's orbit due to their 2 : 3 resonance with the planet , the classical objects have perihelia further from the Sun , free from Neptune 's perturbation . Such objects have relatively low eccentricities (e below 0 @.@ 2) and orbit the Sun in much the same way the planets do . Makemake , however , is a member of the " dynamically hot " class of classical KBOs , meaning that it has a high inclination compared to others in its population . Makemake is , probably coincidentally , near the 11 : 6 resonance with Neptune .

= = Physical characteristics = =

= = = Brightness , size , and rotation = = =

Makemake is currently visually the second @-@ brightest Kuiper belt object after Pluto , having a March opposition apparent magnitude of 17 @.@ 0 in the constellation Coma Berenices . This is bright enough to be visible using a high @-@ end amateur telescope .

Combining the detection in infrared by the Spitzer Space Telescope and Herschel Space Telescope with the similarities of spectrum with Pluto yielded an estimated diameter from 1 @,@ 360 to 1 @,@ 480 km . From the 2011 stellar occultation by Makemake , its dimensions have been initially measured to be (1502 ± 45) × (1430 ± 9) km . However , this analysis of the occultation data was later reanalyzed , which led to the dimension estimate of (1434 + 48
? 18) × (1420 + 18
? 24 km) without a pole @-@ orientation constraint . This means that Makemake is slightly larger than that of Haumea , making it likely the fourth @-@ largest known trans @-@ Neptunian object after Pluto , Eris , and 2007 OR10 , though the error bars with the latter overlap . Makemake was the fourth dwarf planet recognized , because it has a bright V @-@ band absolute magnitude of ? 0 @.@ 44 . Makemake has a high geometrical albedo of 0 @.@ 81 + 0 @.@ 01
? 0 @.@ 02 .

The rotation period of Makemake is estimated at 7 @.@ 77 hours . Its lightcurve amplitude is small , only 0 @.@ 03 mag . This was thought to be due to Makemake currently being viewed pole on from Earth ; however , S / 2015 (136472) 1 's orbital plane (which is probably orbiting with little inclination relative to Makemake 's equator due to tides resulting from its rapid rotation) is edge @-@ on from Earth , implying that Makemake is really being viewed equator @-@ on .

= = = Spectra and surface = = =

Like Pluto , Makemake appears red in the visible spectrum , and significantly redder than the surface of Eris (see colour comparison of TNOs) . The near @-@ infrared spectrum is marked by the presence of the broad methane (CH4) absorption bands . Methane is observed also on Pluto and Eris , but its spectral signature is much weaker .

Spectral analysis of Makemake 's surface revealed that methane must be present in the form of large grains at least one centimetre in size . In addition to methane , large amounts of ethane and tholins as well as smaller amounts of ethylene , acetylene and high @-@ mass alkanes (like propane) may be present , most likely created by photolysis of methane by solar radiation . The tholins are probably responsible for the red color of the visible spectrum . Although evidence exists for the presence of nitrogen ice on its surface , at least mixed with other ices , there is nowhere near

the same level of nitrogen as on Pluto and Triton , where it composes more than 98 percent of the crust . The relative lack of nitrogen ice suggests that its supply of nitrogen has somehow been depleted over the age of the Solar System .

The far @-@ infrared (24 ? 70 ?m) and submillimeter (70 ? 500 ?m) photometry performed by Spitzer and Herschel telescopes revealed that the surface of Makemake is not homogeneous . Although the majority of it is covered by nitrogen and methane ices , where the albedo ranges from 78 to 90 % , there are small patches of dark terrain whose albedo is only 2 to 12 % , and that make up 3 ? 7 % of the surface . These studies were made before S / 2015 (136472) 1 was discovered ; thus , these small dark patches may actually have been the dark surface of the satellite rather than any actual surface features on Makemake .

= = = Atmosphere = = =

Makemake was expected to have an atmosphere similar to that of Pluto but with a lower surface pressure . However , on 23 April 2011 Makemake passed in front of an 18th @-@ magnitude star and abruptly blocked its light . The results showed that Makemake presently lacks a substantial atmosphere and placed an upper limit of 4 ? 12 nanobar on the pressure at its surface .

The presence of methane and possibly nitrogen suggests that Makemake could have a transient atmosphere similar to that of Pluto near its perihelion . Nitrogen , if present , will be the dominant component of it . The existence of an atmosphere also provides a natural explanation for the nitrogen depletion : because the gravity of Makemake is weaker than that of Pluto , Eris and Triton , a large amount of nitrogen was probably lost via atmospheric escape ; methane is lighter than nitrogen , but has significantly lower vapor pressure at temperatures prevalent at the surface of Makemake (32 ? 36 K) , which hinders its escape ; the result of this process is a higher relative abundance of methane . However , studies of Pluto 's atmosphere by New Horizons suggest that methane , not nitrogen , is the dominant escaping gas , suggesting that Makemake 's absence of nitrogen may be more complicated .

= = Satellites = =

On 26 April 2016 , astronomers using observations from the Hubble Space Telescope taken in April 2015 announced the discovery of a moon with a diameter of ~ 175 km (for an assumed albedo of 4 %) orbiting Makemake at a distance of ? 21 @,@ 000 km with a period of ? 12 days (the minimum values are those for a circular orbit ; the actual orbital eccentricity is unknown) . It was given the provisional name S / 2015 (136472) 1 .

Most other large trans @-@ Neptunian objects have at least one satellite : Eris has one , Haumea has two and Pluto has five , though 2007 OR10 has no known satellites . 10 % to 20 % of all trans @-@ Neptunian objects are expected to have one or more satellites . Because satellites offer a simple method to measure an object 's mass , Makemake 's satellite should lead to better estimates of its mass .

= = Exploration = =

It was calculated that a flyby mission to Makemake could take just over 16 years using a Jupiter gravity assist , based on a launch date of 21 August 2024 or 24 August 2036 . Makemake would be approximately 52 AU from the Sun when the spacecraft arrives .