EXOPLANETS

This visualisation shows more than 500 exoplanets discovered before October 2015 (about 1/4 of all exoplanets yet discovered), arranged according to their temperature and density, showcasing the incredible variety of the extraterrestrial worlds. Various known classes of exoplanets are shown on the graphic, such as super-earths, hot jupiters, hot neptunes, water worlds, gas dwarfs or superdense diamond planets. All visualisations are based on the estimated radius and temperature of the planet, however other factors, such as density, age or stellar metallicity were also taken into consideration. These visualisations were meant to be as accurate as possible, however the true nature of the portrayed exoplanets might turn out to be radically different. Nearly 2000 exoplanets have been discovered as of October 2005 in the Milky Way (most of them with the Kepler space telescope). It is estimated that there is at least one planet on average per star. Around 1 in 5 sun-like stars have at least one planet between 1 and 2 times the size of Earth in the habitable zone, putting the number of potentially habitable planets in the Milky Way to more than 20 billion. The closest confirmed exoplanet to the Solar System is Gliese 674 b, 14.8 light years away, however there are also unconfirmed candidate planets orbiting Tau Ceti and Alpha Centauri b.

In the year 1584, when the Italian monk Giordano Bruno said that there were "countless suns and countless earths all rotating around their suns," he was accused of heresy by the Catholic Church. But even in Bruno's time, the idea of a plurality of worlds was not completely new. As far back as in the ancient Greece, philosophers have speculated that other stellar systems might exist and that some even might harbor other forms of life. In the 16th century, when Copernicus discovered that our planet orbits the sun. His insight, reluctantly accepted in the subsequent centuries, changed Western thinking forever. In the beginning of the 20th century, Edwin Hubble, using what was then the largest telescope in the world, found that the small nebulae in the sky were in fact galaxiest located far outside our own galaxy, each containing hundreds of billions of stars. Hubble's observations proved that the number of stars that could house habitable planets is infathomable in number. However, almost the whole of 20th century went by without any convincing proof of planets around other stars. Several times, discoveries of such extrasolar planets were announced, only to be later dismissed as false.

Because planets were too small and distant to be observed directly, astronomers of the 20th century tried to prove their existence by analyzing their effects on the host star. During the late 1960s, astronomer Peter van de Kamp claimed to have detected two planets orbiting the Barnard's Star using this technique. However, subsequent observations failed to verify their existence. The first widely accepted discovery of an extrasolar planet came in the year 1993, when Dr. Alexander Wolszczan, a radio astronomer at Pennsylvania State University, reported what he called "unambiguous proof" of extrasolar planetary systems. Wolszczan had discovered two or three planet-sized objects orbiting a pulsar, a superdense, rapidly spinning remnant of a star gone supernova. Wolszczan made his discovery by observing regular variations in the pulsar's rapidly pulsing radio signal, indicating the planets' complex gravitational effects on the dead star. The first discovery of a planet orbiting a medium-sized star similar to the sun came in 1995. The Swiss team of Michel Mayor and Didier Queloz announced a discovery of a hot world located close to the star 51 Pegasi. The planet was at least half the mass of Jupiter and no more than twice its mass. It was observed indirectly, using the radial velocity method. By the end of the 20th century, several dozen other exoplanets had been discovered, many the result of years of observation of nearby stars. Significant improvements in spectrometers, telescope sensors and software discerning the fluctuations in starlight and the stellar wobbling motion caused by nearby orbiting planets have enabled an abrupt surge of exoplanet discoveries in the recent years. The French CoRoT mission, launched in 2006, was the first space mission dedicated solely to exoplanets, searching for planets that passed in front of their host stars. It has contributed dozens of confirmed exoplanets to those already discovered, including some of the most well-studied planets outside our solar system. First NASA exoplanet mission, Kepler Space Telescope, launched in 2009 and quickly became the most succesful exoplanet-focused mission in history. Among its many discoveries, Kepler has found several hundred terrestrial planets, some of them in the habitable zones of their stars, many multi-planet solar systems and also numerous hot jupiters of incredibly low density. As it continues its mission, it's likely that Kepler will find even more fascinating exoplanets, some of them possibly harboring life.

Being by far the easiest to discover, gas giant class planets form a large portion of known exoplanets. PSR B1620-26 b, the first exoplanet to be discovered also belongs into this class.

Although both gas planets in the solar system (Saturn and Jupiter) are located in the remote and cold regions, with cloud layers mostly composed of ammonia, most known gas planets belong to the class of "Hot Jupiters". Many of them orbit much closer to their parent stars than the planet Mercury is to the Sun, and their median temperature can reach thousands of kelvins, causing them to have cloud layers composed of alkali metals, silicon or even iron. Such hot gas giants are often also known as "puffy planets", as the intense heat from the star can inflate their atmosphere and decrease their density far below that of Saturn.

For gas giants with atmospheric temperatures similar to those of Jupiter there exists a maximum radius that those planets can attain, slightly larger than that of Jupiter, which occurs when their mass reaches a few Jupiter-masses. Adding any further mass beyond this point causes their radius to shrink and their density to sharply increase. Giant gas giants with over ±10 jupiter masses are often no longer considered to be planets, but belong to a distinct class of brown dwarfs, also known as "failed stars".

Not all gaseous planets are giants, however, there also exists a class of smaller gaseous planets, called "gas dwarfs". These planets are usually smaller than Neptune, sometimes even smaller than the Earth, and are composed mostly of gaseous matter. Such planets are thought to be quite rare in the universe, occurring only in very distant orbits and in very low-mass stars.

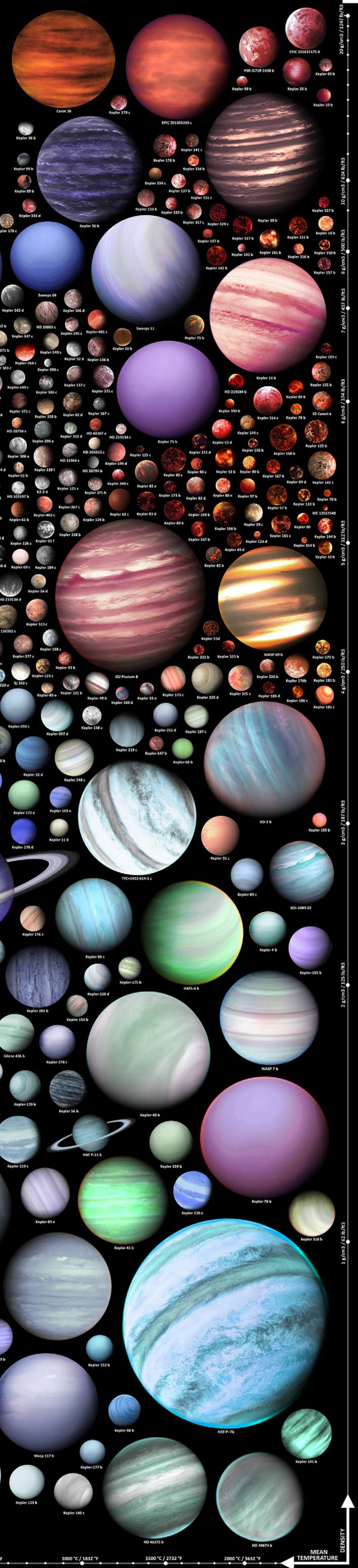
Closest equivalent to a gas dwarf in the solar system would be Saturn's moon Titan, with atmosphere much thicker and heavier than that of Earth. Hypothetical ninth planet of the Solar System that could be located at the edge of the Kuiper Belt might also belong into this class.

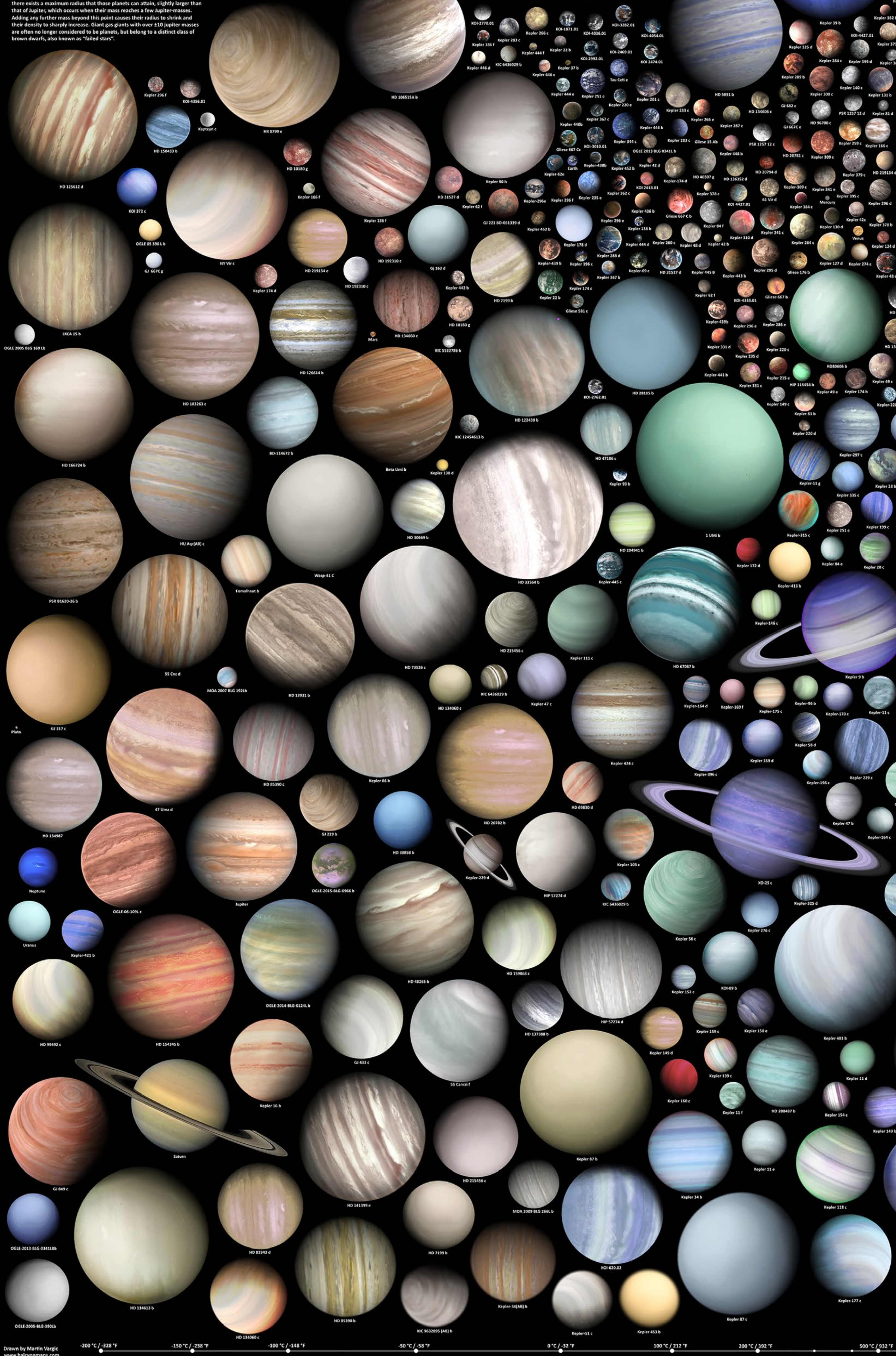
Ice giants are similar to gas giants in that they don't have any solid surface, and are mostly composed of liquids. However, they are not composed mostly of hydrogen and helium, as it is the case with gas giants, but instead of heavier elements, such as oxygen, nitrogen or carbon. Though their upper atmosphere is usually composed of hydrogen and helium, their lower layers are composed mostly of exotic forms of water, ammonia, carbohydrates, carbon dioxide and nitrogen oxides. Similar to gas giants, most ice giants are also presumed to have a large solid core composed of ices and rock.

There are two ice giants in the solar system, Uranus and Neptune, however there are probably a lot more orbiting other stars. Most known ice giant exoplanets belong to the class of "hot neptunes", orbiting very close to their parent stars, and their temperature often reaches thousands of kelvins.

Many of the newly discovered exoplanets belong to othe class of terrestrial (rocky) planets, and are likely composed mostly of silicates and heavy metals. These are the planets most similar to Earth, and many of them are very likely to have oceans of liquid water, enabling the possibility that they bear life.

Most of the known rocky planets belong to the class of "super-earths", many times heavier than the Earth and other rocky planets in the Solar System. Various other classes of rocky planets exist, based chiefly on their composition and temperature, such as lava planets - molten planets that often orbit their parent star in less than a week, water worlds - planets completely covered by an ocean of liquid water, carbon planets - planets made chiefly out of carbon, with carbohydrate oceans, graphite mountains and diamond cores or cannonball planets - planets made almost entirely out of iron and other metals.





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