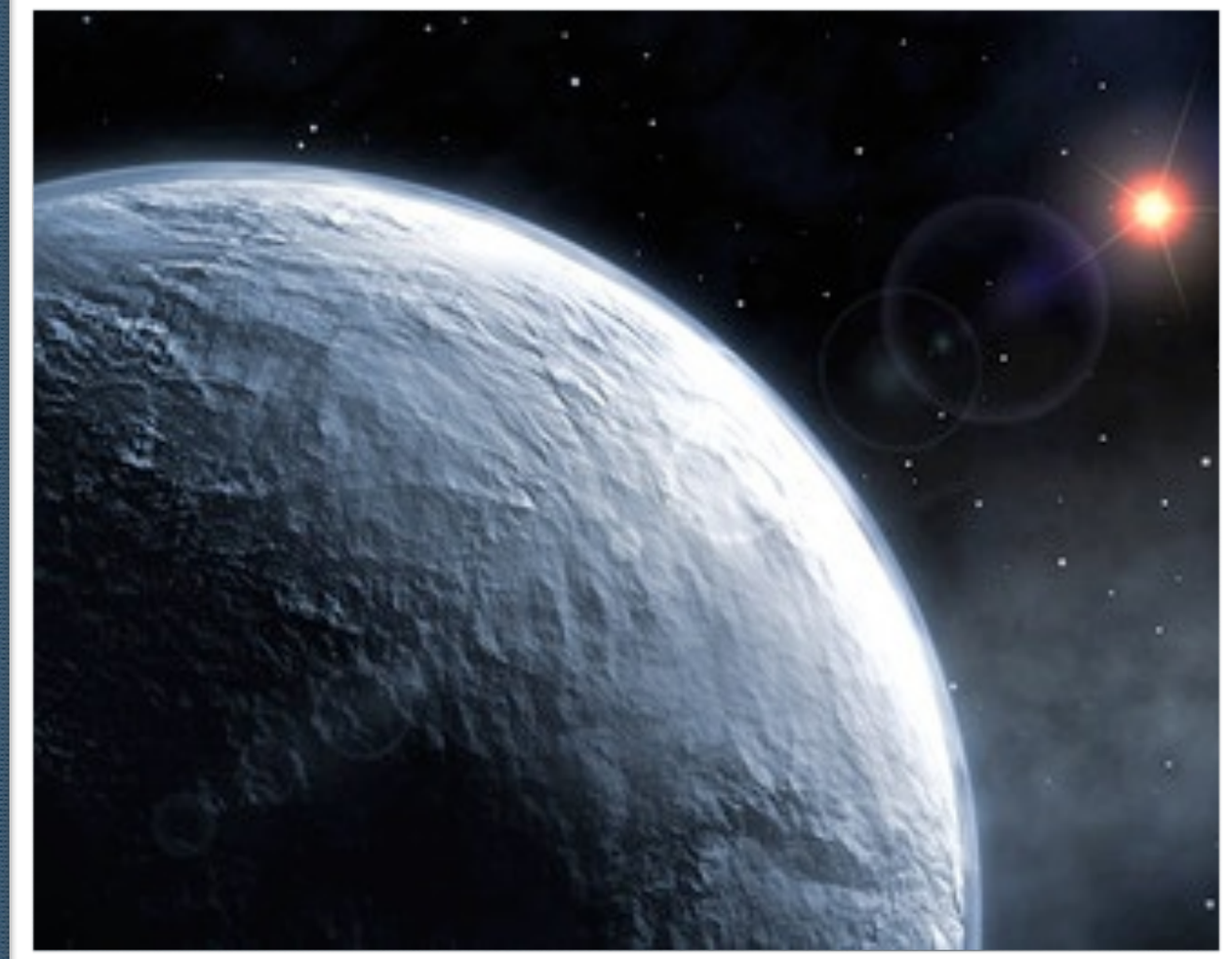
Tessmann Planetarium



A Brief Guide to Exoplanets

Planets Around Other Stars

EXOPLANETS

Planets Around Other Stars

Before 1990, no planets were known outside of our solar system. We did not have the methods to discover these planets yet. But in the nearly 25 years since then, we have discovered at least 1800 planets outside of our system – and the count seems to be increasing almost every day. We call these worlds exoplanets. These worlds have been discovered with the help of new and powerful telescopes, both on Earth and in space, including the Hubble Space Telescope (HST) and most notably, the Kepler spacecraft, that was specifically designed to hunt for new planets.

Methods of Discovery

You're probably wondering how we discover discover new planets. There are several methods, but basically, there are 3 main ways .

The Wobble Method

One method is to look for wobbles in the motions of stars. If a star has planets, the pull of gravity between the planets and the star often causes the star to wobble. This method is very tricky because the wobbles are so slight. So observations have to be carried out very carefully and precisely.

The Eclipse (or Transit) Method

The second and more successful method is to look for an eclipse. This is similar to an eclipse that we observe from the Earth when the moon passes in front of our Sun and blocks all or some of its light. When planets pass in front of distant stars (known as transits), they do block out some of the light – but a very small amount. If the planet passes in front of a star and it happens in our line of sight, Kepler and other powerful telescopes can measure the small drop in brightness of the star – sometimes a reduction as little as 1% of the brightness.

When the Kepler detects a drop in brightness repeatedly from a star, astronomers can go back and study the star using other telescopes and methods. They make predictions about the orbit of the planet or planets orbiting the star. For example, how long does the orbit take? Then they can see if the star's brightness decreases during its next orbit. Eventually they can confirm if a star has one or more planets.

Some planets are close to their stars, especially Super Jupiters. Their orbits are very short and the drop in brightness can be observed over a few weeks or months. Planets that have orbits that take years to complete take a lot more time to confirm. But some planets may have orbits of hundreds of years, for example, Neptune, in our own solar system, takes 186 years to orbit our sun. In such cases, we can't wait for these planets to make a complete orbit.

Photography

A brand new method is now being used. Cameras have recently been developed that block out the light of a star. They have enough resolution to capture an image of one or more planets around the blocked star. One such camera, called the Gemini Planet Imager, is being used with telescopes in South America. Other specialized cameras are VLT Sphere and SCExAO.

Kepler Spacecraft

Types of Planets

At one time we put planets in one of three categories: rocky, gas giants and ice planets. Later, we added dwarf planets as a category. But the discovery of all these new planets has prompted us to create new categories.

Super Jupiters

One group of observed planets is known as Super Jupiters. These are perhaps the easiest to discover because they are so big. These worlds can be up to 10 times the size of Jupiter; if they got much bigger, they would actually be considered stars called brown dwarfs.

Brown dwarfs are stars of low temperature and mass. They are very difficult to observe with optical telescopes, because they are smaller than other stars and don't give off much light.

Super Jupiters, like our Jupiter, are primarily made out of hydrogen gas, and are often called gas giants. Super Jupiters fall into two categories – hot Jupiters and warm Jupiters.

Warm Super Jupiters

Warm Jupiter are a lot like our own solar system's Jupiter. They are significantly distant from their star and are often found in planetary systems with many other planets.

Hot Super Jupiters

Hot Super Jupiters orbit, much like our planet Mercury, very close to their star. But unlike warm Jupiters, they are most likely (but not always) the only planet in the system. One theory is that they started life farther away from their star, but as time went on, they moved closer to the star. As they moved, other planets in the system were flung away from the star due to gravity. They are the last planets left in a game of cosmic musical chairs. They are considered hot because they are very close to their star. We have even found one world that is so close to its star that it is slowly evaporating before our very eyes.

Neptune Class Planets

Another common type of planet is called the Neptune Class. These planets are also gas giants, but smaller than Super Jupiters. We have discovered a lot of Neptune class planets recently as they are large and easier to pick out then Earth-sized planets.

Super Earths and Earth-sized Planets

The category we are the most interested includes planets that are similar to our own planet Earth. These are rocky planets and some may even have atmospheres and water. These planets may be the size of our planet, or up to four or five times larger than the Earth's diameter. We are searching for these worlds because these are the ones that have the best chance for supporting life.

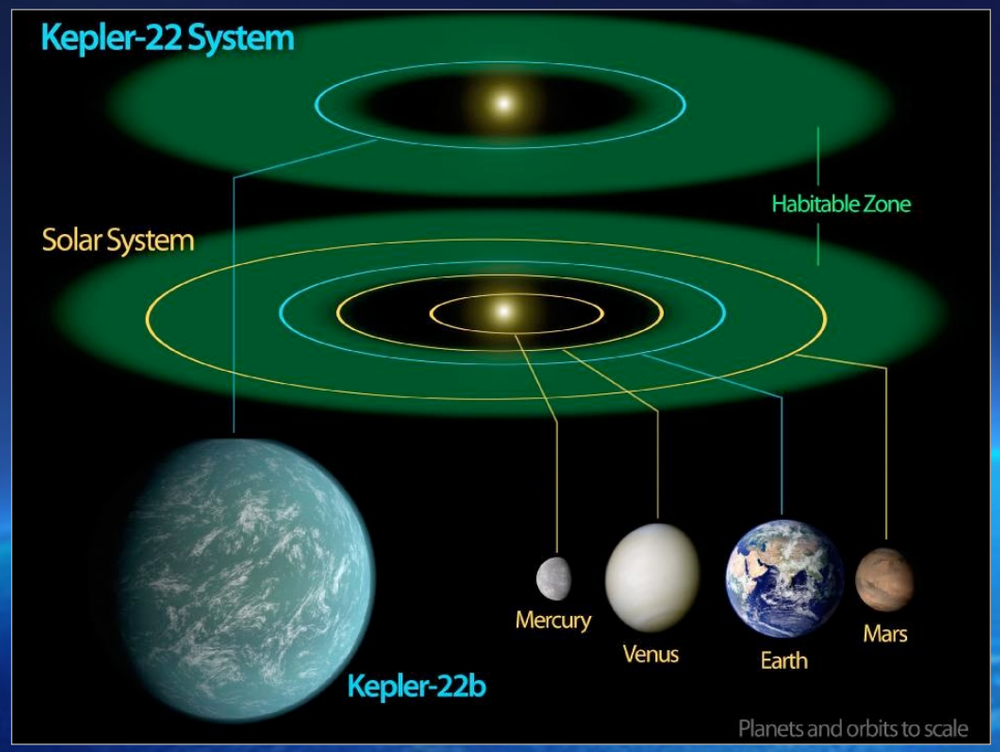
Because they aren't very large, it's difficult to find planets that are the same size as the Earth, but we have found some that are just a bit bigger – they have diameters that are 1.5 and 1.7 times larger than our world.

We have discovered a number of super Earths so far. Two planets circle a star named Kepler 62 that are right in the middle of the "Goldilocks Zone." Perhaps there is life on one or both of these worlds.

But have we found a planet that is similar to our Earth, one that might support life? Well, before we answer that question, we need to consider where we might find a world like this. So we need to discuss the "Goldilocks Zone."

The Goldilocks Zone

Around stars that might be able to support life, there is an area that gives the best chance for life to exist. It is an area that is not too hot and not too cold, but is just right—just like the story of Goldilocks and the Three Bears. So we call this area the Goldilocks zone. The temperature in this area is "just right" to allow water to exist. We believe that water must be present for life to exist. The zone exists around stars that have a similar size of our sun, and even around smaller stars called red dwarfs. Around red dwarfs, the Goldilocks Zone is much closer to the star, because these stars are cooler and smaller than our sun.



Comparison of Goldilocks (Habitable) Zones

Kepler 186f:

A Planet That Might Support Life

On April 17, 2014, NASA made an historic announcement – the first discovery of an Earth-sized planet orbiting in the Goldilocks Zone of another star. The planet may have the potential for life to exist.

The world circles a red dwarf star in the constellation of Cygnus and is about 500 light years away. The planet is known as Kepler 186f and is about 10% larger than the Earth. It is the outermost planets in the 186 system and takes 130 days to orbit its star.

Red dwarfs are known as M class stars. They are smaller, less bright and typically much cooler than our Sun, which is a "G" class star. Kepler 186 is one of the hotter red dwarfs known. 186f is about the same distance from its star as Mercury is from our Sun. Because Kepler 186 is much smaller than our sun, 186f is in the Goldilocks Zone where water, and perhaps life, can exist. Photosynthesis may be possible on 186f. Photosynthesis is the way plants change sunlight into oxygen and other chemicals that are necessary for life to exist on a planet.

The discovery of 186f demonstrates that Earth-sized planets can exist in habitable zones of red dwarf stars. About 7 out of 10 stars in our galaxy, as well as most of our Sun's nearest neighbors, are red dwarfs. Planets around M class stars may be the most common type of habitable worlds in the universe.

Sub Earths

Sub Earths are also rocky planets and are smaller than the Earth. Mars and Mercury are sub Earths. Because they are so small, we have come across only a few of these exoplanets.

Dwarf planets

A few years ago, everyone was upset when Pluto was "demoted" from a planet to a dwarf planet. At the time, creating a new category of planets didn't seem like a popular idea. However, it is now making a lot more sense as we create more and more new categories of planets to keep up with all our discoveries.

Dwarf planets are being discovered because we have created newer and more powerful telescopes. Since the beginning of the 21st century, we developed telescopes that could discern new worlds out past the frozen confines of Pluto. Scientists made observations and studies of these new worlds and decided to create a brand new category for them.

There was precedent for this. In the 19th century, a new category was created when the best new telescopes of that time began to discover asteroids. At first they called these minor planets. After a while, they realized that asteroids came in all sorts of shapes and sizes – and weren't really planets at all.

And so it is with dwarf planets. There may be as many as 40 of these frozen worlds out past Pluto, and maybe even a lot more than that. Despite our advances in telescopes, they still aren't that easy to spot.

A dwarf planet must be round, or nearly round. They need to have enough gravity to clear out some of the area in their orbits. This is why Ceres the asteroid is considered a dwarf planet. It is the only round asteroid.

However, the definition of a dwarf planet may be challenged as we learn more of Pluto when the New Horizons spacecraft reaches this icy world in 2015.We have spotted a lot of moons and debris around Pluto. It may not have enough gravity to clear out its surroundings.

Exotic Planets

Protoplanets

Some worlds are failed planets. They may have started out as planets, but some catastrophic event changed the course of their growth. The asteroid Vesta falls into the category. NASA's Dawn spacecraft orbited Vesta recently. Dawn discovered that Vesta must have been struck by a large object early in its history, breaking it apart. Vesta might have become the ninth planet in our solar system, but now is now considered a protoplanet.

Tatooine Planets

In the original Star Wars movie, Luke Skywalker look at the sunset on his home world of Tatooine, and sees two suns in the sky. In other words, his planet orbits the two suns. You might be interested to know that at least four planets have been discovered that are "Tatooines"so far. A two star system is sometimes referred to as a binary star system.

Super Saturn?

One planet has been discovered that seems to have gigantic rings around it. Another possibility is that it is a micro-solar system. It will take a lot more observations to figure out how to classify this unusual world.

Waterworlds and Diamond Planets

Recently scientists have discovered a planet that seems to be entirely made up of water. Wonder what kind of life might evolve on a world like this?

Some astronomers also believe that there are planets that are made up of diamonds! Diamonds are made of carbon, and there's a great deal of carbon in the universe.

What Else is Out There?

Using the Kepler spacecraft and other telescopes, we have discovered almost 1800 planets and another 3600 candidates that may be confirmed as planets some day. Other telescopes have also discovered exoplanets, for a total of. We have been surprised at the variety of planets we have discovered. Who knows what other sort of planets we may come across someday.

And here's an interesting fact: We have not yet discovered one other planetary system that is like our own. At one time, we thought most planetary systems might be similar to ours – rocky planets near the sun, a few gas giants father away and then a realm of icy worlds in the far reaches. But it seems like each time we turn our telescopes toward another star, we seem to find something brand new. That's one of the reasons it is so exciting to study the universe.

Solar System or Planetary System?

While we are talking about our solar system, you might think that any star that has one or more orbiting planets is called a solar system. Technically speaking, the only solar system is our own. The Sun is sometimes known as Sol. So SOLar system specifically refers to our own system. All other systems should be referred to as planetary systems.

Is It Really a Planet?

Every so often, as a careful study is made of a planetary candidate, it is discovered that it is not a planet at all. Recently, we received data that seemed to point to the discovery of a new planet. It turns out that the data came from large, disruptive sunspots on a star.

Each year, we fine tune our methods and equipment. This means we will update our findings. Some discoveries of planetary candidates may not be what they seem. But by careful studies, we discover new forces at work in space – and those discoveries help us find new ways to hunt for planets.

Keep in mind we are studying stars and planets that are unimaginably far away. It is actually pretty amazing that we can learn anything at all. We are pushing the boundaries of knowledge itself. We're bound to make mistakes and miscalculations. But that's ok. That's how it is with science. We will use what we learn from both our discoveries and mistakes to help better understand the nature of the cosmos.

"There are many hypotheses in science which are wrong. That's perfectly all right: it's the aperture to finding out what's right. Science is a self-correcting process." – Carl Sagan

"Anyone who has never made a mistake has never tried anything new." – Einstein

"Test ideas by experiments and observations. Build on those ideas that pass the test. Reject the ones that fail. Follow the evidence wherever it leads, and question everything. Accept these terms, and the cosmos is yours." – Neil deGrasse Tyson

Exoplanet Factoids

Based on the findings of the Kepler Spacecraft mission, scientists currently believe that as many as 40 billion Earth-sized exoplanets orbit in the Goldilocks zones of stars in our Milky Way galaxy. Most stars in the Milky Way appear to have at least one planet in orbit about them.

An exoplanet may be circling Alpha Centauri B. If so, it would be the nearest exoplanet to our own solar system. Alpha Centauri B is a little over 4 light-years away from us and the Alpha Centauri system stars are our nearest neighbors. However, this has not yet been confirmed and some scientists dispute this discovery. The nearest confirmed exoplanet is 12 light years away.

Currently most of the confirmed exoplanets are Super Jupiters – they are easier to find because of their size. But evidence is mounting that most exoplanets are between the size of the Earth and Neptune.

The smallest mass of a discovered planet so far is for PSR B1257+12 A. It only has about twice the mass of our Moon. DENIS-P J082303.1-491201 b has the most mass and is perhaps 29 times the mass of Jupiter. However, it is possible it is not a planet at all, but a brown dwarf star instead. Scientists have not yet agreed on how large and massive a planet can be before it is considered a brown dwarf star (the smallest type of star).

Exoplanet Links

As information about exoplanets is growing so quickly, most information about exoplanets is found on-line and is updated almost daily. Just type "exoplanets" or related terms into a search engine such as Google. Keep an eye out for the frequent news stories that pop up on this subject. The following are just a few of many sites about exoplanets:

http://kepler.nasa.gov/

(and click the "education" panel on the site for cool activities)

http://www.almaobservatory.org/en/visuals/images (click "astronomy")

http://www.keckobservatory.org/

http://exoplanets.org/rpf.html

http://www.exoplanets.org/

For a list of exoplanet extremes:

http://en.wikipedia.org/wiki/List_of_exoplanet_extremes

An excellent app is available for Apple and Mac users called Exoplanet.

Information in this guide was researched from various NASA and observatory sites, news articles and Wikipedia.

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