Kepler-22b, The Planet That Could Support Life (KePlCoSupLi)

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Romania,

February 2022

ABSTRACT

Man has always been wanted by knowledge. Technology is rapidly evolving and allows it to explore the most remote corners of the universe. The discovery of the first exoplanets was an important achievement for Astronomy, and in recent years researchers have been able to identify more than 4,000 such bodies. The confirmation of the existence of other planets outside the Solar System has opened new leads related to the search for places in the universe that could support life as we know it or even extraterrestrial. The Kepler Space Telescope has made it possible to collect vital information for researchers. Planet Kepler 22b was the first exoplanet to be named Earth 2.0.

1. Introduction

For a long time, astronomers believed that our Solar System is unique in its own way. In 1988 the first extrasolar planet was detected around the star Gamma Cephei, by Canadian astronomers Bruce Campbell, G. A. H. Walker and Stephenson Yang. From that moment all the planets discovered outside our system, became known as exoplanets. The American astronomers have spent the past few years searching the Milky Way for planets that resemble Earth and that could host extraterrestrial life forms. Other planetary systems besides our own are like distant cities whose lights we can see flickering, but whose streets we cannot walk through. But by studying those lights, we can learn how stars and planets interact to form their own ecosystems and give rise to habitats that are life- friendly.

This is an important step in the discovery of other forms of life in the universe.

Since the 1990s, scientists have found several new planets a year, but now, with the help of technology, they are discovered almost every day.

NASA launched the Kepler telescope on March 5, 2009, from Cap Canaveral, Florida, aboard a Delta II rocket, marking the first mission to search for planets outside our solar system that are similar to Earth and could support life. Planets must be as solid as Earth, orbiting stars similar to our sun, not too far away, but not too close, so that temperatures allow liquid water to remain on the surface, an essential condition for the development of life. The NASA probe has been incredibly successful, discovering nearly 1,000 confirmed planets - more than half of the total - out of a total of 3,200 "candidates".

Of the 43,000 stars around which Kepler searches for Earth-like planets, two-thirds appear to be as friendly and non-violent as our Sun, the researchers say, and also added that there is a good chance that

other Earth-like planets will be larger. In the previous two decades of searching before Kepler, only 400 planets had been discovered.

Agency officials announced on October 30, 2018 that the Kepler telescope had run out of fuel. The planet hunter Space Telescope has discovered thousands of alien worlds around distant stars since its launch in 2009.

Kepler showed us that the planets are very widespread and incredibly diverse, the scientist Jessie Dotson from NASA's Ames Research Center in Moffett Field, California, told Space.com.

2. How Kepler-22b was discovered

The Kepler Space Telescope was designed to observe thousands of stars, measuring the smallest changes in brightness over time. If a planet passes in front of a star, we see a small decrease in its brightness as the Planet covers it. The star darkens, and this depends on the physical size of the planet. There are a number of phenomena that can cause the brightness to drop, so the Kepler team would have to do further research to make sure they saw a planet. This normally involves waiting for the planet to bypass its star three times. If three decreases in brightness intensity are observed regularly, it is possible that it is a planet orbiting that Star. This is one of the most used techniques for the discovery of exoplanets. It is useful when the Kepler telescope discovers a point in the brightness of a star for a short period of time. The point of darkness can be explained by the fact that the planet, surrounding the star passed for a short time between the star and the Earth.

A second method, called radial velocity, measures the displacement of a star in the presence of an orbiting gravitational field (a planet). The planet's gravity causes its sun to increase its apparent size. When the planet moves away from the star, the light coming from it becomes redder, and when it approaches the light becomes bluer. Astronomers can detect this change in the light of a star, and the greater the change, the more massive the planet must be.

By combining these two techniques, scientists gain insight into the nature of exoplanets. For example, if a planet has twice the mass of the Earth, but the same volume, it must be very dense and therefore Rocky. But if a planet with the mass of the Earth has 10 times the volume of our planet, it has a low density, like a small gas giant.

In the case of Kepler-22b and similar systems, the researchers made a whole host of other ground observations, plus observations *of* one of the planet's transitions in front of its host star with the Spitzer infrared space telescope. Some simulations have been carried out that help eliminate false positive Astrophysical scenarios. This simulation is so complex that it requires the use of one of the fastest supercomputers in the world, which is operated by NASA.

Kepler-22b was the first of the planets discovered by the Kepler telescope. The first transit of the host star by the planet Kepler 22b was detected in May 2009. The second Transit was observed by the Spitzer telescope in March 2010, and the third was observed again by the Kepler telescope in December 2010. A confirmation of the planet's existence came after the fourth Transit, which lasted 7.4 hours and was observed by Spitzer in October 2011. NASA first presented Kepler-22b as part of a set of 54 habitable planet candidates in February 2011, before the planet's existence was officially confirmed. All these planets were found by the Kepler Space Telescope. The telescope searches for alien worlds by measuring decreases in the luminous intensity of the parent star as the planet approaches the star (in geocentric system). By December 2011, astronomers were able to confirm the existence of Kepler-22b , because scientists published about it in The Astrophysical Journal. More details about Kepler 22b were announced as part of a larger press conference. At the conference, NASA announced that the Kepler telescope had found more

than 1,000 new exoplanet candidates. (by June 2017, Kepler had discovered more than 4,000 planets and potential planets.)

When astronomers discover new objects, they usually give them fairly accurate but rather boring names. Kepler-22b is no exception. Suzanne Aigrain, who was president of NASA at the time the discovery was announced, explains the jargon:

First of all,"b" means that it is the first planetary candidate found around that target (not the second, as you might guess). By convention, when we find a group of two or more stars and / or planets orbiting each other, we label the stars using capital letters (A, B, C, etc) and planets using lowercase letters. The letter " A " always refers to the most massive star in the system and is often omitted, especially in cases where there are no other known stars in the system, as in the case of Kepler 22. The letters for planets always start at" b " because we have never had a case where a planet is the most massive object in the system."

3. Characteristics of the planet Kepler 22 b

Kepler-22b has an estimated mass of 36 Earth masses and a radius 2.38 times that of Earth, making it a Super-Earth. "Radius is the distance from the surface of a sphere to its center. That means Kepler-22b is bigger than our planet, but much smaller than the giants Jupiter and Saturn. Her discovery was reported in the Kepler input Catalog as KIC10593626 (Kepler-22) at RA=19h 16m 52.2 s and Dec=+47°53' 4.2". All information needed to study Kepler-22b is available in the multiple Mission Archive at Space Telescope Science Institute (MAST).

Kepler-22b is located 587.10 light years away in the constellation Cygnus. It has an orbital period of 289.8623 days, the semimajor axis being 0.849 AU, Kepler being found in the habitable zone of its host star. The habitable zone is the region where liquid water could exist on the surface of a planet. Liquid water is a key ingredient for life, so planets found in this area are more likely to be habitable worlds. When researching an exoplanet to decide whether or not it may have conditions suitable for life, there are a few things to consider. For life to exist, there must be a liquid medium in which different molecules can interact with each other (water is usually considered the most likely liquid medium to give rise to life, since it is liquid for a wide range of warm temperatures), and for a liquid medium to exist on a planet, it must exist in the habitable zone of its star. Kepler appears to be a predominantly oceanic planet rather than a rocky, Earth-like composition. But scientists are not sure if Kepler-22b is terrestrial, gaseous or liquid, mostly because of its large size, but its discovery is one step closer to finding Earth-like planets.

One of the other determining factors, to be a habitable planet, is the temperature of the planet. In addition to this, temperature and pressure are decisive in the states of aggregation of substances, and water is one of the necessities of life. One of the decisive factors for the temperature of a planet is the albedo, or level of reflectivity. A totally white planet has an albedo of 1, which means that all the light that reaches the surface of the planet is reflected back into space, and a totally black planet has an albedo of 0, where all the light is absorbed by the planet.

All planets are somewhere on this range, and generally as a planet's albedo approaches 1, the planet will become colder because less and less light is absorbed by the surface. The problem lies in the difficulty of accurately determining the temperature or albedo of such a distant exoplanet. Estimates for Kepler-22b's temperature are around 262K, using this value and inserting it into the equation:

$$T_{eq} = 255K \frac{L(1-A)^{1/4}}{\sqrt{D}}$$

we can estimate the albedo of the exoplanet, where L is the luminosity of the host star expressed in solar luminosities, A is the albedo of the planet, and D is the distance at which the planet orbits the star.

For Kepler-22b to have this temperature of 262k, a fairly moderate temperature, probably capable of allowing life, the albedo must be 0.07. So, based on this temperature estimate, Kepler - 22b, is a very dark planet that absorbs most of the light coming towards it. Note that this albedo is the result of an estimated temperature, so we cannot be sure that it accurately describes the conditions on Kepler-22b. It is worth to observe that planets with a lower albedo do not reflect much light, so they are difficult to find by direct measurements. However, most exoplanets are discovered using indirect techniques, and Kepler-22b was no exception.

The atmosphere is of integral importance for the habitability of a planet, as it helps determine the pressure on the planet's surface. Think about what the Earth's atmosphere does for us: it provides us with breathable oxygen, protects us from the harsh radiation of the sun, maintains an optimal temperature through the greenhouse effect, etc.the many benefits of an atmosphere are obvious, and it could even be safe to say that if Kepler-22b had an optimal atmosphere and with the right composition, there could be life on the planet. However, we do not have a real way to estimate what the atmosphere is like on the planet, and we also have no way to determine the composition of the planet. As a result, all our estimates of the temperature and other factors of Kepler-22b are really just estimates.

Researchers know that Kepler-22b has an 89,764 degree sexagesimal inclination just like Uranus, meaning that its North and South Poles are alternately bathed in sunlight and covered in darkness for half a year.

NASA's Kepler mission site estimates the mass at between 36 and 124 times the mass of Earth, while the Planetary Habitability Laboratory estimates it to be 6.36 times that of Earth, with a radius 2.1 times greater . Given the range of possible masses between 6.36 M amplitudes and 124 M amplitudes (in these cases, the most likely mass is always the lowest), it is also easy to obtain the range of possible gravity at the surface of the exoplanet, from the highest probable value of 1.11 g (11.08 m/s2 - a value very similar to the terrestrial one - assuming a mass of 6.36 M horizontals) to the very high and improbable value of 21.5 g (211 m/s2 , assuming a mass of 124 m). Subsequent studies, however, suggested a maximum mass of 53 times that of Earth and ruled out the presence of exoluns with mass greater than 0.5 times the mass of Planet Earth. However, it is possible to make assumptions based on known data. If the planet was composed of the same elements that make up the Earth, distributed in the same proportions, then it would have a mass of 13.8 M (and a surface weight of 2.4 g). If the planet had the same density as water, it would "weigh" just 2.5 M (and have a surface weight of just 0.43 g).

Since the diameter is 2.4 times that of the Earth, it is possible that it has a different composition than that of the Earth. One of the most plausible hypotheses is that it could be an oceanic planet, formed by a rocky core surrounded by an extensive mantle of ice and water on which a vast surface ocean extends.

“The key driver of an exoplanet's local environment is its host star. This influences the equilibrium temperature of the exoplanet, defining the habitable zone where liquid water could exist on the planet's surface. The host star of Kepler-22b is slightly colder than the sun. It belongs to the same class as our Sun, called Type G, although it is slightly smaller, less massive and colder. It has an effective temperature of 5,518 K and shines with 0.79 solar luminosities (solar luminosities). The distance between Kepler – 22b and its host star is 15% less than the distance between Earth and The Sun. Kepler-22b spins very slowly,

with a rotational speed of only 0.6 km/s. the evolution of the host star is very important for establishing the possibility of survival on Kepler 22b. stars go through different phases in their lives, influencing the planets that orbit around them. At the moment Kepler 22b is still within the habitable zone of its star.

Unlike stars, planets are named sequentially in order of discovery. The number 22 does not mean that it is the 22nd in the list of targets that Kepler monitors (that list has over 150,000 entries), nor the 22nd in the list of targets, in the light curves of which they have found transit-like events (that list has over 3,000 entries). It is the 22nd target for which they have enough information to state, beyond a reasonable doubt, that it is indeed a planet (beyond a reasonable doubt here, which is about 99% probability)."

Figure 1. Mother and Father – to start a peaceful, godless colony on the planet Kepler-22b.
Image Credit: **https://stalker-magazine.rocks/en/2021/05/26/raised-by-wolves/**

4. Practical problems

Issue no. 1-suppose Kepler - 22b is a spherical, rocky planet, like Earth, with an average density similar to Earth (approximately 5.500 kg /m^3). If the radius of Kepler-22b is 15,000 km, what is the mass of Kepler-22b in

A) kilograms?

B) multiples of the Earth's mass ($5,97 \cdot 10^{24} kg$)?

Response:

A) first find the volume of the spherical planet in cubic meters, then multiply by the density of the planet to get the total mass.

R = 15.000 km x (1000 m / 1 km) = 1,5 x 10^7 m.

V = 4/3 πR^3 = 1, 33 x 3, 14 x $(1,5\ x\ 10^7 m)^3 = 1,41 \cdot 10^{22} m^3$

$$M = \rho \cdot V = 5500\ kg/m^3 \cdot 1,41 \cdot 10^{22} m^3 = 7,75 \cdot 10^{25} kg$$

B)

$$M = \frac{7,75 \cdot 10^{25} kg}{5,97 \cdot 10^{24} kg} = 12,9\ Earths$$

Issue no. 2

A) The gravitational acceleration on a planetary surface is given by the formula

$$a = \frac{GM}{R^2}$$

where M is the mass expressed in kilograms, R is expressed in meters and G is Cavendish's constant,

$$G=6{,}67 \text{ x } 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$$

What is the gravitational acceleration at the surface of the planet Kepler-22b

A) in m/s^2?

B) in multiples of Earth's surface gravity 9,8 m/ s^2?

Response:

A) $g_{Kepler} = \frac{6{,}67 \cdot 10^{-11} \cdot 7{,}75 \cdot 10^{25}}{\left(1{,}5 \cdot 10^{7}\right)^2} = 23\ m/s^2$

B) $n = \frac{23}{9{,}8} = 2{,}3$ times greater than the gravitational acceleration at the Earth's surface.

Issue no. 3-the relationship between acceleration g_{Kepler} and our weight is directly proportional. The acceleration of the Earth's surface is 9,8 m/s^2.

If our mass is 90 kilograms on the surface of the Earth, how much will we weigh on the surface of Kepler-22b?

Response: $G_{Kepler} = m \cdot g_{Kepler} = 90\,kg \cdot 23\,m/s^2 = 2070\,kg$

5. Curiosities. Planet Kepler 22b seen from an artistic point of view

Since the discovery of Kepler 22b became official, an attempt has been made to make a graphic representation of it. This was done on the basis of the data obtained by the researchers. It is not possible to know at present what the composition of the planet is, but it is assumed to be Oceanic on the surface.

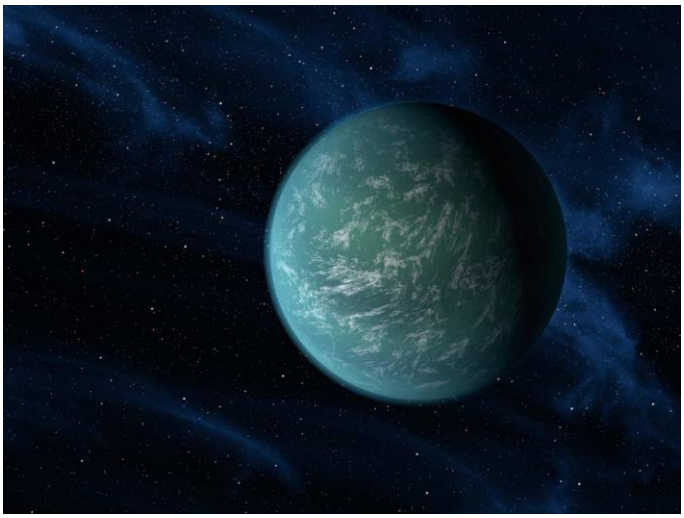

Figure 2. Graphical representation of Kepler 22ba
Image Credit: **NASA/Ames / JPL-Caltech**

This diagram compares Earth's solar system with Kepler-22b's solar System, a solar system containing the first planet in the "habitable zone" discovered by the Kepler Space Telescope mission .

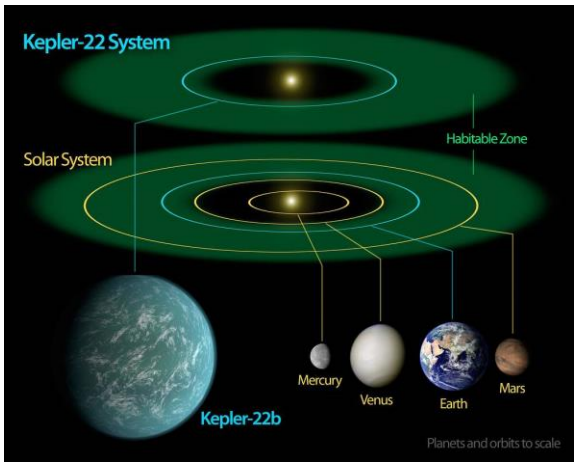

Figure3. Comparison of the Earth's solar system with the Kepler-22b solar system
Image Credit: **NASA/Ames / JPL-Caltech**

Over time, research in the field of astronomy has been a source of inspiration for science fiction literature and films.

The film ***Raised by Wolves*** presents Kepler 22b as a planet larger than Earth, and the sun around which it gravitates is colder, making the climate harsher for humans. It's Ridley Scott's latest sci – fi epic from HBO. The film features the last survivors of the human race, who seek refuge on a planet known as Kepler – 22b. the planet is shown in the film as uninhabited. She is first colonized by a pair of androids, tasked with raising several human children. The planet seems, for the most part, barren, but the air is breathable and the climate is conducive to life. There are also some giant bones, which appear to be all that's left of some giant worms that once roamed the planet. Androids believe that these worms are an extinct species, but they left huge holes in the ground that are a danger to the inhabitants. Androids are able to reach the planet first because they can travel without a life support system and food. They raise human children as best they can, until another spaceship arrives with humans on board.

Tamara Madison, a teacher who teaches English and French at a public high school in Los Angeles wrote a poem dedicated to the planet Kepler 22b. raised on a citrus farm in the Californian desert, life has carried her to many places, including Europe and the former Soviet Union, where she spent fifteen months in the 1970s. A swimmer and dog lover, Tamara says: "all I ever wanted to do with my life was write and especially write poetry because it suits my lifestyle; I love the way so much can be said in the economic space of a poem."**Kepler-22b** by **Tamara Madison (My Poetry Series, 26 mai 2014)**

Figure 4. Realistic portrayal of Keplar-22B
Image Credit: https://screenrant.com/raised-wolves-hbo-kepler-22b-real-location-explained/

- There you are at last;
- I'm sure it's you;
- I can almost see you;
- There, waving at me;
- My twin, my soul mate;
- My lover Now;
- I can give up my search;
- It's only a matter of time;
- When we'll be together;
- My love, my perfect;
- love. At last;
- Someone who sees me;
- Who knows me;
- Who understands me;
- Without words;
- Someone whom I too;
- Will see and understand;
- Someone I can devote;
- My life to;
- It will not matter;
- That our arms;
- May not match;
- That our bodies;
- May not fit;
- That we have no;
- Common language;
- But the language;
- Of desire;
- Pulsing from your heart;
- To mine;
- Over the mere 600 light years;
- That lie in the vast;
- And hopeful darkness;
- Between your balmy;
- Juicy world;
- And mine;

6. Conclusions

The distance separating Kepler-22 b from its star, as we have seen, is about 15% less than that separating the Earth from the sun, but the brightness of the star is less than the Solar one of 25%. The combination of similar parameters is consistent with the hypothesis of a moderate temperature at the surface of the planet; astronomers believe that in the absence of the atmosphere, the equilibrium temperature would be equivalent to about 262 kelvins (-11 °C), while if the eventual atmosphere had a greenhouse effect similar to Earth's, the planet would have an average surface temperature of 295 Kelvins (22 ° C).

Following a further redefinition of the habitable zone Kepler-22 b is found outside, but the fact remains that it may have a cloud system capable of retaining radiation, in addition, it is not possible to know with certainty what its surface temperature is.

At this point, we just have to wait to find out more. We have learned as much about Kepler-22b as our current technologies allow, so until our science improves further, we are at an impasse. But based on what we know, we can make certain assumptions. If Kepler-22b's temperature is indeed at 262k, that means the average surface temperature is 11 degrees Fahrenheit. Although this is quite cold, it is clearly approaching the range required for the water to be liquid. As a result, it seems plausible to imagine Kepler-22b as a cold, frozen and wet world, similar to the Arctic regions of the Earth. While life could certainly exist, it does not seem likely that too many species could exist in abundance at constant temperatures so cold, although it is hard to say. Certain dominant species would emerge that would be immune to the harsh cold and would probably be adapted to spend much of their lives in the water. Penguins, for example, are a well-adapted, versatile species because they are extremely skilled swimmers, but they still generally gather on land. Kepler-22b's temperature would likely make the planet largely liquid, with certain sections frozen in ice, and so would progress evolution. Life would likely begin in the ocean, perhaps by underwater volcanoes that provide the imbalance life needs to begin. As time passes and species continue to evolve, certain animals will make their way on solid ice and begin to live and breed there. If I were a travel agent

hoping to send a family of four on Kepler-22b, it might be hard to convince them to go. First of all there is not enough information about the atmosphere or composition of the planet to even say for sure whether or not it could survive there. The trip would likely be like a cruise through Alaska, and the family could admire the icy conditions on their ship sailing through the waters. Kepler-22b's relative proximity to its star (compared to Earth's distance from the sun) could make for more of an incredible sight, where Kepler-22 could occupy much of the horizon during sunrise and sunset.

The next step to be taken in the research of the planet Kepler – 22b is the calculus of the mass, in order to have more information about the possibility of hosting life. A new telescope, HARPS North, located in the Canary Islands, could do this, having very high accuracy in measuring the speed differences reflected in the Doppler effect. We will thus know whether it is a planet made of rock or a world of water.

Whether or not there is life on the new planet has not yet been established. An organization called SETI (Search for Extraterrestrial Intelligence) in Northern California is now focusing its 42-antenna Allen Telescope toward the planet in hopes of finding a sign of communication. A preliminary search for radio signals from Kepler-22b is underway. Unfortunately, we will not be able to actually travel to our "twin planet" anytime soon, as it is estimated that it would take about 23 million years to get there. Kepler-22b gives us one of the best-known examples of an exoplanet potentially capable of harboring life. Although we do not yet have evidence of biological activity in this distant star system, many of the similarities between the Kepler-22 system and our Solar System lead us to believe that Kepler-22b may be the perfect planet for harboring life. At the moment, we only hope that new scientific discoveries will allow us to study the planet in detail, we hope that one day we will reveal the existence of extraterrestrial life in the Kepler-22 star system.

Matei, Codrin and Ilinca are the authors of Kepler-22b, the planet that could support life.

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