Earth - Like Planet Criteria as Analysis of the Earth Doppelganger

Tua Raja Simbolon, Berthianna Nurcresia, Johny Setiawan[2]

[1] Departemen Fisika, Universitas Sumatera Utara, Medan, Indonesia

[2] Unimatrix UG, Berlin, Germany

Abstract:- The discovery of extrasolar planets has now reached rapid development. Until now many planets that are about the size of Earth have been discovered which can be called terrestrial planets around their parent stars. It is well known, some of these planets orbit their parent stars in habitable zone around the parent star in spectral class G - M. Some parameters have been determined to re-categorize the planets - only habitable planets or Earth doppelganger, so various assumptions arise some basic parameters to re-categorize the planets. We have studied 300 extrasolar planetary data that are in habitable zones according to our calculations to determine the basic parameters that determine the position of the planets in the category of Earth habitable or doppelganger planets. The planet, which is a doppelganger for Earth, must be able to maintain water in liquid form and have fingerprints that are exactly like Earth. hence, we determine four basic parameters, namely the physical condition of the planet, the surface temperature of the planet, the parameters of the parent star, and the location of the habitable zone. we set the Earth doppelganger to have parameters and assume all Earth parameters as a provision value. After four analyzes, from Nine planets occupying Earth doppelganger candidates, we only found two planets in the Earth doppelganger candidate.

Keywords:- *Habitable Planets, Earth's Doppelganger, Kepler-69 C, Kepler-9 d, COROT-7 b, Kepler-20 f, Tau Ceti b, Alphan Cen B b, Kepler-186 f, Kepler-20 e, Proxima b.*

I. INTRODUCTION

Searching for planets that have the possibility of life outside the solar system has become a popular topic today, with the main goal being to find planets similar to Earth (Franck et al, 2007) and orbit stars like the sun. Since the discovery of the first planet orbiting the Pegasi star in 1995 by Major and Queloz, Astrobiology's field of research has become increasingly rapid to explore the possibility of life outside the Earth. Even though so far it is known that only the Earth is the only planet that supports life (Altermann, 2008; Pilat-Lohinger, 2015), researchers have not stopped continuing to detect the existence of planets that support life just like Earth. This statement is supported by the success of NASA's Kepler mission to detect thousands of extrasolar planets and detect galaxy regions where habitable zones can be maintained properly (Chaplain, 2009; Borucki et al, 2011; Fressin et al, 2013; Lissauer et al, 2011) and find many superterran planets (Howard et al., 2012; Batalha et al., 2013; Petigura et al., 2013) to Earth-size (Wittenmeyer et al., 2006; Robertson et al., 2012 a, Zechmeister et al., 2013), and their launch NASA's new vehicle called TESS (the Transiting Exoplanet Survey Satellite) in April 2018 will monitor 200,000 stars that have solar systems (Ricker et al, 2015; Sullivan et al, 2018; Bouma et al, 2017). However, around 2013 to 2015, some researchers revealed in their study that there were about 30% of Earth-like planets surrounding M class stars (Dressing and Charbonneau, 2015), and 20% surrounding FGK class stars (Pettigura et al, 2013; Foreman —Mackey et al, 2014; Burke et al, 2015; Silburt et al, 2015).

As the name suggests, Earth-like planets must have the same characteristics as Earth to support life. The condition of the planet must be rocky (Durand - Manterola, 2010), major spring axes (Kasting et al, 1993), atmospheric conditions (Stevenson, 1999; Schwarz et al, 2005; Vladilo et al, 2013), measures (Erkaev et al, 2014; Wittenmeyer et al., 2014), surface temperature (Lee, 2003; Mallama et al, 2006; Mallama, 2007; Cabrol and Grin, 2010; Leconte et al, 2013), parent star conditions both in shape, size and condition photometric (Kopparapu et al, 2013; Ramirez et al, 2014ab; Leconte et al, 2013; von Braun et al, 2011), and conditions of habitable zone (Kaltenegger and Sasselov, 2011; Selsis et al, 2007; Kasting et al, 1993) are the main conditions for a planet to prove whether or not a planet can support life for living.

The possibility of finding Earth-like planets depends on the same completeness, and the completeness varies greatly. Earth-like planets must have water on their surface (Hart, 1978; Kopparapu et al., 2014) to support the carbon cycle and silicate-carbonate cycle (Kopparapu et al, 2013; Zsom et al 2013). This means Earth-like planets must be in a habitable zone and are habitable planets. habitable zones are defined as areas where rocky planets can retain water in liquid form with the help of the planet's atmospheric conditions (Huang, 1959; Kasting et al, 1993; Selsis et al, 2007; Kane and Hinkel, 2012; Haghighipour and Kaltenegger, 2013; Liu et al, 2013; Forgan, 2014; Mason et al, 2015). Planet sizes are generally small (Pettigura et al, 2013; Burke et al, 2015; Dressing and Charbonneau, 2015), although there are also some giant planets found in habitable zone (Heller and Armstrong, 2014; Barclay et al, 2013) . The habitable zone must also be supported by the appropriate inner and outer values, where the inner is considered based on conditions of atmospheric pressure on the planet's surface sufficient to maintain water in liquid form while the outer boundary is considered based on the planet's ability to maintain CO_2 on its surface (Forget and Pierrehumbert, 1997).

In this paper, we have analyzed the correlation between several parameters that we consider important for Earth-like planets. The results of this analysis will be used as further research material to look for Earth-like planets as closely as possible. We screen data from habitable planets obtained using simple habitable zone models that have been made in the previous paper (Nurcresia, 2019), and some data taken from the catalog of extrasolar planets as a complement.

We describe our consideration in chapter 2 and provide the results of the analysis of Earth-like planet parameters in chapter 3, the discussion in chapter 4, and conclusions that will be discussed in chapter 5.

II. METHOD

Before grouping, we determined some parameters that we would consider to determine the feasibility of an Earth-like planet. Some of these parameters have already been discussed in several studies (Franck et al, 1999; Williams, DM and Pollard, D, 2003; Lucarini et al, 2013; Vladilo et al, 2013; Lisenmeier et al, 2014; Kalidindi et al. 2017), but in the distribution of categories in this paper several parameters are considered important for describing Earth-like planets. The following will be discussed one by one regarding the parameters we consider as feasibility for Earth-like planets.

A. Planet Condition

The interior and exterior conditions of a planet are the main factors to determine whether an Earth-Like planet can sustain life as it is on Earth.

➢ *Size*

(Erkaev et al, 2014). Size, mass, and volume are the easiest parameters that can be identified from exoplanets. According to Dorand - Manterolla (2010), conditions are appropriate for planets that have a mass close to Earth. Although there are several studies that show that giant planets can be inhabited (von Bloh et al, 2007; Valencia et al, 2006; Udry et al, 2007), or take critical mass smaller than Earth's mass (Raymond et al, 2007) we cannot take into account these conditions because we really have to consider the size of the Earth as the main source of feasibility for Earth-like planets because superterran planets also have a dense core (Valencia, 2006), so we will incorporate this type of planet into certain categories.

In this study will be assisted by several relationships relating to.

- *Mass-radius relationship for habitable planets.* This diagram is usually used by previous researchers to understand exoplanet composition (Seager et al, 2007; Lissauer et al, 2011; Sohl et al, 2012; Swift et al, 2012; Enoch et al, 2012; Weiss and Marcy, 2013; Weiss et al, 2013). In this study, the relationship diagram will be used to understand the exact parameters for the Earth-like planet category.
- *Star mass relations - Luminosity to help find the lifetime of a parent star.* This relationship has been modeled before (LoPresto, 2018) and will be used again by our research to find out how long the parent star of a solar system maintains a habitable zone in its environment.

➢ *Distance*

The condition of the distance or the semi major axis is also a major influence on Earth-like planets. This spring major axis will determine whether the planet will be in the right position in the habitable zone or not.

➢ *Interior Conditions*

Also greatly affecting Earth-like planets are dense and rocky interior conditions and dense cores. However, we have filtered the planet from habitable planetary data in a previous paper that we have considered the planet to be a terrestrial planet.

Temperature comparisons	Venus	Earth	Mars
Temperature balance in general	307 K 34°C 93°F	255 K -18°C -0.4°F	206 K -67°C -88.6°F
Green house effect	737 K 464°C 867°F	288 K 15°C 59°F	210 K -63°C -81°F
Tidal locking	Almost	No	no
Albedo	0.9	0.29	0.25

Table 1:- Temperature comparison of Earth-like planets.

B. Planet Surface Temperature

Life on Earth is formed based on the content of carbon molecules as the main foundation for biomass, the presence of water, and allergic chemical reactions. These three components are the main energy source for the Earth to sustain life (Schulze-Makuch, 2015). Terrestrial planets that have a temperature of around 15°C and atmospheric pressure of 1 bar are a general requirement. However, relatively high temperatures are also needed for the continuity of the formation of living, especially DNA that can be formed with temperatures above 150°C (White, 1984; Madigan and Orent, 1999).

A planet can be said to be habitable by living things if it is in equilibrium temperature in an area that has been previously defined. The planet's surface temperature is influenced by climate, orbit, the location of the planet in the habitable zone. this temperature must really be able to maintain life. According to Lee et al (2003), the temperature that allows a planet to sustain life is less than 60°C, and this statement is also supported by Kasting (1993) which states that the right temperature to maintain a greenhouse is not more than 60°C. The statement helps to determine the habitable zone for a solar system. So most studies occupy the semi-major axis of Venus which is the inner boundary for habitable zones in our solar system. In Table 1 the comparative temperature is shown to limit the temperature of Earth-like planets (Mallama, et al, 2006; Mallama, 2007; Cabrol and Grin, 2010).

To estimate the surface temperature of the planet, it can be determined by equations (LoPresto and Hagoort, 2011).

$$T \cong \left(\frac{279}{r^{0.5}}\right) \quad (1)$$

With r is the semi-major axis (AU). Figure 1 shows the habitable zone area in general according to the semi-major axis where the effective temperature estimates for life support are 200 - 300 K. Planets which have a semi-major axis less than 1 AU will receive considerable heat from their parent star. Likewise with planets that have a semi-major axis above 1 AU which has an equilibrium temperature over Earth.

C. Parent Star Condition

The next criterion for an Earth-like planet is the condition of its parent star which must be like the Sun. The similarity is based on photometric conditions (spectrum classes) from the parent star. Therefore the composition of the planet in a solar system will be similar to the composition of a planet that circulates around the Sun. Because it has been seen before that the size of candidates for Earth-like planets found exist in the form of gas planets and superterran, then the size of the planet cannot be relied on to determine whether the planet is Earth-like or not.

We have analyzed some data. We take a number of parameters that we consider quite feasible to determine the conditions for parent Earth-like planet stars, among them are

➢ *Mass and radius*

Are the two most basic parameters that can be measured from a star. There have been many studies that model mass - radius for stars (Kraus et al, 2011; Feiden and Chabover, 2012; Zhou et al, 2014). We will categorize parent stars based on these two parameters which will be used to look for stars that are similar to the Sun (have a mass and a fairly small radius).

➢ *Spectrum class*

The spectrum class of the star indicates the star's photosphere temperature, which (for the main sequence star) is associated with its mass. The appropriate spectrum range for stars for habitable planets is spectral class F with advanced age, or G, until mid-K, corresponding to a temperature range of more than 7000 K to slightly more than 4000 K (6700°C to 3700°C). The sun is in the G5V spectral class which has a temperature of 5777 K, and is still in the effective temperature range to be surrounded by habitable planets. For this spectral class, there are only about 5% to 10% in the Milky Way galaxy. Middle-class stars like this have a number of characteristics that are considered important for the habitability of a planet (Turnbull and Tarter, 2003).

- The life is at least a few billion years to allow life to develop in it. The spectrum classes of O, B and A stars usually live less than one billion years and are usually less than 10 million years old.
- Emitting ultraviolet radiation with high frequency which is enough to trigger atmospheric dynamics that are important for the formation of the ozone layer, but not so much that the ionization process destroys the life that has just formed.
- Water in the liquid phase is probably on the surface of the planet orbiting the stars at a considerable distance so that it does not induce tidal locking.
- Recent research (Shields et al, 2013) shows that stars with cooler temperatures emit lighter infrared radiation and can reduce ice on the planet's surface. This wavelength is absorbed by ice and greenhouse gases inside planets to keep the surface temperature of the planet warm.

➢ *Luminosity*

Luminosity will affect changes in the inner and outer values of the habitable zone. star evolution will affect changes in luminosity values (Danchi and Lopez, 2013).

D. Habitable Zone Condition

One of the most important criteria for doppelganger Earth is that the planet must be a terrestrial planet and in a habitable zone. Habitable zone will help the planet maintain life, and keep surface temperatures in a stable condition. However, in reality some of the Earth-like planet candidates are too close to their parent star or even not in a habitable zone.

To facilitate the screening of Earth-like planets, we use the simple habitable zone model that we have made in previous studies (Nurcresia, 2019). We narrow the habitable zone by taking the semi-major axis from Venus and Mars to get the maximum possible results, aided by the equation

$$i = K_a M_\odot + d_i \quad (2)$$

Which can be used to find inner boundary values, and equations

$$o = K_b M_\odot + d_o \quad (3)$$

To determine the value of the outer boundary. The values of Ka and Kb each have been determined in previous studies.

III. RESULT

To get the results of Earth-like planets, we use several stages by using the specified parameters. The following will be explained in detail.

A. Analysis of Planet Physical Conditions

At this step, we filter data using the criteria for the planet's physical condition. Earth-like planets must have a solid or rocky surface. This condition will make the planet suitable for habitation (Rugheimer et al, 2015). In this stage, the results in table 2 are obtained.

In the table there are still many planet candidates that have masses more than the mass of the Earth. the planet is in the form of a gas planet (measuring more than 10 times the mass of Earth) or even a superterran planet (measuring 2 - 10 times the mass of Earth). Of course there are planets that have not yet been said to be Earth-like planets. However, the planet is a candidate for Earth-like planets because the planets have a radius that still meets the criteria for Earth-like planets.

B. Planet Surface Temperature Analysis

At this step, we analyze using temperature parameters. Previously, there were already several researchers who modeled surface temperatures for Earth-like planets (Vladilo et al, 2015). Planets that have low temperatures will find it easier to lose water on their surface (Kasting et al, 2013). Therefore, this stage will filter the temperature of the planet again so that water can be maintained and the temperature is warm enough to be inhabited by living.

The candidate temperature conditions of the habitable planets are still many that do not meet the criteria. The planets have a surface temperature that is high enough so that they cannot maintain life in them. In figure 2 its show that the larger the semi-major axis of the planet to its parent star, the more surface temperatures of the planet will be colder and harder to maintain life on its surface. However, there are still two candidates for Earth-like planets that have stable surface temperatures due to their location in the habitable zone so that it is possible for the two planets to maintain life on its surface.

C. Analysis of Parent Star Parameters

The parameters calculated at this step are the parameters of the parent star. the condition of the parent star which must be like the Sun. The similarity is based on photometric conditions (spectrum classes) from the parent star. Therefore the composition of the planet in a solar system will be similar to the composition of a planet that circulates around the Sun. Because it has been seen before that the size of candidates for Earth-like planets found exist in the form of gas planets and superterran, then the size of the planet cannot be relied on to determine whether the planet is Earth-like or not. Table 4 will show the photometric conditions of the parent star of the Earth-like candidate planet.

The photometric conditions of candidates for Earth-like planets are in the range of spectral classes G, K, and M. From the temperature of the parent star it can be ascertained that the candidates have conditions suitable for sustaining life for the planets that surround them. So it needs to be reviewed again about supporting criteria to find out the existence of Earth-like planets.

D. Analysis of Planet Habitable Zones

In this paper, habitable zone are the last parameter that is used as a basis for consideration for the Earth doppelganger. According to the results of screening, the results in table 5 are obtained.

The data in table 5 shows that more planets are outside the habitable zone so the surface temperature of the planet will be too hot. Surface temperatures that are too hot cannot sustain life on the planet, or it can be said that the planet is likely to be arid enough to be lived by living.

IV. DISCUSSION

E. Kepler-69 C and Kepler-186 F as Earth Doppelganger Candidates

Based on four categories of analysis with parameters in the form of planetary physical conditions, temperature, parent stars, and their existence in habitable zones, Earth doppelganger candidates in our opinion are Kepler-69 C and Kepler-186 f. according to the analysis, our two planets can still be categorized as Earth doppelganger because some parameters meet the criteria we specify. But it appears in the data, Kepler-186 F has a fairly large mass (Quintana et al, 2014).

According to an analysis of conditions of habitable zones, the two planets have a strategic location and are included in habitable planets (Lissauer, 2007; Raymond, 2007). For Kepler-186 f occupies a boundary position in 0.20 - 0.23 AU (Kopparapu et al, 2013; Kopparapu et al, 2014), and is equivalent to the results we get using our equation (2) which is 0. 25 AU. As for the outer boundary, we get a value of 0.79 AU using equation 3. Likewise with Kepler-69 C, we get the inner and outer boundary values respectively 0.43 AU and 1.34 AU. Whereas according to Kane et al (2013), the inner and outer boundary values are 0.88 AU and 1.51 AU, respectively. Figure 3 shows how the comparison in the Kepler-186 planetary system with planets in the solar system and planetary system Gliese 581. But keep in mind, planets orbiting in habitable zones do not necessarily make the planet habitable (Bolmont et al. 2014). There are still many factors that consider whether the planet is habitable or not (Schulze-Makuch et al, 2011).

In terms of the parameters of the parent star, Kepler-186 f which surrounds its parent star, Kepler-186 has a relatively low parent star temperature, and is in class M (Quintana et al, 2014). However, Kepler-69 C has special features, namely its temperature which almost equates the temperature of the Sun (Barclay et al, 2013). To see the final results, it can be noted table 6 in the appendix as a comparison table of the nine planets that were made as initial candidates during the Earth doppelganger analysis process.

F. The Effects of Master Star Distance Change on Earth's Doppelganger Habitable Zones

Knowledge of star distance has evolved since the launch of the Hipparcos and Gaia missions (Van Leueen, 2007; Prusti et al, 2016). Both of these missions can certainly improve human knowledge regarding star distances (Van Grootel et al, 2018). As already known, in addition to changes in the basic properties of stars and planets, changes in the distance of planetary systems can also change the flux of the system because it depends on measured star luminosity (Kane, 2018). This is what will determine the limits of the habitable zone. generally, the limit of habitable zones is divided into two, namely Optimistic Habitable Zone (OHZ) which has a picture of the limits of Venus and Mars, and Circumstellar Habitable Zone (CHZ) which limits the habitable zone to the amount of CO_2. The two limits of this habitable zone have similarities which are dependent on luminosity and effective temperature of the planet star parent system (Kane, 2014).

In the case of the Kepler-186 planetary system, the planet is categorized as the most Earth-like in terms of size and flux compared to the other four planets in its planetary system (Bolmont et al, 2014). However, increasing star distance to 177.51 0.79 pcs causes luminosity to increase by 38.2% and star radius increases by 17.6% (Kane, 2018). The increase in the radius of the parent star causes an increase in planetary radius of up to 1.31 times the mass of the Earth. this is what causes the planet to be in a terrestrial planet (Chen and Kipping, 2017). For Kepler-186 f planet which was originally outside the habitable and Earth-sized zone it has changed its status to super Earth and is in the middle of a habitable zone (Kane, 2018).

For the record, luminosity is not the only factor that can sustain the planet in a habitable zone. planetary intrinsic factors also influence such as atmospheric boundaries, planetary rotation, or geological processes (Abbot, 2016; Yang et al, 2014).

V. CONCLUSION

The criteria that we used in our study of 300 extrasolar planets in a habitable zone were general criteria that had been used by many previous researchers to determine which planets belong to Earth-like planetary candidates. But in this paper, we have used these parameters as basic criteria or fingerprints for the Earth doppelganger. This criterion will help us to develop more complex advanced criteria for searching Earth doppelgangger.

From 300 extrasolar planets, we filter the data back on the planet's mass and radius, so we only found 9 candidates for the Earth doppelganger. When the analysis process is four times, we only find two early Earth doppelganger candidates, namely Kepler-186 f and Kepler-69 C. Both planets have sufficient properties like Earth in terms of mass (1.5 <Earth mass> 0.5) and radius the planet (2 <Earth's radius> 1.5). Photometric conditions of the parent star of the planet Kepler-69 C have special features, namely being in the G4V class so that the planet has a fairly strategic condition which is in a habitable zone. Whereas for the parent star of Kepler-186 f itself has quite different photometric conditions, namely M1V. cold star conditions, but planets in conditions that are possible in habitable zones due to increased luminosity of the parent star that makes Kepler-186 f experience mass gain. These conditions will be able to maintain the two planets to maintain water in liquid form so that it can be further examined whether the two planets are truly Earth doppelganger or only occupy a position as habitable planet.

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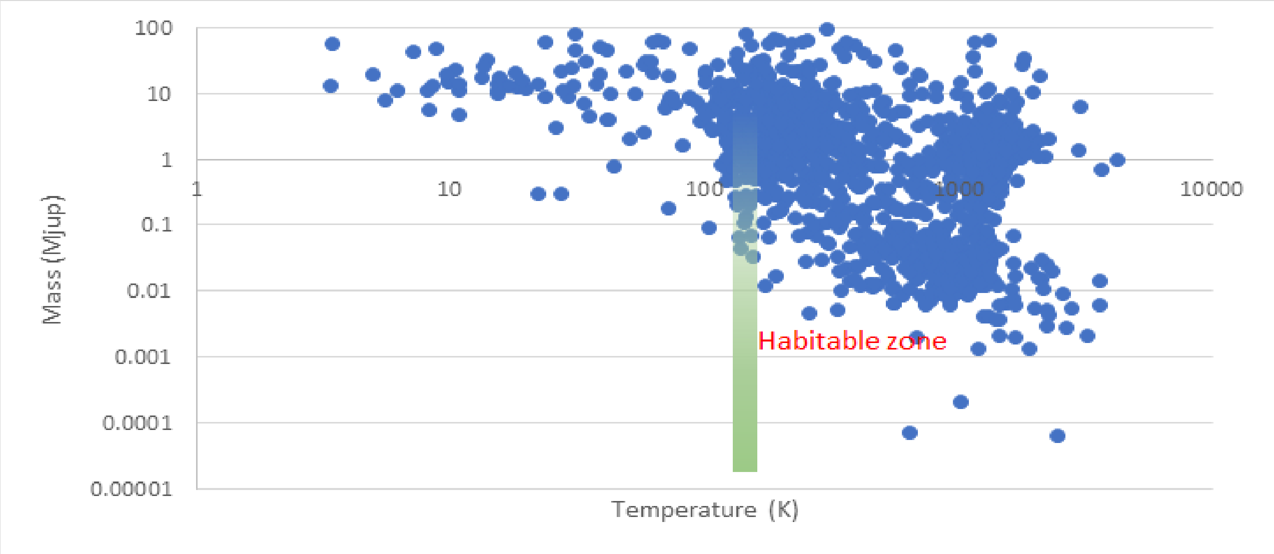

Fig 1:- Planet temperature and habitable zone. By using a semi-major axis (AU), the temperature (K) is obtained on the planet's mass (Mjup). Green areas show habitable zones which are known that habitable planets have temperatures of around 200 - 300 K.

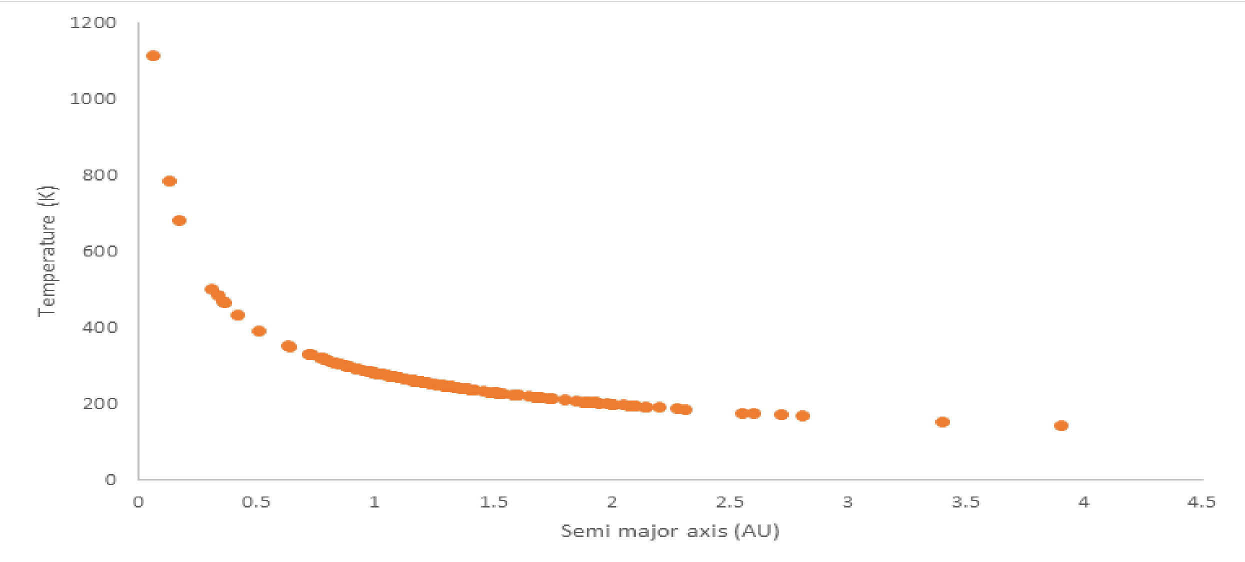

Fig 2:- Relationship between major axis and surface temperature of the planet. The picture shows that the farther the distance between the parent stars, the temperature of the planet's surface gets colder and the closer the distance between the parent planets, the temperature of the planet's surface will get hotter. From the picture it can be concluded that with the semi-major axis 1 SA, the temperature conditions of the planet can be said to be stable.

Name of Planets	Mass ($M_{\oplus}$)	Radius ($R_{\oplus}$)	Information	Ref of Mass	Ref of Radius
Kepler-69 c	0.98	1.7	Yes	Barclay et al, 2013	Barclay et al, 2013
Kepler-9 d	> 1.5	1.64	Yes	Holman et al, 2010	Torres et al, 2011
COROT-7 b	< 9	1.58	No	Queloz et al, 2009	Léger et al, 2009
Kepler-20 f	< 14.3	1.003	No	Fressin et al, 2011	Buchhave et al, 2016
Tau Ceti b	2		Yes	Tuomi et al, 2012	
Alpha Cen Bb	1.1		Yes	Plavchan et al, 2015	
Kepler-186 f	1.4	1.1	Yes	Quintana et al, 2014	Bolmont et al, 2014
Kepler-20 e	< 3.08	0.87	Yes	Fressin et al, 2011	Fressin et al, 2011
Proxima b	> 1.27	> 1.1	Yes	Anglada-Escudé et al, 2016	Bixel dan Apai, 2017

Table 3:- Candidates for the planet Earth doppelganger. Candidates are based on a number of considerations including the mass and radius of the planet as the initial stage of searching the Earth doppelganger.

Name of Planets	Temperature (K)	Information	References
Earth	285.27	Normal	National Oceanic and Atmospheric Administration
Kepler-69 c	$282^{+19}_{-13}, 322^{47}_{21}$	Normal	Barclay et al, 2013
Kepler-9 d	2026 ± 60	Too hot	Torres et al, 2011
CoRoT-7 b	1800-2600	Too hot	L´eger et al, 2009
Kepler-20 f	705 ± 16	Too hot	Francois Fressin et al, 2011
Tau Ceti b	N/A	-	-
Alpha Cen Bb	1143.15	Too hot	Xavier et al, 2012
Kepler-186 f	188	Normal	Planetary Habitability Laboratory UPR
Kepler-20 e	1040 ± 22	Too hot	Francois Fressin et al, 2011
Proxima b	234	Normal	Anglada-Escudé et al, 2016

Table 4:- Temperature conditions of Earth doppelganger candidates. based on benchmark temperature, there are only two planets which can be said to have suitable or normal temperatures, such as Earth.

Name of Planets	Parent Stars	Spectrum classes	Referensces
Kepler-69 c	Kepler-69	G4V	Barclay et al, 2013
Kepler-9 d	Kepler-9	G2V	Havel et al, 2011
COROT-7 b	COROT-7	G9V	Léger, A et al, 2009
Kepler-20 f	Kepler-20	G8V	Gautier III et al, 2012
Tau Ceti b	Tau Ceti	G8.5V	Keenan dan McNeil, 1989
Alpha Cen Bb	Alpha Cen B	K1V	Fuhrmann et al, 2011; Valenti et al, 2005; Santos et al, 2005; Neuforge-Verheecke dan Magain, 1997
Kepler-186 f	Kepler-186	M1V	Quintana et al, 2014
Kepler-20 e	Kepler-20	G8V	Gautier III et al, 2012
Proxima b	Proxima Cen	M6V	Demory et al, 2009

Table 5:- Photometric conditions of planet Earth's doppelgangger star stars. the nine planets filtered on the analysis of the planet's mass and radius have parent stars in class G - M.

Name of Planets	Parent Stars	Semi Major Axis (AU)	Star Mass ($M_{\odot}$)	Inner (AU)	Outer (AU)	Information
Kepler-69 C	Kepler-69	0. 64	0.81	0.43	1.34	Inside of the habitable zone
Kepler-9 d	Kepler-9	0.143	1	0.8	1.5	Outside of the habitable zone
Tau Ceti b	Tau Ceti	0.105	0.783	-	-	Outside of the habitable zone
Alpha Cen Bb	Alpha Cen B	0.04	0.934	0.74	1.4	Outside of the habitable zone
Kepler-186 f	Kepler-186	0.356	0.478	0.38	0.71	Inside of the habitable zone
Kepler-20 e	Kepler-20	0.06	0.912	0.72	1.36	Outside of the habitable zone
Prox Cen b	Prox Cen	0.048	0.12	0.09	0.18	Outside of the habitable zone
CoRoT-7 b	CoRoT-7	0.017	0.87	0.74	1.39	Outside of the habitable zone
Kepler-20 f	Kepler-20	0.139	0.912	0.72	1.36	Outside of the habitable zone

Table 6:- Habitable zone for Earth doppelganger. which is found in a habitable zone of only two planets, Kepler-69 C and Kepler-186 f.

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Name of Planets	Physical conditions	Temperature	Parent stars	Habitable zone
Kepler-69 c	✓	✓	✓	✓
Kepler-9 d	✗	✗	✓	✗
CoRoT-7 b	✗	✗	✓	
Kepler-20 f	✓	✗	✓	
Tau Ceti b	✓	✗	✓	✗
Alpha Cen Bb	✓	✗	✗	✗
Kepler-186 f	✓	✓	✗	✓
Kepler-20 e	✓	✗	✓	✗
Proxima b	✓	✓	✗	✗

Table 7:- Earth doppelganger candidate analysis. shown in the table, Kepler-69 C and Kepler-186 f have basic parameters that are suitable as candidates.

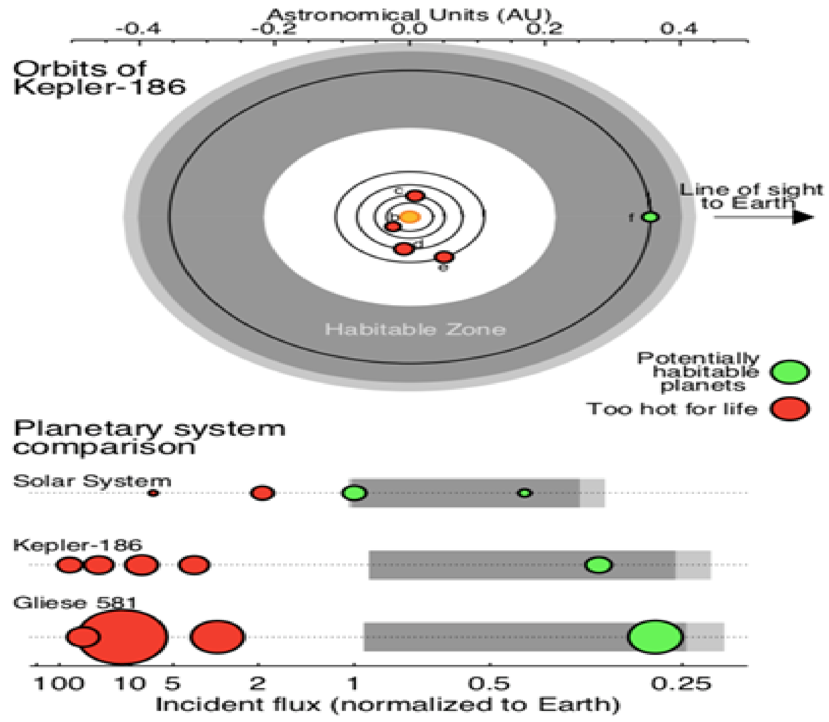

Fig 3:- Overview of orbital comparison of the Kepler-186 planetary system. It is assumed that habitable zones follow the pattern of the solar system. In the Kepler-186 planetary system it only has 1 planet that occupies a habitable zone, namely Kepler-186 f. when compared to the Gliese 581 planetary system (Udry et al, 2007; Major et al, 2009), it is said that the two planetary systems only have one planet entering the habitable zone. The difference is only seen from the mass of the planet from the planetary system Gliese 581 which is quite large than Kepler-186 f.