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# Searching for New Earth

Berthianna Nurcresia[1], Tua Raja Simbolon[2], Johny Setiawan[3]
[1, 2]Department of Physics, University of Sumatera Utara, Medan – Indonesia
[3]Unimatrix UG, Berlin - Germany

**Abstract:- The discovery of exoplanets has intensified interest in the search for extraterrestrial life, especially for planets orbiting the sun like stars in habitable zone. The study of planetary habitability also considers a wide range of other factors in determining the suitability of a planet for hosting life. This study aims to determine to explore the variety exoplanets like giant planets, terrestrial planets, habitable planets, and earth like planets. The method for searching that planets are using five different methods, like radial velocity method, transit method, gravitational micro-lensing, astrometry, and direct imaging. From the study process obtained that there are 1.271 giant planets, 211 terrestrial planets, 291 habitable planets, and 2 earth like planets.**

***Keywords*:-** *Extrasolar Planet, Habitable Zone, Giant Planets, Terrestrial Planets, Habitable Planets, Earth Like Planets.*

## I. INTRODUCTION

Humans have long argued about the existence of solar systems beyond ours, and the possibility of life elsewhere in the universe. In 1992, for the first time, the solar system and its unknown planets were detected, and until now the planet is known as the Exoplanet. Exoplanet is a planet beyond our solar system.

In the 16th century, Giordano Bruno, an Italian philosopher, gave an interesting idea about the discovery of extrasolar planets by arguing that 'there are countless suns and earths all revolving around the sun - their sun in exactly the same way as seven planets from solar system' and explicitly postulates the existence of planets around other stars. Unfortunately, at that time the extreme opinion was not acceptable, so Giordano Bruno was sentenced for his idea.[1]

Exoplanet became the subject of popular scientific research in the mid-19th century. Scientists have suspected that the planets exist, however it is unknown how many planets they are, or what they are similar to the planets in the Solar System. Nevertheless, as time goes by, its been known that there are about 1 in 20 stars that are like the Sun in habitable zones with planets like Earth. Assuming there are 200 billion stars in the Milky Way, we can hypothesize that there are 11 billion stars that could potentially be inhabited by planets like Earth in the Milky Way, and could increase to 40 billion if the included planet orbits a red dwarf star.

The discovery of exoplanets has intensified interest in the search for extraterrestrial life. There is a special attraction for planets orbiting in habitable zones, where the possibility of the planet fulfilling the requirements for water availability as a prerequisite for life. The study of planetary habitability also considers various other factors in determining the planet's feasibility to accommodate life.

The author has classified planets into two, according to the size of the planet and according to its habitability. According to the size of the planet, planets can be categorized into two types, giant planets and dwarf size planets where dwarf planets are terrestrial planets. Whereas according to their habitability, planets are classified as habitable planets and earth-like planets. In grouping habitable planets, a model has been studied for the determination of habitable zones which will produce data in the form of habitable planets. According to data taken from the extrasolar planetary encyclopedia catalog.

## II. METHODS

### *A. Giant Planets*

The classification of giant planets based on extrasolar planetary catalogs must be grouped first based on the method of discovery to facilitate data processing. Before being processed with Microsoft Excel, the mass data of extrasolar planets in the catalog (which still have Jupiter's mass units) must be converted into units of mass of the earth. Knowing that 1 times the mass of Jupiter = 318 times the mass of the earth, the results of the mass of the extrasolar planets in the mass of the Earth can be known. In the process of data processing with Microsoft Excel, the formula = if (mass planet> = 10, "giant planet", "not a giant planet") is used, so that in each planet grouping based on the method of discovery produces new data in the form of the type of planet you want to look for (in the form of a giant planet). After obtaining the new data, the number of giant planets detected per method of discovery can be calculated so that a histogram is obtained to show how many extrasolar planets are found using these methods.

### *B. Dwarf Planets*

The dwarf planet consists of terrestrial planets, which can be subdivided into sub-terran planets, terran planets, and superterran planets. The research method will be explained per each terrestrial planet type, where later the histogram will be produced on the development of terrestrial planetary discovery per method of discovery.

➢ *Sub-Terran Planets*

Sub-terran Planet can be known based on its mass. As it has been done for giant planets, even the sub-terran planet data must be reprocessed from the catalog of extrasolar planets and convert the mass of the planet into a mass unit of Earth. Its just that in processing data with Microsoft Excel, the formula that will be used is = if (planet mass <= 0.5, "planet subterran", "not planet subterran"). After obtaining the results in the form of new data on the sub-terran planet, a new catalog can be made in the form of planetary names, parent star names, and planetary mass that will be used to make histograms for terrestrial planet types.

➢ *Terran Planets*

Data processing for terran planets is the same as previous planetary data processing. Its only that the formula used in Microsoft Excel is made very differently. Terran planets has a mass interval of 0.5 - 2 times the mass of the Earth. Due to limitations, data processing must be done twice. The first data processing is used = if (planet mass <= 2, "terran planet", "not terran planet") to see which teran planets are trapped in masses less than 2. Because there are definitely sub-terran planetary data trapped inside, then the data is reprocessed with the formula = if (planet mass> = 0.5, "terran planet", "not terran planet"), so that the second data is obtained about terran planets. The data is finally reprocessed into a new catalog made similar to the sub-terran planet that will be used to complete the terrestrial planet histogram.

➢ *Superterran Planets*

As terran planets, superterran planets also have differences in data processing. It is known that superterran planets are planets that have mass intervals of 2 - 10 times the mass of the Earth. So, there are two formulas used so that data processing must be done twice using a different formula. The first data processing can be done using the formula = if (mass planet> = 2, "superterran planet", "not superterran planet"), so that the first data is obtained in the form of superterran planets that are still mixed with planet gas data. To clarify the number of superterran planets, the processed data must first be processed a second time using the formula = if (planet mass <= 10, "superterran planet", "not superterran planet") so that the superterran planet can be netted again. From the data processing process, it can be produced in the form of new data about the superterran planets that are netted and must be included in a new catalog made based on the method of discovery. The catalog is then reused as a dwarf planet histogram complement that will be used to see the development of terrestrial planet detection per method of discovery.

### C. Habitable Planets

Habitable planets can be categorized into two types, habitable planets and Earth-like planets. The research design for both types of planets will be very different from the previous types of planets. The following will be discussed about habitable planets and earth-like planets until they will eventually form new data about planets that allow it to accommodate such life.

➢ *Habitable Planets*

As the name suggests, habitable planets are planets that can possibly accommodate life but there are still estimated gas planets or planets that are very dwarfed in them. The planet should have been located in the habitable zone of their solar system. In the process of habitable planetary searching a development model of the previous model will be made (Selsis (2007) and Kopparapu (2013)). Therefore, a stage can be made in detecting habitable planets as follows.

➢ *Earth-Like Planets*

The location of Earth-like planets is definitely in the habitable zone. There are certain criteria where a planet in habitable zones can be categorized into an Earth-like planet. the main criterion is the radius and mass of the extrasolar planet must be the same as the Earth itself. The process of processing earth-like planetary data starts from terran planetary data. Spectrum class data from terran planetary parent stars are collected to classify planets based on their parent star temperature. According to comparative data, the main star class that allows Earth-like planets to live is G, K, and M. In these classes the temperature of the star is not too hot so that the planet's temperature will be in stable condition. The second step is to review data from habitable planets netted in habitable zones. Data from the habitable planet have to be linked back to terran planet data that has been processed according to its parent star class. This step is used to eliminate gas and sub-terran planets in habitable zones, because there is no possibility of life on the planet gas or sub-terran. The last step is the analysis of the planet's habitable mass and radius. The previous literature writes that the mass and habitable radius of a planet belong to an Earth-like planet are ± 1. So in the analysis process, mass and radius are not allowed to be processed together. This is because there are several planets that are found to have significant differences in parameters. After all the data is finished being processed, it will be obtained in the form of new data in the form of data of Earth-like planets (Earth like planets) which can then be made a new catalog containing the data of the planets.

## III. RESULT AND DISCUSSION

### A. Giant Planets

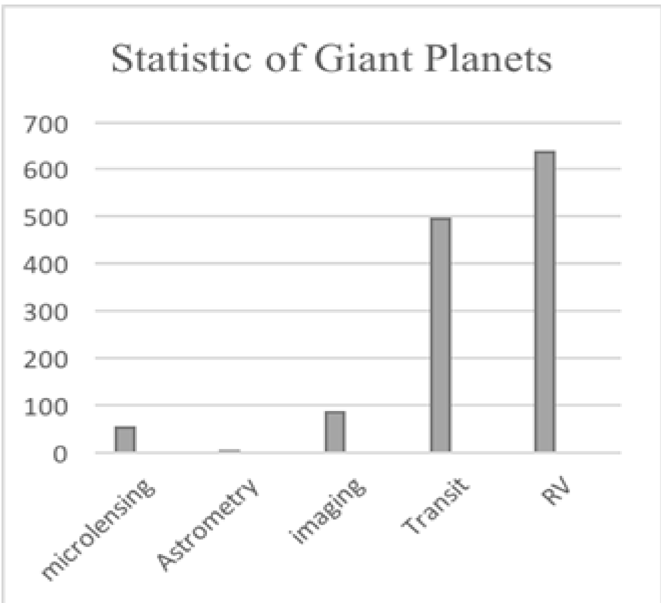


Fig 1:- Statistic for Giant Planets

According to information obtained from the Planetary Habitability Laboratory at the University of Puerto Rico at Arecibo, giant planets are planets with masses of more than 10 times the mass of the Earth (m> 10). Usually giant planets are composed of gas and ice, but some are composed of rock or solid material. Giant planets are also sometimes referred to as Jovian planets.[4-5]

Radial velocity methods (doppler spectroscopy) and transit methods are two very prominent methods. The radial velocity method is considered quite famous because it has detected many new giant planets outside the solar system.6 Most of the extrasolar planets are found around the parent star which is in the main series. Whereas the transit method is the second most famous method for discovering giant extrasolar planets after the radial velocity method (dopler spectroscopy). Both of these methods are the center of attention in looking for giant extrsaolar planets because the data that has been collected has shown that there are about 636 extrasolar planets found by the radial velocity method, and there are 496 by transit method.

*B. Terrestrial Planets*

Terrestrial planets, also called rocky planets or telluric planets are planets that have the main composition of carbon, silicate rocks or metals. In our solar system, this planet is an inner planet that is close to the sun and belongs to the category of small-mass planets. Terrestrial planets have a dense surface, which makes this planet different from giant planets.

Many variables can help define what the terrestrial planet is like. Some of them are the mass of the parent star, the mass and distribution of the protoplanetary disk, and the position of the giant planet. [7] In this paper, the authors review terrestrial planets based on planetary mass. According to Fischer et al (2008) terrestrial planets have a radius of 0.5 - 2 times the radius of the Earth, equivalent to 0.1-10 times the mass of the Earth. The following is shown the statistics on the number of terrestrial planets through the mass variable of the planet that will be compared to the mass of the Earth.

Terran planet (earth size planet) [9] is a planet measuring 0.5 to 2 times the mass of the Earth. This planet is viewed from the mass and composition of the rock, not according to the composition of the atmosphere.

According to Sanchis et al (2013) and Howard et al (2013) the transit method has detected many terran planets. The radial velocity method is not optimal to find many terran planets because it can only detect planets with very small orbits around low-mass stars. With the transit method, the detection of many terran planets makes this method far superior to other methods.[10-11]

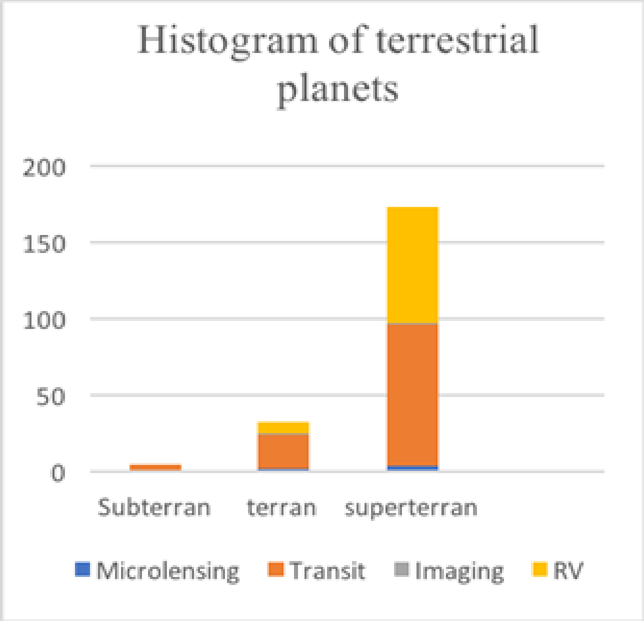


Fig 2:- Data of Terrestrial Planets

*C. Habitable Planets*

The search for extrasolar planets, especially planets located in habitable zones and their life, has become the most interesting subject matter at the moment.[12] Research on extrasolar planets, specifically using NASA's Kepler mission, has revealed that dwarf planets are generally in habitable zones.13-14 However, not all dwarf planets are in habitable zones. According to Heller and Armstrong (2014) There are also giant planets in habitable zones.[15]

Habitable planet is located in a habitable zone. According to Seager (2013) the planets that are in habitable zones have no guarantee of being truly habitable, and habitable environments also do not need to contain life. [16] In the search for habitable planets, surely the habitable zone boundaries have to be known in advance. in a solar system using certain modeling. Estimates of habitable zones for our solar system are 0.5 to 3.0 SA, although this estimates giving a lot of debate, thus there is a lot of things about the inner and outer boundaries of the habitable zone. Dole (1964) argues that the inner boundary of the habitable zone is 0.725 assuming the types and albedo atmospheres remain. Venus also placed in the aphelium. [17]

Hart (1979) gives the inner limit at 0.96 SA around a sun like stars. The previous model is the boundary in the habitable zone for Earth-like planets with a pressure of 10 bars N2.[18] By maximizing the cooling effects of clouds in Earth-like planets, the inner boundary can located at 0.87 SA around the sun according to the 1D cloud model. Using an energy equilibrium model and a range of surface pressures between 0.3 and 3 bars, Vladilo et al (2013) shows that the inner boundary currently on 0.85 SA. [19] Abe (2011) that the boundary argument is a habitable star at 0.77 SA for Earth-like planets with water reservoir boundaries based on 3D circulation models.20 Kopparapu (2013) corrected the estimated habitable zone boundaries by adding the algorithm of the lost greenhouse and water effects. [21]With this estimate, the boundary in the habitable zone is located at 0.99 SA. Taking into account albedo and the greenhouse effect, Lo Presto and Ochoa (2017) get the boundaries in habitable zones around the Sun like stars at 0.45 SA. [22]

In determining habitable zones, we make conclusions from the analysis that the effective inner limits used are 0.54 - 0.70 SA. For the inner limit in accordance with the calculation of the Stellar habitable zone calculator which estimates that the limit in the solar system's habitable zone is 0.5 SA. Most habitable planets are more orbiting their parent star with the K spectrum class type which has a temperature of about 4000 K because the planets have temperatures that allow it to retain water in its liquid form on its surface. The planets also remain stable longer in the main phase than the Sun[23 - 24], allowing longer periods of life to form on planets that surround major series of stars in the spectrum class K.[25]

However, planets orbiting stars in the elderly spectrum K class are thought to be unable to sustain life. This is because the planet can be trapped in synchronous rotation due to tidal attenuation, which is caused by the high incidence of corona mass ejection, which together produces little protection from high energy particle radiation. [26]

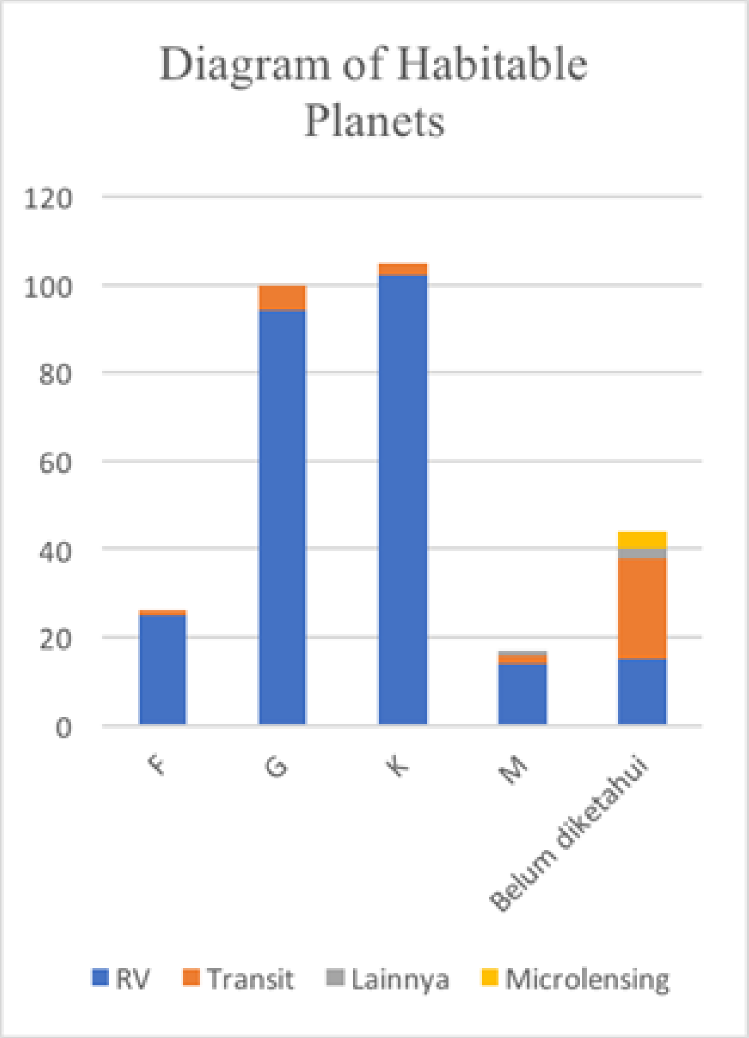


Fig 3:- Diagram of Habitable Planets

*D. Earth-Like Planets*

In 2013, based on the data obtained from the Kepler mission, there were as many as 40 billion Earth-sized planets orbiting their parent stars such as the Sun and red dwarfs in habitable zones in the Milky Way galaxy. 11 billion of these planets have been estimated to orbit stars like the Sun. The closest planet may be 12 light years from Earth.[27]

The possibility of finding Earth-like planets depends on the same completeness, and the completeness varies greatly. Generally, Earth-like planets are considered that the planet is a terrestrial planet and there have been several scientific studies aimed at finding the planet. The conditions that make the planet can be considered Earth-like are the size of the planet, the planet's surface gravity, the condition of the parent star (especially the type of spectrum class), orbital distance and stability, the axis of slope and rotation, geographical conditions, oceans, water, and climatic conditions, the magnetosphere strong and even the same conditions of life as on Earth. The following will be discussed in detail about the criteria for planets that are like Earth.[28 – 33]

## IV. CONCLUSION

Every type of planet (both giant planets and terrestrial planets, habitable planets, and Earth-like planets) has its own method for detection. For radial giant planet planets more dominantly used for detection because it has found 636 planets, terrestrial planets are more dominant in the detection method because they have succeeded in finding 119 planets, habitable planets More dominant in detection by the radial velocity method because it has found 250 planets Earth-like planets are dominantly detected by using the transit method because they have found 2 planets.

| No | Planets | Parent Stars | Mass ($M_{jup}$) | Mass ($M_e$) |
|---|---|---|---|---|
| 1 | KIC 12557548 b | KIC 12557548 | 6.30 x $10^{-5}$ | 0.020034 |
| 2 | Kepler 106 b | Kepler 106 | 0.000047 | 0.14946 |
| 3 | Kepler 138 b | Kepler 138 | 0.00021 | 0.06678 |
| 4 | Trappist 1 d | Trappist 1 | 0.0013 | 0.4134 |
| 5 | WD 1145+017 b | WD 1145+017 | 2 x $10^{-6}$ | 6.36 x $10^{-4}$ |

Tabel 1:- Data of Subterran Planets.

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