Identifying Exoplanets' Potentiality for Life in Habitable Zones: Giving New Dimension to Cosmological

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Abstract

The discovery of exoplanets has altered our understanding of the universe. But, for the planets to show the possibility to harbour life in it or have biosignatures, it must have optimum physical, biological, geological and chemical conditions. There are two types of indicators of habitability: direct and indirect. The former indication is the presence of water and its stability on the surface of the planet. Thus, the reflection from the waterbody will lead to 'glint'. Polarization of light is another alternative method to find water. The reflection, emission of radiation help us to characterize habitable zones. Indirect methods include the presence of CO2 and water vapour in the atmosphere, size of the planet and extent of axial tilt. The presence of magnetic fields and satellites revolving around the planet also play an important role. In this review article, we aim to provide a comprehensive explanation to the researches done till date to characterize habitable zones for exoplanets. The methods devised to retrieve results will also be discussed. Future prospects, the voids which could be amended are also elaborated. This could give cosmological research a new dimension, demonstrating that life is not limited to our planet.

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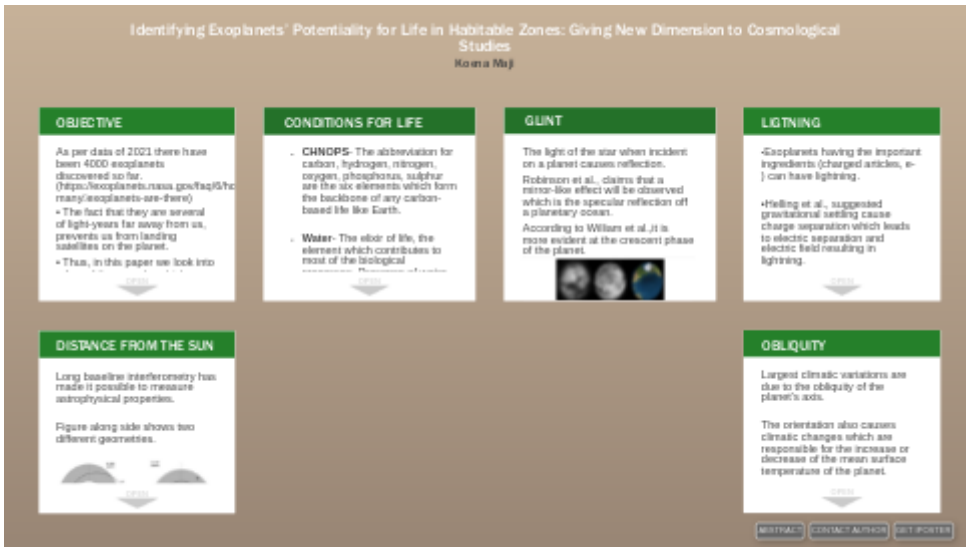

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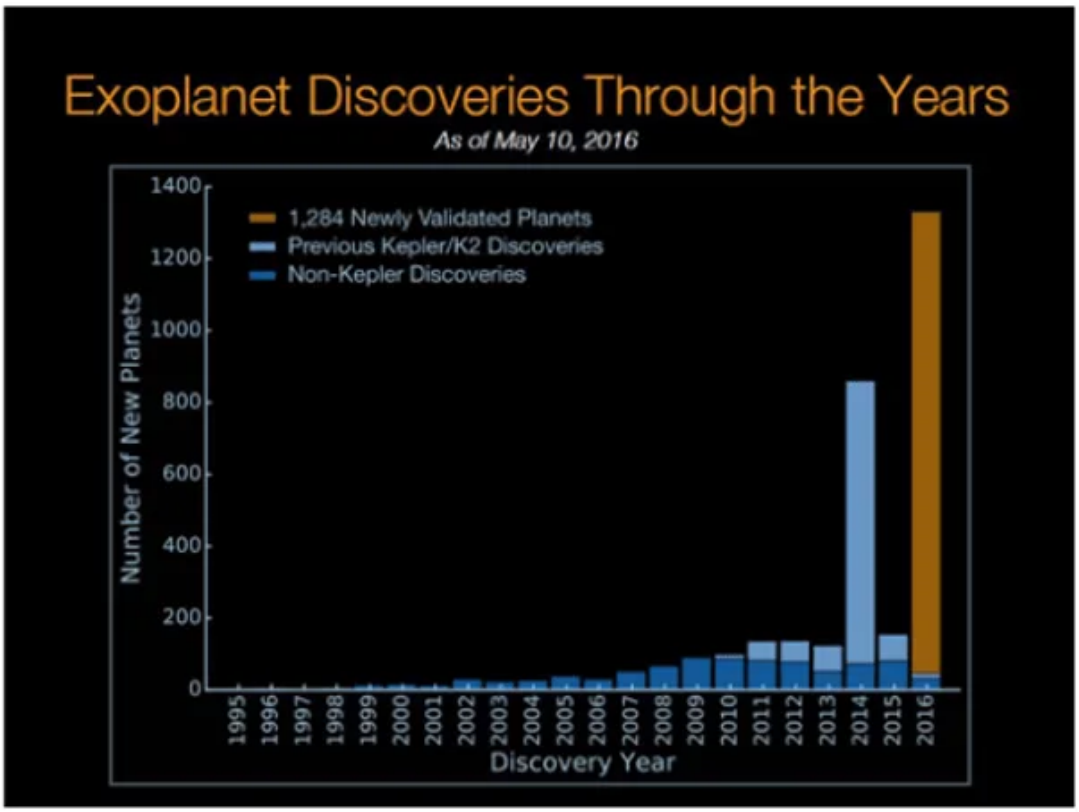
PRESENTED AT:

OBJECTIVE

As per data of 2021 there have been 4000 exoplanets discovered so far. (https://exoplanets.nasa.gov/faq/6/how-many exoplanets-are-there)

• The fact that they are several of light-years far away from us, prevents us from landing satellites on the planet.

• Thus, in this paper we look into a few of the ways by which habitability in these exoplanets can be detected by satellites maneuvering in space.



Number of new exoplanet discoveries by year since 1995. Credit: NASA Ames/W. Stenzel; Princeton University/T. Morton

CONDITIONS FOR LIFE

- **CHNOPS**- The abbreviation for carbon, hydrogen, nitrogen, oxygen, phosphorus, sulphur are the six elements which form the backbone of any carbon-based life like Earth.

- **Water**- The elixir of life, the element which contributes to most of the biological processes. Presence of water and its stability on the surface of the planet is a direct indicator of habitability.

- **Energy**- The distance from the season varies the amount of solar energy received by planets.

- **Change of seasons**- Tilt of the planet's axis with respect to its orbit about the sun. Having a proper tilt angle is necessary for moderate conditions.

GLINT

The light of the star when incident on a planet causes reflection.

Robinson et al., claims that a mirror-like effect will be observed which is the specular reflection off a planetary ocean. He claimed this to be glint. It is observed by the Lunar Crater Observation and Sensing Satellite (LCROSS).

According to William et al., it is more evident at the planet's crescent phase than the quadrature-phase (Fig. 1) because starlight will be incident on the planet's surface at a highly oblique angle when the planet is at the crescent phase.

Morever, as the planets will rotate, glint spot 'blinks' as Lambertian scattering continents interrupt the specular reflection from the ocean.

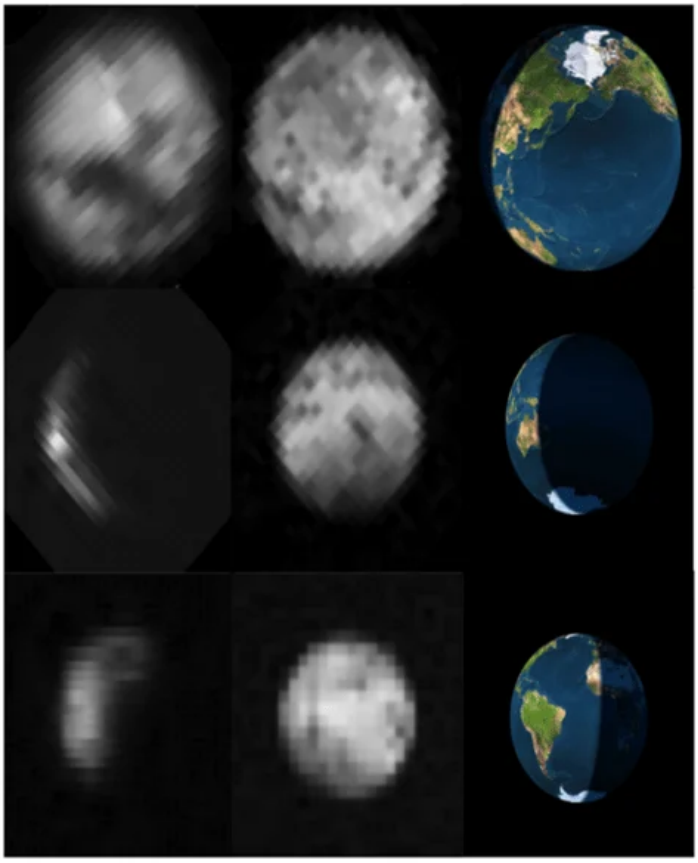


Figure 1. Images of Earth taken by NIR2 (0.9−1.7 μm) (left), MIR1 (6.0−10.0 μm) (middle) from each Earthlook. A schematic showing Earth's orientation is also shown (right), which were generated using the Earth and Moon Viewer, first implemented by J. Walker (http://www.fourmilab.ch/cgi-bin/Earth). Rows top to bottom are Earthlook 1 (2009 August 1), Earthlook 2 (2009 August 17), and Earthlook 3 (2009 September 18) where Earth's angular diameter spanned 2.2, 1.6, and 1.5, respectively. Each image box represents a 2.5 × 2.5 FOV. A glint spot can be seen near the center of the crescent in the Earthlook 2 NIR2 image, and is located in the Indian Ocean off the western coast of Australia.

LIGTNING

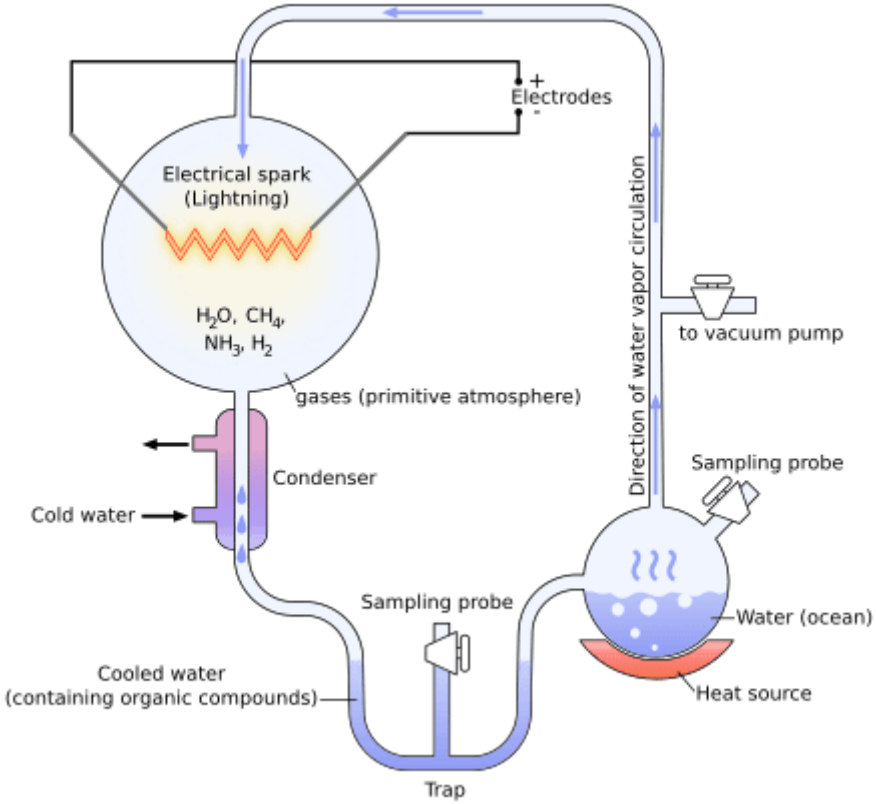
Lightning is observed by radio emission.Exoplanets having the important ingredients (charged articles, e-) can have lightning.

Helling et al., suggested by observing kinetic cloud models that in extrasolar atmospher, gravitational settling cause charge separation which leads to electric potential and electric field resulting in lightning.

Lightning produces gases essential for life and cause changes in the atmosphere. These gases can be detected by sophisticated remote sensing space telescopes.

Biosignature gases like CH4, N2O alter the trophosphere of planets. Redox chemical reactions, removes or adds electrons from atoms or molecules. Thus, it can be concluded that this usage of electrons or series of chemical reactions are brought about by life.

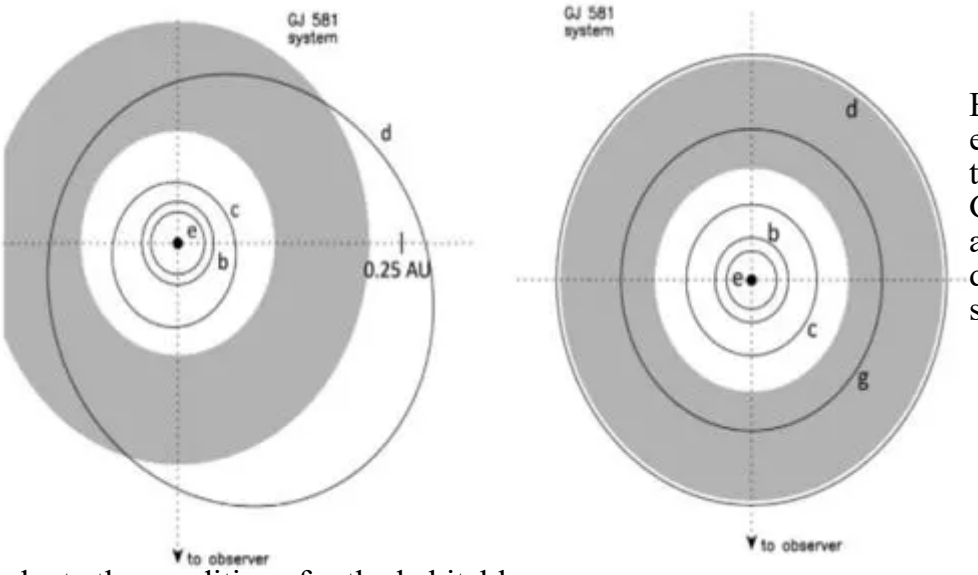
If we consider Earth as an exoplanet and examine it now, it will have high Oxygen absorption feature compared to methane. While in primitive Earth since it had a reducinfg atmosphere, methane detection was higher.



DISTANCE FROM THE SUN

Long baseline interferometry has made it possible to measure astrophysical properties.

Figure along side shows two different geometries.



Braun et al., tested GJ581, an M dwarf star, to evaluate the conditions for the habitable zone.

Equations by Underwood et al., were used to determine the inner and outer boundary of the habitable zone. This equation relates the radii of inner and outer edges of HZ to luminosity and effective temperature of host star. To find which of GJ581's planets lie in HZ, Teq is calculated.

$$T_{eq}^4 = \frac{S(1-A)}{f\sigma},$$

Here, f is the redistribution factor which is 2 for hot dayside and 4 for even heat distribution. S=stellar energy flux, A=bond albedo. Teq is a function of time and hence, as it moves from periastron to apastron (Fig.1), it shifts its HZ. Thus, presence of sufficient greenhouse gases will maintain the inner temperatur of the planet.

Equilibrium Temperatures for the GJ 581 System Planets

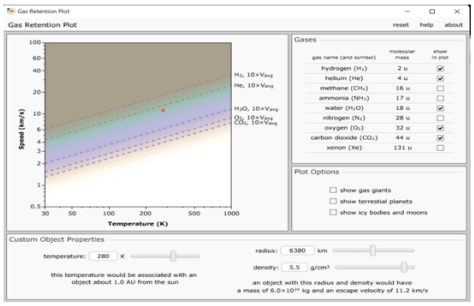
Planet	a (AU)	$T_{eq}^{f=4}$ (K)	$T_{eq}^{f=2}$ (K)
b	0.041	418 ± 3	498 ± 3
c	0.070	320 ± 2	381 ± 2
d	0.220	181 ± 1	215 ± 2
e	0.030	489 ± 2	582 ± 3
f	0.758	97 ± 1	116 ± 1
g	0.146	222 ± 2	264 ± 2

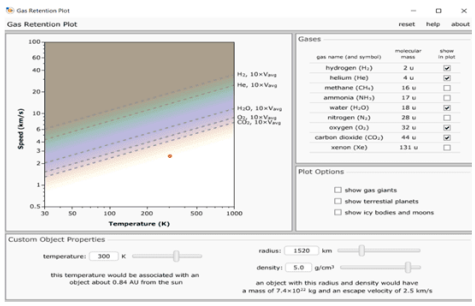
Table shows the calculated equilibrium temperatures.

In Fig.1 HZ is depicted in grey. We can see that 'g' spends all its time in HZ with even heat distribution while 'd' is on outer edge.

My Hypothesis

- Presence of too thick or thin atmosphere enclosing the planet prevents the possibility of life.
- Lack of species in the planet will cause an imbalance to the ecological cycle. In this case, the planet might have an onset of habitability but it will not persist for long.





Conclusion

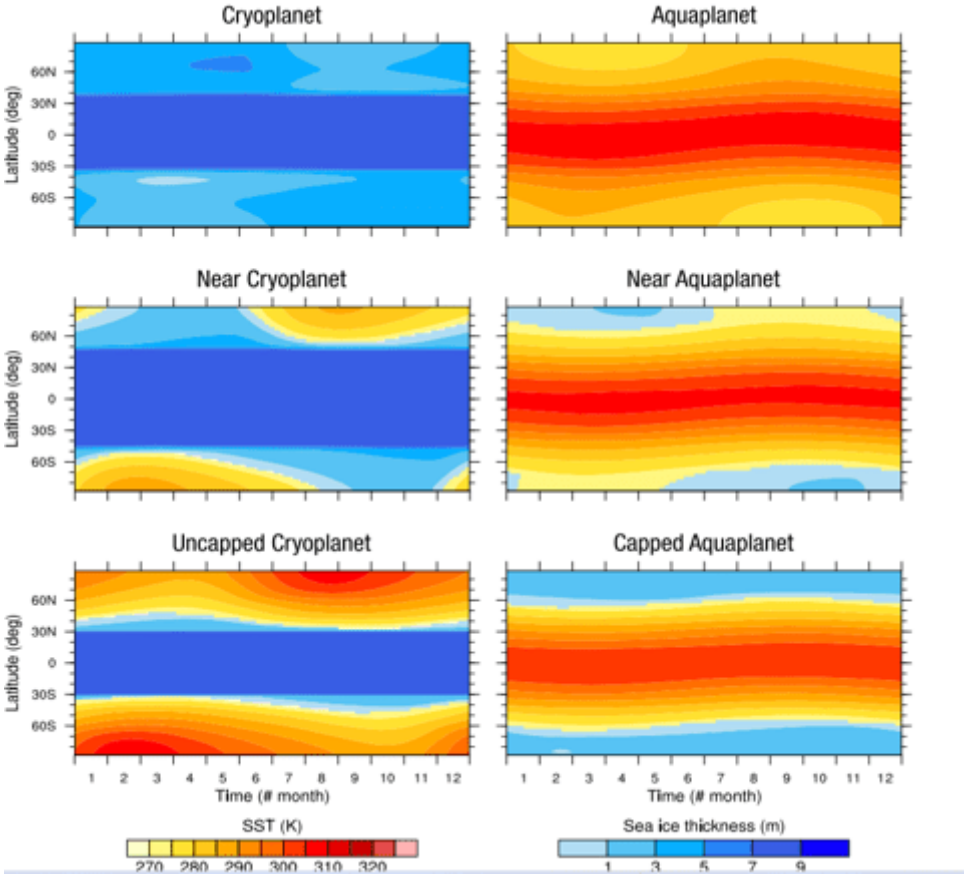
- In this presentation we explored the various methods by which we can explore the possibility of life on exoplanets.
- We also gave our insights about what should the other conditions that should be looked into in order to find a higher probability of life.

OBLIQUITY

Largest climatic variations are due to the obliquity of the planet's rotation axis.

The orientation also causes climatic changes which are responsible for the increase or decrease of the mean surface temperature of the planet.

Kilic et al., explored the impact of changes in obliquity to characterize climatic states on a general basis.



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