Characterization of the exoplanet TOI-560c using data from the ESA's CHEOPS satellite: Hacking an Exoplanet.

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ABSTRACT

In this article, the activity of ESA hacking an exoplanet was documented, which involved analyzing real data from the exoplanet TOI-560c captured by the CHEOPS satellite for subsequent characterization. This was done by estimating its size, orbital period, density, and temperature. Additionally, various cross-curricular activities were developed for teaching astronomy, such as astrobiology, which involved studying tardigrades in extreme conditions. The study of sunspots was conducted using the Celestron Omni XLT 150 telescope and a solar filter. A planetary system was simulated and constructed using a Creality Cr200b 3D printer, and the study of solar energy was also included. Twenty participants between the ages of 14 and 18 were selected, and on the day of the activity, they were divided into groups of three students who documented their findings in a guide or logbook. Through the activities conducted, an increase in motivation towards astronomy and mathematics was observed, as well as an improvement in teamwork skills, hypothesis formulation, drawing conclusions, and proposing models. It was also concluded that TOI-560c does not offer habitable conditions for known forms of life due to its high temperatures, as its average orbit around the star is 0.1242 AU. This would lead to significant changes in the chemical composition of biomolecules, such as denaturation, and in the planet's atmosphere.

Keywords: Education, astronomy, exoplanets, hack an exoplanet, european space agency ESA

INTRODUCTION

The history of humanity is filled with questions regarding the existence of other worlds, exoplanets that may harbor life. Furthermore, for many years, the possibility of other solar systems and their habitability for known life forms has been a subject of debate. In the past two decades, significant progress has been made [1], leading to the confirmation of 4,189 planetary systems [2]. The vast diversity of discovered exoplanets is evident, for instance, when studying gas giant planets orbiting close to their host star, as well as the abundance of rocky planets in inner orbits. Various methods have been developed to detect exoplanets, including Doppler measurements, transit observations as described in this study, gravitational microlensing, astrometry, and direct imaging. These techniques are complementary in nature. Furthermore, current technologies enhance these methods, although each one has its inherent challenges. For instance, the lens through which we detect exoplanetary systems biases the parameter space we can observe.

On the other hand, this article describes the results obtained from the activity proposed by the Education Section of the European Space Agency (ESA) called "Hack an Exoplanet." In this activity, participating students characterized the exoplanet named TOI-560c using real data taken by the ESA's

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CHaracterising ExOPlanet Satellite (CHEOPS). The objective was to understand the potential habitability of this extraterrestrial world and contemplate the opportunity, perhaps in the future, of leaving this planet (which many desire). TOI-560c is an exoplanet that orbits a K-type star, with a mass of 9.7 Earth radii ($9.7R_{\oplus}$). It takes 18.9 days to complete its orbit around its host star and is located at a distance of 0.124 astronomical units (au) from Earth.

Furthermore, this article is organized as follows. The section titled "Exoplanets and How They Are Studied" addresses basic conceptual aspects of exoplanets. In the "Materials and Methods" section, a brief schedule is presented, outlining the materials and activities chosen for this hackathon. The "Results and Discussion" section describes the modeling using the online software Alleesfitter, calculates the orbital velocity, and presents hypotheses about habitability. Finally, the conclusions and consulted bibliographic references are presented.

THE STUDY OF EXOPLANETS

Exoplanets are well-known as extrasolar planets or celestial bodies that orbit stars other than our Sun. These fascinating worlds exist beyond our solar system and have sparked significant interest within the scientific community due to their potential for understanding planetary diversity and the possibility of hosting life—a question that has intrigued us since the dawn of civilization. The field of exoplanet studies has experienced rapid advancement in recent decades, thanks to the combination of innovative technologies and new detection methods.

One of the most widely used methods for investigating exoplanets is the radial velocity method. This approach relies on detecting small oscillations in the velocity of the host star caused by the gravitational attraction of the orbiting planet. By measuring these changes in velocity, astronomers can infer the presence and basic characteristics of exoplanets.

Another method is the transit method, which was applied in this experimental research. This method is based on observing the periodic decrease in brightness of a star when an exoplanet transits in front of it. By analyzing the variations in brightness, scientists can determine the size and orbit of the exoplanet, as well as gather information about its atmosphere.

Furthermore, the gravitational microlensing method relies on the distortion of light from a background star due to the presence of a massive exoplanet between the star and the observer. This technique enables the detection of exoplanets that do not transit in front of their host star, expanding the range of detection.

Once an exoplanet is discovered, scientists focus on its characterization. One of the most exciting areas of research is the study of exoplanetary atmospheres. Using spectroscopic techniques, astronomers can analyze the light passing through an exoplanet's atmosphere during a transit and determine the chemical components present. This provides valuable clues about the atmospheric conditions and composition, including the presence of molecules that could be indicative of life.

To carry out these studies, technologies and observatories have been developed both in space and on Earth. Space telescopes such as the Hubble Space Telescope and the James Webb Space Telescope have enabled high-precision and high-quality observations across different wavelength ranges. Additionally, dedicated missions such as Kepler, TESS, and CHEOPS have significantly expanded our knowledge of exoplanets and provided crucial data for further studies.

METHODOLOGY

The "Hack an Exoplanet" activity proposed by the ESA took place on May 3rd, from 1 to 6 pm, entirely at the Marcelino Champagnat educational institution in the city of Armenia, Quindío department, Colombia. This activity was carried out as a strengthening strategy for outreach, scientific literacy, and experimental research in the field of astronomy, astrophysics, and space sciences, proposed by the Kepler4 group as part of their objectives for 2022. The Kepler4 group was created and is led by electronic engineer Jairo Andres Acevedo, a physics teacher at the institution. The members of this group are students from the Marcelino Champagnat educational institution who participate in personalized astronomy and astrophysics classes aimed at preparing for the Colombian Astronomy, Astrophysics, and Astronautics Olympiad, as well as conducting experimental research projects in the field of astronomy, such as developing a light pollution map of the city. As achievements of the Kepler4 group, one student qualified for the Latin American Astronomy and Astronautics Olympiad in 2022, held in Panama City. Astronomy outreach activities, such as the one presented in this article, "Hack an Exoplanet," have also been developed.

The hackathon was aimed at students in 9th to 11th grade from the educational institution and some schools in Armenia. These students ranged in age from 14 to 18 years old. Potential students were invited to participate through social media or personalized invitations based on their specific interests, and they had to fill out a registration form created using the Microsoft 365 Forms application. Additionally, students interested in participating, through their guardians or caregivers, signed the informed consent form in accordance with the guidelines proposed for this activity, allowing audiovisual recording.

After the call for participation, 20 students registered and took part in the activity. Once the participants were selected, on the day of the event, they were divided into teams of 3 students, who were given time to work on each of the proposed activities. Throughout the activity, they recorded the results, hypotheses, and conclusions in a logbook or guide.

In addition to studying the exoplanet TOI 560c, several of the cross-cutting activities proposed on the ESA's website were selected, including: 1) "Space Bears: Experimenting with Tardigrades," 2) "The Power of Sunlight: Solar Energy in Space Exploration," and 3) "Exoplanets in Motion: Building Your Own Exoplanetary System." Furthermore, the Kepler4 group developed additional activities, such as: 1) Study and observation of sunspots using a telescope. Each activity took place in different classrooms, referred to as Activity Creation Site (CAS), with each group of students setting achievable goals. **Table 1** presents the schedule, summarizing the proposed activities and the materials required for our Hackathon.

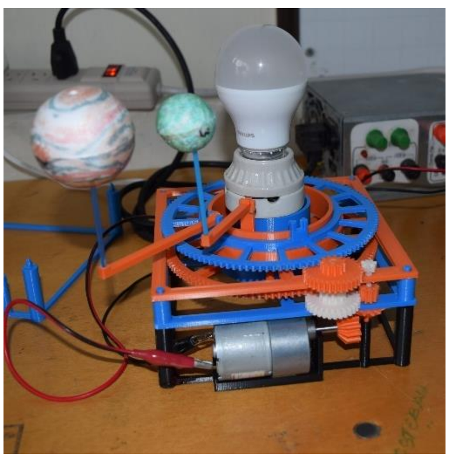
TABLE 1. List of Hack an Exoplanet Activities at Marcelino Champagnat school in Armenia, Colombia.

CAS	ACTIVITY	MATERIALS
1	**Astrobiology**: Can life survive in space? Study of tardigrades in extreme conditions.	Microscope, tardigrades, guides, Petri dishes, tweezers, dropper, lemon, hot water.
2	**Simulation of a planetary system**: Designing a 3D model to study Kepler's laws and the transit method.	Smartphone, Arduino Science Journal app, calculator, pencil, AA battery, light bulb, 3D printer.
3	**Hack an Exoplanet**: Characterization of exoplanet TOI-560c. Planet size, Orbital period, Habitability, Composition.	Computador portátil, calculadora científica, bloc, lápiz, borrador, datos satélites Cheops, software Allesfitter.
4	**Solar energy in space exploration**: Understanding concepts influencing the design of solar panels for space missions, such as the inverse square law and incident angle.	Multimeter, cardboard, marker, solar panel.
5	**Study of sunspots and observation:** Using a reflecting telescope.	Celestron Omni XLT 150 telescope, solar filter, Nikon 3300 camera, ZWO ASI120MC-S camera, Luminos 23mm eyepiece, Magnetology app.
8	Results analysis, team report.	Notepad, calculator, pencil.

As shown in **Table 1**, the students characterized the exoplanet TOI-560c as the main activity, analyzing the data acquired by the ESA's CHEOPS satellite. The students worked like scientists to fit a model to the data in order to obtain the best-fit parameters. In order to achieve this, they observed and studied sunspots using the telescope from the Kepler4 group. They used a Celestron Omni XLT 150 reflecting telescope with a Thousand Oaks Optical solar filter and a Celestron Luminos 23mm eyepiece (**Figure 1.a**). Sunspots were photographed using a DSLR camera (Nikon D3300) and a smartphone, and the students recorded their observations, taking the Kp index from the Magnetology app, calculating the solar radiant flux, and forming hypotheses. Additionally, tardigrades were collected to observe their behavior under acidic pH and high temperatures using the microscope shown in **Figure 1.b**. Another activity involved the simulation of a planetary system (**Figure 4.c**), which generated great interest among the students. They utilized 3D design and printing with the Creality CR200B 3D printer (**Figure 4.d**) and PLA filament to create a system where they studied Kepler's laws and the transit method. Throughout the activity, documentation was carried out using a guided format to complete the record for the exoplanet. The documented results can be found in **Attached 1**.

a.

b.



c.

d.

Figure 1. Main materials in the Hacke an exoplanet activity. a) Celestron Omni XLT 150 Telescope. b) Zeiss Primo Star Microscope. c) 3D electronic and mechanical parts of the planetary system. d) Creality CR200B 3D Printer.

ANALYSIS AND RESULTS

A. Modeling based on the transit data of TOI-560c

Figures 2 and **3** display images showing the Allesfitter interface with the brightness data that were adjusted to find the best model. This data fitting process is performed using the statistical method called Markov Chain Monte Carlo. The calculation of the parameters took several minutes to complete, ultimately resulting in the model shown in **Figure 4**.

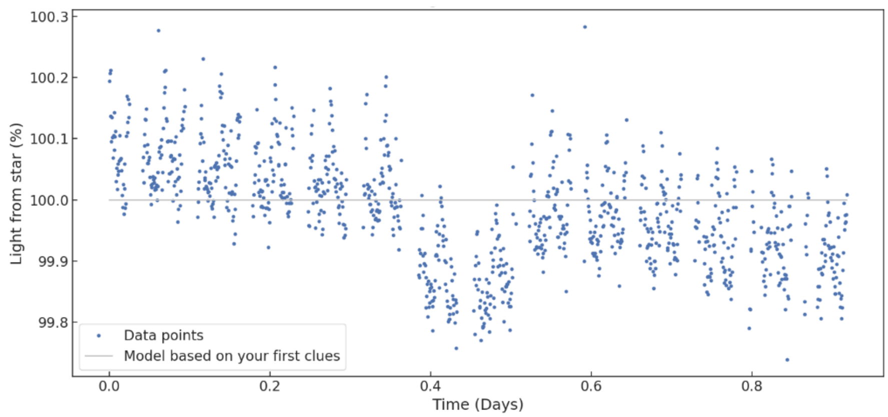


FIGURE 2. Allesfitter interface for fitting the light curve of the transit of TOI-560c.

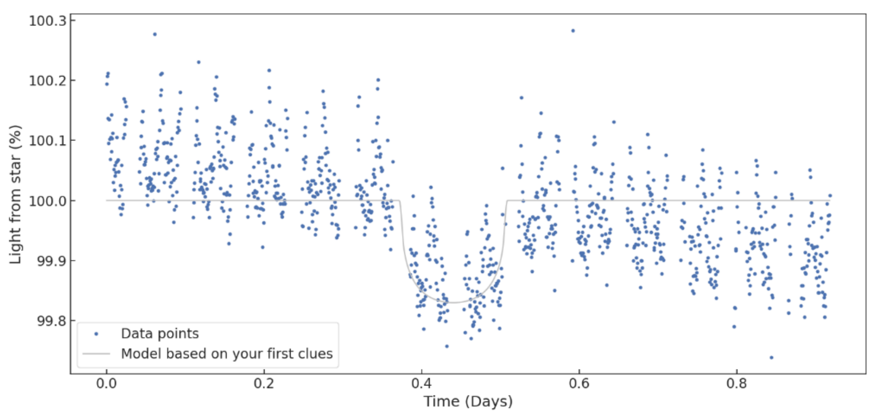


FIGURE 3. Allesfitter interface for fitting the light curve of the transit of TOI-560c.

In **Figure 4**, the light axis of the star is normalized to 100%. However, some outlier values appear above 100%, which may be related to stellar flares or stellar storms. Therefore, the asymmetry in the transit can be observed. This is because the transit of the exoplanet in front of its host star can be asymmetric in nature. Hence, these phenomena affect the shape of the exoplanet's transit curve, resulting in luminosity values exceeding 100%.

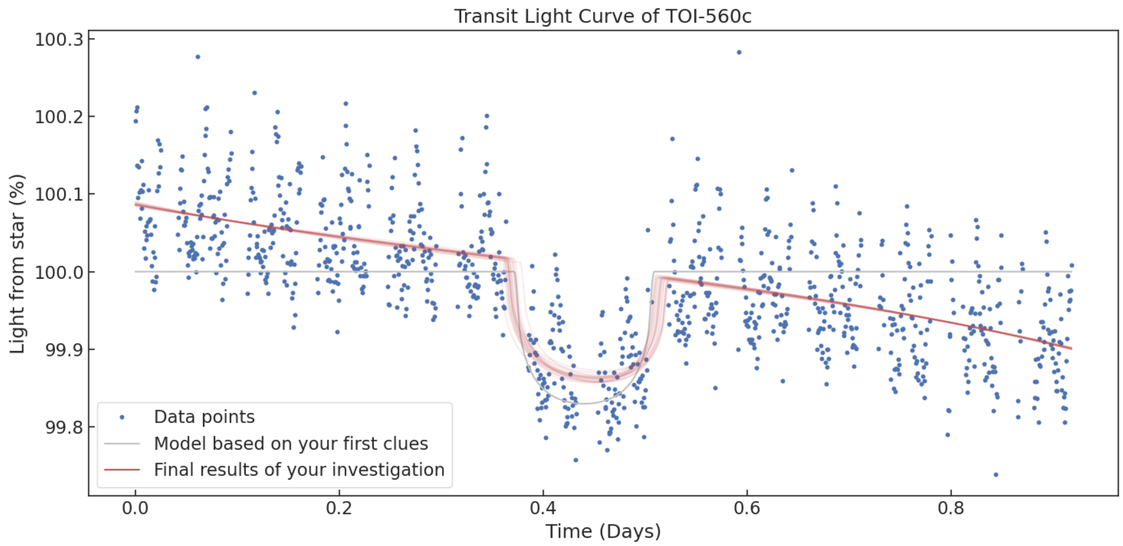


FIGURE 4. Transit light curve fitting for TOI-560c.

On the other hand, **Figure 5** displays a statistical probability histogram of the estimated parameters of the transit of the exoplanet TOI-560c, providing a visual representation of the probability distribution of the data. This is useful for analyzing centrality, dispersion, the shape of the distribution, and detecting outliers. This knowledge is crucial for statistical analysis and interpretation of results in exoplanet research.

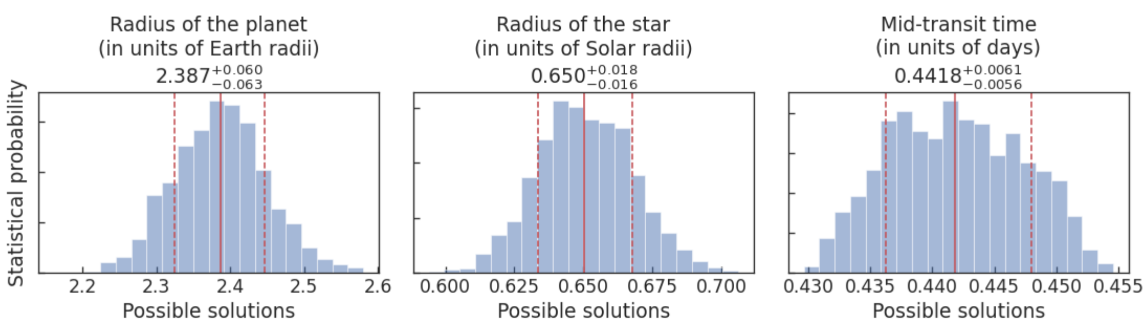


FIGURE 5. Probability histogram of values and parameters for TOI-560c

Finally, the estimated data by the Allesfitter software are shown in **Table 2**. This version of the tool already has the loaded data sets and only allows the exploration of specific parameters: planet radius, star radius, semi-major axis of the orbit, and mean transit time.

TABLE 2. Fitting data for the exoplanet estimated by Allesfitter

Name	Median value	Lower error	Upper error	Case note	Target
Radius of the planet (in units of Earth radii)	2.387	0.063	0.060	Cheops observations	TOI-560c
Radius of the star (in units of Solar radii)	0.65	0.016	0.018	Cheops observations	TOI-560c
Mid-transit time (in units of days)	0.4418	0.0056	0.0061	Cheops observations	TOI-560c
Orbital period (in units of days)	18.8797			Other observations from the archive	TOI-560c
Orbital semi-major axis (in units of AU)	0.1242			Other observations from the archive	TOI-560c

B. Calculation of Orbital Distance

The ESA's Cheops satellite observed TOI-560c on January 23, 2023, at 13:12 CET, using transit photometry. The estimated radius of the star TOI-560 (HD 73583) was determined to be $0.65R_\odot$. Consequently, through the analysis of the data, we can measure the transit depth of the exoplanet to be approximately 0.12%, as shown in **Figure 6.**

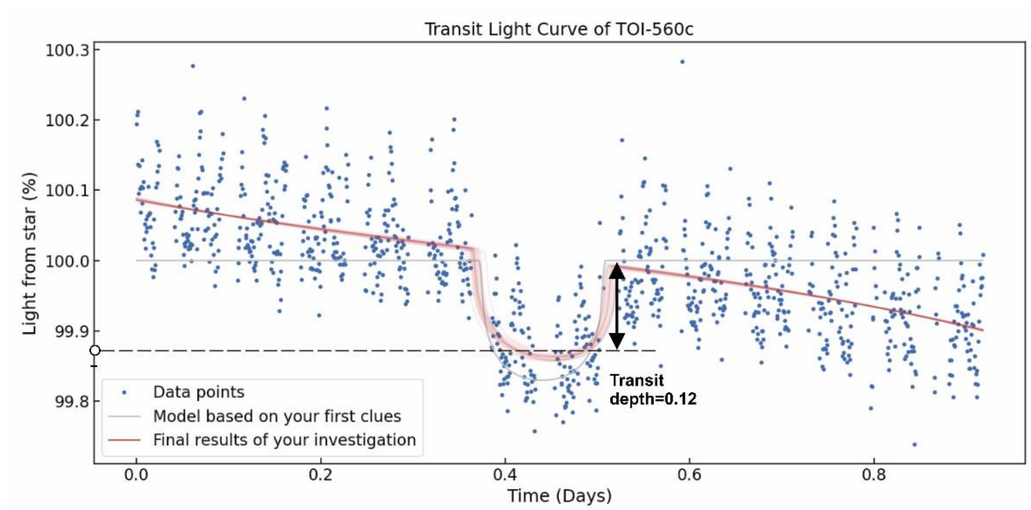


FIGURE 6. Transit light curve depth for TOI-560c.

This depth is directly related to the radius of the star (Rs) and the radius of the planet (Rp), as shown in **Equation 1**. Here, Rp represents the planet's radius and Rs represents the star's radius, resulting in the percentage of the transit depth.

This depth is directly related to the radius of the star (Rs) and the radius of the planet (Rp), as shown in **Equation 1**, where Rp represents the planet's radius, Rs represents the star's radius, and the transit depth is expressed as a percentage.

$$transit\ depth\ (\%) \approx \frac{\pi {R_p}^2}{\pi {R_s}^2} \times 100 \qquad (1)$$

Calculus:

$$R_p = \sqrt{{R_s}^2 \times \frac{trasit\ depth}{100}}$$

$$R_p = \sqrt{{R_s}^2 \times \frac{trasit\ depth}{100}} = \sqrt{0.65\ {R_\odot}^2 \times \frac{0.12}{100}} = 0.022 R_\odot$$

In order to compare with the radius of Earth, a unit conversion is performed.

$$R_p = 0.022 \cancel{R_\odot} \times \frac{109 R_\oplus}{1 \cancel{R_\odot}} = \mathbf{2,45} \boldsymbol{R_\oplus}$$

In light of this result of 2.45R⊕, the radius obtained from the Allesfitter fit is 2.387R⊕. It can be observed that they are close and this result can be compared with some known planets in the solar system. The planet that is most similar, albeit smaller in size, is Neptune with a radius of 3.88R⊕. It is well known that Neptune is a gas giant, as described in the specialized literature, and its formation was primarily based on processes occurring in protoplanetary disks, which are byproducts of the stellar formation process. [3]

To further study TOI-560c, the calculation of the orbital period (d) must be done by applying Kepler's third law, as shown in **Equation 2**.

$$T^2 = \left(\frac{4\pi^2}{G M_S}\right) d^3 \qquad (2)$$

Where G is the gravitational constant, Ms is the mass of the star, d is the mean orbital distance, and T is the orbital period. Note that the mass of the star, as shown in **Table 2**, is 0.73M⊙. Additionally, for the calculations, unit conversion to SI units is performed, resulting in 1.45×10^30 kg for the mass of the star. The orbital period of 18.8797 days, obtained from the fitting data in the Allesfitter software (**Table 2**), is also converted to seconds.

Calculus:

$$d = \sqrt[3]{\frac{G M_s}{4\pi^2} T^2} = \sqrt[3]{\frac{(6.674 \times 10^{-11}) \times 1.452 \times 10^{30}}{4\pi^2} \times 1631206^{\ 2}} = 18.69 \times 10^9\ m$$

In order to compare the calculated distance with other reference data, it is necessary to convert the units into astronomical units (AU). The mean distance between the exoplanet and its host star is 0.124 AU. Below, in **Table 3**, a comparison can be made between the orbital period and the mean orbital distance with some planets in our solar system, as well as another studied exoplanet, Kelt-3b.

Table 3. Comparison of the period and mean orbital distance of TOI-560c and the planets of the Solar System.

Planet	Period (days)	Mean orbital distance (ua)
Kelt-3b	2.70339	0.048
TOI-560c*	**18.8797**	**0.124**
Mercury	87.97	0.4
Earth	365.25	1
Neptuno	60266.25	30

C. *Habitability of TOI-560c*

An important factor to consider when assessing the habitability of a planet is its temperature. This can be studied by taking into account the distance to its host star, where water remains in a liquid state on the planet's surface, known as the habitable zone. Water is a vital component for the development of life as we know it. If the planet is too far from its host star, water remains in a solid state due to freezing, and if it is too close, water could be in a gaseous state. In this particular context, TOI-560c has a shorter orbital period than Mercury, which is the closest planet to the sun. As stated by Zhu [4], planets with radii between 1 and $4R_{\oplus}$ are frequently found in close orbits around Sun-like stars. It is unlikely that TOI-560c can support life, as it is very close to its host star. This proximity results in high levels of radiation. As a consequence, the temperature of TOI-560c is 225± 15 °C, which is extremely high and would have significant implications for the development of life as we know it. Other authors, such as Barragán et al [6], propose temperatures of 498±15 °C for this exoplanet, which, in the context of this study, still represent inhospitable conditions for an extraterrestrial world.

1. In summary, due to the extreme conditions such as high temperature and lack of liquid water, it would be highly unlikely for carbon-based life and organic compounds to exist on the exoplanet TOI 560c. At such high temperatures, the planet would present:
2. Inhospitable environments: High temperatures would create an extremely inhospitable environment for most known forms of life.
3. Water evaporation: Liquid water would quickly evaporate. Water vapor would rise into the atmosphere and could have a significant impact on the climate and atmospheric composition of the planet.
4. Chemical anomalies: Many chemical compounds would decompose or react differently at high temperatures. Therefore, the surface chemistry and atmospheric composition could change dramatically.
5. Detrimental effects on the atmosphere: The high temperature could affect the stability of the planet's atmosphere. Intense atmospheric movements, such as extremely strong winds or violent storms, could occur.

These factors collectively suggest that TOI 560c is highly unfavorable for the development and sustainability of life as we know it.

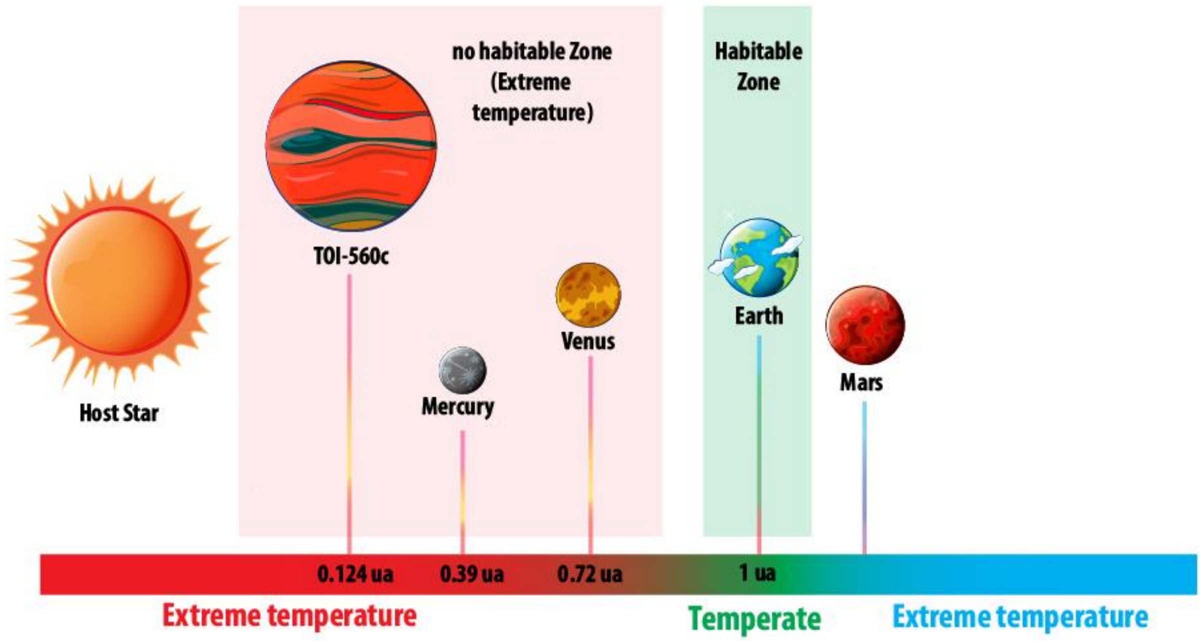


FIGURA 7. Illustrative diagram presenting the size and temperature of planets relative to their distance from their host star.

In this application context, the concept of habitability, as proposed by Charnonnel et al., does not solely depend on the effective temperature of the host star. Other variables, such as the relative position within the habitable zone, direct influence of intrinsic interstellar parameters, tidal, magnetic, and atmospheric interactions, also play a role. However, for life as we know it based on carbon, the primary factor of inhabitability is high radiation associated with high temperature. Compared to other planets in the solar system, as depicted in Figure 7 (a visual representation of size and distance), the radiation from the star and other forms of electromagnetic radiation could be much more intense, considering that known life is based on water and carbon.

D. The composition of TOI-560c

Once the radius of the exoplanet is calculated, assuming it is a perfect sphere, Equation 3 is applied, which is known for mass density, taking the mass of the Earth as 6 × 10^24 kg and the radius of the Earth as 6.37 × 10^6 m. By calculating the average density of an exoplanet, it is possible to get an idea of its composition.

$$\rho = \frac{M}{V} \quad (3)$$

$$V = \frac{4}{3}\pi {R_p}^3 \quad (4)$$

Where M is the mass of the exoplanet, V is the volume of the exoplanet, and ρ is the mass density with dimensions $[\rho] = ML^{-3}$.

Calculus:

$$R_p = \mathbf{2,45}\boldsymbol{R_\oplus} = \mathbf{1.56 \times 10^9}\ \boldsymbol{cm}$$

$$M_p = 9.70\boldsymbol{M_{\oplus}} = \mathbf{5.82 \times 10^{28}}\boldsymbol{g}$$

$$V_p = \frac{4}{3}\pi(1.56 \times 10^9\ cm)^3 = 1.59 \times 10^{28}\ cm^3$$

$$\rho_p = \frac{M_p}{V_p} = 3.65\ gcm^{-3}$$

Although average density can provide some clues about the composition of a planet, additional information and a more detailed analysis are required to obtain a comprehensive and accurate understanding of its composition. However, for the purpose of this study, we can infer that if the average density of the planet is similar to the density of rocky materials, it may be primarily composed of silicate rocks such as basalt or granite. If the average density is higher, it could indicate the presence of denser metals such as iron or nickel in its core. An average density of 3.65 g/cm³ could indicate a composition within the density range of some common materials.

Table 2 presents a list of solid materials in the range of 3 to 4 gcm^{-3}. It is likely that TOI-560c is composed of silicates, specifically some iron-rich silicate minerals such as olivine or pyroxene, which have densities ranging from 3.2 to 4.5 gcm^{-3}. If the planet contains a significant amount of these minerals, its average density could fall within that range. Additionally, it could contain metallic alloys indicating the presence of alloys like bronze or brass, which have similar densities.

Table 2. Materials with densities in the range of 3 to 4 g/cm³

Material	Density (gcm^{-3})
Basalt	2.7 - 3.3
Granite	2.63 - 2.75
Pyrite	3.2 - 4.5
Olivine	3.2 - 4.5

In summary, **Table 3** presents a summary of the estimated properties for TOI-560c (HD 73583 c). It has a mass of 9.7 Earth masses (9.7 M⊕), a volume of 1.59×10^28 cm³, resulting in an apparent density of 3.65 g/cm³. The exoplanet TOI-560c is consistent with a planet composed of a Earth-like interior, which is why some authors refer to it as a "super-Earth." It is also surrounded by a hydrogen envelope that may represent 1% of its mass. Through the completion of this outreach work and experimental research, it was possible to reproduce physical information reported in the specialized literature for this exoplanet. [5]

TABLA 3. Summary of an estimation of TOI-560c properties

PARAMETER	ESTIMATION
Planet type	Mini-Neptuno
Radio ($\boldsymbol{R}_{\oplus}$)	2,39 (Allesfiter) 2,45 (transit depth)
Mass ($\boldsymbol{M}_{\oplus}$)	9.70
Volumen (cm^3)	$1.59 \times 10^{28}\ cm^3$
Orbital period (days)	18.8797
Mean orbital distance (au)	0.124
Density (gcm^{-3})	3.65
Mean temperature (°C)	225 ±15

CONCLUSIONS

Allesfitter software and data from the CHEOPS satellite were used. It was possible to reproduce the physical information reported in the specialized literature for the exoplanet TOI-560c. The exoplanet is a mini-Neptune with high temperatures and a mass of $9.70M_{\oplus}$. The star TOI-560 is a K-type spectral star, also known as HD 73583, located in the Hydra constellation at a distance of approximately 103 light-years from Earth. It has a radius of $0.65R_{\odot}$ and appears reddish-orange in color.

In this study, the exoplanet TOI-560c was characterized, and it was found that due to its proximity to the host star with a mean orbital distance of 0.124 au and a planet radius of $2.45R_{\oplus}$, it is unlikely to host life. This would result in high levels of radiation due to the high temperatures near the melting point of tin, which would have significant consequences for life as we know it. First, biomolecules such as proteins and amino acids would denature at high temperatures, losing their structure and function. Second, the absence of liquid water would hinder the existence of life as we know it, as water would be in a gaseous state at such temperatures. Third, the scarcity of stable organic compounds would make it difficult for the formation and preservation of complex biological molecules, as high temperatures would cause the decomposition of these compounds. Lastly, the intense radiation exposure would be harmful to living organisms, including humans.

The density of TOI-560c is 3.65 gcm^{-3}, suggesting that it is likely composed of silicates. Specifically, it could contain silicate minerals rich in iron, such as olivine or pyroxene, which have densities ranging from 3.2 to 4.5 gcm^{-3}. It has also been reported to have an atmosphere rich in hydrogen, comprising at least 1% of its mass.

Finally, there is always the remote possibility of the existence of extremophilic life forms with unique and unknown adaptations that could survive in extreme environments, this remains purely speculative at this time.

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Attached 1

RETO 2 - Completar los datos que faltan en el expediente TOI-560c

TOI - 560c

esa

TOI- 560c
CASE FILE

Datos de

TIPO

Mini-Neptuno

RADIO DEL PLANETA

2,834R⊕

MASA DEL PLANETA

$9.70^{+1.80}_{-1.70}$ MTIERRA

PERÍODO ORBITAL

18.8797 DíAS.

DISTANCIA A LA ESTRELLA ANFITRIONA

0,124586UA

DENSIDAD

3.65 g/cm3

DESCUBIERT

2021 por el sondeo TESS

CARACTERÍSTICAS

se cree que es similar a Neptuno

COMPOSICIÓN

Solido - GAS.

TEMPERATURA

225 ± 15 °C ✓

Comparado con KELT-3b, TOI-560c es casi tropical, aunque sigue siendo cientos de grados centígrados más cálido que la Tierra.

Cheops observó este misterioso exoplaneta el **23 de enero de 2023** a las **13:12 CET**. Analizando estos datos hemos descubierto que TOI 560c es...

Mini Neptuno.

Tiene un radio de 2.45 R⊕ y un volumen 1,59 x 10[illegible] cm3

Un planeta compuesto de Hidrogeno y un interior rocoso. (silicatos ricos en Hierro).

En comparación con los planetas del Sistema Solar, TOI-560c...

Es caliente, tiene una Temperatura Alta.

NO ES HABITABLE.

TOI-560, también conocida como HD 73583, es una pequeña estrella de color rojo anaranjado situada en la constelación de Hydra, a unos 103 años luz de la Tierra.
TOI-560 es más pequeño y más frío que nuestro Sol.
Además de TOI-560c, hay un segundo planeta orbitando esta estrella, TOI-560b.

Masa de la estrella = **0.73 ± 0.02 M_{Sol}**

Radio de la estrella = **0.65 ± 0.02 R_{Sol}**

MANCHAS SOLARES

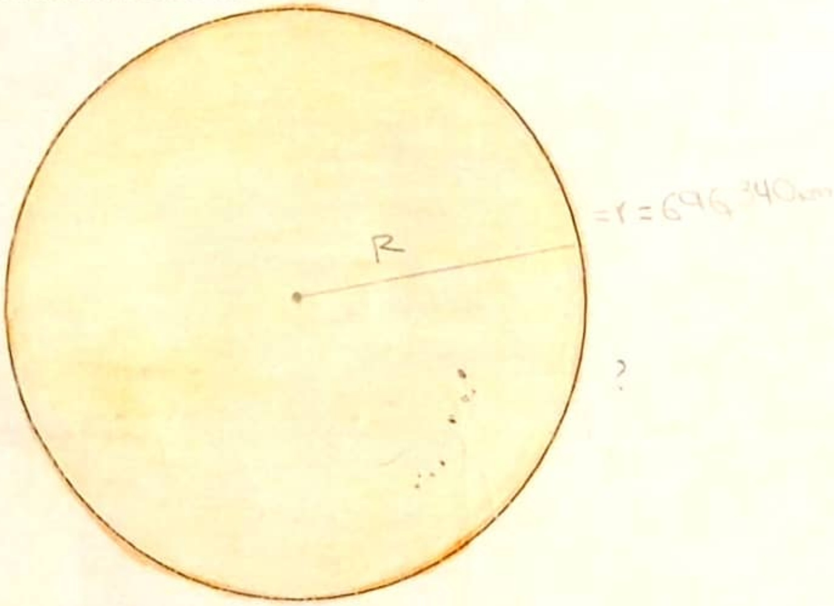
Precaución: Nunca debe usar un telescopio para ver el sol directamente.

<u>Previo</u>: Descargar magnetology: «Magnetología» es una aplicación que permite observar el pronóstico de tormentas geomagnéticas y el estado del campo geomagnético de la Tierra. ¿POR QUE ES TAN IMPORTANTE? Las tormentas geomagnéticas afectan negativamente la salud de los humanos.

A. ¿Cuál es el índice Kp[1] para hoy? Que implicación podría tener para la salud

3, Ninguna. Si es alto, afecta la salud.

B. ¿Dibuje las manchas solares, que relación podría tener el índice **Kp**? ¡Use Colores!



C. Calcular el valor del flujo radiante del sol.[2] ¿Como se le conoce a este valor?

D. Use un panel solar para medir el voltaje que produce a la exposición del sol. ¿Como ocurre?

E. Proponga un método para medir el tamaño de una mancha solar escalando el área del disco solar. Use regla si lo desea.

$$F = \frac{L_\odot}{4\pi r^2} = \frac{3.8\times10^{26}\,W}{4\pi.(6,9\times10^{8}\,m)^2} = 1358\ W/m^2$$

Irradiancia Solar..

[1] El índice Kp describe la perturbación del campo magnético terrestre causada por el viento solar. Cuanto más rápido sopla el viento solar, mayor es la turbulencia. El índice va de 0, de baja actividad, a 9, lo que significa que se está produciendo una intensa tormenta geomagnética.

2 Ley del inverso al cuadrado

$$F = \frac{L_\odot}{4\pi r^2}$$