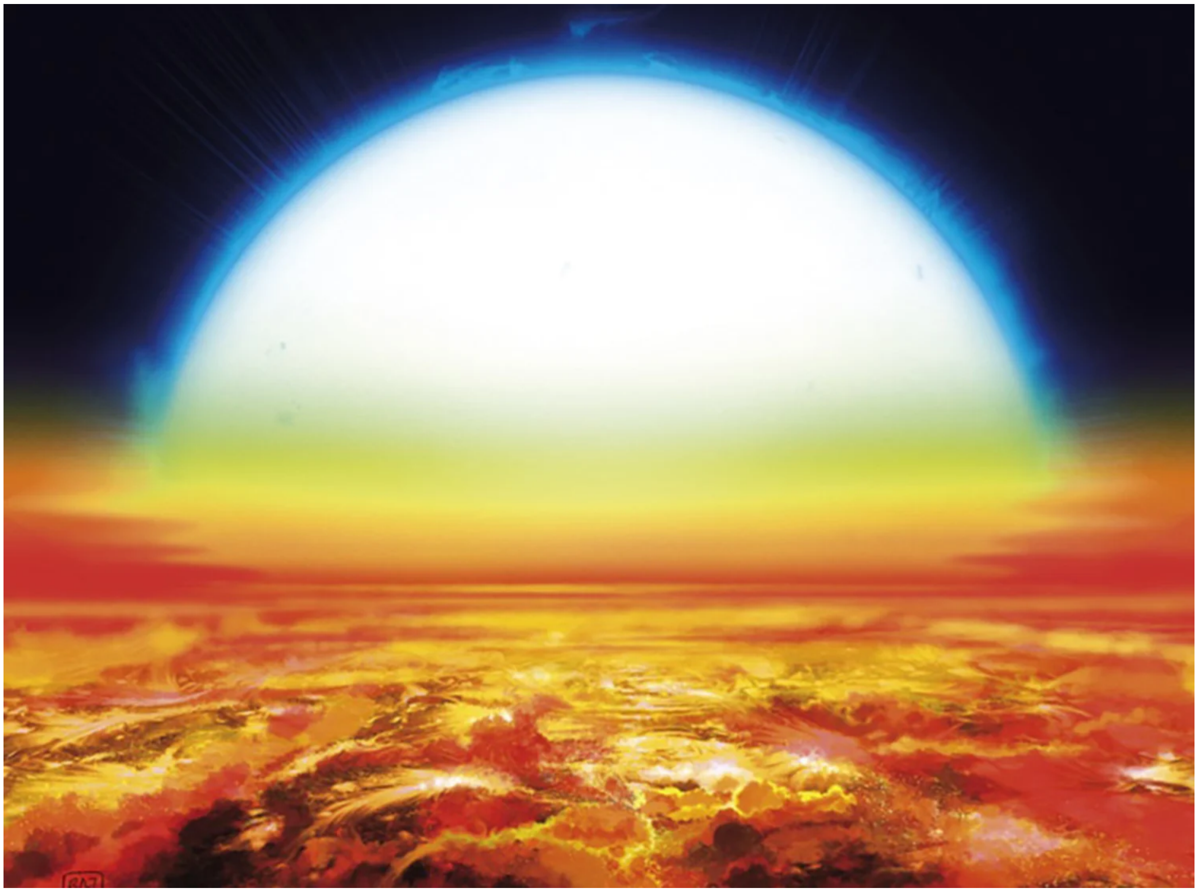


696 × 392

Finding Exoplanet: KELT - 3B

18.05.2023

—

Mudit Mehta and Kenny Li
Lausanne, Switzerland

Abstract

Since the beginning of civilizations, humans have been intrigued by the celestial bodies seen up in the sky. They have wondered and strived to understand them resulting in a dedicated stem of science known as Astronomy. Yet it was only with discovery of large telescopes and technology that deep space research became a reality in the 20th century. Today with the advent of AI and Science of big data, we now can spot celestial bodies and exo-planets directly by analyzing the data from satellites, space probes, telescopes, etc. One such celestial body is KELT - 3b, an extrasolar planet orbiting the F-type main-sequence star KELT-3, 690 light years in the zodiac constellation Leo, discovered in 2013 by KELT's telescope in Arizona

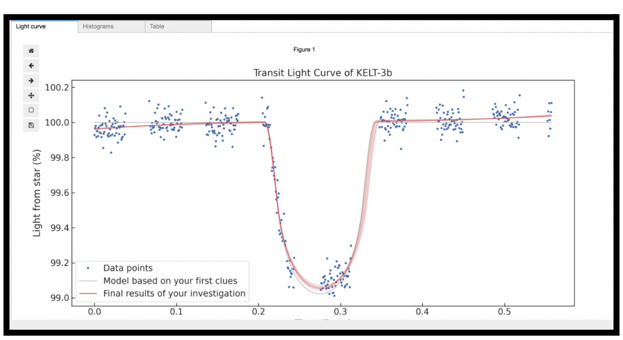
Goal for this study is to analyze the data collected by ESA's Cheops (CHaracterising ExOPlanet Satellite) satellite in 2023 to find its

- size
- distance from its Host star
- temperature and its habitability
- composition

Method

For this study, the data used was the one gathered by ESA's CHEOPS satellite in 2023. CHEOPS used the Trans photometry method, that measures the dip in the brightness of the star, to see whether an exoplanet has passed or not. We analyzed the data points gathered by CHEOPS and using the ALLESfitter software calculated the size of the planet, size of the star, trans period - which was used to find the distance of the planet from its host star and the orbital period. We also estimated the temperature and the habitability of the planet by using the trans period

Analysis of the data using Allesfitter



Name	Median value	Lower error	Upper error	Case note	Target
Radius of the planet (in units of Earth radii)	16.81	0.15	0.17	Cheops observations	KELT-3b
Radius of the star (in units of Solar radii)	1.736	0.021	0.023	Cheops observations	KELT-3b
Mid-transit time (in units of days)	0.27635	0.00086	0.0010	Cheops observations	KELT-3b
Orbital period (in units of days)	2.70339			Other observations from the archive	KELT-3b
Orbital semi-major axis (in units of AU)	0.0464			Other observations from the archive	KELT-3b

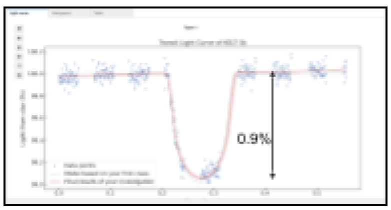
Results and findings: From the graph above, we found

I. The size of KELT - 3B

We have the Median value of the radius of the planet, the radius of the sun, and the time taken for the planet to pass across the star. With this data we can find its transit depth from the transit light curve, which is the amount of light that the exoplanet blocks when passing in between the sattletie and the star using below formula : $Tr = (\pi * Rp^2/\pi * Rs^2) * 100$

From the case file we get, Rp (Radius of planet) = 16.81*Radius of Earth = 16.81*6371 Km and Rs (stellar radius) = 1.736*Radius of Sun = 1.736*696,340 Km

Therefore Tr = 0.9%



Now plugging in Stellar radius and the Transit depth back to the equation, we can find the exact Radius of the exoplanet Rp.

Rp = $\sqrt{Rs^2 * Tr/100}$ = 17.63*Radius of Earth = 17.63*6371 Km

Therefore the Radius of KELT 3B Rp = 1122303.04 Km

II. Orbital distance

The Orbital period and distance can be found by using the orbital transit time (T). From the data we collected, we find that T= 2.7 days . Rearranging the Kepler's law of Period i.e. $T^2 = (4\pi^2/GMs)d^3$, where T is the transit time, G is the gravitational constant, Ms is the mass of the star and d is the distance between the star and planet, we get the equation, $d = \sqrt[3]{GMs/4\pi^2 * T^2}$

Plugging G= 6.7×10−11 Nm^2Kg^{-2} , M_s =1.96*M_{sun} =1.96* 3.90x10^{30} Kg and T=2.7 days, we get the distance between the star and KELT 3B

d = $7.112\, x\, 10^9 m$ or <u>0.0048 au</u> (astronomical unit)

III. Temperature and habitability

We know that KELT 3B is very close to its host star. Referring to the "KELT-3b: A Hot Jupiter Transiting a V = 9.8 Late-F Star", *The Astrophysical Journal*. **773** (1) we know that the temperature of KELT 3B is 1811 'K or to be 1538 'C

Being near to the host star it would be exposed to very high radiation. With such high temperature and high radiations, its surface becomes inhabitable. Hence KELT 3b would be inhabitable for humans.

IV. Composition

The composition of a planet is the type of material that it is made of. This is determined through its mean density.

Density can be defined as ρ = Mp/Vp

where M is the mass of the planet and V is the volume of the planet.

The Mass of the planet using the Radial velocity method is given in the case file as

Mp = 617 ± 105 x Mass of earth = 617 ± 105 x 5.972 x 10^{24} Kg = 3.685 x 10^{30} g

Volume of the planet Vp= $4/3\, \pi\, r^3$, where r is the radius of the planet

Since r = 17.63 x Radius of Earth = 17.63 x 6371 Km = 1122303.04 Km

Hence **Vp**= $5.93\ x\ 10^{15}$ cubic Km

By plugging the Volume and the mass into the equation, we find

ρ = $0.632 g/cm^3$

With such low density compared to the Earth or other rocky planets, we can tell that KELT 3B is primarily a gaseous planet

Conclusion:

KELT 3b is a primarily a giant gaseous planet with radius of 1122303.04 Km (17.6 times radius of Earth, making it bigger than Jupiter). Its surface temperature is as high as 1538 'C. Its stellar distance is 0.0048 au making it very near to its host star. And hence it is exposed to high radiation making it inhabitable for humans