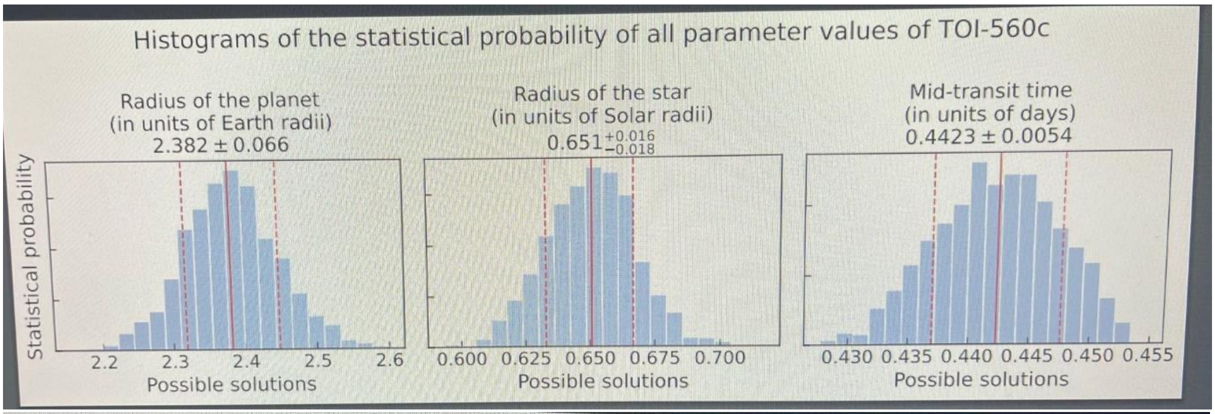
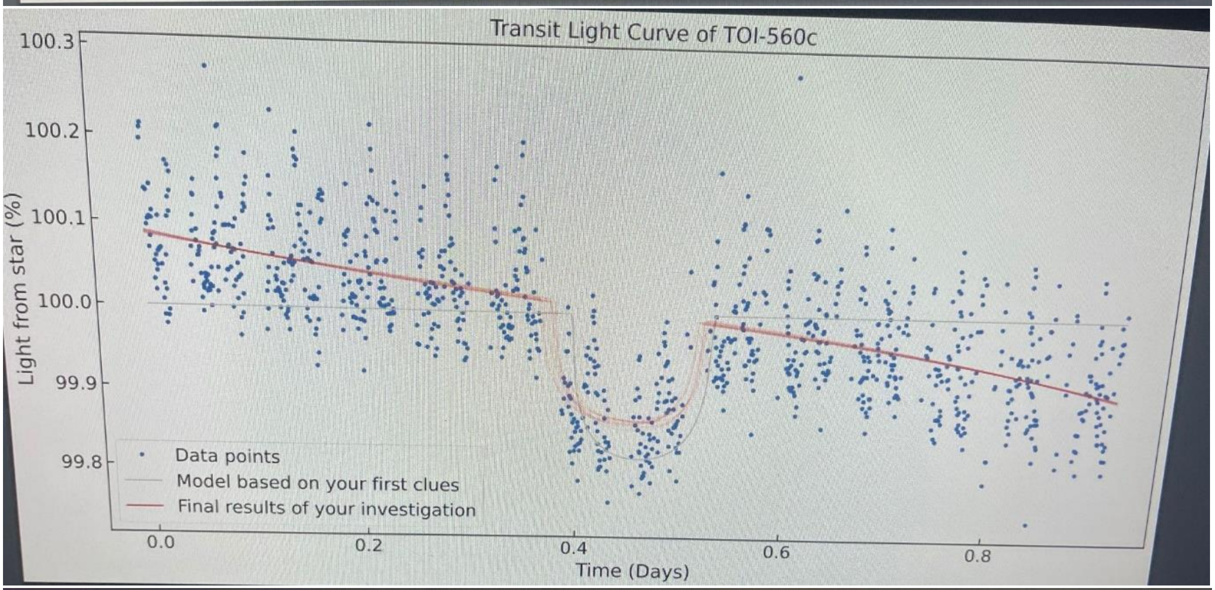
Abstract

Our calculation and data analyzation for the exoplanet TOI-560c were made to determine the exoplanet's characteristics like the Radius, Mass or its location in relation to its star. Those results were used to compare TOI-560c to planets of our solar system. The data used originates out of data collected by the space telescope CHEOPS. One method used for determining for example the radius of the planet was the analyzation of a graph made with the transit method. The main result of our investigation was the planets similarity in size to the planet Neptun in our solar system as well as the planets really low density, which is even lower than Saturn's. Additionally, the planet is relatively close to its star, in comparison being even closer than Mercury to our sun.

Analysis and Results

Assumptions/values:
$R_{planet} = R_p = 2.50 \times R_{earth}$
$M_{planet} = 9.70 \times M_{earth}$
$R_{star} = R_s = 0.65 \times R_{sun}$
Mid transit time = 0.46 days
Transit depth (estimated from curve) = td = 0.18%
$M_{star} = 0.73 \times M_{sun} = 1.45153 \times 10^{30}$kg
$G = 6.6743 \times 10^{-11}\ m^3kg^{-1}s^{-2}$
1AE = 149 597 870.7 km
R_{earth} = 6 378 km
R_{sun} = 695700 km
$M_{sun} = 1.9884 \times 10^{30}$ kg
$M_{earth} = 5.9722 \times 10^{24}$kg





Name	Median value	Lower error	Upper error	Case note	Target
Radius of the planet (in units of Earth radii)	2.382	0.064	0.066	Cheops observations	TOI-560c
Radius of the star (in units of Solar radii)	0.651	0.018	0.016	Cheops observations	TOI-560c
Mid-transit time (in units of days)	0.4423	0.0054	0.0053	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

These are the data that were determined through the "allesfitter" program, which used data acquired by CHEOPS using the transit method.

Radius of the planet:

$$td\,[\%] = \frac{\pi \cdot R_P^2}{\pi \cdot R_S^2} \cdot 100$$

$$\hookrightarrow \quad R_P = \sqrt{\frac{td}{100} \cdot R_S^2}$$

$$= \sqrt{\frac{0.18}{100} \cdot (0.65 \cdot R_{SUN})^2}$$

$$= 0.028 \cdot R_{SUN}$$

$$= 0.02758 \cdot 109\, R_{EARTH}$$

$$= 3.0059 \cdot R_{EARTH}$$

$$= 19171.63\ km$$

$$= 1{,}9 \cdot 10^4\ km$$

Orbital period:

$$18.8797\ days =$$

$$= 453.118\,h$$

$$= 1631206.08\ s$$

$$= 1{,}63 \cdot 10^6\ s$$

Orbital distance:

$$T^2 = \left(\frac{4\pi^2}{G \cdot M_{STAR}}\right) \cdot d^3$$

$$\hookrightarrow d = \sqrt[3]{\frac{G \cdot M_{STAR}}{4\pi^2} \cdot T^2}$$

$$= \sqrt[3]{\frac{6.6743 \cdot 10^{-11}\, m^3 kg^{-1} s^{-2} \cdot 1.45153 \cdot 10^{30}\, kg}{4\pi^2} \cdot 1631206.08 s}$$

$$= 1.8690886 \cdot 10^{10}\ m$$

$$= 18690886\ km$$

in au: $d : 149597870.7$ au

$$= 0.124941\ au$$

Density (by determining the Volume):

$$V_p = \frac{4}{3}\pi \cdot R^3 = \frac{4}{3}\pi \cdot (R_p)^3$$

$$= \frac{4}{3} \cdot \pi \cdot (3.0059 \cdot R_{EARTH})^3$$

$$= 1.6603065 \cdot 10^{13}\ km^3$$

$$\rho = \frac{M}{V} = \frac{M_P}{V_P}$$

$$= \frac{9.70 \cdot M_{EARTH}}{1.6603065 \cdot 10^{13}\ km^3}$$

$$= \frac{9.70 \cdot 5.9722 \cdot 10^{24}\ kg}{1.6603065 \cdot 10^{13}\ km^3}$$

$$= 348913.5\ \frac{kg}{km^3}$$

$$= 3.49 \cdot 10^{5}\ \frac{kg}{km^3}$$

Converting to g/cm^3:

$$\frac{3.49 \cdot 10^{5}\ kg}{1\ \ km^3}$$

$$= \frac{3.49 g}{10^{7}\ cm^3} = 3.49 \cdot 10^{-7}$$

Conclusion

With the calculations' results and our analyzing of the data we came to following conclusions: The exoplanet's radius of 3.0059 times the radius of the Earth is only a bit smaller than Neptun's radius of 3.88 times the radius of the Earth. This means that the exoplanet is relatively big compared to half of the planets of our solar system, Neptun being one of the bigger planets. The planet's orbital period – determined through the transit method – in in comparison to the planets of our solar system is really low, with it being about 19 days, which less than a fifth of the lowest orbital period in our solar system, which is about 88 days (Mercury). This also has to mean that it is way closer to its star than our planets to the sun: its orbital distance is about 0.125 au with again is way lower than Mercuries (0,39 au). From this follows that the temperature of the planet has to be a lot higher than Mercuries (167) too in our data it was estimated to be about 225 °C. But the temperature is lower than Venus' 464°C. This means that the planet could not be habitable – at least in our understanding of possibility and necessities for life -, because possible water would not be fluid there but a gas. Furthermore, the temperature would also be way to high for life to survive there. TOI-560c's composition is also pretty different to the planets in our solar system: its density is about 3.49 times 10^5 kg/km^3 or 3,49 times 10^{-7} g/cm^3, which is a lot lower than the lowest density in our solar system (Saturn: 0.69 g/cm^3) which means the exoplanet has to be a gas planet even less dense than Saturn.
Summarizing: TOI-560c has a lot of differences in characteristics compared to the planets in our solar system. Although it's at least similar in some aspects such as the size, it is mostly different. The planet isn't probable to be habitable, because of its low density, which means it's a gas planet, as well as the high temperature, which means that there could be no fluid water. This is also recognizable by the distance to its star with is a lot smaller than a planet that would be in the habitable zone of a star.