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A4_2 The Moon Overwatching Us

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Abstract

In the video game Overwatch, it is possible to determine the radius of the Moon in that world using in-game screenshots. In this paper, we show this and some of the effects the Moon would have in the world of Overwatch. The Moon has a radius of 1200km and causes 8 high tides a day with a tidal bulge of 3.28km heavily impacting the habitability of the planet.

Introduction

Overwatch is a team-based shooter created by Blizzard Entertainment released in 2016 set on a fictional Earth in the late 21st century [1]. Using values obtained from in-game screenshots, it is possible to calculate information about the Earth-Moon system in this fictional world. In this paper, we will find out how the dynamics of the Earth-Moon system in this fictional universe affect the habitability of the world of Overwatch.

Theory

To calculate the effects of the Earth-Moon system, the first thing that needs to be calculated is the universal gravitational constant. This is because Overwatch uses a game engine with different gravitational effects to the real world to make the gameplay feel more unique. The universal gravitational constant, G, can be calculated by finding the acceleration due to gravity, g, of a falling object and then using equation 1, where M is the mass of the body, and r is the radius. In the game, the effect of gravity on the Moon map is 25% that of on the Earth maps [2], so we can calculate the g on the Moon by multiplying the value for Earth by 0.25.

$$g = \frac{GM}{r^2} \tag{1}$$

The next step is to find out the properties of the Earth-Moon system, and we will be starting with the radius of the Moon and the semi-major axis of the Earth-Moon system. We will be assuming that the orbit is approximately circular. From in-game screenshots, we can calculate the angular radius of both the Moon and the Earth from each other, as well as their height over the horizon by counting the number of pixels that make up each object and accounting for the field of view. Once the angular radius has been calculated, we construct multiple triangles between points on the surface of both the Moon and the Earth and the centre of them. Using these triangles, we can calculate the radius of the moon and the orbital radius using the sine and cosine rules to construct quadratic equations for them.

To calculate the orbital period of the Moon, we can use Kepler's third law seen in equation 2 where T is the orbital period, a is the semi-major axis, G is the gravitational constant and M is the mass of the host body.

$$T = 2\pi\sqrt{\frac{a^3}{GM}} \tag{2}$$

Once we have calculated all these parameters, it is important to know whether the Moon can exist on such a system, or if the tidal forces acting upon the Moon are so strong, they tear the Moon apart [3]. We can find this out by calculating the Roche Limit, which is the closest distance from a celestial body which a satellite can form when the only forces acting upon the satellite is their gravity. The Roche Limit is given by equation 3 where d is the Roche Limit, R is the radius of the parent body, ρ_M is the density of the parent body and ρ_m is the density of the satellite.

$$d = 2.46R\Big(\frac{\rho_M}{\rho_m}\Big)^{1/3} \tag{3}$$

A key impact the Moon has upon the Earth is that it controls the tides. This is due to the tidal forces of the Moon [4]. The tidal bulge caused by an orbiting satellite onto its parent's body can be calculated using equation 4 where H is the height, m is the satellite mass, r is the distance between the satellite and the host, M is the host Mass and A is the host radius.

$$H = \frac{15}{8}\frac{mA^4}{Mr^3} \tag{4}$$

Discussion

The character Pharah has an ability that launches her 11.5m into the air [5] and she lands 2.35 seconds after pressing the initial button, taking the falling half of her flight, we can calculate the acceleration due to gravity is 16.7ms^{-2} on Earth, and thus, it is 4.16ms^{-2} on the Moon. Thus, the gravitational constant for the world of Overwatch is $1.12\text{x}10^{-10}\text{m}^3\text{kg}^{-1}\text{s}^{-2}$. The Moon has an angular radius of 4.20 degrees from Earth and is 29.4 degrees over the horizon. The Earth has an angular radius of 18.6 degrees from the Moon and is 15.1 degrees over the horizon [2]. In-game monitors show the Earth having the same radius and mass of the Earth in our universe [2]. Using this information, constructed triangles between the Earth and the Moon to calculate that the Moon has a radius of 1200km and orbits at a distance of $2.03\text{x}10^7$m. Using equation 2, the Moon orbits with a period of $2.22\text{x}10^4$ seconds, or 6.18 hours meaning the moon orbits 4 times in an Earth day. We can calculate the mass of the Moon using the acceleration due to gravity on it, and equation 1. This gives a mass of $5.32\text{x}10^{22}$kg. Using this, We can determine that the Roche Limit is $1.43\text{x}10^7$m so the Moon could exist in this orbit. Finally, using equation 4, we determine that the tidal bulge on Earth due to the Moon is 3.28km in the world of Overwatch.

Conclusion

With a Moon that orbits 4 times a day, there would be 8 high tides on the Earth creating havoc for boats and severely restricting where humans can live. This value doesn't take into account any topography which would increase it's height further. A tidal bulge of 3.28km would cause large parts of the world to be underwater depending on the tides, including the whole of the UK and Australia where the King's Row and Junkertown maps are based rendering them unplayable. Whilst it is possible that there would be some areas humans could live, the habitable range would be greatly reduced. Further research can be done to outline the specific effects that occur and how they could harness the tides.

References

[1] `https://playoverwatch.com/en-us/` [Accessed 30th October 2020]

[2] Overwatch v1.53, Published by Blizzard, 2016,

[3] J. S. Lewis, *Encyclopedia of Physical Science and Technology (Third Edition)* (Academic, Huntsville, 2003), Ch. 7

[4] P.Goldreich, S. Soter, Q in the solar system, 1966 81 (1992).

[5] `https://overwatch.gamepedia.com/Pharah` [Accessed 30th October 2020]