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A1_5 Planet Smash

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Abstract

In this paper, the terminal falling velocity of the character Mario in Super Smash Bros. Wii U is used to calculate the gravity of the planet shown in the background of the "Battlefield" stage of the game. This information is used to calculate a value of gravity g = 0.33 ms^{-2}, and a radius of 338 km for the planet, which is used to deduce tectonic activity, a magnetic field and a sea of potentially N_2O_4 on the planet.

Introduction

The Battlefield stage in Super Smash Bros. Wii U (see Figure 1) is a series of platforms suspended in the air above a mysterious, fog-shrouded planet. Since the planet can support life for Mario and the plant life present on the stage, it is reasonable to assume a breathable atmosphere and a similar atmospheric pressure to Earth.

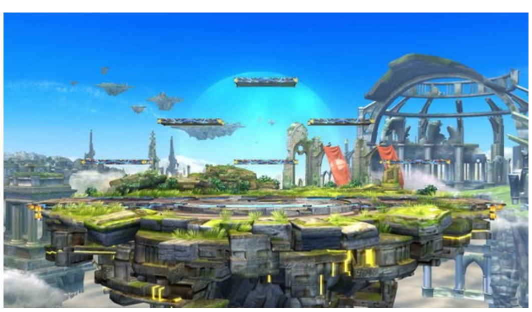

Figure 1: A screenshot of the battlefield stage, taken directly from Super Smash Bros. Wii U.

But is that where the similarities end? In this paper, we aim to gather evidence from the game in order to paint a picture of what a "Planet Smash" might look like, including size, rotation speed and some more general conditions.

Theory

We calculated the gravitational field strength on the planet by looking at the terminal velocity of the character Mario, which is given by the following equation:

$$v = (2mg/\rho_{air}CA)^{1/2} \quad (1)$$

where v is terminal velocity, m is mass of the falling object, g is acceleration due to gravity, ρ_{air} is the density of air (which we assume to be similar to that on Earth due to the presence of plant life), C is the drag coefficient and A is the projected area of the falling object.

The terminal velocity of Mario in the game was measured in an experiment done by Smash Highlights [1], and was found to be 8 times the height of Mario in 1.32 s (see Figure 2). If the height of Mario is 150 cm [3], we can say that Mario fell 12 m in 1.32 s, so we used $v = s/t$ to calculate that his terminal velocity is 9.1 m s^{-1}. To calculate g from this, we re-arranged equation (1) such that $g = v^2\rho_{air}CA/2m$.

By modelling Mario as a long cylinder we took the drag coefficient C to be 0.82 [2], his projected

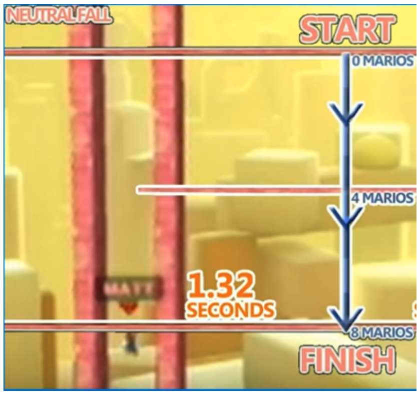

Figure 2: A screenshot of the experiment conducted by Smash Highlights [1]

area to be roughly given by an ellipse with area $A = \pi ab$ (where a and b are half of his width and depth respectively [3]) which is 0.40 m^2, the air density ρ is 1.225 kg m^{-3} [4] and the mass of Mario to be 50.5 kg [5], we can say that g on Planet Smash is 0.33 m s^{-2}.

We were also able to calculate how fast Planet Smash is rotating about its axis. The Battlefield stage undergoes day/night cycles in games, which we timed to be 131.2 s (T) for one full cycle. Using $\omega = 2\pi/T$, we calculated the angular velocity of the planet (ω) to be 4.7×10^{-2} rad s^{-1}, far faster than that of Earth (7.29×10^{-5} rad s^{-1}).

Analysis

If we assume the density of the planet is the same as that of Earth, and that both bodies can have their volumes estimated by $V = \frac{4}{3}\pi r^3$, we can take the ratio of the two gravity values g_{earth}/g_{smash} and use $g = GM/r^2$ such that:

$$\frac{g_{earth}}{g_{smash}} = \frac{\frac{4}{3}\pi r_{earth}}{\frac{4}{3}\pi r_{smash}} \tag{2}$$

Which produces a value for r_{smash} of 214 km. This demonstrates that Planet Smash would be far less massive than our own planet, and smaller than some of the largest observed asteroids [6], making it a dwarf planet at best that would in reality be unlikely to hold an atmosphere.

If we do assume that an atmosphere exists, as demonstrated by the plant life in Figure 1, it can also tell us some interesting things about Planet Smash. The presence of an atmosphere that supports life implies that the planet has a magnetic field that would shield said life from solar wind that would otherwise be harmful to it [7]. This also suggests the presence of a liquid metallic core and plate tectonics, since for a planet to have a magnetic field it must have a conductive, convective core and the planet must be rotating. This in turn suggests that their must be a cooling substance on the planets surface, such that the surface of the planet is cool enough compared to the core that convection takes place, however due to the planet's low mass and high spin speed this substance cannot be liquid water. This is because Planet Smash is shown to have a moon close by in Figure 1, which would create tidal forces in liquid water that would slow down the spin speed we calculated earlier [8]. We theorise that the cooling substance could be a "sea" of gaseous nitrogen tetroxide (N_2O_4) depicted by the clouds in Figure 1, since it has a heat capacity at constant pressure (C_p) similar to that of water [9].

Conclusion

In conclusion, the values of gravity (0.33 m s^{-2}) and planetary angular velocity (4.7×10^{-2} rad s^{-1}) on Planet Smash were calculated and used in conjunction with the contextual clue of plant life from Figure 1 to deduce that the planet would be much smaller and faster spinning than Earth, with an atmosphere, weak magnetic field and sea of N_20_4 to allow for plate tectonics.

References

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