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A2_4 'It appears to have gone into orbit, sir'

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Abstract

In this article we calculated the mass and acceleration due to gravity of a planetoid, featured in an episode of the BBC series 'Red Dwarf', if a golf ball is hit into orbit. We then compared that result to the portrayal of the crew's movement around the planetoid's surface. We found that the mass of the planetoid is 1.4×10^{-4}% of the mass of the Earth and its acceleration due to gravity is 0.05 m s^{-2}.

Introduction

In the episode 'Blue' in series VII of the BBC cult series 'Red Dwarf' the crew decide to play a game of golf on a passing planetoid, Traga 16. At the tee off on one of the holes Dave Lister, a crewman on board Red Dwarf, inadvertently strikes the ball such that it is directed upwards consequently sending the ball into orbit. It is quoted by the Android servant Kryten that the planetoid has a thin atmosphere, therefore making the hole a 15-mile, par 3. While a thin atmosphere would reduce the amount of air resistance on the golf ball it would still have to overcome the force of gravity to reach escape velocity. Using this information we can calculate the escape velocity of the golf ball which we can then use to calculate the radius of the planetoid. This will allow us to compare the movements of the crew, as portrayed in the episode, to how they should move in a realistic situation.

Method

To calculate the initial velocity of the golf ball we have to find the force on the ball as it is hit. According to [1] the average normal force on a golf ball due to the club is 9000 N and the time of impact is given as half a millisecond (5×10^{-4} s). The maximum mass of a golf ball is regulated by the Royal and Ancient Golf Club of St. Andrews [2] and is given as 46 g. We can then use this information to calculate the acceleration of the golf ball using Newton's second law, equation (1).

$$F = ma \tag{1}$$

We can then find the velocity of the golf ball due to the acceleration as we know the time of impact, we then use this as the escape velocity of the planetoid. The escape velocity of any planet is given by equation (2)

$$V_{\mathrm{esc}} = \sqrt{\frac{2GM_{\mathrm{p}}}{R_{\mathrm{p}}}} \tag{2}$$

Where G is the gravitational constant, M_{p} is the mass of the planet and R_{p} is the radius of the planetoid. However, as the radius of the planet is unknown, we must substitute a relation between the mass of the planet and its radius in instead. This relation was found in [3] which is an empirical study into the mass-radius relationship of different planets and is shown in equation (3).

$$\frac{R_\mathrm{p}}{R_\mathrm{e}} = \left(\frac{M_\mathrm{p}}{M_\mathrm{e}}\right)^x \quad (3)$$

The ratio of the planet's radius to that of Earth's, R_e, is equal to the ratio of the planet's mass to Earth's, M_e, to some power x. In the case of the planetoid we are investigating, the power x is 0.3 as the planetoid in the episode is portrayed as rocky. If we substitute equation (3) into equation (2) we find that the mass of the planetoid is given by equation (4).

$$M_\mathrm{p} = \sqrt[0.7]{\frac{R_\mathrm{e} {V_\mathrm{esc}}^2}{2G{M_\mathrm{e}}^{0.3}}} \quad (4)$$

The mass is one important feature of the planetoid, we can also calculate the radius and the acceleration due to gravity. The acceleration due to gravity is given in equation (5).

$$g = -\frac{GM_\mathrm{p}}{{R_\mathrm{p}}^2} \quad (5)$$

Results

We took equation (1) and calculated the acceleration of the golf ball due to our values of the force on the golf ball and its mass and found an acceleration of $200,000$ m s^{-2}. Subsequently, due to already having a value of the time of contact, the initial velocity and therefore the escape velocity was found to be 100 m s^{-1} Then substituting the escape velocity into equation (4), we found the mass of the planetoid to be 8.36×10^{18} kg or 1.4×10^{-4}% of the mass of the Earth. We then substituted the mass of the planetoid into equation (3) and found the radius to be about 110 km and taking this value and placing it into equation (5) we found the acceleration due to gravity to be 0.05 m s^{-2}.

Discussion

We have found that, compared to Earth, Traga 16 has a small mass and acceleration due to gravity. If we take these results and compare them to how the crew moves around the planetoid there are discrepancies between what we expect and what is shown. The portrayal of how the crew moves around is similar to what we expect for people walking on the Moon, slight bounces but still mostly touching the ground, which has 16.5% of the gravity of the Earth. However our calculations show that the gravity is 0.5% of the Earth, therefore, realistically, the crew would bounce higher every time they walk forward.

Conclusion

We have shown that the crew would not be able to move around Traga 16 as easily as portrayed and while the physics of the situation may be wrong it is obvious that the writers of the show were attempting, successfully, to produce a comedic effect as per the purpose of 'Red Dwarf'.

References

[1] Haake, Steve. "The Physics of Golf." Science Spectra. Number 13 (1997).

[2] https://www.randa.org/en/rules-of-equipment/2019/rules/equipment-rules/part-4-conformance-of-balls#42-weight [Accessed 15/10/2019]

[3] http://phl.upr.edu/library/notes/standardmass-radiusrelationforexoplanets [Accessed 15/10/2019]