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P2_1 Interplanetary Golf: Driving to Escape Velocity

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Abstract

This paper set out to investigate whether a golf ball could be hit to escape velocity from the surface of various celestial bodies. The results are shown on a 3D surface of all theoretical escape velocities for a range of radii and masses. We found that even the famously small ex-planet, Pluto, unfortunately has an escape velocity higher than can be achieved by a human swing. Notable examples which have a low enough escape velocity are Hyperion and Phobos.

Introduction

In 1971, the Astronaut Alan Shepard made a golf club on the moon using a lunar soil sampler and proceeded to use the Apollo 14 landing site as his own personal driving range [1]. We can foresee this idea of extra-terrestrial golf becoming a tradition as humanity visits other celestial bodies in the solar system. The most exciting places would be where you could feasibly hit a golf ball which could reach escape velocity, so in this short paper we decided to determine some of the locations in the solar system where this would be possible.

Theory

We began by looking at the maximum initial speed achieved by a golf ball on a driving range. The world record is currently 97.05 ms^{-1} [2]. For bodies with negligible atmospheric drag, we will use this as the maximum value for escape velocity where it would be possible for the golf ball to escape. Additionally,the angle at which the ball is hit does not impact the velocity needed to escape. To evaluate candidate bodies for our game of golf, we created a 3 dimensional model based on the equation for escape velocity, derived from equating the gravitational potential energy of the ball to its kinetic energy [3]:

$$v_e = \sqrt{\frac{2GM}{R}} \tag{1}$$

Where v_e is the escape velocity, G is the universal gravitational constant, M is the mass of the parent body and R its the radius.

Method

Using equation 1, we constructed a 3 dimensional plot which modeled the equation as a surface with axes of mass, radius and escape velocity. We decided to use a log scale to make the surface flat. The range of data starts with a large reference body, Pluto, and goes down to the smallest, Phobos [4]. With this model in place, we were able to add known asteroids and dwarf-planets to the graph. The surface is an ideal model for objects that are perfect spheres of uniform density. For calculating the escape velocity, this assumption is accurate enough for high mass spherical objects. However, as the data approaches lower mass asteroids which are more

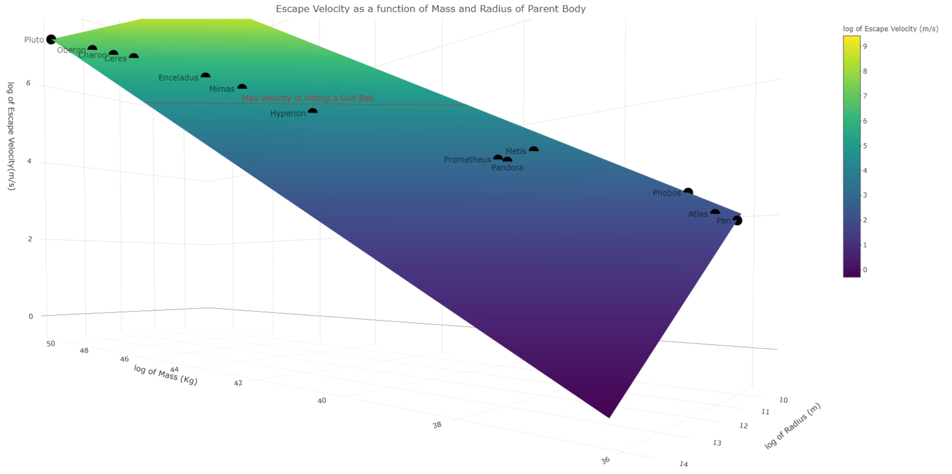

Figure 1: The surface represents the possible configurations for mass, radius and escape velocity for the spherical uniform density assumption. The black dots are actual solar system bodies plotted on the model, and the red line is the cutoff where the escape velocity is 97.05 m/s.

irregularly shaped and non uniform; real bodies will begin to stray from our hypothetical model. For the majority of the data in this model, this is not of concern as they have enough mass to approach hydrostatic equilibrium. On our plot, the region where escape is possible for a driven golf ball is beneath the flat plain at $z = 97.05$ ms^{-1}.

Results and Discussion

The results of our model, seen in Figure 1, reveal that the largest notable object in the Solar system from which escape velocity could be achieved is Hyperion. Everything else below the red line with Hyperion would also be viable, such as the elongated moon of Saturn, Prometheus, and mars' moon Phobos. Unfortunately none of these objects are very planet-like.

Interestingly, all of the celestial bodies plotted appear to follow a linear diagonal across the plane. This tells us that they all gather around a similar density. If a gas giant such as Saturn was added, It would not follow this relationship and have a much lower average density.

Conclusion

To conclude; the findings of this paper show a group of celestial bodies that a future golf enthusiast could hit a golf ball on and have it achieve escape velocity. The model also states the range of values for the highest hypothetical mass and radius an object could have while still having an escape velocity below 97.05 ms^{-1} with the closest real analogy to this being Hyperion.

References

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[3] P. Tipler and G. Mosca, Physics for Scientists and Engineers, (W.H. Freeman and Company, New York, 2008), 6th ed. (Academic, New York, 1980)

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