A3_5 Evaluating the Effects of a Moon Made of Cheese

B. Carlisle, C. Dickens, J. Healings, E. Sampson

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

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Abstract

In this paper we discuss the variety of changes that would occur if the Moon were made out of cheese. Assuming the Moon has a constant volume and the mass changes we found the tidal bulge due to the Moon would be negligible and all tides would be due to the Sun. The escape velocity for this Moon was calculated to be 0.029 ms^{-1}, which is low enough that a person jumping could escape the gravitational pull. If the mass were to be kept constant the volume of the Moon required was found to be 1.6×10^{20} m^3. This would cause no change in the tidal bulge.

Introduction

In pop culture there have been numerous references to the Moon stating that it is made completely out of cheese. However, this is obviously not true. In this paper we have assumed that the Moon is made from cheddar cheese and not composed of a mixture of elements to form a rocky surface. We then investigated the effects this would have on the Earth.

Method

There were two ways to begin this investigation. The first method used was to assume the volume of the Moon stays constant and the mass changes. The other assumed constant mass, and the volume of the Moon changes. In this paper we have analysed both possibilities and considered the results for both.

In order to calculate the changes in mass or volume, equation (1) was used.

$$\rho = \frac{m}{V} \tag{1}$$

This was used by assuming the density, ρ, of the Moon is that of cheddar cheese. Following this, in both scenarios, the escape velocity of the new Moon was calculated using equation (2).

$$v_{escape} = \sqrt{\frac{2GM}{r}} \tag{2}$$

In this equation G is the gravitational constant, 6.7×10^{-11} Nm^{2}kg^{-2}, M is the mass of the Moon and r is the radius of the body, in this case the Moon. For the constant mass scenario the radius in equation (2) changed, and for constant volume the mass changed.

The final route of investigation led to the calculation of the tidal bulge on Earth due to the cheese Moon. The tidal bulge is the change in water level due to the gravitational effects of other massive bodies. In this case we only accounted for the Moon. The height of the water due to the tidal bulge, H, was calculated by using equation (3).

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

This equation uses the mass of the body being affected, M, its radius, A, the mass of the body

causing the tidal bulge, m, and the distance between the center of the two bodies, r. This equation is found by finding the ratio of the gravitational potential disturbance due to the Moon to the gravitational field strength on the surface of the Earth.

Constant Volume Findings

In the first scenario we kept the volume of the cheese Moon constant and calculated the mass given the density for cheddar cheese is 470 kgm^{-3} [1]. This resulted in a mass of the Moon to be 1.0×10^{10} kg, much less massive than the mass of the actual Moon, 7.3×10^{22} kg [2]. By using this mass in equation (2) the escape velocity was calculated to be 0.029 ms^{-1}. Given that an average human can jump at approximately 1.37 ms^{-1} [3] this would mean that it would be feasible to escape the gravitational pull of the cheese Moon just by jumping. The tidal bulge due to the cheese Moon was also calculated to be dramatically different to the tidal bulge that occurs normally. It was calculated, using equation (3), that the height of water due to the Moon normally is 0.70 m. This is dramatically less for the cheese Moon due to the reduced mass. By using the mass of the Earth, m, as 6.0×10^{24} kg [4], the radius of Earth, A, as 6.4×10^{6} m [4], the distance between the two bodies, r, as 3.8×10^{8} m [2] and the new mass of the cheese Moon, M, as 1.0×10^{10} kg, it was calculated the height of tides due to the cheese Moon would be negligible.

Constant Mass Findings

Another calculation completed was finding out the volume the Moon would have to be to have the same mass when made out of cheese. This was again done by using equation (1) but keeping the mass of the Moon, 7.3×10^{22} kg [2], constant. The volume required was found to be 1.6×10^{20} m^3. By assuming the cheese Moon is completely spherical the radius was found to be 3.3×10^{6} m, which is approximately double the radius the Moon actually is, 1.7×10^{6} m [2]. Using this new radius the process was repeated to calculate the escape velocity. The escape veloc-

ity for this Moon was calculated as $1,700 \text{ ms}^{-1}$, which is far greater than the previous value due to the much larger mass. The tidal bulge effect would not change on Earth with a Moon made of cheese with the same mass but larger volume due to the fact that equation (3) does not depend on the volume or radius of the Moon.

Conclusion

To conclude a Moon made of cheese would be vastly different from the one we have now. We determined that with a Moon composed of cheese, with the same volume as the Moon now, the escape velocity would be extremely low, 0.029 ms^{-1}. There would also be a huge reduction in tides on Earth as the predominant force would now be from the Sun. This would cause havoc to oceans globally. From our calculations a cheese Moon with an increased volume but same mass would not have as big an impact. The tidal bulge force would be the same, however, the Moon would obviously much larger and much more visible in the sky. We have analysed and discussed some possible changes that would happen with a Moon made of cheese, however, not all aspects have been covered. Other changes to life would occur such as a lighter (or darker) night sky due to the difference in albedo of cheese compared to the rocky surface of the Moon. Unfortunately, the albedo of cheese is not a well researched area of physics and hence no values could be found to further assess the impact of this.

References

[1] https://tinyurl.com/cheesedensity[Accessed 26 October 2020]

[2] https://tinyurl.com/Moonfacts12[Accessed 26 October 2020]

[3] https://tinyurl.com/jumpacc[Accessed 26 October 2020]

[4] https://tinyurl.com/Earthfacts2[Accessed 26 October 2020]