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P3_6 What did the Moon say to the Earth? I'm falling for you.

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Abstract

The amount of energy required to put the Moon in a new stable orbit closer to Earth if it became destabilised, was found to be 9.9×10^{27} J and the new orbit described would have a period of 2.5 days. It would take 8.5 billion years for the UK to produce the high amount of energy required and even if we could produce the energy, the tidal effects from the Moon would be disastrous.

Introduction

Imagine all of a sudden, the tangential velocity of the Moon is reduced to zero which has resulted in the orbit of the Moon destabilising and it has started to fall through space on its way to collide with Earth. In order to prevent the moon from impact with our planet, we would need to apply enough energy to the Moon to move the body to a new stable orbit, closer to the Earth. This paper looks at what energy would be needed to do this; what the orbital period will be for the new orbit of the Moon and how this situation would affect tides on Earth.

Theory

In order to look at this situation, we first have to make an assumption that the Moon has a perfectly perpendicular trajectory as it is falling. The Moon has an elliptical orbit around the Earth and Figure 1 shows the orbit of the Moon around the Earth. As the Moon falls closer to the Earth, r will decrease. In this paper we will be using a value of 10000 km as the distance between the Moon and Earth.

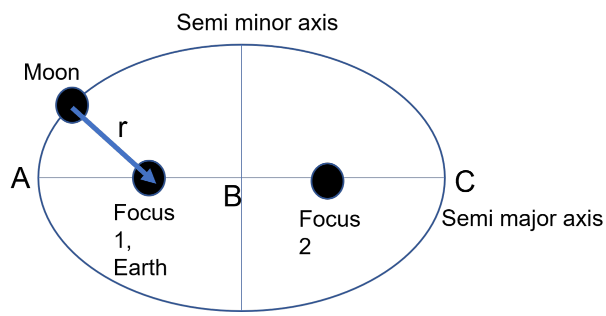

Figure 1: Simple diagram displaying the Earth and Moon orbit, where AB= BC= semi-major axis, a and r is the orbital radius.

In order to find the energy required for the destabilised Moon to be put into a new stable orbit, first the tangential velocity required needs to be worked out using Eq.(1).

$$v_t = \sqrt{\frac{GM}{r}} \quad (1)$$

where v_t is the tangential velocity, G is the gravitational constant, M is the mass of the orbiting body, which in this case is the mass of the Moon, 0.0735×10^{24} kg [2], and r is the orbital radius. The value of r is given by Eq.(2)

$$r = d + r_{Moon} + r_{Earth} \tag{2}$$

where d is 10000 km; r_{Moon} is the radius of the Moon, which is 1738.1 km [2]; and r_{Earth} is the radius Earth which 6378.1 km [2]. The value of d is chosen to be 10000 km as stated above since the new orbit will be closer to Earth.

Once the tangential velocity is found, the energy required to put the Moon in the new stable orbit can be worked out using Eq.(3).

$$E = \frac{1}{2}Mv^2 \tag{3}$$

where E is the energy required , M is the mass of the Moon and v is the tangential velocity.

Finally the period, T, for the orbit in this situation an be found using Eq.(4)

$$T = \sqrt{\frac{4\pi^2}{GM}r^3} \tag{4}$$

Results

The tangential velocity required for the new orbit of the Moon was found to be 520 m/s, which gave an energy of 9.9×10^{27} J. The period of the orbit for the new position of the Moon was found to be 220000 seconds which is 2.5 days.

Discussion

In 2019 the UK produced around 323.7 TWh of energy, [3], which is 1.16×10^{18} J. This means that it would take 8.5 billion years to harness enough energy to reach the amount required stabilise the new orbit.

The destabilisation of the Moon's orbit would result in disastrous tidal effects for our planet. In this scenario, we are moving the Moon to a distance much closer to the Earth, which would result in an extremely aggressive tidal pull. The size of tides would increase as the Moon approached the Earth (at a proportional rate to the cube of the reduction in the distance between the Earth and Moon). This means that the low tides would much lower and high tides would be much higher, resulting in coastlines being flooded, destroying homes and injuring/killing many people and animals. However, if the Moon instead of being put into a new stable orbit, completely cleared the Earth's orbit, then the tides would be around 33 percent smaller, [1] than they are now because without the Moon, the Sun would influence the tides and the Sun has a much weaker pull.

Conclusion

To conclude, the new orbit described will have a time period of 2.5 days, which is a lot less than the original orbital period which is 27 days [4]. The new orbit of the moon will have an orbital radius of 1.8×10^7 km and the amount of energy needed to put the Moon in this new orbit is around 9.9×10^{27} J. To put this in perspective, in 2019 the UK produced around 1.16×10^{18} J of energy, it would take around 8.5 billion years for the UK to produce that kind of energy. Creating that kind of energy would be impossible, and along with the disastrous tidal affects, if this scenario ever took place, we are all doomed.

References

[1] `https://nineplanets.org/questions/what-would-happen-if-there-was-no-Moon/#:~:text=Scientists%20suggest%20that%20without%20the,which%20would%20decrease%20the%20tides.` [Accessed 10/11/2021]

[2] `https://nssdc.gsfc.nasa.gov/planetary/factsheet/Moonfact.html` [Accessed 10/11/2021]

[3] `https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/877047/Press_Notice_March_2020.pdf` [Accessed 10/11/2021]

[4] `https://www.sciencedirect.com/topics/physics-and-astronomy/lunar-orbits#:~:text=The%20orbital%20period%20is%2027.32,synodic%20period%20is%2029.53%20days` [Accessed 10/11/2021]