P5_7 Palpatine's Pudding Powered Paws

G. Knott, M. Sharman, B. Rayson, D. Molloy

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

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Abstract

In this paper we have calculated the number of calories Palpatine would have needed to consume in order to charge his hands to produce the force lightning used to kill Mace Windu. We find that Palpatine would have had to eat 38,334 portions of Wetherspoons "Apple Crumble and Custard" in order to generate the energy required to produce the force lightning. The magnitude of the value is highlighted by the fact that he would need to have 1 portion of pudding, a day, for 105 years to achieve this, showing 'The Force' must play a role since this is an unfeasible amount to eat.

Introduction

In George Lucas' *Star Wars Episode III: Revenge of the Sith*, there is a fight scene in which Mace Windu unveils and confronts the evil Emperor Palpatine. During the scene the superior Mace Windu hesitates before finishing off Palpatine, some dialogue ensues and the scene culminates when Windu is struck by around 16 s of force lightning [1].

We would like to calculate the number of calories Palpatine would have needed to eat in order to generate this energy output, assuming all of the calories are used solely on the generation of force lightning.

Theory

In order for a lightning strike to occur, the air between the two points needs to undergo 'dielectric breakdown'. This process occurs once a critical electric field strength is reached, and it turns from an insulator into a conductor. This is because the particles in the air are ionised so that there are free electrons. The dielectric breakdown for air under standard conditions is $E = {\sim}3{\times}10^6$ Vm^{-1} [2]. We will assume that the atmosphere of Coruscant is the same as that on Earth. To find the potential energy that a field of this strength would require, we will use:

$$U = VQ \tag{1}$$

Where U is the electric potential energy, V is the potential difference, and Q is the charge.

We found the potential difference by using the field strength required for dielectric breakdown (E) and the distance between the start (Palpatine's fingers) and the end (Mace Windu) of the lightning bolt. By watching the movie scene, we estimated this distance (L) is approximately 1.5 m. We could then substitute these values into the equation below:

$$V = EL \tag{2}$$

We then needed to find the charge, and to do this we used an average value for the maximum linear charge density of a lightning bolt which is $\lambda =$

$\sim 3 \times 10^{-3}$ Cm^{-1} [3]. We used this to calculate the total charge by multiplying this by the length of the lightning bolt (L).

$$Q = \lambda L \qquad (3)$$

We could then substitute these two equations into Eq. 1 to obtain:

$$U = EL^2\lambda \qquad (4)$$

In a real system, the lightning strike acts to equalise the potential between the clouds and the ground. The Sith lightning used by Palpatine is more like a continuous stream of electricity, however for simplicity, we will treat this as multiple lightning strikes happening in quick succession. In this way, the potential energy is released, then recharged through his fingers ready for the next strike. We will assume the 'charging up' process is instantaneous. A normal lighting strike lasts on average around $t_{strike} = 30$ μs [4], which means that the number of lighting strikes can be found by dividing the total time ($t = 16$ s) by the time for one strike. We can then multiply our value for potential energy U by the number of times this energy needs to be generated to find total energy.

In the movie, Palpatine can be seen sending lighting from his 4 fingers on each hand. This means that this value then needs to be multiplied by 8 to find the energy for the lighting from every finger. Therefore the final equation to find total energy is:

$$U_{tot} = EL^2\lambda n \frac{t}{t_{strike}} \qquad (5)$$

Where n is the number of fingers the lighting is being released from.

Results and Discussion

When we substituted all of the values into Eq. 5, we found a value of $U_{tot} = 8.64 \times 10^{10}$ J. We converted this to calories by dividing by 4184 to give $U_{tot} = 2.07 \times 10^7$ kcal.

We wanted to quantify how much food this would correspond to, assuming that the Emperor gets the energy from food and not from the Force. We have decided to rationalise the sheer quantity of calories this is by comparing it to a standard Wetherspoons portion of Bramley Apple Crumble and Custard. A single serving of the pudding comes out to around 540 calories [5]. This means the emperor would have to consume 38,334 puddings, or 1 a day for 105 years, to be able to acquire the energy required to produce the force lightning. This of course assumes that none of the consumed calories are used in any other bodily function!

Conclusion

In this paper we have estimated the energy released in the lightning Palpatine uses to dispatch Mace Windu, and found it to be 8.64×10^{10} J. We have converted this to calories and found he would need to consume 38,334 portions of Wetherspoons crumble and custard.

Based on these results, we can be confident in saying that food is not the main source of energy for Palpatine's Sith lightning. This shows the need for 'The Force' since using standard physics cannot provide a feasible explanation.

References

[1] *Star Wars: Episode III - Revenge of the Sith* (2005) Directed by George Lucas [Film]. 20th Century Fox.

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[4] URL: https://www.public.asu.edu/~gbadams/lightning/lightning.html.

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