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Calculating the Power Change of a Lightsaber Due to Colour

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Abstract
This paper investigates the effect of different coloured lightsabers on their subsequent power output, by assuming that the lightsaber produces pure photonic energy as the name would suggest. It was found that the power output of a lightsaber increases with decreasing wavelength, causing the lightsabers of shorter wavelength to cut through a titanium blast door in a shorter time period. For example, the purple lightsaber was found to melt through the titanium door in 8.20 seconds in comparison to the red lightsabers 14.00 seconds, which shows the purple lightsaber to be the more powerful of the two.

Introduction
The lightsaber is the iconic weapon from the Star Wars universe. These weapons are extremely powerful and although they differ in style, shape and colour they are always portrayed to be equal to each other.

Figure 1 – The different colours of a lightsaber [1]

This paper considers if the power of a lightsaber would change assuming it produced pure photonic energy, i.e. does changing the lightsaber colour produce a different power output. Thus the final power calculation obtained from the previous paper on the power of a standard green lightsaber is used [2]. During these calculations it is assumed that the lightsabers are all standard, to simplify equations i.e. the lightsabers are all of length 91cm and width 4cm [3]. The paper then shows the effect of differing power output for different colour.

Number of photons produced by a lightsaber
In order to calculate the power of the different lightsabers a reference lightsaber power was needed, therefore the power of the standard green lightsaber was found previously to be 6.96MW [2]. As power is the ratio of energy to time (Equation 1), the component that will change is the energy produced, due to the colour change.

The total energy produced by the standard green lightsaber was calculated. To do this a reference time for how long a lightsaber can remain continuously active is needed. It is known that lightsabers can last a long time, from months to years because Jedi rarely use the weapons [4]. As well as this Jedi frequently charge the power cell using the force. However, in deleted scenes from Star Wars Episode 1, it is noted that Obi-Wans lightsaber becomes drained [5]. This comes after a several hours of fighting, assuming Obi-Wan had a fully charged lightsaber before fighting it means the lightsaber can last several hours of continuous use without recharging. Therefore, assuming a lightsaber can be used continuously for approximately 8 hours, the total energy produced by a green lightsaber without recharging is:

$$Energy = Power \times time = \ 2.00 \times 10^{11} J \quad (1)$$

As the assumption is to treat the lightsaber as pure photonic energy then the energy is calculated with Equation 2.

$$E = \frac{nhc}{\lambda} \qquad (2)$$

Where E is the energy, h is Planck's constant, c is the speed of light, n is the number of photons and λ is the wavelength of light. Across the different coloured lightsabers, if they all have the same standard dimensions as assumed, then n, h and c are all constant but the wavelength of light will differ between lightsabers. Therefore, in order to find the energy produced by each lightsaber, the number of photons was calculated by rearranging Equation 2:

$$n = \frac{E\lambda}{hc}$$

The energy for the standard green lightsaber is stated in Equation 1. An estimation is made on the wavelength as green can cover a multitude of wavelengths, thus to simplify only a single wavelength is chosen for each colour. For the green lightsaber a wavelength of 5.5×10^{-7}m is used. Therefore, the number of photons produced by a standard lightsaber is:

$$n = \frac{(2.00 \times 10^{11}) \times (5.5 \times 10^{-7})}{(6.626 \times 10^{-34}) \times (2.998 \times 10^{8})} \qquad (3)$$

$$n = 5.55 \times 10^{29}\ photons$$

Therefore, each lightsaber of standard dimensions produces 5.55×10^{29} photons of light in its 8 hours of continuous use.

Calculating the Power

Now that the number of photons produced by a standard lightsaber is known Equation 2 can be reused for the different colours of a lightsaber. For example, finding the total energy produced by a red lightsaber with wavelength 7×10^{-7}m, is shown below;

$$E = \frac{(5.55 \times 10^{29})(6.626 \times 10^{-34})(2.998 \times 10^{8})}{(7 \times 10^{-7})}$$

$$E = 1.57 \times 10^{11} J$$

Then the power for each lightsaber can be calculated:

$$Power = \frac{E}{T} = \frac{1.57 \times 10^{11} J}{(8 \times 60 \times 60)s} = 5.47MW$$

This shows that the power of a red lightsaber, of wavelength 7×10^{-7}m, is 5.47MW. This is smaller than that produced by the green lightsaber and thus there will be a difference in the effect of each lightsaber. To illustrate the difference in effect, the time it would take this lightsaber to melt through the same titanium blast door, as shown in the previous paper on the power of the green lightsaber, can be calculated [2]. It was stated that the energy required to melt through a mass of 40.77kg titanium was 76.56MJ [2]. Therefore, rearranging Equation 1 for time gives:

$$Time = \frac{E}{P} = \frac{76.56 \times 10^{6}}{5.47 \times 10^{6}} = 14.00s$$

Comparing this to the standard green lightsaber which melted through the door in 11 seconds, it is evident that a red lightsaber would melt through the door in significantly more time. The calculations were completed to respond to all common lightsaber colours with the results tabulated below:

Colour	λ (m)	E_{tot} (J)	P (MW)	Time (s)
Red	7.0×10^{-7}	1.57×10^{11}	5.47	14.00
Yellow	6.0×10^{-7}	1.84×10^{11}	6.38	12.00
Green	5.5×10^{-7}	2.00×10^{11}	6.96	11.00
Blue	4.8×10^{-7}	2.30×10^{11}	7.97	9.60
Purple	4.1×10^{-7}	2.69×10^{11}	9.34	8.20

Table 1 –Lightsaber colour and its corresponding wavelength, energy, power and time to melt through titanium door

As shown in Table 1, as the wavelength decreases, the power output increases and thus the time taken to melt from a titanium door decreases. Therefore, this shows that lightsabers of short wavelengths such as the purple lightsaber are the most powerful and effective. However, as the lightsabers are supposed to be of equal power, it means that the lightsaber is not pure photonic energy as the name would suggest. Instead, it is known that the lightsaber itself is made of plasma [6].

Conclusion

In conclusion, if the lightsaber did, as the name suggests, produce purely photonic energy, the power output of lightsabers would differ. In this case, as the shorter the wavelength the more powerful the lightsaber, then all Jedi and Sith alike would utilise the purple lightsaber as it is the most powerful. However, the lightsabers do not produce photonic energy but rather produce plasma. In which case the lightsaber should be called the plasma blade or equivalent in order to be accurate.

References

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