

S4_1 Pickle Rick: One Rickdiculously Lucky Pickle

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Abstract

We investigate the energy and monochromatic specific intensity of Pickle Rick's homemade laser gun, which has the god-like power to burn through people. We found the energy to be 2.67 MJ, equivalent to 285 AA batteries, and the monochromatic specific intensity to be $1.61 \times 10^{19} \text{ Wm}^{-2}\text{sr}^{-1}$.

Introduction

During season 3, episode 3 of the popular cartoon show 'Rick and Morty', the eccentric scientist known as Rick C-137 turns himself into a pickle to escape counselling with his family. While he does indeed get out of family therapy, he finds himself at the mercy of his surroundings, which results in him being hunted by members of the Russian embassy while wearing a modified rat suit. His main makeshift-weapon is a laser gun powerful enough to burn through three perfectly lined up enemy heads with a single AA battery. In this paper we will determine the energy of the battery and the specific intensity of the laser beam.

Theory

The last substance to be disintegrated during cremation are the bones due to their specific heat and material make-up. The temperature at which the human body is cremated is 593°C [1]; since the unfortunate humans are at this point still alive, their body temperature is around 37°C . Thus we can calculate the change in energy required to raise their temperatures to the melting point using equation (1) below, where m

represents mass, c the specific heat capacity, and ΔT the resultant change in temperature.

$$Q = mc\Delta T \quad (1)$$

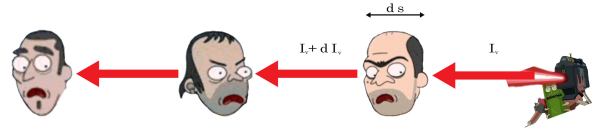


Figure 1: Illustration of the radiative transfer to matter from the aforementioned Pickle Rick laser gun.

We know the specific heat capacity of bone to be $440 \text{ J kg}^{-1} \text{ K}^{-1}$ [2], and that the mean head mass for a male is 3.65 kg [3]. Using equation (1) the change in energy (energy absorbed by the head) is equal to 0.89 MJ ; Rick's laser gun must transfer at least this amount of energy to incinerate one head, $E_{\text{Head}} = 0.89 \text{ MJ}$. Since the laser beam passes through all three heads and then emerges out of the back of the third, the total energy of the laser gun must be $E_{\text{laser}} \geq 3E_{\text{melt}}$, totalling 2.67 MJ .

Using the energy of the laser and the Radiative Transfer equation we can determine the monochromatic specific intensity, I_ν [4]

$$\frac{dI_\nu}{ds} = j_\nu - \alpha_\nu I_\nu. \quad (2)$$

Since biological matter does not emit radiation of this frequency, the emission term, j_ν , is equal to zero:

$$\Rightarrow \frac{dI_\nu}{ds} = -\alpha_\nu I_\nu. \quad (3)$$

The solution for equation (3) is

$$I_\nu = I_\nu(s_0)e^{-\tau_\nu}, \quad (4)$$

where the optical depth, $\tau = \int_s^{s_0} \alpha(s')ds'$, and α is the absorption coefficient. The relationship between energy and the monochromatic specific intensity is

$$dE = I_\nu \cos\theta dA dt d\Omega. \quad (5)$$

Re-arranging equation (6) to make I_ν the subject and substituting for the resultant monochromatic specific intensity in equation (5) gives equation (7) below

$$\frac{dE}{\cos\theta dA dt d\Omega} = I_\nu(s_0)e^{-\tau_\nu}. \quad (6)$$

Results

Using the equation for optical depth τ with a grey matter absorption coefficient of $\alpha = 0.05 \text{ mm}^{-1}$ [5] and an average head depth of 19.7 cm [6], the optical depth was found to be neither optically thin or thick, with τ corresponding to a value of 1. The value for the grey matter absorption co-efficient was based on a wavelength of 640 nm [5] due to the fact that the images of the laser show red light emission. Since the laser beam travels along the normal to the face, the angle θ is zero, and therefore $\cos\theta$ is 1. The average area, dA , of a human face is 0.028 m^2 [6]. Using $v = \Delta x/t$ and assuming that the laser was travelling at the speed of light, the time taken to pass through a head was determined to be $6.57 \times 10^{-10} \text{ s}$. For the solid angle equation, $\Omega = A/r^2$, the distance from the source to the third head was estimated to be 3 m, resulting in a solid angle of

0.003 sr . Substituting all these factors into equation (7), integrating and rearranging for $I_\nu(s_0)$ provides us with a monochromatic specific intensity of $1.61 \times 10^{19} \text{ Wm}^{-2} \text{ sr}^{-1}$, just over 5×10^{26} times greater than the specific intensity of our Sun.

Discussion

The characteristics of batteries prevent them from discharging all of their energy linearly in a very short time interval (e.g. one second), but if they could then the batteries Rick found contained 285 times more energy than a standard alkaline long-life AA battery. Our calculation of τ was flawed in that only the absorption coefficient of brain tissue was used rather than that of skin, bone, and brain tissue; however it is worth noting that the absorption co-efficient of skin was markedly similar to that of grey matter (0.033 mm^{-1}) at the wavelengths relevant to the investigation. The difference in specific intensities of the laser and the Sun comes as no surprise; the former provides enough energy to melt a human head in an area the size of a human face!

References

- [1] [//science.howstuffworks.com/cremation1.htm](http://science.howstuffworks.com/cremation1.htm) [Accessed 3 October 2017]
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