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P2_6 Out with a Bang

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Abstract

In the Harry Potter book and film series, Wizards are able to disappear at one location and reappear at another instantly. We wanted to calculate how loud this would be, assuming this sound is caused by air rushing into the leftover space. We calculate the sound to be 160 dB, approximately that of a plane taking off, and significantly louder than the described 'pop' or 'crack' sound in the books. We also looked into how much energy the Wizard would need to control, and calculated that if this dissapearence occurred due to the Wizard travelling at the speed of light, they could transform their body weight into 94 x 10^{18} J of energy, enough to power the United States for 24 days.

Introduction

In the first scene of Harry Potter and the Philosophers Stone, Albus Dumbledore appears on Privet Drive out of thin air,[1] and later disappears the same way. Such a feat is later revealed to be standard in the wizarding world, referred to as apparition - the ability to disappear from one place and reappear instantly at another. When reading the books, it is usual for this to make a 'pop' or 'crack' sound. We investigate what sound apparition would create, assuming it is generated by the rush of air into the space in which the wizard had previously occupied.

Method

We do this by modelling the pressure in 2 dimensions, approximating the person as a 2D rectangle of height $h = 1.8$ m [2], and width $w = 0.41$ m. If we consider only the front and back of the persons' surface area, we find this to be $A = 1.5$ m^2.

This gives the area on which the pressure is acting before the dissaparition. We have assumed, when they disappear, the air moves with laminar flow inwards until it collides with the other side of the air, meeting in the middle over a surface area of 0.73 m^2. This is shown in Figure [1].

We also assumed the force acting on that air due to the pressure is the same before as after. We can then use Equation (1):

$$F = p_{\mathrm{a}} A, \tag{1}$$

where $p_{\mathrm{a}} = 2100000$ Pa, the atmospheric pressure at sea level and $A = 1.5$ m^2 is the surface area on which the force F is acting, to calculate the initial force as being 147000 Pa. By rearranging, we can use this value along with the final area value 0.73 m^2, to calculate the final pressure, $P = 200000$ Pa.

We can then substitute this into Equation (2) [3]:

$$dB = 20 \log \frac{P}{P_{\mathrm{lim}}}. \tag{2}$$

Where $P_{\mathrm{lim}} = 2 \times 10^{-5}$ Pa is the pressure at the

Figure 1: Figure showing the model used in this paper. The air pressing on the blue rectangles rushes into the centre, where it collides and produces a noise.

limit of human hearing [3]. This gives a value of the sound level at the point to be 200 dB. If we consider a person standing 10 m away, we can calculate how loud the sound would be to them using Equation (3):

$$I_{\mathrm{o}} = I/d^2, \tag{3}$$

where I_{o} is the sound intensity at the observer, I is the sound intensity at the source, and d is the distance. By assuming pressure and intensity are proportional, we can divide the calculated pressure at the source by 100 and use equation (2) to find the decibel level to be 160 dB. This is approximately equivalent to the sound of a shotgun [4]. Referring to this as a 'crack' may then be an understatement, unless magic was used to supress the sound to a less painful level.

We can also look at how much energy the wizard would have to control if they converted all their mass into energy, so they could travel at the speed of light. If we assume the persons' mass is transferred wholly into energy, we can also use Equation (4),

$$E = mc^2, \tag{4}$$

to calculate the mass to energy conversion they would have to undergo. Taking the average mass of an adult male to be 70 kg [5], we find an energy of 6.29×10^{18} J, or 6.0 EJ. For comparison, the United States energy consumption per year is approximately 94 EJ [6], so this would be enough to power the country for 24 days.

Approximations

We have modelled this problem only in 2 dimensions, approximating a human body to be a rectangle. Further study could look at this in 3 dimensions to create a more realistic picture. We assumed air particles would move into the centre of the vacuum with laminar flow, and that the force before is equal to the force after. We have assumed that energy is converted wholly into sound, whereas some would be dissipated as heat or lost to friction. For calculating the mass-energy conversion, we have assumed all mass turns into energy.

Conclusion

We found the sound of an average male dissaparating, to an observer 10 m away, to be 160 dB, approximately equal to the sound of a plane taking off next to them [4]. We also find that if the mass of the body was converted into energy by which to travel at the speed of light, the Wizard would need to control 6.3 EJ, enough to power the United States for 24 days.

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