Journal of Physics Special Topics
An undergraduate physics journal

A2_1 Disaster Area

T. Gittins, D. Moore, R. Smith, G. Wattam, A. Yiu

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

October 14, 2018

Abstract

This report explores the feasibility of the plutonium rock band Disaster Area featured in Douglas Adams' second novel. The band was found to produce a loudness of 304 dB 1 m away from the speaker. This gave an estimate of 2.64×10^{20} kg of plutonium undergoing fission in order to allow the two hour concert to perform at this noise level.

Introduction

In Douglas Adams' second novel, *The Restaurant at the End of the Universe*, the band Disaster Area are noted for being the loudest noise in the entire galaxy. Using information given in the books, it is possible to explore this idea, calculating their true loudness and how much plutonium is required to power such an intense band.

Theory

Adams' book states that "regular concert-goers judge that the best sound is usually to be heard from within large concrete bunkers some thirty-seven miles [60 km] from the stage." (Adams, 1980) [1] The method chosen to determine the feasibility for a two-hour Disaster Area concert was to work backwards from the loudness (dB) in the bunkers where listening is recommended. This allows for calculation of the loudness outside the bunker, and subsequent calculation of how loud the concert would be at 1 m from the stage. From this, the total energy required for the concert can be determined, and then the amount of plutonium needed to generate this energy by fission can be calculated.

The starting point for this estimate begins with the average loudness of a rock concert, which is 120 dB [2]. This can be taken as the loudness within the bunker. Assuming the bunker walls are made of concrete of uniform density, the transmission loss of sound waves through the bunker walls can be calculated using Equation 1 [3], given below.

$$T_L = 20log(m_s f) - 48 \qquad (1)$$

In this equation, T_L is the transmission loss (dB), m_s is the surface area density of the concrete (kgm^{-2}), and f is the average frequency of the sound waves (Hz) from the concert. The value for the transmission loss through the bunker walls can be added to the 120 dB within the bunker to determine an estimate for the loudness outside the bunker.

From this value, Equation 2 [4] can be used to determine the loudness at 1 m from the stage.

$$\Delta L = \mid 20log(r_1/r_2) \mid \qquad (2)$$

In this equation, ΔL is the change in loudness between outside the bunker and the stage (dB), where r_1 (m) is the position of the bunker and the r_2 is the reference point, 1 m from the stage.

The loudness of the band at the stage can be converted to a power required to produce those levels, which can be calculated through Equation 4, which is a rearrangement of Equation 3 [5].

$$N_{dB} = 10log(P_2/P_1) \tag{3}$$

$$P_2 = 10^{N_{dB}/10} \tag{4}$$

In this equation, N_{dB} represents the loudness at the stage (dB), and P_2 is the power (W) on the stage. P_1 is the input power (assumed to be 1 W). The calculation of the power, along with the assumption of a two hour concert, allows the total energy required to be determined.

If Disaster Area's power is generated by the nuclear fission of plutonium-239 at 100 % efficiency with no energy loss in the equipment, from knowing the amount of energy produced in the fission of one Pu-239 atom, the total mass of plutonium required to generate that energy for a Disaster Area concert can be calculated.

Results

Equation 1 was used with a wall depth of 10 m (which results in a surface density m_s of 24,000 kgm^{-2}), and an average frequency f of 250 Hz (just below middle C, a common musical note). For a wall depth of 10 m, this gave a transmission loss through the bunker walls of 88 dB. Adding this change in loudness to the 120 dB experienced within the bunker, the loudness outside the bunker walls can be estimated at 208 dB.

Using Equation 2 with the value for r_1 as 60 km and the reference point r_2 as 1 m from the stage, the change in loudness between outside the bunker and the stage was calculated. When added to 208 dB from outside the bunker, the loudness at the stage was calculated as 304 dB.

When this loudness is equated to a power using Equation 4, the power output for the speakers was determined to be 2.51×10^{30} W; over two hours, this results in a total energy output of 1.81×10^{34} J.

The most common decay chain of the fission of one Pu-239 atom produces 3.32×10^{-11} J [3], so 5.45×10^{44} Pu-239 atoms are required to produce this amount of energy. Assuming that the nuclear reactor used can convert this energy into useful electrical energy for the speakers with 100 % efficiency, the mass of plutonium required to power the 2-hour concert is 2.16×10^{20} kg. However, reactor-grade plutonium has roughly 82 % Pu-239 with an 18 % impurity of non-reactive Pu-240 [4], meaning that the total mass of plutonium required to get the desired mass of Pu-239 was estimated to be 2.64×10^{20} kg.

Discussion

While the extremely large mass of plutonium required to power Disaster Area seems reasonable given the loudness required, there are still several assumptions that have been made, as stated in this paper. Eliminating these assumptions would improve the validity of this result.

Conclusion

This investigation has shown that it would be almost impossible to power a Disaster Area concert. If it was assumed that the vast amount of plutonium required was available, there would be issues to consider that go beyond the scope of this paper, such as whether it is possible to build a speaker system capable of withstanding the intense vibrations produced by Disaster Area.

References

[1] Adams, D (1980). *The Restaurant at the End of the Universe*, Pan Books, London.

[2] https://myhealth.alberta.ca/Health/Pages/conditions.aspx?hwid=tf4173 [Accessed 3 October 2018]

[3] http://personal.inet.fi/koti/juhladude/soundproofing.html [Accessed 3 October 2018]

[4] http://www.sengpielaudio.com/calculator-distance.htm [Accessed 3 October 2018]

[5] https://www.radio-electronics.com/info/formulae/decibels/decibel-formulae-equation.php [Accessed 3 October 2018]