Journal of Physics Special Topics
An undergraduate physics journal

A1_3 Dinosaur In-dial-gestion

Gregory A. Childs, Taranpreet K. Sohal, Harneet K. Sangha, Heidi B. Thiemann

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

December 7, 2016

Abstract

In this paper we investigate the attenuation of sound waves originating from a ringing mobile phone, as they travel outwards from the stomach of a Spinosaurus, in order to determine whether they could act as a warning of the approaching dinosaur. Calculating the intensity lost passing between the various media in the dinosaur's body, as well as air outside of the dinosaur, we determined this would not be audible. We calculated that the intensity of the phone ringing would be -19.6 dB when it reached the main characters, which puts it just below the range of human hearing.

Introduction

In the third instalment of the Jurassic Park trilogy, the characters come to Isla Sorna in the hopes of finding the missing character Eric. During their efforts, they get chased by a Spinosaurus which promptly eats one of their colleagues. A later scene depicts the reunion of the parents and their son. During this, they begin to hear the familiar ring of the deceased colleague's satellite phone. As they turn to look towards the incoming sound they are faced with the Spinosaurus, eyeing them up, with the ringing coming from inside it. We aimed to calculate whether or not they would actually be able to hear the phone.

Theory

In order to properly analyse how the sound travels through the dinosaur we built a simple model of the path the sound takes, as shown in Figure 1.

The model comprises of multiple layers of different tissue in the Spinosaurus. Therefore there are various amounts of attenuation and reflection in the tissue and at tissue boundaries respectively. We calculated how much the sound was attenuated step by step, beginning with attenuation in the stomach fluid, then reflection at the stomach-muscle boundary, then attenuation in the muscle, repeating this process until all layers had been accounted for.

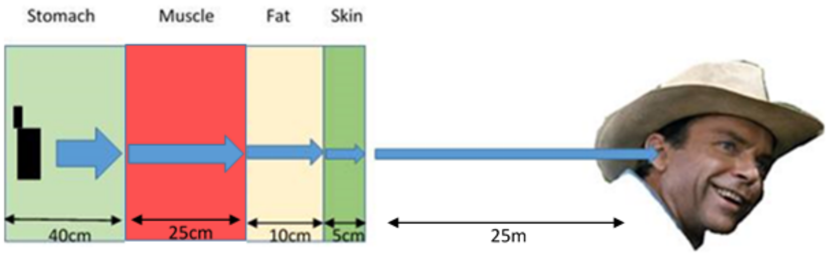
As sound waves travel through a lossy medium, energy losses occur through absorption, reflection, and scattering. This process is known as attenuation. In a liquid the attenuation coefficient α is given by

$$\alpha = \frac{2\eta\omega^2}{3\rho v^2}, \tag{1}$$

where η = coefficient of viscosity, ω = angular frequency, ρ = density of the liquid and v = sound speed in the liquid [1].

Using Equation (1), we calculated the attenuation coefficient of the liquid in the Spinosaurus' stomach, assuming the liquid has the same viscosity and sound speed as water. Next we accounted for the different organs and tissues, which have various attenuation coefficients [2]. Using each of these coefficients, the attenuation A in each tissue

$$A = \alpha f d \tag{2}$$



Medium	Z-Value
Stomach Fluid (Water)	1.46×10^8
Muscle	1.70×10^6
Fat	1.38×10^6
Skin (Cancellous Bone)	1.87×10^6
Air	4.29×10^2

Figure 1: A rough model of the path travelled by the sound, with Z-values from the literature.

was found [3], where f = the frequency of the ringing tone in MHz and d = the distance the wave travels in the matter.

At the boundary between two media, some of the wave is reflected and some is transmitted. This is due to the difference in the acoustic impedances (Z) of the media. The acoustic impedance of the material relates to the density of the material and the sound speed.

In order to calculate the wave intensity transmitted across a boundary, the intensity was multiplied by the Intensity Transmission Coefficient (ITC) [3]

$$ITC = 1 - IRC \tag{3}$$

where the Intensity Reflection Coefficient,

$$IRC = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}. \tag{4}$$

The respective Z-values were obtained from literature [2], Figure 1. For the Z value of dinosaur skin we used the median value of cancellous bone, and used the median value for the muscle layer.

Results

We assumed the phone would have a ringer volume of 80 dB, which is the average for mobile phones [4]. As the sound moved through the dinosaur the volume losses were primarily at the boundaries between tissue. The sound fell by ≈ 3.5 dB by the time it had reached the skin. The boundary between skin and air proved to be far more effective at reducing the volume than any other stage, with the intensity falling from 76.4 dB to 0.07 dB upon exiting the body. The journey through the air to Dr. Grant's ears further reduces the sound volume by 19.7 dB to a final volume of -19.6 dB, just below the range of human hearing, which is capable of distinguishing sound intensities as low as -15 dB [5].

Discussion

These results are to be expected as while sounds within someone's body can often be heard by that person, they usually can't be heard by others, let alone from 25 metres away. We roughly assumed this distance based on the time the dinosaur took to reach the fence [6] and the length of its stride, which we took to be 5 metres once every second. Our model is not entirely representative of dinosaur physiology, for example our Z value estimates. However, we believe it to be accurate enough for the scope of our paper.

References

[1] Warren P. Mason, *Properties of Gases, Liquids, and Solutions: Principles and Methods.* pp. 293 (found in paper 1 by group A2)

[2] Pascal Laugier and Guillaume Haiat, *Introduction to the Physics of Ultrasound*, 2011, Chapter 2 p.39

[3] Dr Emma Chung (2016), *Ultrasound* [Lecture to MPhys and BSc Physics], *PA3675: Introduction to Medical Physics*, University of Leicester, Jan/Feb 2016

[4] `http://http://tinyurl.com/ovjgmml` accessed on 25/10/16

[5] `http://tinyurl.com/zymbewb` accessed on 25/10/16

[6] `https://www.youtube.com/watch?v=cVA4BO2v7zs` accessed on 25/10/16