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## The Range of the Dragon Shout in Skyrim

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### Abstract

The 'call dragon' shout from the popular Bethesda game Skyrim has the ability to summon a dragon from any point on the games 40km<sup>2</sup> map. By modelling the attenuation of the human voice, it was discovered that the male and female human voices would only carry between ~0.11-0.15 km. For the shout to travel the entire map and arrive at an audible level, the shout must be at a volume of the order 10<sup>36</sup> dB or 10<sup>48</sup> dB for males and females respectively. Alternatively, for a very loud human shout (129 dB), the dragon would have to hear magnitudes as low as 10<sup>-46</sup> dB.

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### Introduction

In the most recent console instalment of the Elder Scrolls series by Bethesda Softworks, *Skyrim*, gamers take the role of a powerful individual known as the Last Dragonborn (Dovahkiin). This character possesses the ability to 'shout' magical commands such as the well-known '*Fus ro dah*'. One of these shout abilities enables the Dovahkiin to summon a dragon from any location in Skyrim.

Through the 'call dragon' shout (also known as 'Thu'um'), the dragon Odahviing can be summoned by the Dovahkiin. This shout has been shown to work across any distance in Skyrim, but not from the island of Solstheim (from the downloadable content 'Dragonborn'). This suggests that although the Thu'um is strong enough to call Odahviing between any distances spanning the width of Skyrim, the shout must have a limit to its range. The aim of this paper is to determine the minimum volume that the Thu'um must have to be in order for Odahviing to hear it across all of Skyrim.

### Attenuation

The limit on the distance the Thu'um can travel can be explained by the process of attenuation. As sound travels across a distance, it is partly scattered and absorbed by the surrounding medium, reducing its intensity. The properties of the atmosphere determine how effectively the intensity is reduced, with attenuation being much greater at higher humidities and for sounds at greater frequencies. Attenuation is also affected by temperature.

To determine how far the released Thu'um is capable of travelling through air, the attenuation factor must be taken into account. The variables of humidity,  $h$  (%), initial and final temperatures,  $T_0$  and  $T$  (both taken to be 293.15K), as well as frequency,  $f$  (Hz), can be used to find the attenuation,  $a$  (dB/100m) [1]:

$$a = 869 \times f^2 \left\{ 1.84 \times 10^{-11} \left( \frac{T}{T_0} \right)^{1/2} + \left( \frac{T}{T_0} \right)^{-5/2} \left[ 0.01275 \frac{e^{-2239.1/T}}{F_{r,O} + f^2/F_{r,O}} + 0.1068 \frac{e^{-3352/T}}{F_{r,N} + f^2/F_{r,N}} \right] \right\} \quad (1)$$

For the purpose of the calculations, the values for the initial and final temperatures (293.15K or 20°C) were taken to represent a relatively warm location on the map with the Dovahkiin and Odahviing being within similar climates in different locations (hence, equivalent temperatures). The calculation of  $a$ , from equation (1), requires the calculation of the relaxation frequency for both oxygen ( $F_{r,O}$ ) and nitrogen ( $F_{r,N}$ ) from

equations (2) and (3), also taken from [1], where  $F_{r,N}$  is 230.2 and  $F_{r,O}$  is 21,913.9 for a humidity of 79% (0.79):

$$F_{r,O} = 24 + 4.04 \times 10^4 h \left( \frac{0.02 + h}{0.391 + h} \right) \quad (2)$$

$$F_{r,N} = \left( \frac{T}{T_0} \right)^{-1/2} \left( 9 + 280 h e^{\left\{ -4.17 \left[ \left( \frac{T}{T_0} \right)^{-1/3} - 1 \right] \right\}} \right) \quad (3)$$

Humidity,  $h$ , was determined by considering the climate. It can be assumed that the Dragonborn is situated in a region with a temperate climate, similar to England. The humidity in England for Spring 1961-1990 ranged between 71-92% [2] with most regions experiencing humidity between 76-82%. Taking the midpoint of the latter range gives the approximation used for  $h$  (79%). The time scale of 1961-1990 was used for the calculations as this covers a large window of time and so gives a better approximation of the 'midpoint' for the possible percentage humidity in England. However, the assumption of a very warm English climate could be considered a limitation of the calculations due to the much greater variation of climate in Skyrim.

The fundamental frequency,  $f$ , of a shout for a human has been shown to be  $359.7 \pm 0.7$  Hz for a female and  $259.4 \pm 0.4$  Hz for a male [3]. Therefore, from equation (1), the attenuation coefficient  $a$  can be calculated at  $\sim 0.1975$  dB/100m ( $\sim 1.98$  dB/km) for a female and  $\sim 0.1467$  dB/100m ( $\sim 1.47$  dB/km) for a male human.

As the hearing abilities of Odahviing cannot be known, this can be modelled as another human listening from a distance away from the Dovahkiin. For the travelling sound wave to be audible to a human a distance  $x$  away from the shouter, the minimum volume must be 0 dB. However, in order to hear a clear response at 'conversation' volume, this final volume would have to be  $\sim 20$  dB for a whisper [4]. If it is assumed that the shouting individual is emitting a plane sound wave of 129 dB [5], the loudest recorded shout by a human. Then, rearranging equation (4) from [6], the distance can be calculated for the attenuation values from (1):

$$A = A_0 e^{-ax/0.1151} \quad (4)$$

For this calculation  $A$  is the amplitude heard (20 dB) and  $A_0$  is the amplitude emitted (129 dB). To account for the change in units in (4) from nepers/length to dB/length, an additional factor of 0.1151 must be included. This gives a distance of  $\sim 0.108$  km for the female voice and  $\sim 0.146$  km for the male voice.

As the area of Skyrim is approximated as  $40\text{km}^2$  [7], if it is assumed that the region is a square, this equates to a length of 6.32km. Using this as the distance  $x$  in (4), the resulting volume heard by the dragon is  $7.84 \times 10^{-46}$  dB for a female and  $1.138 \times 10^{-33}$  dB for a male. These values are very low and can be considered inaudible. Therefore, for Odahviing to hear the Dovahkiin, the Dovahkiin must be shouting significantly louder than a human. The initial shout amplitude  $A_0$  for a final volume  $A$  of 20dB is estimated at  $3.29 \times 10^{48}$  dB for the female Dovahkiin and  $2.27 \times 10^{36}$  dB for the male.

## Conclusion

From the calculations made, in order for Odahviing to hear the Dovahkiin's shout across Skyrim, the Dragonborn must emit a shout which has a fatal volume of the order  $10^{48}$  or  $10^{36}$  dB. Comparatively, the decibel count of a 1 ton TNT explosion from a distance of 250ft is said to be 210 dB [8]. It is more likely that Odahviing would be able to hear the volumes of the order  $10^{-33}$  and  $10^{-46}$  than the Dovahkiin producing such loud shouts, particularly due to some animals having more acute hearing than humans.

## References

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