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# EXPERIMENTAL CHARACTERIZATION OF THE STEEL TONGUE DRUM

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The steel tongue drum (also known as hank drum) is a relatively new musical instrument (2007) in the pitched percussion family, generally made from a metal sheet or from the base of a tank. Several tongues are cut on its surface, making the instrument capable of producing different tones depending on the shape of the tongues. The sound produced has interesting features such as a long decay and a rich and colourful harmony that differentiates this instrument from other mallet instruments as chimes, xylophones or marimbas. The main objective of this work is to present an acoustical characterization of this instrument from direct experimental measurements. Using a class-A measurement system composed of two microphones, a multichannel data acquisition system with pc interface and a computer, the sounds produced by each one of the single tongues were recorded and analysed. Spectrograms were obtained covering from the attack to the decay of each note of the drum. This work is a first step towards the physical characterization of this musical instrument and shows the presence of the harmonic interference between the notes that gives to the steel tongue drum its characteristic sound.

Keywords: Fourier transform, mallet, percussion, steel tongue drum, pitched percussion.

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## 1. Introduction

Steel tongue drum, tank drum, hank drum or zen drum is the name given to a relatively new musical instrument which is produced since 2007. Made of metal, in some cases it is obtained from a recycled steel tank [1].

A very scarce literature can be found about this musical instrument [2], whereas some other similar music instruments (wood made) were studied, such as the Nigerian slit gong [3] or the resonance in wooden tongue drums [4].

Some other tuned metal drums such as the hang drum can be confused with the tank drum by the general aspect shape (*oblate spheroid*) and by the characteristic sound rich in harmonics. The steel pan drum is a traditional metal drum from the Caribbean made from old cylindrical tanks that inspired the origin of the handpan; both instruments are tuned to different keys by altering locally the elasticity and mass density of a the continuous membrane which forms the drum.

The physical mechanism which induces the sound production of these latter drums is very different if compared with the steel tongue drum, since for a steel tongue drum the tuning is obtained by cutting tongues of different shapes on the surface, and a simple model based on the vibration of a rod (with fixed-free ends) can represent the mechanism of the tongues' vibration.

The aim of this work is to present a first approximation of the acoustic characterization of this musical instrument derived from experimental measurements on a small commercial drum.

## 2. Methodology

An 11-notes steel-tongue drum characterized by an external diameter of 250±1 mm was studied for each single note, i.e. by the direct measuring of the sound produced by each tongue under the action of a soft (rubber) mallet. The measurements were done using two ½-inch condenser microphones (PCB Model 377A60, each one attached to a PCB 426A30 ½-inch preamplifier) and a multichannel real-time data acquisition system (01dB Orchestra). Two signals were recorded simultaneously for each note, with the microphones positioned one meter apart form the centre of the drum, one just in front of it (at the same height) and the second one at 15± 1° above the horizontal plane. During the acquisition of each tongue the other ones were muted in order to reduce the harmonic resonance. By the application of Fast Fourier Transform FFT the tonal content of the registered signals was obtained.

## 3. Results

Figure 1 shows the relationship between the fundamental frequency and the length of the tongue for the studied drum. The relation is nonlinear and, as expected, the pitch increases if the tongue becomes shorter. All the tongues considered here have similar shape, thickness and width. The experimental points represented in the chart also show the uncertainty in both length and frequency.

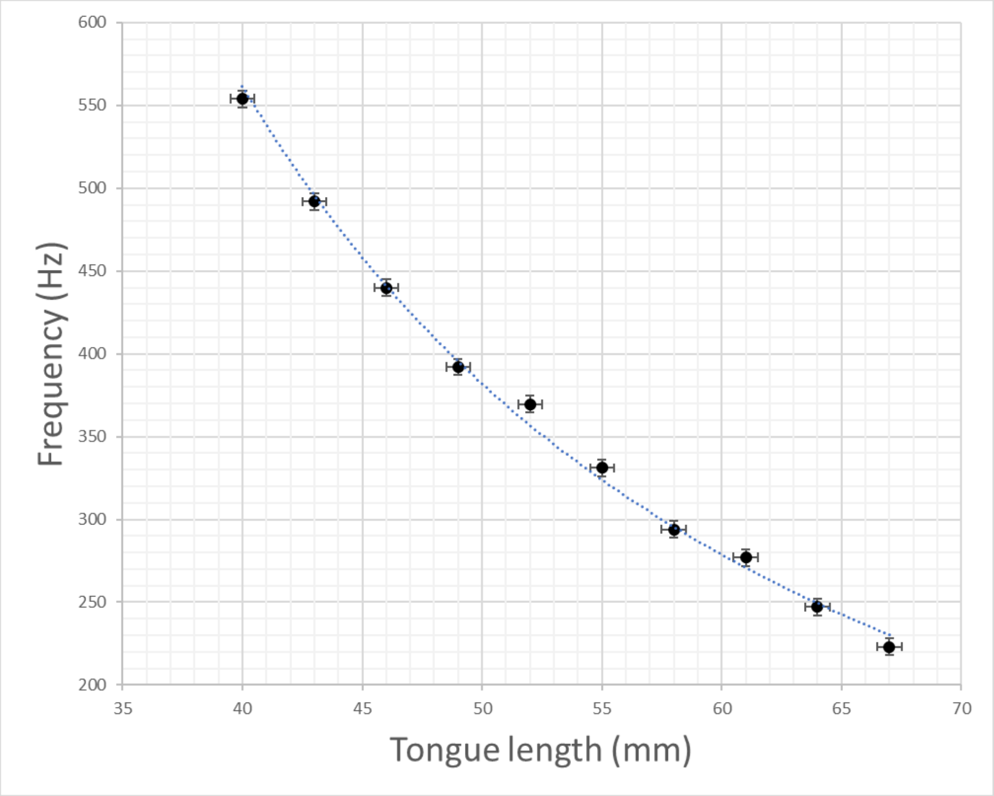

Figure 1: Main peak in relation with tongue length.

By means of FFT analysis of the signals (8192 samples, Hanning window) the plots of the spectrums were obtained. As an example, figure 2 shows the spectrum for the G4 note, which is characterized by a tongue length of 49±1 mm, a fundamental frequency equal to 392±5 Hz, and harmonics of 1179±5 Hz, 1960±5 Hz, 2745±5 Hz, 3531±5 Hz and so on. Between each pair of those harmonics, some other peaks with lower relative levels appear just at the frequencies corresponding to the harmonic series of the neighbor tongues.

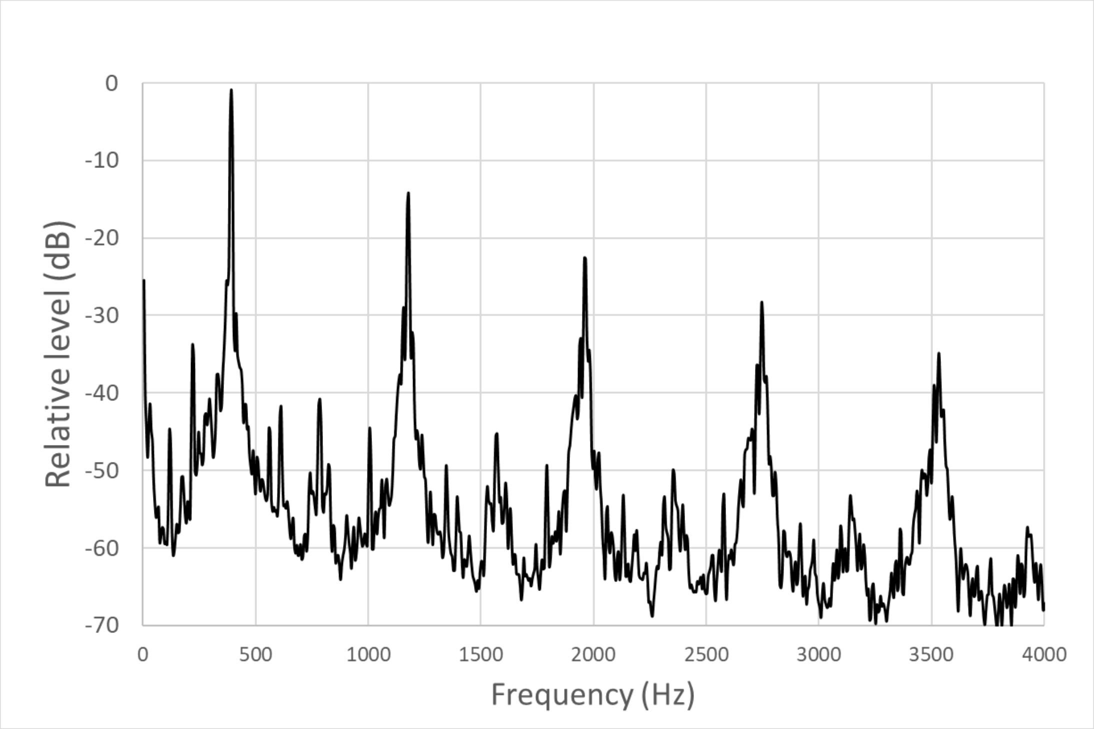

Figure 2: Typical spectrum for a steel tongue drum. Note G4.

## 4. Discussion and conclusions

An empirical equation, Eq. (1), has been obtained by a nonlinear regression ($R^2 = 0.9955$) to determine the fundamental frequency $f$ $(Hz)$ of a given tongue with length $L$ $(mm)$, by the inclusion of a proportionality constant $C$ that contains information about material density, shape (cross section area) and stiffness of the material. It is of course expected that this constant changes from drum to drum:

$$\boldsymbol{f = C \cdot L^{-1.728}} \tag{1}$$

As it was expected, for a simple one-dimensional analysis the fixed-free boundary conditions drive to the presence of uneven transversal harmonics, $f_n = (2n + 1)\ f_0$, but even applying a constraint to the movement of the neighbouring tongues when a single one is under study, it is possible to observe the harmonic interference between all the tongues, which gives the characteristic timbre of the instrument. This musical instrument is nowadays becoming very popular, and more experimental studies aimed to describe its physical behaviour (e.g. modal analyses), as well as numerical simulations for the design, the optimization and the tuning of the instrument, are desirable and foreseeable.

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