

Physics of Musical Tunings

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Abstract

An audio-video program with many additional files concerning the concept of musical tuning is described. This program was supported by the foundation FRVŠ 2742/2003 and may be used at secondary schools.

Introduction

With generous donation by FRVŠ 2742/2003, an audio-video program has been made to explain, from the physical point of view, the basic musical concepts generally and the principles of the musical tunings specifically. The program is in Czech and at the level of a secondary school. In addition, many demonstrative musical files (*.wav) are supported by this program.

1 Main Program

After the very basic facts (names of tones, intervals, octaves) are shown and explained, the concept of harmonics is presented demonstrating step by step the Fourier synthesis of one particular sound of a metallic strip. Using harmonics, the diatonic scale is constructed – thus based upon the S – T – D accords rather than using the Pythagorean circle. Intervals are presented by a unique manner using a part of the piano keyboard wrapped around so that one octave makes one full circle, i.e. 360° . Thus, intervals are shown as the angles between keys. It enables the demonstration of different important micro-intervals: the major tone d-c ($9/8$), the minor tone e-d ($10/9$) and their difference – comma of Didymos ($81/80$), the Pythagorean comma ($3^{12}/2^{19}$) etc. The presentation of simultaneous tones and pictures of touched keys is very engaging.

Then, the explanation of three natural tunings (Aristoxenes, Delezenne, Ptolemaios) continues in a special plane diagram showing tones in the fifths (horizontally) and pure thirds (diagonally) with their normalized frequencies, compared to the well-tuned tones.

The audio-video then demonstrates identical cadences in different tunings, “painful” intervals for particular tunings, etc. Parts of a tonal composition (J. S. Bach, Preludium C-major) and an atonal one (A. Honegger, La

neige sur Rome) are presented in different tunings (tempered, natural in C major, natural in D-flat major).

2 Demonstration

Instead of the rather large audio-video in Czech (cca 70 min), a short demonstration in English (20 min) will be presented, showing the methods used rather than the full explanation.

3 Additional files

In addition to the main program, a set of *.wav files has been included in some folders, namely:

- 4 classical compositions (Bach, Mozart, Haendel, Chopin) played by a professional pianist, transposed to different tunings
- A set of successive intervals of 0-1-2-3-4-6-8-12-16-24-32-48-64-96-128 cents, both ascending and descending
- The octave divided equidistantly into 5-6-7-8-9-10-11-12-24-36 parts (6: tempered tone, 12: semitone, 24: quartertone, 36: sixth part of a tone)
- For tunings of Aristoxenes, Delezenne, Ptolemaios, Pythagoras and well-tempered, the full set of tones is presented from f-flat to b-sharp, consisting of an exactly calculated frequency f and its multiples $f \cdot 2^n$ for $n = -5 \dots +5$, to avoid problems while crossing the range of one octave.

4 Conclusions

Musical acoustics, being “the Bridge between the Art and the Science” – yields splendid possibilities for multimedia applications. This project is more or less a preliminary one intended to determine the possibilities rather than the full multimedia program; the interactivity is still very limited here. Nevertheless, it has given us very valuable tips to be used in following projects on this topic.

An English version of this and further projects are in preparation.