

Microtonal music with ABC (**microabc** tutorial)

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1 Introduction

How to make microtonal music using a computer? How to obtain a score with a special, customised, microtone notation? How to get an audible “previewing” of a microtonal composition? Is all that feasible today with 100% free software? The answer for the last question is yes, thanks to some ABC music notation softwares. Answers for the other questions will be addressed through this text. **microabc** was written to make it easy to get microtonal music scores and MIDI files with ABC tools.

2 Software requirements

First, you will need to obtain some pieces of software:¹

- Get the (free/ libre/ open source) ABC software tools:²
 - **abcpp**, the ABC preprocessor.
 - **abc2midi**, an ABC to MIDI converter.
 - **abcm2ps**, a music typesetter that generates PostScript files.
- Get a program to compute musical scales:
 - **Scala** (free of charge).
- Get a PostScript interpreter and previewer:
 - **ghostscript**.
 - **ghostview**.
- Get a MIDI player with Standard MIDI Tuning support:
 - **timidity++**.
- And do not miss **microabc**, of course!

You should be aware that **abcpp** must be compiled with sufficient room for the macros generated by **microabc**. Find the definition of `MAX_MACROS` in the source code and (re)define it as 512 or like,³ then compile the program. In order to work with “normal” versions of **abcpp**, several samples in this tutorial use a limited pitch range.

The sample commands in this tutorial were tested on a Debian GNU+Linux operating system. For other systems, they may need a few adaptations.

3 Understanding the basic concepts

One needs to know a set of concepts, in order to get started to **microabc**.⁴

¹URIs for the sites from which the programs can be obtained are provided at the end of this document.

²Tip for Windows users: download the “ABC command line tools for Windows” package from <http://abcplus.sourceforge.net/#abctools>

³For **abcpp** version 1.3.2, the line 43 of `abcpp.c` may be changed to, for instance:
`#define MAX_MACROS 512 /* # of #defined macros */`

⁴Basic knowledge of ABC music notation is required – ABC will not be described here. Fortunately, ABC is easy – you can learn it in a short time. A good text for introduction and reference is “Making Music With ABC Plus” by Guido Gonzato. Visit: <http://abcplus.sourceforge.net/#ABCGuide>.

3.1 ABC and microtones

There are a few ABC programs with support for microtonalism. **abcm2ps** and **abc2midi** provide rich features to get microtonal PostScript scores and MIDI files.⁵

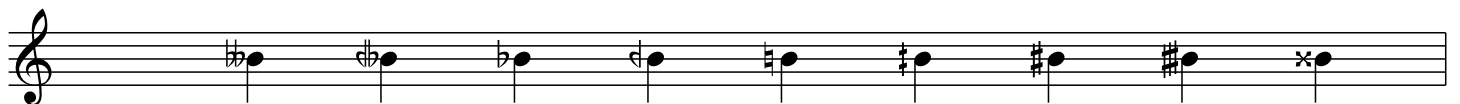
Both **abcm2ps** and **abc2midi** represent microtonal pitches with a fraction associated to an accidental. It is assumed that the fraction is a fraction of a conventional tempered semitone. For instance, $\sim 1/2C$ is the pitch C raised by 1/2 semitone, while $_14/100E$ is the pitch E lowered by 14 cents.⁶

However, there are limitations in both programs: **abcm2ps** only includes glyphs for conventional and quarter-tone accidentals (in a Tartini-Couper style). Any other accidentals are indefinite, hence the user should provide the PostScript definitions for their glyphs. In turn, **abc2midi** cannot deal freely with microtonal accidentals in chords, because normally the notes inside a chord go into a same MIDI channel, and the pitch bend messages (which assign the tuning to the notes) are applied to all simultaneous notes sharing a same channel.⁷ Another difference is that **abcm2ps** only accepts fractions which numerator and denominator are lesser than 256.

To handle such limitations and differences between **abcm2ps** and **abc2midi**, and to provide shorter ways to represent pitches like $_137/1000A$, and also to compute the proper fractions for each note, it seems to be a good idea to use a preprocessor and a tool to generate the macro definitions required for a given tuning.

```
X:1
T:microabc tutorial
T:abcm2ps built-in microtonal accidentals
M:none
L:1/4
%%stretchlast
K:C
yy __B _3/B _B _/B =B ^/B ^B ^3/B ^^B |
```

microabc tutorial
abcm2ps built-in microtonal accidentals



3.2 Macros and preprocessors

microabc is a generator of *macros*, that is, a definition of a character string to be replaced with another character string. A *preprocessor* is a tool which (among other features) can carry out macro replacements. This works much like the “Find/Replace” feature present in text editors.

For instance, let us suppose that we want to use a short macro name to be replaced with the string `%%begintext`. For the **abcpp** preprocessor, we could define a macro like this:

```
#define %%BT %%begintext
```

⁵**jcabc2ps** and **BarFly** provide some (limited) support for microtonalism. Also, **tblabc** includes a program called **tkabc**, which is a graphical interface to write ABC files – **tkabc** supports the same quarter-tone accidentals as **abcm2ps**.

⁶**abc2midi** (since 2006-09-26) also supports temperaments of the linear class, thanks to the command `%%MIDI temperamentlinear octave_cents fifth_cents`, where octave and fifth sizes are given in cents.

⁷Since 2006-10-03, **abc2midi** supports microtonal chords provided that a number of MIDI channels be reserved with the command `%%MIDI makechordchannels n`, where *n* is the number of additional channels to allocate for the current voice.

Given the definition above, all occurrences of %%BT in the input file will be replaced with %%begintext. You can try with macros just now, by using **abcpp**.

First, create a text file named `macroin.txt` with this content:

```
#define SCALE CDEFGABc
#define CHORD  [CEGc]
A C-major scale in written in ABC as:
    SCALE
A C-major tonic chord is written as:
    CHORD
```

Then, run **abcpp** on the file `macroin.txt`, by using this command:

```
abcpp macroin.txt macroout.txt
```

abcpp will read the file `macroin.txt`, and convert it in a new file named `macroout.txt`, replacing all defined macro names with their corresponding replacement texts:

```
A C major scale in written in ABC as:
    CDEFGABc
A C major tonic chord is written as:
    [CEGc]
```

3.3 **microabc** is a generator of macros

microabc was primarily intended to be a program to generate macro definitions to represent micro-tonal music in ABC. Let us try its basic features with a few short examples.

Create a file `ex1.txt` with this content:

```
range: -5 7
alias: 0
0
1
2
```

Now run **microabc** on that file:

```
microabc < ex1.txt
```

microabc will print on the screen a list of macro definitions based on the file `ex1.txt`, including these lines:

```
#define [1,,] =G,
#define [2,,] ^G,
#define [0,] =A,
#define [1,] ^A,
#define [2,] =B,
#define [0] =C
#define [1] ^C
#define [2] =D
#define [0'] ^D
#define [1'] =E
#define [2'] =F
#define [0''] ^F
#define [1''] =G
```

Please note that, by default, the macro names are generated with square braces, and the replacements are conventional ABC pitches in a chromatic sequence, with =C as the central pitch (our first scale degree, named [0]). Such chromatic sequences (mappings) are useful, for instance, when retuning MIDI files with the program **Scala**.

Note that there are 5 macros before [0], and 7 macros after it. This is the result of the command range: -5 7 of the input file.

Please note yet that the macros use the given numbers 0, 1 and 2, with additional commas (,) or apostrophes (') for lower or upper instances (normally used for octaves).

Finally, the command `alias: 0` was used to tell **microabc** that the first column (starting from 0) in the input file contains the strings for the macro names. One can create several macro definitions ("aliases") for each pitch (same replacement), thus the name of the command.

Of course, to use the definitions generated with **microabc**, we will want to store the output in a file. This can be done by either of these commands:

```
microabc < ex1.txt > ex1.abh
microabc -iex1.txt -oex1.abh
```

3.4 **microabc** as a preprocessor

Although preprocessing was not its initial goal, **microabc** can be used as a specialised preprocessor. In special, **microabc** preprocessor provides considerable support for the Sagittal Notation System.⁸ That feature is presented in the section 5.4 (page 18).

3.5 MIDI limitations

One should be aware that MIDI has severe limitations to represent microtonal music.

One way to accomplish microtonal pitches is by using Pitch Bend messages to change the tuning of the note; unfortunately that message affects *all* notes which share a same MIDI channel. Thus, the number of differently tuned pitches played simultaneously is limited by the number of channels in use. Sophisticated algorithms can optimise the use of pitch bend messages, redirecting each note to a suitable MIDI channel. This can be done with **Scala**, when using its *.seq file format, but there is not currently any ABC program with such a feature. **abc2midi** usually outputs each voice to a different channel, therefore chords in a same voice share a same channel, so there is no easy way to tune the individual notes in a chord.^{9 10}

Another approach is to map every MIDI pitch to a given frequency. For MIDI devices with such capability, one can have available up to 128 different frequencies. There is not the problem with simultaneous notes in a same channel. That can be fine in several cases, specially when the scale has not too many degrees in an octave, for instance: 19-EDO or 24-EDO.¹¹ But with 31 degrees in an octave (e.g. 31-EDO), the range is reduced to four octaves only ($128/31 = 4.129$). The frequency mapping usually is device-specific. However there is the Standard MIDI Tuning specification, which set the frequencies by using System Exclusive messages (those messages can be inserted in a MIDI file). Standard MIDI Tuning is not supported by all MIDI devices, thus it is not recommended to use in MIDI files for distribution. An alternative is to use the program **Scala** to retune files which assume a frequency mapping, converting them to files which use Pitch Bend messages instead.

Such MIDI limitations force users of ABC programs to choose between those two main approaches to obtain micro-tuned MIDI files. **microabc** provides the *chromatic* and *diatonic* modes for frequency

⁸<http://users.bigpond.net.au/d.keenan/sagittal/>

⁹The program **abc2alias** included in **microabc** package can split ABC chords in a set of temporary voices. However it is still somewhat limited understanding ABC syntax, so that the user may need to change a bit the ABC source to get the proper results. Nonetheless, **abc2alias** can be very useful if used with care. See inside the `tools/` folder.

¹⁰See also the footnote 7 at page 4.

¹¹"EDO" stands for "Equal Divisions of Octave".

mapping (ABC with conventional accidentals or with no accidentals respectively), and the *microtonal* mode to use pitch bend messages (ABC with microtonal accidentals).

4 The steps

With `abcpp` — These are the traditional steps to write microtonal music with **`microabc`**:

1. Define the scale in a **`microabc`** text file;
2. Generate the file(s) containing the macros definitions, by running **`microabc`**;
3. Write the music in ABC code with macros;
4. Concatenate or include the macros definitions file(s) with the ABC code and generate pure ABC file(s), by running **`abcpp`**;
5. Run **`abcm2ps`** to get the score as a PostScript file and/or run **`abc2midi`** to get a MIDI file.

Without `abcpp` — To use **`microabc`** as preprocessor, the steps are:

1. Define the scale in a **`microabc`** text file;
2. Write the music in ABC code with macros;
3. Preprocess the music file with **`microabc`** to obtain ABC file(s) for MIDI and/or PostScript;
4. Run **`abcm2ps`** to get the score as a PostScript file and/or run **`abc2midi`** to get a MIDI file.

Sagittal — To use **`microabc`** as a preprocessor for Sagittal notation, the steps are simply these:

1. Write the music in ABC code with Sagittal pitches (between square braces);
2. Preprocess the music file with **`microabc`** to obtain ABC file(s) for MIDI and/or PostScript;
3. Run **`abcm2ps`** to get the PostScript score file and/or run **`abc2midi`** to get a MIDI file.

5 Examples

5.1 Quick start

Just start doing. This example requires only these programs:

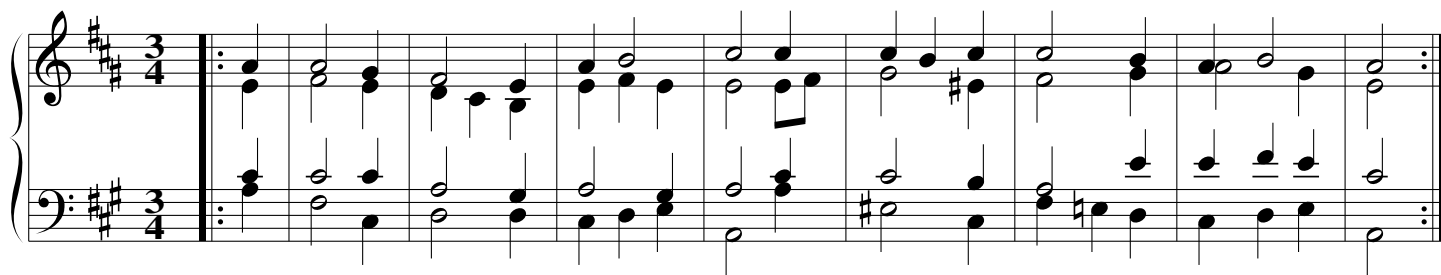
- **`microabc`**;
- **`abcm2ps`**;
- **`abc2midi`**;
- Any MIDI player;
- Any PostScript viewer.

5.1.1 Bach's choral

Here is the sample music, from a J. S. Bach's choral:

microabc tutorial Nun lob', mein Seel', den Herren

J.S.Bach



And here is its corresponding code, written as ABC with Sagittal macros:

```
%%format sagittal.fmt
%%format sagittal-mixed.fmt
%%postscript sagmixed
%%continueall
%%maxshrink .8

%%microabc: equaltemp: 19

X:1
T:microabc tutorial
T:Nun lob', mein Seel', den Herren
C:J.S.Bach
L:1/4
M:3/4
K:A exp [F#'] [C#'] [G#'] % key signature
%
%%staves {(1 2) (3 4)}
%
V:1 clef=treble % Voice 1
%%MIDI nobeataccents
%%MIDI program 16
%%MIDI trim 1/5
|: [A] | [A]2 [:G#] | [:F#]2 [E] | [A] [B]2 | [:C#']2 \
[:C#'] | [:C#'] [B] [:C#'] | [:C#']2 [B] | [A] [B]2 | [A]2 :|
V:2 clef=treble % Voice 2
%%MIDI nobeataccents
%%MIDI program 16
%%MIDI trim 1/5
|: [E] | [:F#]2 [E] | [D] [:C#] [B,] | [E] [:F#] [E] | [E]2 \
[E]/[:F#]/ | [:G#]2 [E#] | [:F#]2 [:G#] | [A]2 [:G#] | [E]2 :|
V:3 clef=bass % Voice 3
%%MIDI nobeataccents
%%MIDI program 16
%%MIDI trim 1/5
|: [:C#] | [:C#]2 [:C#] | [A,]2 [:G#,] | [A,]2 [:G#,] | [A,]2 \
```



```

[:C#] | [:C#]2 [B,] | [A,]2 [E] | [E] [:F#] [E] | [:C#]2 :|
V:4 clef=bass % Voice 4
%%MIDI nobeataccents
%%MIDI program 16
%%MIDI trim 1/5
|: [A,] | [:F#,]2 [:C#,] | [D,]2 [D,] | [:C#,] [D,] [E,] | [A,,]2 \
[A,] | [E#,]2 [:C#,] | [:F#,] [Ee,] [D,] | [:C#,] [D,] [E,] | [A,,]2 :|

```

The code above (saved as `bach.abp`) can be converted to PostScript and MIDI with the commands:

```

microabc -E -Pbach.abp -obach.abc
microabc -E -Mbach.abp -obach-midi.abc
abcm2ps -O= bach.abc
abc2midi bach-midi.abc

```

Use the PostScript viewer and the MIDI player to enjoy the results.
Then start to make changes in the code to learn more...

5.1.2 Make changes, learn more

The MIDI file of the Bach's choral was generated in 19-EDO. Note the line with `%%microabc: equaltemp: 19`. You may make experiments with various equal temperaments, by replacing 19 with other numbers. Or else disable that command to get fifths of $3/2$ (Pythagorean just intonation) – to do this, simply remove one character % of the start of that line.

You may also get a score in pure Sagittal notation, just removing the line `%%postscript sagmixed` or changing `sagmixed` to `sagpure`.

Take some time trying to understand the code. Focus the attention on the lines of notes. Notice that the accidentals are not shown in the score for pitches starting with a colon, like in `[:C#]`. Also notice that a \flat is represented with a small letter “e”, in `[Ee,]`. Experiment to change the code and see the effects of your changes.

As an additional exercise, if you know a bit of Sagittal, use Pythagorean tuning (fifths of $3/2$) and then change some accidentals to get pure thirds in the chords.

To learn more about how to use Sagittal with **microabc**, read the section 5.4 (page 18). See also the section 5.5 (page 20), and the **microabc** documentation. To learn more about the Sagittal Notation System itself, visit <http://users.bigpond.net.au/d.keenan/sagittal/>.

The following sections illustrate in more detail several features of **microabc**.

5.2 A scale of harmonics – microabc output modes

As an example to illustrate the **microabc** *microtonal*, *chromatic*, *diatonic* and *literal* modes, we will take the first odd elements of the harmonic series up to 23rd harmonic, reduced to the range of an octave. That scale can be obtained by executing the following commands in the program **Scala**:

```

harm 1 23
norm
show

```

Here is the resulting scale:

0:	1/1	0.000 unison, perfect prime
1:	17/16	104.955 17th harmonic
2:	9/8	203.910 major whole tone
3:	19/16	297.513 19th harmonic

4:	5/4	386.314 major third
5:	21/16	470.781 narrow fourth
6:	11/8	551.318 undecimal semi-augmented fourth
7:	23/16	628.274 23rd harmonic
8:	3/2	701.955 perfect fifth
9:	13/8	840.528 tridecimal neutral sixth
10:	7/4	968.826 harmonic seventh
11:	15/8	1088.269 classic major seventh
12:	2/1	1200.000 octave

5.2.1 The microabc input file

We will make the input file for **microabc** by adding these commands above the scale data generated by **Scala**:

```
alias:0      {column 0 gives the aliases}
scl:1        {column 1 gives the intervals of the scale for microtonal mode}
range:-40 40 {pitch range (ambitus)}
```

Then, we edit the output of **Scala** accordingly: we will use the numbers 0–11 as aliases (without the colons of the **Scala** output), and we will remove the last line (octave, 2/1, which is the pitch class 0 again, octave up).¹² Let us save this as `harmonic.txt`:

```
{-----begin-----}
alias:0      {column 0 gives the aliases}
scl:1        {column 1 gives the intervals of the scale for microtonal mode}
range:-40 40 {pitch range (ambitus)}
0           1/1           0.000 unison, perfect prime
1           17/16         104.955 17th harmonic
2           9/8           203.910 major whole tone
3           19/16         297.513 19th harmonic
4           5/4           386.314 major third
5           21/16         470.781 narrow fourth
6           11/8          551.318 undecimal semi-augmented fourth
7           23/16         628.274 23rd harmonic
8           3/2           701.955 perfect fifth
9           13/8          840.528 tridecimal neutral sixth
10          7/4           968.826 harmonic seventh
11          15/8          1088.269 classic major seventh
{-----end-----}
```

5.2.2 The ABC file with macros

To try with our example, let us write a music file. Remember, the pitches are defined as the numbers 0–11 delimited by square braces (provided by **microabc**); octaves up or down are represented like in ABC, with apostrophes or commas.¹³ Let us save this as `harmonic.abp`.

```
X:1
T:microabc tutorial
T:harmonics
```

¹²Unlike **Scala** files, the input format for **microabc** starts with pitch 1/1 and ends with the last pitch *before* the octave (or other equivalence interval). To use a different equivalence interval, insert a `sclmod:<interval>` line.

¹³The delimiters can be changed with the command `delim:`, and the octave modifiers with the command `updown:`.

```

M:6/8
L:1/8
Q:1/8=90
V:1
%%MIDI program 16
V:2
%%MIDI program 16
K:none
%%continueall
%%maxshrink 0.9
V:1
[0'] [1'] [2'] [3'] [4'] [5'] | [6'] [7'] [8'] [9'] [10'] [11'] |
[0] [1] [2] [3] [4] [5] | [6] [7] [8] [9] [10] [11] |
[0,] [1,] [2,] [3,] [4,] [5,] | [6,] [7,] [8,] [9,] [10,] [11,] |]
V:2
[0,,]6- | [0,,]6 |
[0,,]6- | [0,,]6 |
[0,,]6- | [0,,]6 |]
%
```

5.2.3 Microtonal mode

The command `scl:1` included in the input file (section 5.2.1, page 10) is sufficient to activate the microtonal mode. To generate the macro definitions for MIDI files, execute:

```
microabc < harmonic.txt > harm4mid.abh
```

You may be interested in to see inside the generated file `harmonic.txt`, to know the definitions. It will contain lines like these, where you can see microtonal ABC pitches in the resolution of 1/4096 semitone:

```

#define [9,] _2436/4096A,
#define [10,] ^2819/4096A,
#define [11,] _481/4096B,
#define [0] =C
#define [1] _3893/4096D
#define [2] ^160/4096D
#define [3] ^3994/4096D
#define [4] _561/4096E
#define [5] _1197/4096F
#define [6] ^2102/4096F
#define [7] _2938/4096G
#define [8] ^80/4096G
#define [9] _2436/4096A
#define [10] ^2819/4096A
#define [11] _481/4096B
#define [0'] =c
#define [1'] _3893/4096d
```

Let us create the ABC code and the MIDI file:¹⁴

```
cat harm4mid.abh harmonic.abp | abcpp > harm4mid.abc
abc2midi harm4mid.abc
```

¹⁴DOS/Windows users should use `type` instead of `cat` in the command line.

To get a score in microtonal mode, we want quantise those accidentals from 1/4096 semitone to a smaller denominator. **abcm2ps** supports quarter-tones (1/2 semitone), but we may choose a finer resolution: 1/4 semitone, once **microabc** can provide the required glyphs for the accidentals.

The command below will create a file with the macros for our scale quantised to eighth-tones (**harm4ps.abh**). Please note the command-line options **den:4**, which sets the denominator to 1/4 semitone, **abcm2ps:4** which sets the same quantisation for **abcm2ps**, and **psacc:1** which tells **microabc** to create the glyphs for the microtonal accidentals:

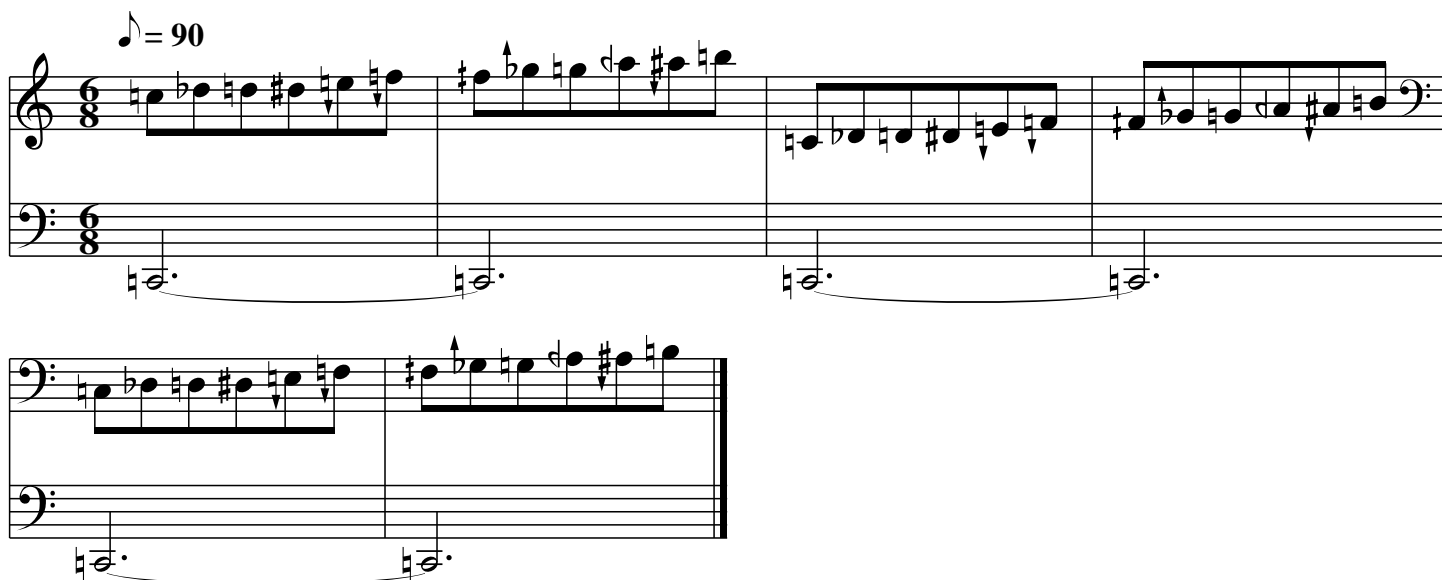
```
microabc den:4 abcm2ps:4 psacc:1 < harmonic.txt > harm4ps.abh
```

These commands will create the ABC code and the PostScript score file from it:

```
cat harm4ps.abh harmonic.abp | abcpp > harm4ps.abc
abcm2ps -O= harm4ps.abc
```

The score should look like this:

microabc tutorial harmonics



5.2.4 Chromatic mode, timidity++ and Scala

It was said before (section 3.5, page 6) that the microtonal mode is not suitable to obtain MIDI files with **abc2midi** when chords are used. In such circumstances, a solution can be using the chromatic mode and retune the MIDI file with **Scala**, or playing it with **timidity++**, or yet creating it with Standard MIDI Tuning messages.¹⁵

The following commands will create the macro definitions in chromatic mode, and then generate the ABC and MIDI files:

```
microabc chromatic:1 < harmonic.txt > harmchrm.abh
cat harmchrm.abh harmonic.abp | abcpp > harmchrm.abc
abc2midi harmchrm.abc
```

¹⁵Another solution can be using the program **abc2alias** (included in **microabc** package) to expand the chords to temporary voices (voice overlay).

The option `chromatic:1` in the command line will cancel the effect of the `scl:1` command from the file `harmonic.txt`, that is, the microtonal mode will be disabled and the chromatic mode will be enabled. As a consequence, the tuning information will be ignored – but we need using that information to retune or play the MIDI file.

To play the file with **timidity++**, we need firstly export the scale in a format suitable for that program. A frequency table will be output to the file `harmonic.tbl` with the command:¹⁶

```
microabc timidity:harmonic.tbl < harmonic.txt > /dev/null
```

Now we can hear the MIDI file with **timidity++**, using the option `-Z` to load the frequencies file:¹⁷

```
timidity harmchrml.mid -Z harmonic.tbl
```

Our alternative approach is retuning the MIDI file. We can export the tuning from the **microabc** input, in the **Scala** file format:

```
microabc scala:harmonic.scl < harmonic.txt > /dev/null
```

This command calls **Scala** to retune the MIDI file – supposed to be named `harmchrml.mid` – as a new file called `harm-scl.mid`:

```
scala harmonic.scl --example/midi harmchrml.mid harm-scl.mid --exit
```

Still using the ABC code generated with the chromatic mode, we could create a MIDI file with Standard MIDI Tuning messages. This option is illustrated in the section 5.3 (page 15).

5.2.5 Diatonic mode

The diatonic mode is not necessary in the present example of scale of harmonics. Nonetheless, it will be used for the purpose of illustration.

The following commands will generate a score using a diatonic mapping of the pitches of our scale (the **microabc** option `diatonic:1` is to set the diatonic mode):

```
microabc diatonic:1 < harmonic.txt > harmdiat.abh
cat harmdiat.abh harmonic.abp | abcpp > harmdiat.abc
abcm2ps -O= harmdiat.abc
```

The resultant score (below) uses only the natural pitches, without any accidentals. The diatonic mode can be used to create non-conventional staves. Note that, in this specific case in which there are 12 notes per octave, every octave instance spans on 6 staff lines.¹⁸ Such property could be used to simulate a sort of “keyboard-view” like those present in some MIDI sequencer programs.

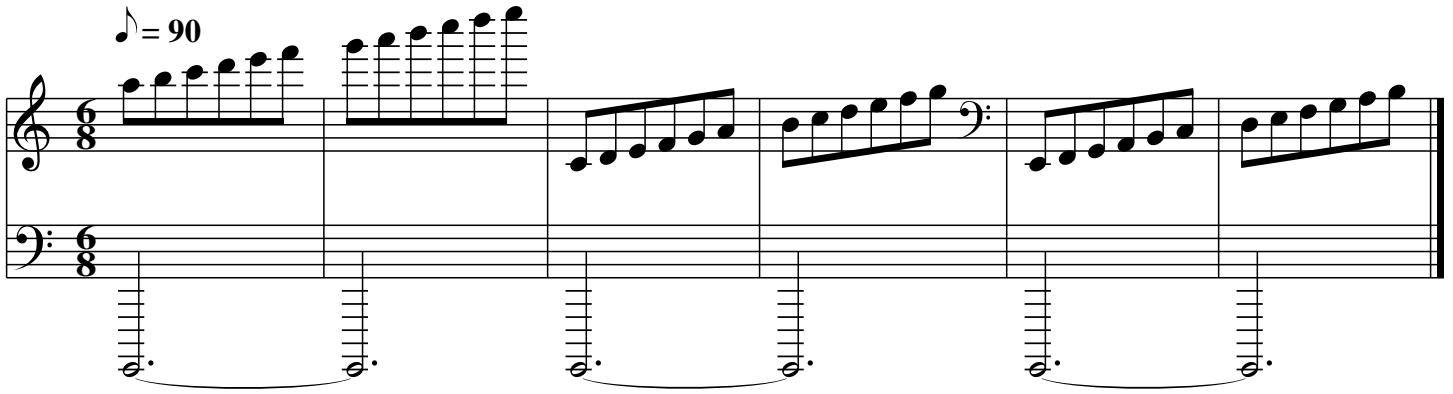
¹⁶DOS/Windows users should exclude the part “> /dev/null” from the commands; some data will be printed on the screen.

¹⁷Playing the file with **timidity++**, using a frequency table, will result in a finer tuning, compared with other approaches.

¹⁸An additional observation is that – as a coincidence – the pitch class [0] lies in the same helper line in both treble and bass clefs (see the first note in the upper voice, at measures 3 and 5).

microabc tutorial

harmonics



5.2.6 *Literal mode*

The remaining **microabc** mode allows setting arbitrary replacement strings for the aliases. We will not show, at this point, any useful examples – we will rather simply inspect which macro definitions are generated when we use the second column of the input file (index 1: that column with the intervals of the scale).¹⁹

```
microabc replace:1 < harmonic.txt | less
```

The result printed on the screen should contain lines such as these ones:

```
#define [9,] 13/8
#define [10,] 7/4
#define [11,] 15/8
#define [0] 1/1
#define [1] 17/16
#define [2] 9/8
#define [3] 19/16
#define [4] 5/4
#define [5] 21/16
#define [6] 11/8
#define [7] 23/16
#define [8] 3/2
#define [9] 13/8
#define [10] 7/4
#define [11] 15/8
#define [0'] 1/1
#define [1'] 17/16
```

The **microabc** literal mode has a few variants, used when the replacement text is in a special format: `replaceabc:` and `replacesagittal:`, respectively for ABC and Sagittal formats.²⁰

Also, there is the option `replaceupdn:` to insert “octave” modifiers (like `'` and `,` in ABC) in the replacements. In the example above, the replacement text does not contain such modifiers: any instance of pitch class [0] is replaced with 1/1, any instance of pitch class [11] is replaced with 15/8 and so on.

¹⁹DOS/Windows users should use `more` instead of `less` in the command line.

²⁰Sagittal format does not work with **abcp**; it will work only when using **microabc** as preprocessor. See section 5.4 at page 18.

5.3 An example in 19-EDO

Let us suppose we want to write a music in 19 equal divisions of octave. The score can be accomplished using the conventional accidentals flat, natural and sharp, but we need tune the pitches for MIDI files. Of course, we want to write only one ABC input code to obtain both PostScript and MIDI outputs.

5.3.1 The microabc file

A solution is to use macros for each pitch instead of simple ABC pitches. The replacement for each macro should be different, depending on output format: one for PostScript generation, another for MIDI generation. By default, the **microabc** macros are delimited by square braces [and].

5.3.2 PostScript

For PostScript, we want “common” pitches and accidentals. Therefore: C can be represented as the macro [C]; ^C as [^C]; _D as [_D]; and so on, that is: all macro names are the corresponding ABC pitch names between square braces.

5.3.3 MIDI

For MIDI, the things are not so simple, because normally we have 12 chromatic pitches per octave, but our scale has 19. The frequencies for all pitches need to be set, to get a tuned MIDI file. Let us use **abc2midi**’s %%MIDI snt command for Standard MIDI Tuning.²¹

5.3.4 The code

Below is the basic **microabc** code for our scale, `tut.txt`. It sets a scale with 19 steps of size, which is an equal temperament defined by 19 divisions of a octave (2/1). The pitch names are like ABC pitch names, listed at columns 0 and 1. Enharmonic pitches share a same line in the following list, and here they are considered as synonyms (“aliases”).

```
{-----begin-----}  
size:19  
equaltemp: 19 2/1  
aliasabc: 0 1  
range:-20 20  
{}  
=C C  
^C __D  
_D ^^C  
=D D  
^D __E  
_E ^^D  
=E E  
^E _F  
=F F  
^F __G  
_G ^^F  
=G G
```

²¹Standard MIDI Tuning is not implemented in several MIDI devices, but it is supported by the program **timidity++**. If you are creating MIDI files for distribution, you may prefer retune them with **Scala** using Pitch Bend messages, which are more portable. The **microabc** command `scala:` allows you to export a *.scl file. To retune a MIDI file with **Scala**, issue a command like this:

```
scala scalefile.scl --example/midi inputfile.mid outputfile.mid --exit
```

```

^G __A
_A ^^G
=A A
^A __B
_B ^^A
=B B
^B _c
{}
{-----end-----}

```

5.3.5 Macro definitions files

In **microabc**, macros can have several aliases (synonyms), but only one meaning, that is, only one replacement. To maintain a strict correspondence between macros and pitches for a PostScript score (enharmonic pitches should be differentiated in a score), **microabc** needs to be ran twice, and the outputs concatenated. The first run sets the macro definitions for the first (indexed by 0) column of the input file; the second run sets the macros for the enharmonic pitches (second column of input). In this example, the replacement is one of the list columns, taken as an ABC pitch.

The command `cat` concatenates the files into `tut-ps.abh` (MS-DOS users should use `type` instead).

```

microabc -itut.txt aliasabc:0 replaceabc:0 -otut-ps.ab1
microabc -itut.txt aliasabc:1 replaceabc:1 -otut-ps.ab2
cat tut-ps.ab1 tut-ps.ab2 > tut-ps.abh

```

The macros for MIDI are easier to obtain, because both input columns 0 and 1 mean a same pitch (enharmonic differentiation is irrelevant here). Our **microabc** input file already has selected both columns with `aliasabc: 0 1` (above overridden for PostScript score). The additional command option `snt`: generates the file `tut.snt` for Standard MIDI Tuning.

```

microabc -itut.txt -otut-mid.abh snt:tut.snt

```

5.3.6 The ABC file with macros

The next step is to write the music in ABC notation with macros, stored in the file `tut.abp`. Remember that all pitches must be between square braces (they are macro names, and **microabc** macro names are delimited by square braces), and note the `#include` command to insert the Standard MIDI Tuning definitions from the file `tut.snt`.²² Here is our scale:

```

X:1
T:microabc tutorial
T:19-edo
#include "tut.snt"
M:6/8
L:1/8
K:C
[C][^C][_D] [=D][^D][_E] |\
[=E]2 z [E][^E][F] |\
[^F][_G][=G][^G][_A][=A] |\
[^A][_B][=B][^B]3 | [c]3 z3 |]

```

²²If you want to use **Scala** to retune the MIDI file, create a `*.scl` file with:

```

microabc -itut.txt scala:tut.scl

```

Then, remove the line

```

#include "tut.snt"

```

of the sample source given in this section and follow the instructions in the footnote number 21 (page 15) to retune the MIDI file according to the scale file `tut.scl`.

5.3.7 Preprocessing

The ABC code with macros (`tut.abp`) needs to be preprocessed and converted to pure ABC code.

ABC file for PostScript score generation:

```
cat tut-ps.abh tut.abp | abcpp > tut-ps.abc
```

ABC file for MIDI file generation:

```
cat tut-mid.abh tut.abp | abcpp > tut-mid.abc
```

5.3.8 Getting the MIDI file

The MIDI simulation is generated by **abc2midi**, with the following command:

```
abc2midi tut-mid.abc -o tut.mid
```

The synthesizer **timidity++** can play the MIDI file and convert it to other formats like `.wav` or `.ogg`.

5.3.9 Getting the PostScript score file

Use **abcm2ps** to convert the ABC code into a graphical PostScript score:

```
abcm2ps tut-ps.abc -O tut.ps
```

The output can be previewed with **ghostview**, and then printed or converted to PDF or other formats.

5.3.10 Customisation of the accidentals in the PostScript score file

Just to show another interesting feature of **abcm2ps** – the insertion of PostScript instructions to (re)define symbols, let us customise the score glyphs for the accidentals sharp and flat. Put this code in the original ABC file (`tut.abp`), before the music, then follow again the steps of the sections 5.3.7 and 5.3.9:

```
%%postscript /sh0{ gsave exch .45 add exch T .85 SLW
%%postscript   -1.2 -8.4 M 0 15.4 RL
%%postscript   1.4 -7.2 M 0 15.4 RL stroke
%%postscript   -1 0 translate .9 1 scale
%%postscript   -2.6 -3 M 5.4 1.6 RL 0 -2.2 RL -5.4 -1.6 RL 0 2.2 RL fill
%%postscript   -2.6 3.4 M 5.4 1.6 RL 0 -2.2 RL -5.4 -1.6 RL 0 2.2 RL fill
%%postscript   grestore}!
%%postscript /ft0{ gsave T .95 SLW
%%postscript   -1.8 2.5 M
%%postscript   6.4 3.3 6.5 -3.6 0 -6.6 RC
%%postscript   4.6 3.9 4.5 7.6 0 5.7 RC
%%postscript   currentpoint fill M
%%postscript   0 7.1 RM 0 -7.1 RL stroke
%%postscript   grestore}!
```

Here is the resulting score:

microabc tutorial
19-EDO



5.4 Sagittal notation – using microabc as preprocessor

microabc can do a specialised form of preprocessing. Unlike **abcpp**, macro definitions are not declared with `#define` statements. The definitions are based on the **microabc** input file itself (option `-i`), which defines the working mode, the scale, the aliases and other options – or the definitions are built-in, in the case of using the Sagittal microtonal notation. To omit the input file, use the option `-i-`.

The command line options `-p`, `-M` and `-P` preprocess the file given as argument. The option `-S` enables the support for Sagittal notation.

5.4.1 Just Intonation

You find below the sample music file `sagit.abp`. It uses the format file `sagittal-pfb.fmt`, which is included in **microabc** package.²³ ²⁴ Note that the octaves are indicated with `,` (down) and `'` (up) – the latest is a grave accent, not the apostrophe (`'`) used in ABC.

```
%%format sagittal-pfb.fmt
%%stretchlast

X:1
T:microabc tutorial
T:Sagittal preprocessing
K:C
%%text Pure intonation (fifth=2:3, octave=1:2)
V:1
[C][E\!] [G][B!!!!) [D'] [F/|\'] [A(!/' [B\!' | \
[C''] [B\!' [A(!/' [F/|\'] [D'] [B!!!!) [G][E\!] | [C]4 z4 |]
V:2
[C,]8 | [C]8 | [C,]4 z4 |]
```

To get a MIDI file, preprocess with the option `-M`:²⁵

```
microabc -i- -S -Msagit.abp > sagit-mid.abc
abc2midi sagit-mid.abc
```

And to get a PostScript score, use the option `-P`:²⁶

```
microabc -i- -S -Psagit.abp > sagit.abc
abcm2ps -O= sagit.abc
```

The score will look like this:

²³**abcm2ps** expects that the format file be stored in the current directory or in the “default format directory” which you can know by issuing `abcm2ps -V`. The directory for format files can also be indicated with the **abcm2ps** option `-D`. For details, please consult the **abcm2ps** documentation.

²⁴The use of `sagittal-pfb.fmt` assumes that the Sagittal PostScript Type 1 font is installed in your system. You can alternatively try with `sagittal.fmt` which embeds the font in the output PostScript file, or yet, use the flag `-e` when running **microabc**.

²⁵The MIDI file will be generated in microtonal mode, that is, using MIDI Pitch Bend messages. It has the limitation of do not support chords. Splitting the chords into multiple voices can be made with **abc2alias**. You may alternatively use a special command for **abc2midi** (see note 7 at page 4).

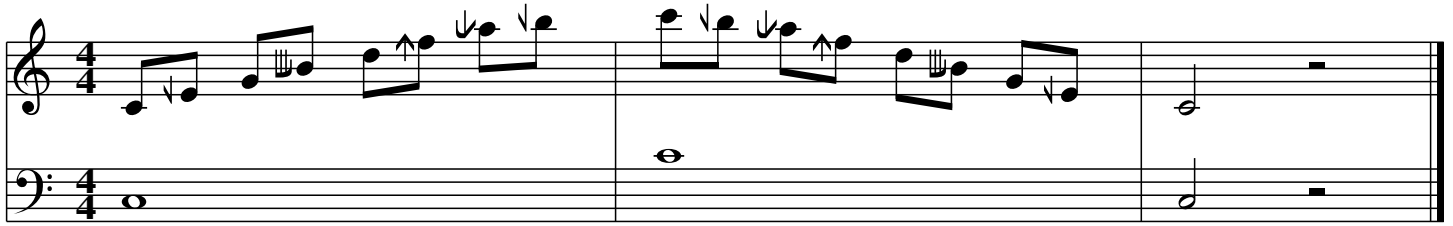
²⁶If you do not want to use **abcm2ps** format files, call **microabc** with the flag `-e`:

```
microabc -i- -S -e -Psagit.abp > sagit.abc
```

microabc tutorial

Sagittal preprocessing

Pure intonation (fifth=2:3, octave=1:2)



5.4.2 Equal divisions of octave

The conversion of Sagittal pitches for MIDI is, by default, done in just intonation, based on pythagorean nominals – with fifths of 2:3 and octaves of 1:2.

Equal divisions of octave can be set with the **microabc** command `equaltemp:`, which can be given in an input file, from the command line or even from the music source file (.abp), in this format:

```
%%microabc: equaltemp:24

%%format sagittal-pfb.fmt
%%stretchlast
%%continueall

X:1
T:microabc tutorial
T:equal divisions of octave
M:none
L:1/2
%%MIDI program 16
%%MIDI trim 1/4
K:C
%%microabc: equaltemp:24
"^24-EDO"\  
[Ce] [C^] [C/N\] [D\U/] [Dv] [De] z
%%microabc: equaltemp:31
"^31-EDO"\  
[Ce] [C^] [C/N\] [D\U/] [Dv] [De] |
```

Just like in the previous example, these commands will convert the file `edo.abp` into `edo-midi.abc` (for **abc2midi**) and `edo.abc` (for **abcm2ps**):

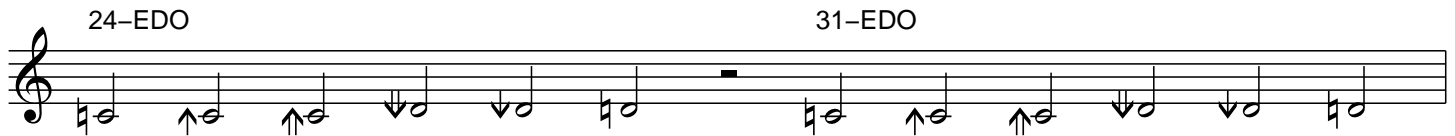
```
microabc -i- -S -Medo.abp > edo-midi.abc
microabc -i- -S -Pedo.abp > edo.abc
```

The score and the MIDI file are obtained with:

```
abcm2ps -O= edo.abc
abc2midi edo-midi.abc -o edo.mid
```

microabc tutorial

equal divisions of octave



This example (edo.abp) uses the “same” pitches in two different tunings: 24-EDO and 31-EDO. The difference is noticeable in the MIDI file: C/N\ and D\U/ are equivalent in 24-EDO, but not in 31-EDO.

5.5 Using Sagittal notation for arbitrary scales

This is an example which may be used as reference for many applications. It uses **Scala** to aid with Sagittal notation. The MIDI file is created in *chromatic* mode, and then retuned with **Scala**. As the scale size is small, there is no a “range *versus* chord” conflict.²⁷

5.5.1 Pick out a scale — make the microabc input file

Start the program **Scala** and create or load a scale. For instance, click the button Open, select the file barlow_17.scl and then click on OK.

Now, we need to name the pitches. Let us use a Sagittal notation for just intonation, with short mixed names. Execute these commands in the **Scala** prompt (the bottom line of the interface):

```
set notation saji1
set sagittal short mixed
show
```

The result is shown below. Save these lines in a text file.²⁸

0:	1/1	C	B#\ unison, perfect prime
1:	25/24	Db\	C#_ classic chromatic semitone, minor chroma
2:	27/25	C#/	Db= large limma, BP small semitone
3:	9/8	D	major whole tone
4:	32/27	Eb	D#\ Pythagorean minor third
5:	11/9	Eo	D#f undecimal neutral third
6:	32/25	E/	Fb= classic diminished fourth
7:	4/3	F	E#\ perfect fourth
8:	25/18	Gb\	F#_ classic augmented fourth
9:	36/25	F#/	Gb= classic diminished fifth
10:	3/2	G	perfect fifth
11:	25/16	Ab\	G#_ classic augmented fifth
12:	18/11	Av	G#q undecimal neutral sixth
13:	27/16	A	Pythagorean major sixth
14:	16/9	Bb	A#\ Pythagorean minor seventh
15:	50/27	B_	Cb\ grave major seventh
16:	48/25	B/	Cb= classic diminished octave
17:	2/1	C	B#\ octave

We need editing the file to adapt it for **microabc**.

First, delete the last line. It is just the pitch 0 an octave higher.²⁹

²⁷See section 3.5, page 6.

²⁸Tip: To copy the text, do click with the right button of the mouse on the text window of **Scala** and select the option Edit with @edit...

²⁹The equivalence interval (formal octave) is defined, in **microabc** with the instruction sclmod:<interval>.

Note the presence of equivalent pitches, like C and B#\ . There are a few pitches with no equivalents: D, G and A/. For such pitches, fill the fourth column with a dot (.).³⁰

Note yet that the pairs of equivalents {C B#\}, {B_ Cb\} and {B/ Cb=} do not specify the different octaves. Add a comma (,) to B#\ to make clear that the B#\, is of the lower octave. Then add a grave accent (‘) to Cb/ and Cb= to indicate the higher octave: Cb/‘ Cb=‘.

The next step is to tell **microabc** how to interpret the data. Insert these instructions above the scale data:

```
scl:1
aliassagittal:2 3
chromatic:1
```

“scl:1” means that the column 1 (start counting by zero) contains the tuning.

“aliassagittal:2 3” tells **microabc** that the columns 2 and 3 contains the pitch names in Sagittal.

“chromatic:1” selects the *chromatic* mode. Its effect is that, when generating the MIDI file, the pitches will be mapped to the chromatic scale (rather than be tuned with pitchbends). The MIDI file will be retuned later with **Scala**.

Save the file as blw17.txt. Here are its contents:

```
scl:1
aliassagittal:2 3
chromatic:1
0:      1/1      C      B#\, unison, perfect prime
1:      25/24    Db\    C#_ classic chromatic semitone, minor chroma
2:      27/25    C#/    Db= large limma, BP small semitone
3:      9/8      D      .      major whole tone
4:      32/27    Eb     D#\ Pythagorean minor third
5:      11/9     Eo     D#f undecimal neutral third
6:      32/25    E/     Fb= classic diminished fourth
7:      4/3      F      E#\ perfect fourth
8:      25/18    Gb\    F#_ classic augmented fourth
9:      36/25    F#/    Gb= classic diminished fifth
10:     3/2      G      .      perfect fifth
11:     25/16    Ab\    G#_ classic augmented fifth
12:     18/11    Av     G#q undecimal neutral sixth
13:     27/16    A      .      Pythagorean major sixth
14:     16/9     Bb     A#\ Pythagorean minor seventh
15:     50/27    B_     Cb\‘ grave major seventh
16:     48/25    B/     Cb=‘ classic diminished octave
```

5.5.2 The microabc test file

We want to see and to listen to the Barlow’s 11-limit rational 17-equal, Barlow, On the Quantification of Harmony and Metre scale, to test and check our **microabc** input file.

Let **microabc** create a test file blw.abp:

```
microabc -tblw.abp < blw17.txt
```

Now, preprocess the test file. One command generates ABC code for **abc2midi**. The other command generates ABC code for **abcm2ps** (without using blw17.txt).

³⁰For certain scales, **Scala** shows some intervals in cents, adding the word “cents”. A similar procedure may be then necessary in order to assure the correspondence of columns for **microabc**.

```
microabc -Mblw.abp < blw17.txt > blw-midi.abc
microabc -i- -S -Pblw.abp > blw.abc
```

Now, let us convert the ABC files to MIDI and PostScript. Put a copy of the file `sagittal.fmt`³¹ in the same directory where the ABC files are, and execute:

```
abc2midi blw-midi.abc
abcm2ps blw.abc -O=
```

Recall that the MIDI file was not generated in the Barlow's scale, but in chromatic mapping. To tune it, load the scale file `barlow_17.scl` into **Scala** and access the menu Tools | Retune MIDI-file..., then select the input file `blw-midi1.mid` and choose the output file name `blw.mid`. Finally, click the OK button. Running **Scala** with this command line does the same:

```
scala barlow_17.scl --example/midi blw-midi1.mid blw.mid --exit
```

Check the resulting PostScript and MIDI files. You may find the MIDI file just boring, but the PostScript file contains information of interest, for example: the score covers the complete range (*ambitus*) available.

Now, let us generate a test file just covering just one octave, and without the equivalent pitches. Modify the file `blw17.txt` according to this:

1. Change “`aliassagittal:2 3`” to “`aliassagittal:2`”; this will omit the equivalent pitches.
2. Add a line with “`range:0 17`”; this will limit the range to the central octave.

The first four lines of `blw17.txt` will now be:

```
scl:1
aliassagittal:2
range:0 17
chromatic:1
```

Redo the process of generation of the test file and its conversion to PostScript and MIDI files:³²

```
microabc -tblw.abp < blw17.txt
microabc -Mblw.abp < blw17.txt > blw-midi.abc
microabc -i- -S -Pblw.abp > blw.abc
abc2midi blw-midi.abc
abcm2ps blw.abc -O=
scala barlow_17.scl --example/midi blw-midi1.mid blw.mid --exit
```

The example below uses “`aliassagittal:2 3`” to show the equivalents:

³¹`sagittal.fmt` is included in the **microabc** package. It is used by **abcm2ps** to provide the Sagittal font. If you prefer do not deal with format files, add the flag `-e` to the **microabc** command line in the previous step:

```
microabc -i- -S -e -Pblw.abp > blw.abc
```

³²You may want issue the third command as:

```
microabc -i- -S -e -Pblw.abp > blw.abc
```

COMMAND LINE: microabc -tblw.abp
 MICROABC INPUT FILE:
 MICROABC MODE: chromatic
 SCALA *.scl INPUT FILE:
 SCALA *.scl OUTPUT FILE:
 SCALA *.kbn OUTPUT FILE:
 TIMIDITY OUTPUT FILE:
 SCALE SIZE: 17
 RANGE: 0 17 (18)
 NUMBER OF DEFINITIONS: 33

Test file generated by microabc

*microabc (C) 2006–2007
 Hudson Lacerda*



5.5.3 Create your own *.abp music file

If the tests with the test file succeeded, we are ready to write some music.³³

Scala will help us to write a scale. Issue show/notation in the command prompt (or press F7), then copy the pitches:

```
C Db\ C#/ D Eb Eo E/ F Gb\ F#/ G Ab\ Av A Bb B_ B/ C.1
```

Note that **Scala** uses numbers to indicate the octaves. Replace the last pitch C.1 with C' as we are using characters ' and , as octave modifiers.³⁴ Then enclose all pitches between brackets [and], and add an ABC header. The example below includes also a few chords:

```
%%format sagittal-pfb.fmt
%%format sagittal-mixed.fmt
%%postscript sagmixed
```

```
X:1
T:microabc tutorial
T:Barlow's 17-tone scale
M:none
K:C
[C] [Db\] [C#/] [D] [Eb] [Eo] [E/] [F] [Gb\]
[F#/] [G] [Ab\] [Av] [A] [Bb] [B_] [B/] [C'] ||
```

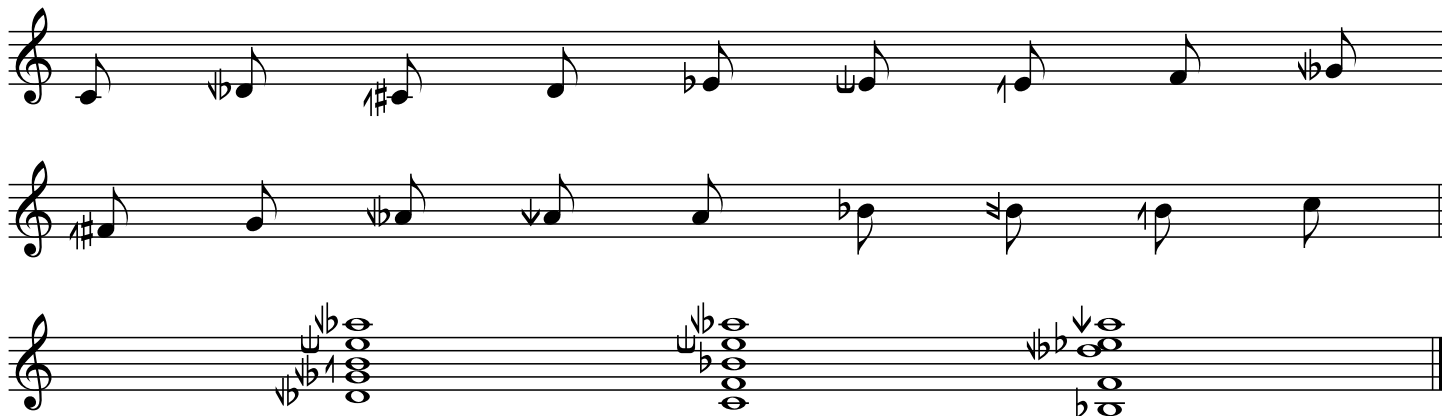
³³Be sure to remove the "range:" limitation of the file blw17.txt!

³⁴Although in this section we are using Sagittal pitch names, we are not preprocessing for MIDI with the flag -S. Hence, the Sagittal pitches from the *.abp files are not interpreted as such, but as ordinary macros: variants like [Ce] for [C], or even [:Ce,,] for [C,,] will not work without the flag -S. However, do not use -S to generate MIDI with arbitrary scales: **microabc** would ignore the user-defined scale and interpret the Sagittal pitches in the default way. If you want to add variants, add more sagittalalias: columns to the **microabc** input file. Be rigorous to use the pitch names exactly as defined.

```
x4 \
[[Db\] [Gb\] [B/] [Eo'] [Ab\'']]8 \
[[C] [F] [Bb] [Eo'] [Ab\'']]8 \
[[Bb,] [F] [Db\''] [Eb'] [Av\'']]8 |]
```

Here is the resulting score:

microabc tutorial Barlow's 17-tone scale



5.6 More possibilities

There are many other interesting things to do with **microabc** and ABC music tools. The reader is invited to read the documentation of the programs, and to browse their sample files directories.

6 HTTP addresses

“Making Music With ABC Plus” (Guido Gonzato):

<http://abcplus.sourceforge.net/#ABCGuide>

“Sagittal – A Microtonal Notation System” (David Keenan & George Secor):

<http://users.bigpond.net.au/d.keenan/sagittal/>

abc2midi: <http://ifdo.pugmarks.com/~seymour/runabc/top.html>

abcm2ps and **tclabc**: <http://moinejf.free.fr>

abcpp: <http://abcplus.sourceforge.net>

ghostscript and **ghostview**: <http://www.cs.wisc.edu/~ghost>

microabc: <http://br.geocities.com/hfmlacerda/abc/microabc-about.html>

Scala: <http://www.xs4all.nl/~huygensf/scala>

timidity++: <http://timidity.sourceforge.net>