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CHAPTER 5

The inherent microtonality of the bass clarinet

5.1 Introduction

The inherent microtonality of the bass clarinet refers to the instrument's capability to generate microtonal variants based upon the natural overtone series. As discussed and demonstrated in Chapter 1, all the pitches which can be played on the instrument higher than B♭2 are overtones and are based upon root fingering patterns.

The decision about which root fingering pattern became the standard fingering pattern in semitonal music, particularly from C♯4 upwards, is based upon intonation, reliability, and ease of response. For example, the fingering pattern for C♯4 is based upon A1, the fingering pattern for D4 is based upon B♭1, that for D♯4 upon B1, and so on. However, C♯4 could also be produced using root fingering patterns for D♯1 and F♯2.[70]

The different root fingering patterns with which any pitch above B♭2 can be played each lead to small microtonal variants of the desired pitch. By exploiting the overtone system of the instrument this intrinsic form of microtonality on the bass clarinet can be uncovered. The microtonal possibilities that this approach has to offer will be discussed and detailed in this chapter.

5.2 The root-overtone approach

Root-overtone microtonality is produced by playing different pitches from the harmonic series of the instrument by overblowing root fingering patterns. In *Spectral Immersions*, Watts has detailed the harmonic series of the bass clarinet on root C1 (2015, p.33).

[70] The F♯2 option, often called an 'open' fingering, is regularly used on the bass clarinet as an alternative fingering pattern, whereas on the soprano clarinet this is still rare.

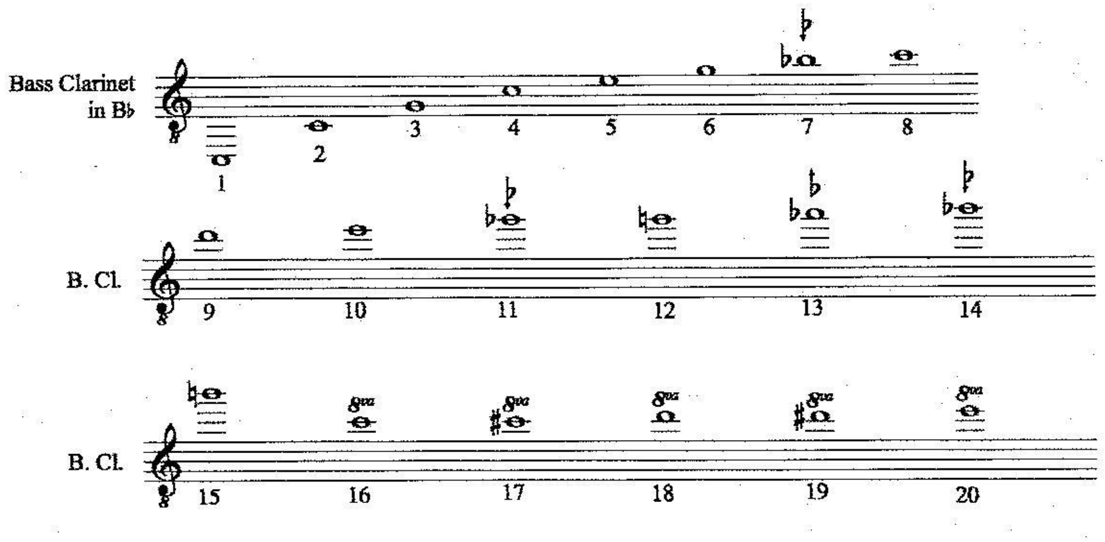

Figure 100: Watts (2015, p.33), the harmonic series of the bass clarinet

Watts states that since the bass clarinet overblows at the twelfth and has a cylindrical tube closed at one end, it "should be able to play only the uneven partials of the harmonic series" but argues that "it is usual to find that in fact most if not all partials will be present other than the lowest partials – certainly all partials from the seventh up should appear" (2015, pp.33-34). Watts has based these conclusions on spectral analyses using *AudioSculpt*,[71] in which the partials are captured in the C1 sound (Figure 101).

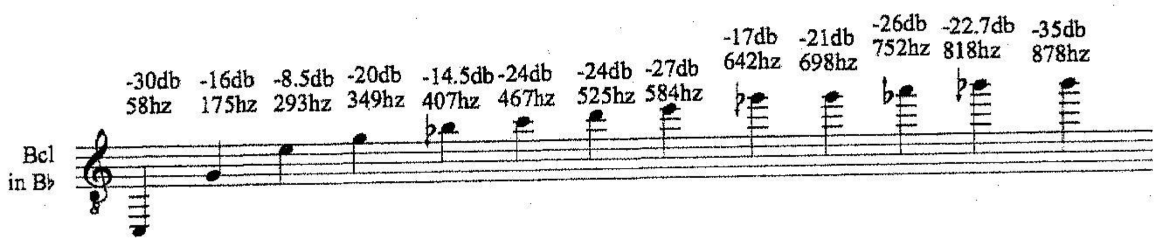

Figure 101: Watts (2015, p.40), the most prominent partials on the bass clarinet's low C [C1, HB]

[71] AudioSculpt is a software programme for viewing, analysing, and processing sounds, developed by IRCAM.

There is a marked difference, however, between the overtones which can be seen on a spectral analysis of a note using a computer programme and the overtones of the harmonic series which can be separated on the instrument by the player. As British acousticians Murray Campbell, Clive Greated, and Arnold Myers formulate it:

> The reception afforded to odd and even harmonics by the air column is however very different. Each odd harmonic of the exciting air flow is in tune with a natural mode of the air column…The even harmonics, in contrast, find no helpful air column resonances at their frequencies, and therefore make only a weak contribution to the radiated sound. (2006, p.76)

To pick out the right pitch from the cluster of overtones, the technique of overblowing is used. Precise lower lip positions are crucial in allowing the desired overtone from the natural overtone series to sound. Isolating each overtone in a row by changing the position of the lower lip, it is not possible to sound the 2nd (C2), 4th (C3), 6th (G3), 8th (C4), 10th (E4), 12th (G4), and 15th (B4) harmonics.[72] Campbell and Greated remark: "In the upper registers there are only a few harmonics present, but the even ones become more significant, since the resonances of the tube deviate progressively away from the discrete multiples of the fundamental" (1987, p.270). Therefore, after the 13th harmonic, the spectrum changes and starts to favour the even harmonics. This phenomenon can be clearly seen in the measurements shown in Appendix G1.

[72] This is in contrast with the flute, oboe, bassoon, and saxophone, which should be able to play the whole series.

5.2.1 The microtonal effects of using different root fingering patterns

The fourth and fifth octaves of the bass clarinet offer a wealth of overtones, as the same overtone pitches occur in the harmonic series for several different fundamentals (root fingering patterns). For example, C5 can be sounded using the following roots: C1, D1, E1, G1, B♭1, D2, and A2 (Figure 102).

Figure 102: Seven root fingering patterns which can be used to sound overtone C5

Audio example 16: Seven root fingering patterns which can be used to sound overtone C5

When notes are produced following the root-overtone approach, their pitch is expected to follow the rules of the natural harmonic series. This means that, in comparison with twelve-tone equal temperament tuning, some pitches are flat, others sharp, following the mathematical rules of acoustics.[73] Traditionally, the choice of which fingering pattern to use for notes higher than B♭2 on the bass clarinet, has been made for their ease of production, ease of articulation, and good intonation. These intonation choices have, though, typically been based on twelve-tone equal temperament playing.[74]

The chart in Appendix G1 documents the sonic results of the overtone pitches for each root fingering pattern played. This has been done in cents difference from semitone pitches with the instrument tuned to A=442 Hz. Measurements

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[73] For example, the 7th harmonic is flat and the 11th harmonic is sharp (Campbell, Greated, & Myers, 2006, p.44).

[74] The so-called 'open' fingerings (see also section 1.3.1.1 and Videos 5 and 6) consist of roots F2-B♭2 and are generally accepted fingering patterns for A♭4-C5.

were done vertically, that is in an accumulative way, starting with the root and playing the overtones from lowest to highest.

As can clearly be seen in this chart, overtones in the fifth octave, from C5 to F♯5, are coupled with the most root options, six alternatives or more. As can be deduced from the measurement results, using different root fingering patterns to play notes leads to microtonal variations of twelve-tone equal temperament pitches. This kind of microtonality is markedly different from the types documented in Chapters 3 and 4: no special fingering patterns are used to generate pitches which are in effect microtonal, just standard root fingering patterns with different lower lip positions.

Although the microtonal differences documented in Appendix G1 show the results of all the vertical measurements, a 'horizontal' test was also completed. This was done by playing D4 using each different root fingering pattern with which it is possible to sound the note: C1, E1, B♭1, and G2 respectively. The outcomes were measured three times in order to obtain average readings.

Root fingering pattern	Position of D4 in the harmonic series	Horizontal	Vertical
C1	9	+17	+15
E1	7	-31	-31
B♭1	5	-19	-11
G2	3	-10	-3

Figure 103: Table comparing the results of using four different root fingering patterns to play the overtone D4

The horizontal and vertical readings for root fingering pattern C1 are almost identical, with a difference of only 2 cents,[75] whilst horizontal and vertical readings for root fingering pattern E1 are exactly the same. The other two root fingering patterns, for B♭1 and G2 respectively, show slightly more discrepancy, with a difference of 7-8 cents. These differences could possibly be explained by

[75] Considering the results for D4/C1 (Figure 103), this microtonal option, which is directly linked to the acoustic architecture of the bass clarinet, could be used in a version of Christopher Fox's *Early one morning* (2014), where deviations from equal temperament of +16/+17 cents occur several times.

the influence of the embouchure. Generally speaking, there is greater flexibility for relaxing the embouchure (as shown by the horizontal reading), than there is for tightening the embouchure (as shown by the vertical reading).

Appendix G2 shows the results of a comparison between the expected frequencies of the harmonic series for root fingering pattern E1 and the obtained results taken on three readings, all in hertz. Tuning to A=442 Hz, the note E1 on the bass clarinet gave a reading of 73 Hz. The supposed pitches of the harmonic series have been calculated, and the equal temperament pitches have also been included. Then three readings of the actual pitch produced have been taken and documented. The average reading for each harmonic has been calculated and has been added to the chart.

As the table shows, the bass clarinet readings were close to either the expected harmonic series pitches or the equal temperament pitches for the 3rd, 5th, 7th, and 9th harmonics.[76] The readings for the 11th and the 13th harmonics both show a lower frequency than the expected pitch in the harmonic series.

Up to the 13th harmonic the readings are generally close to the expected harmonic series pitch. However, the 14th, 16th, and 18th harmonics show much more deviation. For all three of these harmonics the results are much higher than expected from the harmonic series frequency calculations. It is notable that this phenomenon occurs exactly at the changing point between odd and even harmonics.

The 14th, 16th, and 18th harmonics find themselves at the very top of the bass clarinet's (harmonic) range and for that reason are unstable. There is an extremely precise location for the lower lip to be in, in order to generate these altissimo harmonics. That the pitch of harmonics 14, 16, and 18 is higher than expected is due to the lower lip position requirements.

To gain greater insight into the flexibility of pitch control, whilst using the root-overtone system, I studied the extent to which the lower lip position can be manipulated. Root E1 was selected as a paradigm[77] and the results of the measurements, showing the margins with which the pitch of each overtone on this root fingering pattern could be lowered or raised, have been documented in Appendix G3. Measurements have been taken in cents difference from semitone pitches with the instrument tuned to A=442 Hz. Three different

[76] In the case of the 7th harmonic the discrepancy was slightly bigger.

[77] Root E1 was chosen for two reasons: it is a low note available on all bass clarinet models (there still are old models going down to E1 only) and secondly, E1 was used to demonstrate the bass clarinet's harmonic series in Figure 6 and Video 2.

readings have been taken and the measurements for each reading have been done vertically, that is from the root (1st harmonic) up to the 18th harmonic. The average manoeuvrability for each harmonic has been calculated and has been included in the chart.

The readings in Appendix G3 show that there is room for manoeuvre with each and every harmonic. As can clearly be deduced from the measurements, there is more space for manoeuvre lipping down (lowering the pitch), than lipping up (raising the pitch). This did not come as a surprise, because, as discussed in Chapter 1, it is easier to relax the lower lip than to tighten it.

Analysing my results further, it is notable that between the 7th and the 13th harmonic the highest degree of flexibility is found (between one and two semitones). At both ends of the harmonic series (the 3rd and 5th harmonics at the bottom, and the 18th harmonic at the top) the space for manoeuvre is more modest. This is due to the fact that these three harmonics are more difficult to generate or to sustain. The more limited room for pitch manipulation of the 3rd and 5th harmonics is related to their proximity to the root, which will sound together with the overtone as soon as the lip is bent too much or too quickly, especially in the case of a downward movement. The 18th harmonic is at the top of the bass clarinet's ambitus and, when lipped down too much, will turn into the 16th harmonic, as the distance between the two is minute. At the top of the harmonic series the overtones are much denser, much closer together, generally a major second apart. This means that there is little room to adapt the lower lip position for one overtone before the lower lip manipulation leads to a different overtone sounding.

As remarked earlier in this section, the fourth and fifth octaves of the bass clarinet, from C4 upwards, offer a wealth of overtones. Concerning manoeuvrability, Appendix G3 clearly shows that the same area (the 7th to the 13th harmonics) also offers the largest amount of flexibility, thereby contributing even more to the bass clarinet's root-overtone microtonal potential. The data clearly demonstrate that the use of the root-overtone system to create microtonal variants is valid and can be an efficient tool in enlarging microtonal possibilities.

5.2.2 Carter's *Steep Steps*: an analysis to highlight issues with the use of the root-overtone system

Elliott Carter's *Steep Steps* is dedicated to American clarinettist Virgil Blackwell. Carter states in the 'Composer's Note' that the overblowing system inherent to the bass clarinet is the central idea of the piece: "Its title comes from the fact that, unlike the other woodwind instruments, the clarinet overblows at the twelfth, a large interval that forms the basis of much of this composition" (2001).[78] Therefore, some features of the root-overtone system and some of the issues which arise by its use can be illustrated by taking a closer look at *Steep Steps*.

In bar 2 of the piece, the third (E3) and fourth (A1) notes are connected: E3 is an overtone of root fingering pattern A1 (Figure 104). E3 could therefore be played by overblowing the root fingering pattern for A1.

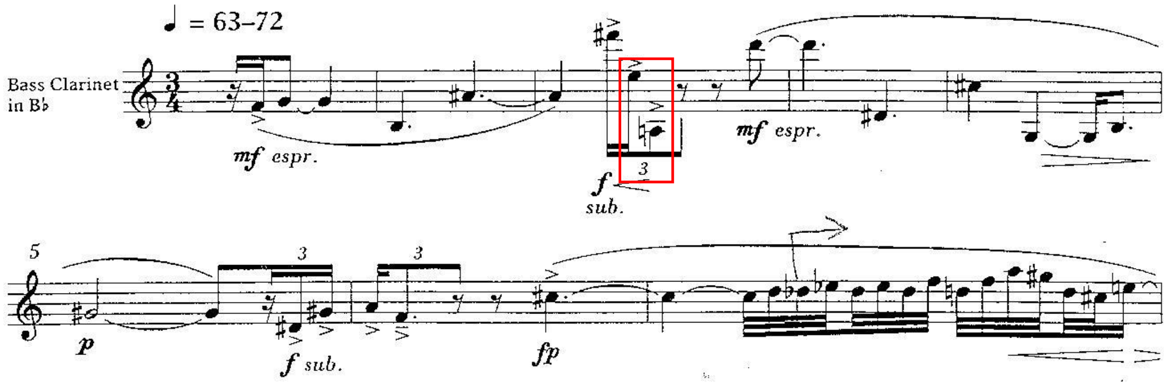

Figure 104: Carter, *Steep Steps*, bars 1-7

Another example of the way in which the root-overtone system can be applied to this work is found in bars 11 and 12 (Figure 105). The first two notes of bar 12, F4 and A♭3, are both overtones of the third note, D♭2 (marked in red in Figure 105). Therefore, it would seem logical to play these three notes using the root fingering pattern for D♭2.

[78] There is a later, revised version of the score (2005), but the original version of the score (2001) has been studied here.

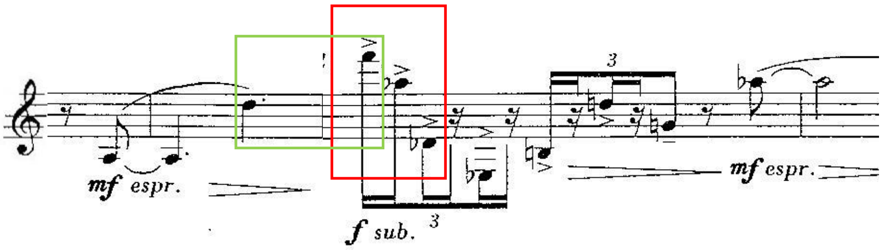

Figure 105: Carter, *Steep Steps*, bars 11-12

However, the note preceding the F4 is a D3 (last note of bar 11). Both F4 and D3 can be played using the root fingering pattern for G1. Therefore, F4 can be played as an overtone of the root fingering pattern for either G1 or D♭2. The F4 in bar 12 can, thus, be considered a ‘pivot’ note, that is, a note which is in the same overtone series as both the note which precedes it and that which follows it.

The possible dilemma posed by the choice of two root-overtone fingering patterns does not give the entire picture of the decision which must be made by the performer. There is also another aspect which could influence the performer’s choice of which fingering pattern to use. Whilst theoretically it would be possible to play all three of the pitches marked in red in Figure 105 using only the root fingering pattern for D♭2, in reality, the tempo is too fast to make this a reliable option. As all three pitches require a different lower lip position, the speed at which they can be played is limited. Therefore, whilst this piece exhibits clear links with the instrument’s harmonic series, it is not always practicable to play all the pitches using the root-overtone system.

One possible solution, which would allow the overtones to sound with greater ease, is to add extra keys. For example, if F4, A♭3, and D♭2 are all played using the root fingering pattern for D♭2, then key 18 (the register key) could be added in order to play A♭3, and both key 18 and key 16 could be added to aid the production of F4. Although key 18 and key 16 both help the instrument to produce the prescribed overtone, they do also have an influence on the pitch of the note.[79] Bastardized fingering patterns, using additional keys or leaving keys out, create nano tones, the subject of section 5.3.

The final bar of *Steep Steps* can be seen as a summary of Carter's interest in the roots and overtones of the bass clarinet (Figure 106). The final two notes can be played using just one root fingering pattern. As both C♯3 and G♯4 are overtones of the root fingering pattern for F♯1 and because of the clear connection between the last two notes, I would use the same root fingering pattern, but due to the loud dynamic (***ff***) and the accent, I would half-close LHK1, in order to aid the production of this note.[80]

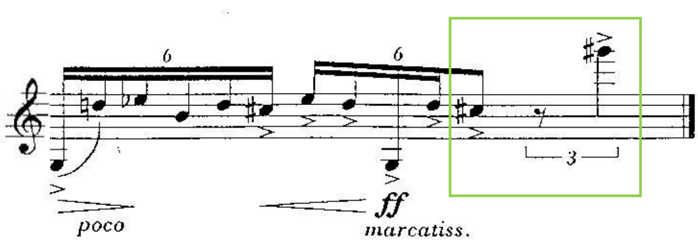

Figure 106: Carter, *Steep Steps*, bars 26-27

Although Carter did not include any fingering patterns in the score, and therefore the choice of fingering patterns is left to the performer, his comment that the overblowing system of the bass clarinet is the central idea of the piece requires the performer to make informed choices about fingering patterns and when the root-overtone system can be used. The issues raised by this piece, the choice of root fingering patterns, and the use of additional keys, are matters which will be covered in more detail in the next section.

[79] It is not stated in the score if Carter wanted the piece to be played using harmonic series tuning, or whether the use of additional keys, to perhaps bring the pitches closer to equal temperament tuning, would have been welcomed by the composer.

[80] If one were to play *Steep Steps* immediately *da capo*, there is a connection between the last note of the piece and the first note: the F2 fingering pattern (first note of the piece) can also be used for G♯4 (last note of the piece).

5.3 Additional microtonal variants of root-overtone sounds

Tiny pitch variations are possible on standard fingering patterns from A♭1 upwards, by using additional keys. This technique is not possible within the lowest fifth, as there are no keys available to make microtonal changes, with the exception of key number 7, F♯1 (see section 1.2.6). As discussed in connection with Carter's *Steep Steps*, single pitches produced using different root fingering patterns, can also be combined with additional keys. This technique generates even more, small microtonal pitch variations. I call these pitch variations of less than an eighth-tone on either standard fingering patterns or root-overtone fingering patterns, nano tones. For example, if key 1, 2, 3, 4, 5, 6, 7, or 8, is added to the (root) fingering pattern for A1, small pitch changes are produced. When the same fingering pattern is used to generate overtone C♯4, the addition of any one of the same keys will also produce small pitch variations. Similar pitch variations can be heard on other overtones higher in the harmonic series, such as G4 and B4.

As a test, measurements were executed on two root fingering patterns, one using keys located on both the upper and lower joints, B♭1, and the other, D2, which uses keys on the upper joint only. The aim of this test was to investigate whether similar pitch variations of the overtones would occur, when different keys were added to each of the root fingering patterns, thus giving an insight into yet another microtonal universe.

Having tuned to A=442 Hz, the root fingering pattern for B♭1 was used to play D4, the 5th harmonic. This pitch was measured to be five cents flatter than equal temperament tuning (D4 -5 cents). The pitch was then measured when each key was added to this root fingering pattern in turn. The following readings were taken:

Key added	Pitch deviation from equal temperament	Pitch deviation from D4 -5 cents
1	-18	-13
2	-12	-7
3	-7	-2
4	-2	+3
5	+8	+13
6	-14	-9
7	-9	-4
8	-2	+3
RHK3	-35	-30

Figure 107: Pitch deviation on D4

The pitch varied with each key used but the pitch variations measured were relatively small, between 2 cents and 13 cents, except for RHK3, which gave the biggest pitch deviation of 30 cents.

I then used the same root fingering pattern, for B♭1, to play the overtone A♭4, the 7th harmonic. The pitch of this overtone, without additional keys, was measured as A♭4 -62 cents (this reading could also be given as A4 +38 cents). Adding keys, the following readings were taken:

Key used	Pitch deviation from equal temperament	Pitch deviation from A♭4 -62 cents
1	-54	+8
2	-50	+12
3	-73	-11
4	-59	+3
5	-43	+19
6	-41	+21
7	-58	+4
8	-38	+24
RHK3	-111 (G4 -11)	-49

Figure 108: Pitch deviation on A♭4

The pitch variations in this case are larger, between 3 cents and 49 cents. The biggest pitch variation is almost a quartertone.

Finally, the root fingering pattern for D2 was put to the test in order to see the extent to which the overtone F♯4, the 5th harmonic, could be modified. As this is a fingering pattern which uses only the upper joint, five more keys were available to test: RHK1, RHK2, RHK3, key 9, and key 14. At the beginning of the test, F♯4, played using the root fingering pattern for D2, sounded a note which measured as F♯4 -28 cents. Adding keys, the following readings were taken:

Key used	Pitch deviation from equal temperament	Pitch deviation from F♯4 -28 cents
1	-27	+1
2	-25	+3
3	-24	+4
4	-25	+3
5	-33	-5
6	-31	-3
7	-31	-3
8	-30	-2
9	-21	+7
14	-22	+6
RHK1	-80	-52
RHK2	-45	-17
RHK3	-33	-5

Figure 109: Pitch deviation on F♯4

The results show that when the root fingering pattern for D2 is used to play the overtone F♯4, the addition of keys 1-9 and key 14 produce the smallest nano tone variants of all three pitches tested here: differences between 1 cent and 7 cents were measured. The key operated by the right hand ring finger (RHK3) also produced similar results. The two keys operated by the right hand index and middle fingers, by contrast, show a very different picture. RHK2 produces a pitch variation of -17 cents, but the key operated by the right hand index finger

(RHK1) really jumps out, with a reading of F♯4 -80 cents. This constitutes a deviation of 52 cents, approximately a quarter of a tone difference with the initial pitch measurement.

To conclude, the addition of available keys to vary the pitch of notes played using root-overtone fingering patterns is a productive method of generating more microtonal options. The test data show that in all three cases the use of keys 1-8 resulted in small microtonal differences, nano tones. Adding the index (RHK1), middle (RHK2), and ring finger (RHK3) keys during the overtone F♯4 test gave a mixed result. Although two of the three variants gave results suitable for inclusion as nano modifiers, the pitch difference resulting from the use of RHK1 makes it unsuitable for my work on microtonal pitch variants of less than an eighth of a tone. The extra options offered by adding different keys to root-overtone fingering patterns creates a myriad of possibilities for nano microtonality.

5.3.1 Type 1 multiphonics

In *New Techniques for the Bass Clarinet* I described type 1 multiphonics as "a stack of harmonics played as one block…by using traditional fingering and by changing the embouchure by means of strong pressure of the lips" (Bok, 2011, p.40). Indeed, a type 1 multiphonic contains several or all of the natural overtones of the root. This means that when playing type 1 multiphonics in a sequence, all overtones in the 'chord' move in the same direction.[81]

As previously mentioned, since writing *New Techniques for the Bass Clarinet*, I have changed my opinion regarding the technique used to sound overtones. I now believe that it is lip placement, not lip pressure, which allows different overtones to sound. It is also lip placement which enables type 1 multiphonics (a combination of harmonics) to be produced.

An interesting aspect of varying the lip placement is the change between monophonic and multiphonic uses of the root-overtone system. It is possible to shift between monophonic and multiphonic sounds, both played using root

[81] I will not consider type 2 multiphonics in this study. Type 2 multiphonics are produced using alternative (special) fingerings. Each type 2 multiphonic gives a specific result, which can vary according to instrument make, and materials used (such as mouthpiece and reed). Type 1 multiphonics, which are characterized by the instrument's natural overtones, can be sounded on any brand or make of bass clarinet, making them 'inherent' components of the bass clarinet's sonic universe.

fingering patterns. This kind of sound manipulation, which can be done smoothly and without interruption, requires skilled finger technique, air management, and control of lower lip positioning. A good ear is also needed to guide these technical skills and push them in the right direction. With the correct technique and the ability to hear what you want to play, different notes of the type 1 multiphonic can also be brought out more prominently.

The same microtonal differences that have been documented when individual pitches from the harmonic series are played using different root fingering patterns, occur when type 1 multiphonics are played, but here the changes affect all the notes sounding in the harmonic series. The application of the root-overtone system within type 1 multiphonics creates the same microtonal variants as with monophonic sounds, where the use of different root fingering patterns to play notes leads to microtonal variations of the twelve-tone equal temperament pitches. Bringing out shared overtones within a sequence of type 1 multiphonics enhances this ‘multi-micro’ effect.[82]

Figure 110 is an example of a possible sequence, whereby the changes between roots, single sounds, and multisounds result in an uninterrupted line of microtonally varied sonic elements.

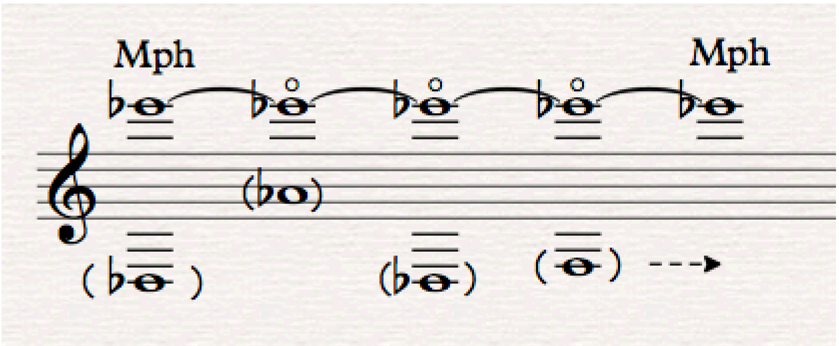

Figure 110: A root-overtone phrase shifting between single sounds and multisounds

Audio example 17: Recording of the root-overtone phrase in Figure 110

[82] *Multi-Micro I* is the title of my composition dealing with this particular aspect of microtonal writing (Audio example 32).

The same process of applying additional keys to root fingering patterns, which has previously been discussed with regard to individual tones, can also be applied to type 1 multiphonics. Adding keys to root fingering patterns when playing type 1 multiphonics changes both the root and all the overtone pitches. The keys used in section 5.3 thus produce nano variants of type 1 multiphonics.

5.4 Applications

5.4.1 Mc Laughlin: *a point on many lines*

Irish composer Scott Mc Laughlin's piece *a point on many lines* has a meditative and intense character. The score is structured in blocks of material, separated by empty space. Each block should be played at a different tempo, between "60-80 bpm" (metronome mark), and the chosen tempo should stay constant within each block (Mc Laughlin, 2013). The central pitch of the composition, D♯, is omnipresent, but occurs in different octaves, either as a root fingering pattern or as an overtone from a root fingering pattern. Mc Laughlin also combines monophonic and multiphonic sounds within this piece. He describes type 1 multiphonics as "multiphonics derived from the harmonic series of the lower note" (Mc Laughlin, 2013). He also prescribes three "special-fingered" multiphonics (type 2), which can be freely chosen by the performer, as long as they "allow the high D♯ [D♯4, HB] to be isolated" (Mc Laughlin, 2013).

The opening four blocks of the piece feature three different ways in which the central pitch should be played (Figure 111). Whereas the choice of fingering pattern for the opening note D♯4 (block 1) is left to the performer,[83] the second appearance of D♯4 (block 2) is based on the root fingering pattern for C♯1. This starts as a split sound, where both C♯1 and D♯4 can be heard, before resolving to only the D♯4. In block 4 Mc Laughlin asks that D♯4 is played as the overtone of the root fingering pattern for B1. At the start of this block only the overtone should be sounded, but, after four quavers, the root should be brought in.

[83] I chose a fingering pattern which is a combination of keys 16 and 18, basically a root-overtone fingering pattern based on G♯2.

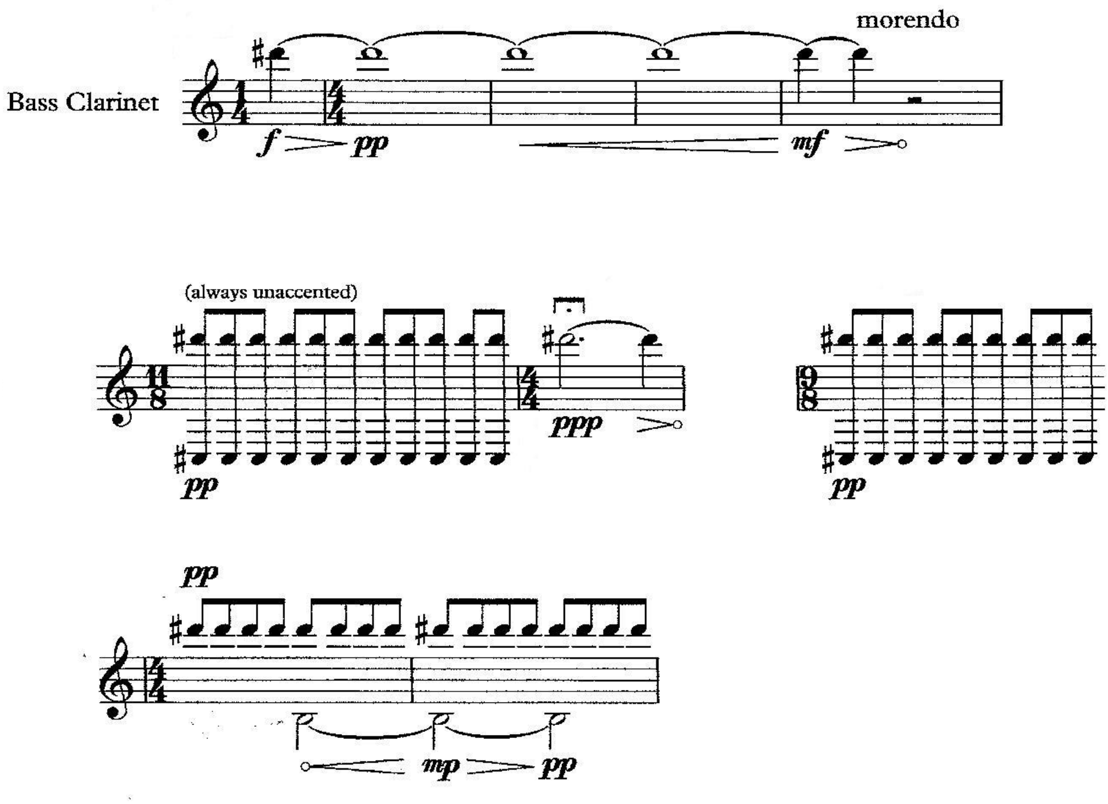

Figure 111: Mc Laughlin, *a point on many lines*, blocks 1-4

Audio example 18: Mc Laughlin, *a point on many lines*, blocks 1-4

In bar 34 Mc Laughlin introduces another root fingering pattern (F1), which allows the overtone D♯4 to be played (Figure 112), before returning to the root fingering pattern for B1.[84] It is on this root fingering pattern that Mc Laughlin asks the performer to sustain the root, B1, whilst playing D♯4 in a quaver rhythm. These pitches are then transformed into a type 1 multiphonic at the end of the phrase. As the pitches B1 and D♯4 are root and overtone of the same root fingering pattern, technically speaking, B1 cannot be played as a sustained note, whilst D♯4 is played in a repeated quaver rhythm. It is rather the manipulation of the prominence of different pitches within the harmonic series that allows the D♯4 to repeatedly drop away and return.

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[84] Bar numbers in the score jump from bar 15 to 21. I here refer to the bars according to the numbering in the score.

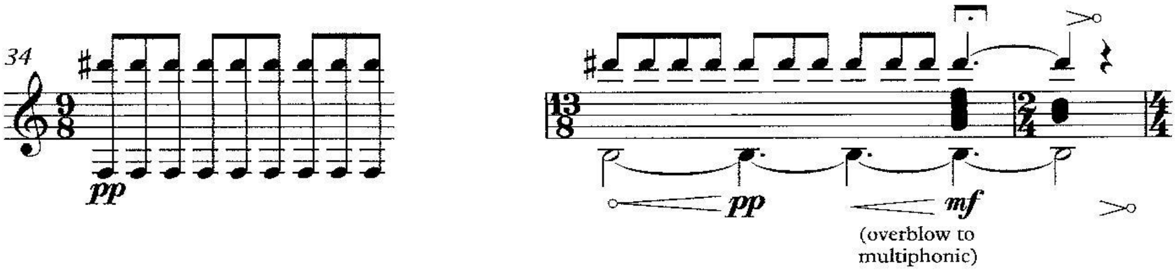

Figure 112: Mc Laughlin, *a point on many lines*, bars 34-37

Audio example 19: Mc Laughlin, *a point on many lines*, bars 34-37

The manipulation of the root-overtone system continues in bars 81-82, where Mc Laughlin writes a tremolo between root fingering patterns for C♯1 and B1 before bringing in the D♯4, which is an overtone common to both these root fingering patterns (Figure 113).

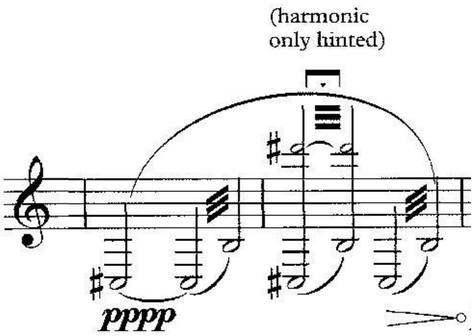

Figure 113: Mc Laughlin, *a point on many lines*, bars 81-82

Audio example 20: Mc Laughlin, *a point on many lines*, bars 81-82

A new element is introduced in bars 92-93 and then repeated: a glissando from the overtone D♯4 to the next playable overtone higher in the harmonic series. This occurs in bars 92-93 based on the root fingering pattern for F1, and in bars

95-97 based on the root fingering pattern for C♯1. Although the notation shows a glissando between these pitches, the composer has said that he does not mean an actual glissando: “gliss here meaning, change harmonics as smoothly as possible, not actual portamento/slide” (Mc Laughlin, 2013, p.4).[85]

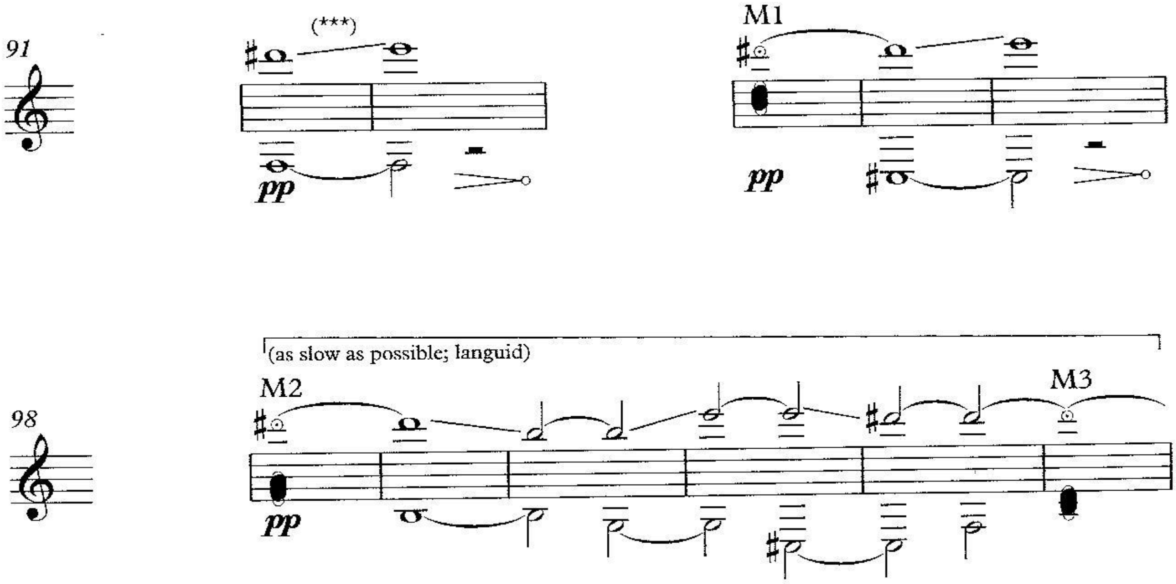

Figure 114: Mc Laughlin, *a point on many lines*, bars 92-104

Mc Laughlin’s remark about the written glissandi in bars 92-104 of *a point on many lines* might resolve what could be considered as inconsistencies in Mc Laughlin’s use of the different overtones in this section, as he chooses pitches which are not in the overtone series of the prescribed root fingering pattern. On the root fingering pattern for F1, the next overtone in the series (above D♯4) is actually G4, not E4. Similarly, on the root fingering pattern for C♯1, the next overtone in the series, above D♯4, sounds as F♯4 (see Appendix G1 for the resultant pitches). Whilst the composer’s choice of pitches does not comply with the overtone series of the bass clarinet, this area of the overtone series, roughly in the fourth octave of the instrument, is rather flexible and there is room for embouchure manipulation. As stated in section 5.2.1, the 7th, 9th, 11th, and 13th harmonics are the most flexible, but, as documented in Appendix G3 I had not previously been able to produce the extreme pitch manipulation that Mc Laughlin had requested here. However, Audio example 21 shows that I was

[85] Maybe an arrow would have conveyed the composer’s intentions in a more succinct manner.

able to push the limits of my pitch manipulation on this occasion, in order to fulfil the composer's request. Therefore, on root fingering pattern F1, the 9th partial could be sufficiently altered in order to sound an E4 and, likewise, on root fingering pattern C♯1, the 11th partial could be sufficiently altered to sound E4 (Audio example 21).

Audio example 21: Mc Laughlin, *a point on many lines*, bars 92-104

Mc Laughlin's work, *a point on many lines*, is a demanding but rewarding solo piece in which the natural overtone series of the bass clarinet comes to fruition through the use of the root-overtone system. Monophonic and multiphonic use of the root-overtone system amply shows the diversity of this inherent form of microtonality on the bass clarinet.

5.4.2 Domínguez: *Cuerpo Negro*

In *Cuerpo Negro* Francisco Domínguez combines quartertone microtonal writing (see section 3.4.1) with root-overtone harmonics. Following the initial slap tongue in bar 1, he makes considerable use of the root-overtone system in order to change the pitches of the notes microtonally. Domínguez prescribes different root fingering patterns from bar 2 onwards for a large part of section A (bars 2-21). The overtone pitches chosen by Domínguez are: B4, B𝄳4, C5, C𝄳5, C♯5, D♭5, E♭5, and F5 (Figure 115).

Although Domínguez continues his use of the root-overtone system to explore microtonal variants, in bars 4 and 20 he does it in a manner which does not return for the remainder of the piece: he changes the root fingering pattern used whilst the same overtone pitch should continue to sound (Figure 115).

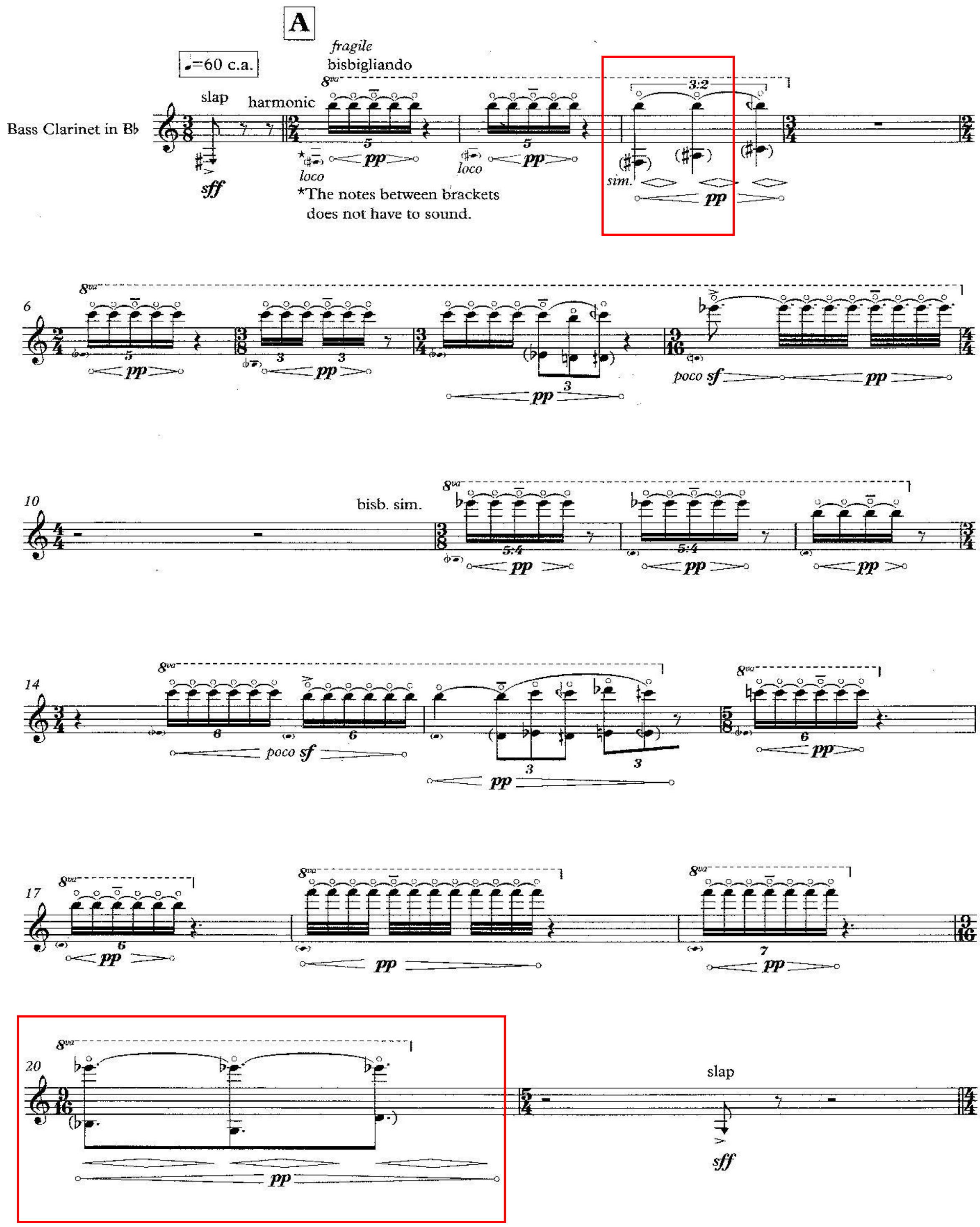

Figure 115: Domínguez, *Cuerpo Negro*, bars 1-21

Changing the roots but keeping the same overtone going (bars 4 and 20) requires a highly controlled change in lower lip position—position 3 for the B4 in bar 4 and position 4 for the E♭5 in bar 20 (see also section 1.3.1.1)—but also the knowledge and ability to instantly find the correct position.

Audio example 22: Domínguez, *Cuerpo Negro*, bars 1-21

From letter B onward Domínguez exploits the bass clarinet's root-overtone resources highlighting the flexibility of this form of microtonality. For example, in bar 22 an overtone produced by a given fingering pattern (B♭1) shifts to the root (Figure 116).

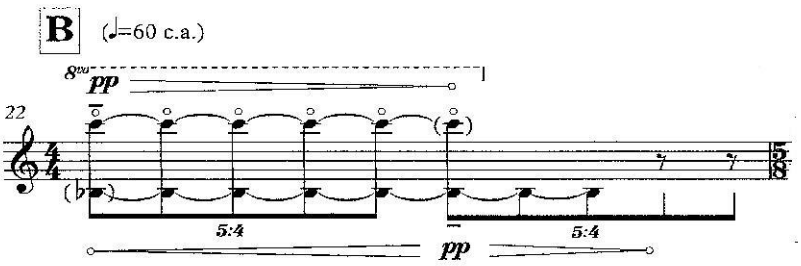

Figure 116: Domínguez, *Cuerpo Negro*, bar 22

Audio example 23: Domínguez, *Cuerpo Negro*, bar 22

In bar 24 there is a combination of quartertone writing and root-overtone writing. The quartertone sequence—E𝄳2, E♭2, D𝄲2—ends on D2, which is used as the root to produce E♭5, three octaves higher than the second note of the bar (E♭2). The D2 fingering pattern specified by the composer will not produce an E♭5 that is an exact octavation of E♭2, but instead, a microtonal variant.

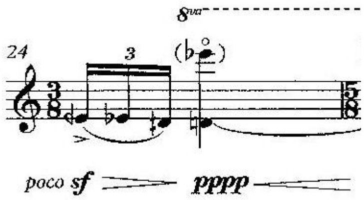

Figure 117: Domínguez, *Cuerpo Negro*, bar 24

Audio example 24: Domínguez, *Cuerpo Negro*, bar 24

In bar 27 the composer again combines quartertone and root-overtone writing. The overtone sequence—B4, C5, C♯5, D♯5—produced by the prescribed roots—A1, B♭1, B1, C♯1—will not produce an exact semitonal sequence. The small microtonal pitch changes, which are inherent to the sequence, have been deliberately chosen by Domínguez (F. Domínguez, personal communication, June 2, 2017).

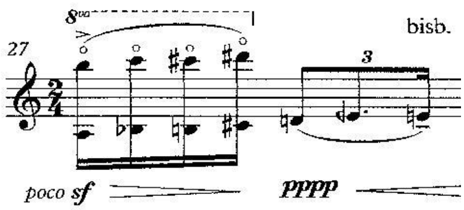

Figure 118: Domínguez, *Cuerpo Negro*, bar 27

Audio example 25: Domínguez, *Cuerpo Negro*, bar 27

The combination of quartertone writing and the microtonality found in the root-overtone system is characteristic of Domínguez's writing in *Cuerpo Negro*. On occasion he uses the same root to produce different overtones, for example, D2 to generate first E♭5 in bar 12, and then to generate B4 in bar 13 (Figure 115). His juxtaposition of different roots to produce the same overtone shows his awareness of the root options available for altissimo harmonic series writing. Two of Domínguez's favourite root-overtone combinations in this composition are the use of D2 for B4 and E♭5, and B♭1 to generate either C5 or E♭5 (Figure 115).

5.4.3 Laufer: *verse & refrain*

Norbert Laufer's work for solo bass clarinet, *verse & refrain*, focuses on two aspects of microtonal playing: 31-tone intonation and root-overtone microtonal variants. Two sections of *verse & refrain* focus particularly on the microtonal possibilities of the root-overtone approach: bars 16-23 and bars 44-51. The central pitch of the first section (bars 16-23) is D (either D4 or D5) and that of the second section (bars 44-51) is G (either G4 or G5).

Laufer couples the D5 in bars 16 and 17 with two different root fingering patterns, D1 and G1 respectively, thus creating a microtonal difference for the overtone. The same happens in the following two bars: overtone D4 is produced by root fingering patterns for E1 and B♭1 respectively. The second D4, based on B♭1, is then turned into a type 1 multiphonic in bar 20. This process is repeated in bar 21 (D4 based on the root fingering pattern for E1) and in bar 22 (D5 based on the root fingering pattern for G1). The section ends with D1 transforming into a type 1 multiphonic, whilst making a decrescendo, and also sounding overtone D5 (Figure 119).

Figure 119: Laufer, *verse & refrain*, bars 16-23

Audio example 26: Laufer, *verse & refrain*, bars 16-23

The structure of the second root-overtone section (bars 44-51) is almost identical, but this time with G4 and G5 as the central pitches. However, in this section, the root fingering pattern used to play the third note in each bar (an overtone), is not that of the first note in each bar. For example, in bar 44 the first note is G1, whilst for the third note (G4), the root fingering pattern for D1 has to be used. Similarly, in bar 45 the first note is C1, but the third note of the bar (G4) should be played by overblowing the root fingering pattern for F1.

In bars 49-50 (Figure 120) Laufer makes similar use of the root-overtone system to Domínguez (see [Figure 115](#)): an overtone pitch is held whilst the root fingering pattern changes. Laufer goes one step further than Domínguez though, as the second root fingering pattern used in each bar must also sound a multiphonic.

Figure 120: Laufer, *verse & refrain*, bars 44-51

Audio example 27: Laufer, *verse & refrain*, bars 44-51

Like Mc Laughlin, Laufer makes monophonic and multiphonic use of the root-overtone connections. However, whereas for Mc Laughlin root-overtone based microtonality is the principal aesthetic in *a point on many lines*, Laufer combines “traditional intonation” (N. Laufer, personal communication, June 6, 2017), 31-tone microtonal intonation, and root-overtone based microtonality to create his musical language in *verse & refrain*.

5.4.4 Own compositions

5.4.4.1 Bok: *There is a place for multiphonics*

Microtonality as a result of the root-overtone system plays a primary role in my composition *There is a place for multiphonics*. I wrote this composition for solo bass clarinet in the summer of 2012 and premiered it at a concert in Potsdam, New York on September 27, 2012. In June 2013 I revised the piece and premiered the revised (and final) version on June 15, 2013 in Düsseldorf.

One day, when experimenting with different roots and overtones, I discovered that I could play a lot of the opening melody of *There's a place for us* from Leonard Bernstein's *West Side Story*, by manipulating overtones. The start of this line can be played using the overtones of the root fingering pattern for E♭1. As can be seen in Figure 121, root E♭1 provides most of the overtones needed to play the melody. However, C4 and E♭4 do not form part of the natural harmonic series of this root. These pitches have to be produced by using embouchure manipulation to lower the pitch, lipping down the pitches of the natural overtone series, D♭4 and F4 respectively. As discussed in section 5.2.1, there is substantial space for manoeuvre, lipping down, in the fourth and fifth octaves.

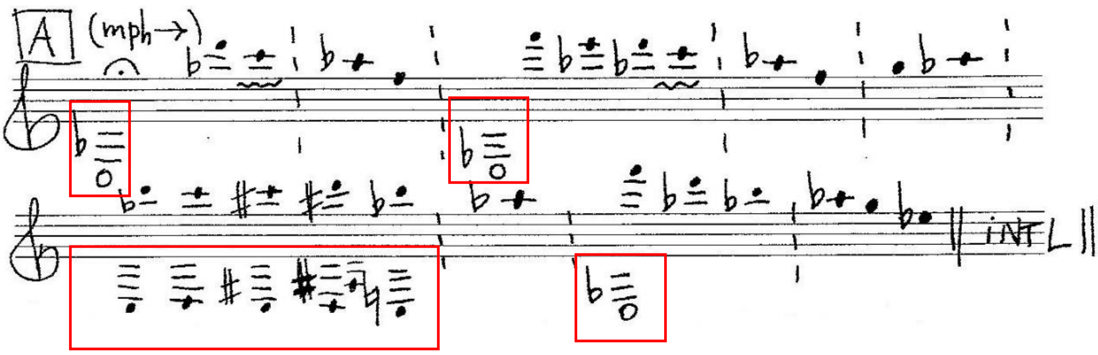

Figure 121: Bok, *There is a place for multiphonics*, section A

Audio example 28: Bok, *There is a place for multiphonics*, section A

The discovery that I could combine overtones based on root E♭1 with extreme manipulation of the lower lip in order to play the melody provided the inspiration for my composition. At the beginning of section B standard fingering patterns are used to play B♭3 and C4, but when the same notes are repeated, root-overtone fingering patterns are used (C1 and D1 respectively). This process of alternating standard fingering patterns with root-overtone fingering patterns continues, culminating in the two last pitches of the section, which are first played as single pitches, using standard fingering patterns, but then repeated an octave higher, utilizing root-overtone fingering patterns to sound a type 1 multiphonic (Figure 122).

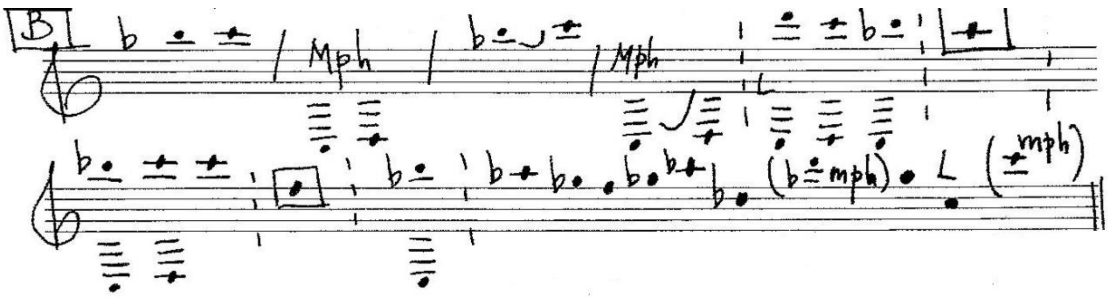

Figure 122: Bok, *There is a place for multiphonics*, section B

[**Audio example 29: Bok, *There is a place for multiphonics*, section B**]

The bar before Coda 2 is the last root-overtone occurrence in the piece. The notes of the melody, C4, D4, and E4, are played as type 1 multiphonics, using root-overtone fingering patterns G♯1, B♭1, and C2 respectively (Figure 123).

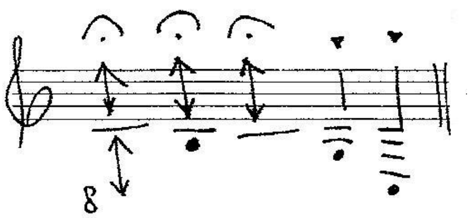

Figure 123: Bok, *There is a place for multiphonics*, penultimate bar

These three notes, notated in the score as fingering patterns, do not produce the original chords, but do provide the chordal ending to the piece that I had in mind.

[**Audio example 30: Bok, *There is a place for multiphonics*, penultimate bar**]()

5.4.4.2 Bok: *Microclimate I*

Microclimate I (2017), for two bass clarinets, also makes use of the microtonal variants resulting from the use of the root-overtone system. A note occupying a central place in this section of the piece is E♭. One bar before section C the melody ends on an E♭, the second bass clarinet plays an E♭1, and the first bass clarinet plays an E♭3. In the first bar of section C the E♭3 is taken up one octave (E♭4, first bass clarinet), whilst the second bass clarinet repeats the E♭1 from the bar before. However, after a grace note (E♭4)—the final note in Figure 124 played using a standard fingering pattern—the fermata semibreve (E♭4) in the first bass clarinet part has to be played using the root-overtone fingering pattern for F1. This allows the single pitch to be transformed into a type 1 multiphonic.

Figure 124: Bok, *Microclimate I*, section C

The final bars of the piece reprise the opening, this time, however, including root-overtone microtonal variations (Figure 125). In the first bass clarinet part the pitch C4 is played using either standard fingering patterns or the root fingering patterns for D1 or A♭1, thus creating microtonal pitch variations.

The piece ends with a C4/C♯4 trill in the first bass clarinet part, which is produced using the root fingering patterns for D1 and E♭1, combined with a microtonal trill C𝄳4/C4 (31-tone) in the second bass clarinet part. The sonic result is a combination of two disparate microtonal systems.

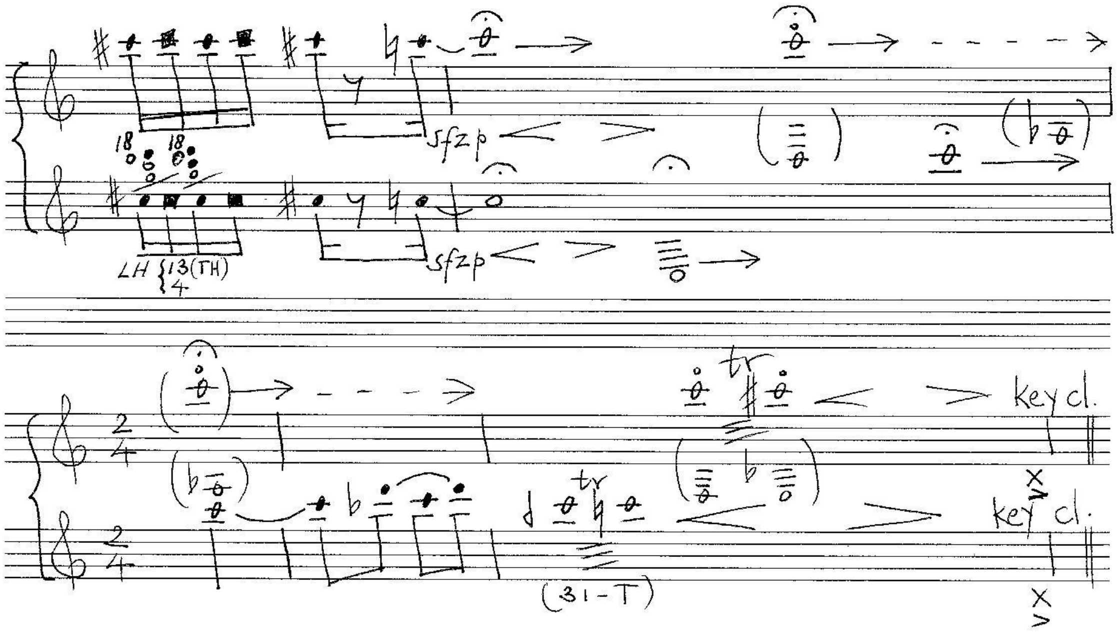

Figure 125: Bok, *Microclimate I*, end of section E

<u>5.4.4.3 Bok*: smaller change*</u>

Another of my compositions, *smaller change* (2017), also uses root-overtone microtonality. In this composition I tried to apply all my microtonal findings (as a performer) to a piece of music (as a composer) in order to show the richness of the microtonal universe of the bass clarinet.

Although it was my original intention to use D4 as the binding factor of the composition, I decided during the process to also include a few D5's, attracted by the fact that D5 is a natural overtone in the harmonic series of D1, the lowest D on the bass clarinet. The piece also features split sounds and type 1 multiphonics, which all include either D4 or D5 as the most prominent pitch.

In Figure 126 four different root fingering patterns are used to produce D4: C1, E1, B♭1, and G2. I also use four nano variants of the fingering pattern for root B♭1, produced by adding key 2, key 5a, key 8, or RHK3. In bar four (Figure 126) there is a microtonal trill created by the movement between the three different root fingering patterns used to play D4 in the three previous bars. The last bar of the root-overtone section reiterates the section’s opening idea (bars 1-4). However, the microtonal trill here is based on only two roots, B♭1 and E1, and develops into a multiphonic trill on the same two root fingering patterns. This produces nano pitch variations throughout the whole multiphonic cluster.

Figure 126: Bok, *smaller change* for solo bass clarinet, root-overtone section

Audio example 31: Bok, *smaller change*, root-overtone section

5.5 Summary and conclusions

I have used the term, the inherent microtonality of the bass clarinet, to refer to the instrument's ability to sound microtonal pitch variations by utilizing the notes of the overtone series based on the root fingering patterns from C1 to B♭2. These microtonal variants can be single, isolated pitches (monophonic), but can also comprise overtones (multiphonic), as type 1 multiphonics are based upon the root-overtone production system. Adding keys to the root fingering patterns produces nano tones (see Glossary), the use of which increases the number of microtonal variants, not only for the roots, but also for any overtone pitch a root can generate.

Root-overtone production clearly demonstrates how bass clarinet acoustics work and how it leads to the 'inner' or intrinsic microtonality of the instrument. Pitch measurements for all the overtones producible by the root pitches of the instrument, from C1 to B♭2, have been documented (Appendix G1). Appendix G2 compares three readings of the harmonic series frequencies for root fingering pattern E1 with the supposed harmonic series pitches and the equal temperament pitches. Appendix G3 shows the overtone manoeuvrability for the same root fingering pattern (E1).

Harnessing the inherent microtonality of the bass clarinet by documenting the root-overtone system in this way, shows that it is a viable form of microtonal practice and adds another dimension to the sound world of the microtonal bass clarinet. This can be further extended through the use of additional keys in order to create nano microtonality. Given the abundance of possibilities, it is no wonder that I have been fascinated by the microtonal variants of the root-overtone system for a very long time, not only as a performer and an improviser, but also as a composer.

Video 17: Summary of the core elements of root-overtone playing on the bass clarinet