NEW SOUNDS FOR CELLO AND DOUBLE BASS (MULTIPHONICS)

Michael Liebman (mliebman209@gmail.com) Tel-Aviv, Israel

Abstract

This research is intended for composers and theorists interested in new sonorous capabilities of cello and double bass, as well as for use as a study aid for performers of these instruments. We aimed at a detailed description of possible nuances in creative usage of multiphonics. We have stressed a necessity to take individual characteristics of instruments. We have paid special attention to explanations of methods of successful performance of chords. An original instruction system for performer helps to locate and perform chords. Tables of chords based on natural flageolets have been developed, showing a rich choice in chord selection as well as diversity of their usage.

Introduction

The title of this article owes a debt to the well-known book "New Sounds for Wood Wind" (London 1967) by Bruno Bartolozzi. (BB)

The writer has taken this name although there are some later researches devoted to this theme, to emphasize that his work was inspired by the BB book, which changed the direction of his creative work.

Bruno Bartolozzi (BB), Italian composer and theorist (1911-1980), was the first to describe a chord technique on woodwinds which he called **"**multiphonics**"**. He opened huge new vistas for composers searching for new sounds.

BB developed and described new techniques to influence and affect sounds, and showed that woodwinds are capable of great timbre and fingering variety. However, the central area of his discoveries is related to multiphonics - a chord technique.

Under certain conditions, such as specific fingering, specified wind and lip pressure**,** etc.**,** some tones are "split" into various combinations of flageolets – that is, chords.

The simultaneous sounding of these overtones produces a cold, even gloomy and yet bewitching effect.

Just as scientists penetrating the atom were amazed by its mysteries, so, too, were composers, having found a new way to explore the space of a sound, listening attentively to its secrets: new and mysterious sounds, coming not from electronic synthesizers, but from old, established and seemingly thoroughly investigated instruments.

Despite its widespread use in woodwind compositions, this new facet of the expressive musical spectrum has been much less used by other wind instruments. Better known is the use of multiphonics on the trombone (I. Xenakis, L.Berio).

When modern authors use this technique only for woodwinds in their music for mixed ensemble, they create an imbalance in the timbral and structural profile of a composition - as if the instruments were speaking different languages.

One cannot dismiss the feeling that these compositions would have gained in harmonicity, if only their authors had had the information allowing them to apply this technique to the strings as well.

In 1997 author took a viola with the desire to experiment. Unexpectedly, the instrument presented new information. Thus, "Tremolet-Sonata"(1997) was written, in which the multiphonic intervals were used.

The discovery of multiphonic chords and other interesting effects followed in 1998, when the cello became the new subject of investigations.

During that year “Movement of Repose” for cello solo, was written, in which the new technique was applied. The premiere of this composition (2000) was carried out by Frances Mari Uitti, widely known as the discoverer of two-bow cello technique /over and under the strings, played by the right hand / who applied it brilliantly.
During 1998, both the Table of Multiphonics for Cello and the article were prepared and published (*Das Orchester, “Multiphonics Neue Moglichkeiten im Cellospiel” 04/ 2001 Germany*).

The study of multiphonics for the double bass in 2000-2001 crystallized into Sonata solo for double bass (2001), with a wide use of not only chord technique but also “percussive” as well as other techniques. That year the second article was written for double bass and the table of multiphonics was prepared.
While investigating the potential of stringed instruments, the author also attempted to discover multiphonic chords on the viola and violin but was unable to produce such effects, most likely due to their small size, though the usage of the multiphonic potential (clusters and intervals) of these instruments is still in its infancy**.** (One can find examples for violin, however, in the music of Norwegian composer Ole-Henrik Moe jr.).
Despite the availability of the information these days, author only recently become aware of similar research by another musician, French double-bass player Jean-Pierre Robert, who described this technique, applied to the double-bass, in his book **"Modes of playing the double bass",** published in 1995 by Musica Guild. While different in many ways, these two studies complement one another.
Among the multiphonic technique “pioneers” were such composers as Kimmo Hakola, Philippe Boivin and Gilles Tremblay.
Nowadays a number of musicians and researchers work on the subject.
Mark Dresser, for example, provides in his articles practical advice on playing flageolets and multiphonics. Knut Guettler and Haakon Thelin are preparing the release the book “Multiphonics on the double bass"…

Diversity of musical instrument structures and the chord technique

Although there are many manufacturers and individual masters producing various kinds of stringed instruments none of the latter has multifunctional possibilities that make it possible to perform any existing multiphonics. Similar problems exist for woodwinds as well. Differences in the structure of partitions in grand pianos sometimes create difficulties while playing on their strings. Differences persist also in ranges of the instruments. Differences in the length of a fingerboard and, therefore, in the distance between its edge and the bridge, change bow placement parameters, as bow placement on a double-bass with a regular fingerboard, described as *tasto* or *molto tasto* (see page 9, paragraph ***"The placement of the bow”*****),** would occur on an elongated fingerboard.
An attempt to perform *the* Sonata for Double-bass has led to a realization that certain effects cannot be performed as written on all instruments due to their individual properties.
The sounding of complex examples in this article may vary in each case.
Two factors may facilitate the overcoming of the described challenges:

1. Use of the chord table (see pages 21-30) for choosing chords suitable for a particular instrument.
2. A creative collaborative attitude on the part of the artist who is willing to adapt non-performable parts of the text (a chord, a group of chords, adaptation of harmonics within the chord, or some other specific sound) to his own instrument; a willingness to find (without reference to the table) a proper equivalent. When the instrument doesn't make it

possible to find a proper substitute it is important to reject the non-performable effect. The latter refers to very specific effects found on a particular instrument.

It can be stated with confidence that the structure of a chord will also vary on different instruments. The variation in resulting sounds of multiphonics specifies an originality of their application as sonoristic complexes, (especially in an ensemble's *tutti* and in orchestra) where the effect as such is more important than nuances in pitch.

Thus it is possible to recommend the following - either to write for the concrete performer and to create all the effects possible on the instrument of this musician, or to keep in mind that some effects will have to be adapted for each concrete instrument.

Flageolets

The multiphonic technique is based on flageolet technique.

As is well known, the most widespread uses of the flageolets are the fourth and fifth, and these are the most stable. Changing the bowing position from *tasto* to *ordinare* inclusively does not affect the pitch of their overtones**.** New overtones can be generated only in *ponticello* and *molto ponticello*. Thirds and sixths are generally less frequently used due to their lesser stability. Accordingly**,** flageolets of seconds, tritones and sevenths are not used, to say nothing of quarter- tone flageolets. However these flageolets are of major interest, both as the basis for the chord technique and as well as a means of expanding flageolet experience.

Natural flageolets are produced practically along the whole length of the fingerboard.

They can give a somewhat non-well-tempered tuning, which is probably why they haven't been used.

Several years ago a table of flageolets (seconds, tritone, etc.) was compiled with the participation of Israeli cellist Yonathan Gotlibovich (the first performer in Israel of "Movement of Repose").

Notation

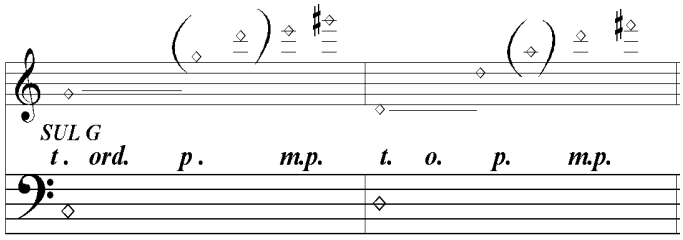
In the note-examples used in this article, the notes being performed are written on the low line. The sounds that should be produced are written on the one upper line or two lines. Also, the string being used is indicated.

For convenience of reading, the following notation is used for these unconventional flageolets: The finger position is designated by a "diamond"- which with full pressure would correspond to the ordinary note - and the chosen string is indicated. An artificial flageolet is notated in the traditional manner.

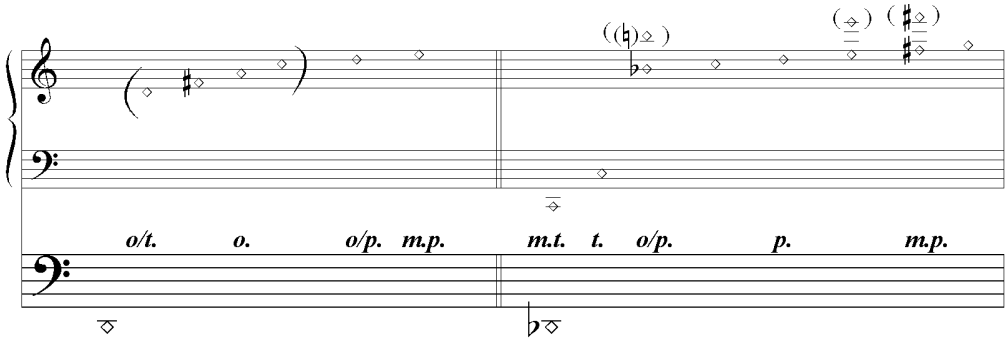
In example # 1 it is the fourth and fifth flageolets on open string G on cello.

Here is an example of what happens with these most stable, traditional flageolets while going from *tasto* to molto *pont.* The harmonics are very unstable in the *ponticello* area and the slightest shift of the bow or the finger position will cause a change in the harmonics, so the result may vary from performance to performance. This is marked by the brackets. With one-time performance of this and other examples some of the indicated harmonics may not sound at all, but hereinafter we show the most comprehensive option for all possible soundings. (see ex. №1)

Ex. #1 Cello:



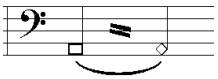
In the next example, while using second-interval flageolets, moving the bow from *tasto* to *molto ponticello*, a non-stable flageolet sequence is created.
This use of flageolets is possible when stability and accuracy of pitch is not a necessary condition. (see ex. #2)
Ex. #2 Cello:



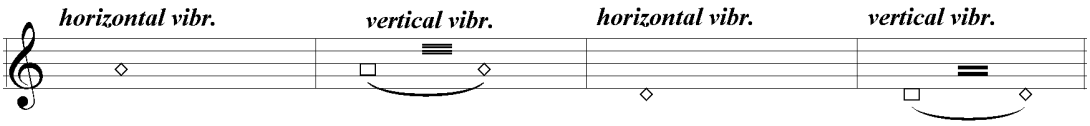
Multiphonics will sound in the unused parts of the fingerboard, besides the bow placements noted in this example.

Vertical vibrato

In classical music, there are no indications to performing flageolets with vibrato though some performers add this effect.
Such an example is found in "Quartet for the End of Time" by Olivier Messiaen.
However, besides this kind of conditional "horizontal" vibrato, it is possible to apply to a flageolet another kind of vibrato, here designated as "vertical". By rapidly varying the amplitude of finger pressure on a string from slight to deep (almost, but not actually touching the fingerboard), one achieves the vertical vibrato of a flageolet.
Accordingly, this technique allows flageolets to be played with a specific vibrato effect, quite different from horizontal vibrato.
A notation in the form of a rectangle is designated to mark pressure on a string almost touching the fingerboard. (see ex. #3)
Ex. #3:



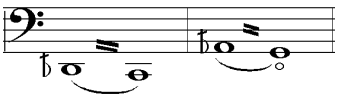
It is easier to perceive original features of horizontal and vertical vibrato by comparing their characteristics. (see ex. #4)
Ex. #4 Cello:



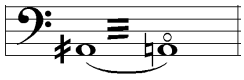
Let us look at some varieties of this vibrato:

Vertical vibrato on "open" strings

By rapidly pressing and releasing an open string as near as possible to the nut, we achieve the full effect of vibration with only a slight shift in pitch which is virtually unregistered by the ear. As compared to performers, composers usually are not familiar with this possibility. (see ex. #5 and ex. #5a)
Ex. #5 Cello:



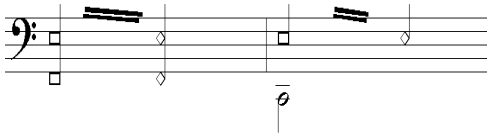
Ex. #5a Double bass:



Vertical Vibrato on two adjacent strings

Additional colors are obtained when two adjacent strings are played. It can be double vibrato (the first measure of ex. #6) or vibrato and open string simultaneously (the second measure of ex. #6) and so on. In the second example, one has to take into account that an open string is much brighter dynamically than a flageolet. (see ex. #6)

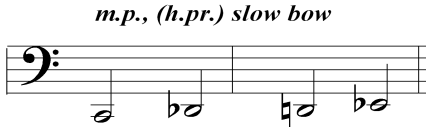
Ex. #6 Cello:



Clusters

Where there is strong bowing [normal or heavy pressure] in *ponticello* and *molto ponticello*, a cluster of harmonics will appear. Often both the cluster and the basic note sound. In this example the notes of the sounding clusters are not shown due to complexity of their interpretation and instability. (see ex. #7)

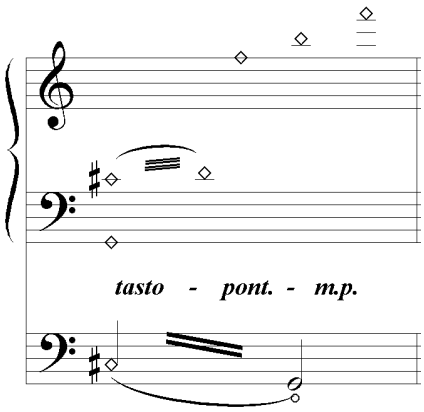
Ex. #7 Cello:



Quasi multiphonic effect

In the next example one sees that the tremolo between flageolet and open string can produce a new effect - a type of multiphonic effect combining overtones with the underlying sound. In this example the following would be alternately sounded: open G; tremolo between c#^{1} and d^{1}; f^{2}; b^{2} and f^{3}. The beauty and originality of this technique becomes apparent by constantly *and* consistently changing the bowing placement. As a result the various harmonics appear and disappear. (see ex.#8)

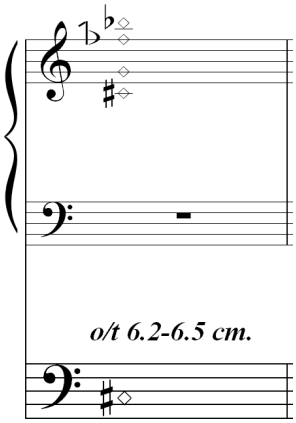
Ex. #8 Cello:



Multiphonics

That the previous example is only quasi-multiphonics can be seen by comparing it with the real multiphonics of the same flageolet: c# on the G string on Cello: (see ex. #9)

Ex. #9:



Definition

The term "multiphonics" refers to a group of simultaneously sounding overtones creating a peculiar polyphonic effect, in other words, a chord.
In the present study, this term refers specifically to a polyphony or a chord, although quite often the very appearance of an multiphonic interval is called "multiphonics".
These are, indeed, similar phenomena, however different in their degree of complexity.

The chord tables

It was already mentioned that, while working on articles, tables of multiphonics for cello and double bass were prepared. This was done in part for:
- composers**,** in order to develop the ability to choose particular, suitable chords for their compositions;
- performers, who might need to find chords suitable for their instruments and thus to adapt for themselves various compositions. As opposed to those for the double-bass, for the cello there are examples of chords for the two strings (C and G) and one chord only for D string.
Not all flageolets produce multiphonics, and besides that, not all performable chords are stable. Those chords which lack stability are not included in the chord tables, though they may be used in performance, e. g. while shifting legato from chord to chord or from flageolet to chord.
In these and other cases**,** playing of chords is facilitated. Chords are most difficult to derive extemporaneously, but this is precisely the requirement for the chords included in the tables. Thus the chord tables for both instruments don't include *all* existent chords.
Due to the large size of the cello and double bass, it is possible to incorporate quarter-tones and microtones into the chord formation – but this would have complicated the work and overloaded the table. That's why the diatonic frame has been left intact in the case of double bass, but quarter-tones were used in the cello table.

Notation of multiphonics

Composers B.B. and Kimmo Hakola, flutists Pierre-Yves Artaud and Carin Levine, as well as other authors have identified and transcribed sounds in considerable detail. Due to variability in chord-sounding on different instruments, some composers avoid decoding multiphonics, whereas others employ a spectral analysis for exact notation. However, a spectral analysis of the physical nature of this phenomenon, which in certain cases provides an exact depiction of pitch and a clear idea of the multiphonic structure, is not compulsory for the practical use of

chords, due to the great variety of instruments as well as the fluidity of resulting sounds with even slight bow shifts.
For this reason, this area of study is not covered in our research. Instead, a traditional, aural analysis of the chord structure has been utilized here.

The definition and notation of the individual pitches of the multiphonics were often rather difficult - especially in the lower register. But only harmonics clearly audible while playing a chord have been selected and identified. Seeing the notation of the chord is necessary only when a composer is looking for nuances of this technique. It is relevant in those cases when a chord is perceived by the composer as not just a sonorous entity, but as a full-blown chord, with its melodic and harmonic features. To some extent, the set of harmonics constituting *the chord* may be determined by playing a flageolet (where multiphonics are possible) and gradually moving the bow all the way between the fingerboard and the bridge in small increments. This way the chord components will sound distinctly. However, this method doesn't allow us to distinguish differences when playing the same chord, e.g. in *ponticello* and *tasto* - providing that such differences are there in the first place)**.** So, finally, to identify and define the components of a chord, one must play multiphonics and listen to them.

Conditions for successful usage of multiphonics

It should be stressed that the lack of familiarity with multiphonics may make more difficult any attempts to achieve this effect on cello and double bass.
In order properly to play a chord, it is necessary to perceive and comprehend its unique sound. A performer who has never studied this technique is capable of producing multiphonics only upon direct perception of its performance, though in practical work there are cases of "erroneous" performance of multiphonics, when their accidental performance is perceived by the performer as a certain audio mishap.
This is based on a universal principle, characteristic of all kinds of performance art: Without clear figurative imagination, without exact internal hearing of the character of an effect that needs to be performed, it is impossible precisely (in pitch and character, image) to perform it. Situations arose repeatedly where the performer could not independently play a chord in an indicated place, but having heard and having seen the playing of multiphonics, a performer there and then finds it. The performer simply reproduces that of which he has a prior perception. Having grasped the unique sounding of multiphonics, it becomes impossible to confuse them with other effects. That's why it seems desirable to acquaint oneself with this phenomenon through the recording included with Bruno Bartolozzi's book or, for example, **Veale, Peter, Mahnkopf, Claus-Steffen,** The Techniques of Oboe Playing (Kassel, Bärenreiter, 2001) or through a study of contemporary compositions for woodwinds or trombone utilizing multiphonics - or to use this edition's audiodisc.

It is possible to consider that the instrument might eventually "remember" the vibration created by multiphonics. While mastering one's multiphonic technique, the performer feels that his or her instrument becomes more sensitive to reproduction of these chords.
It also needs to be mentioned that it is easier to produce chords in the event of a repetition, after having already achieved the desired vibration of the instrument.

A natural or artificial flageolet can be separated into a component group of overtones - multiphonics) under strict observance of the following parameters:

1. *Pitch control*

Precise finger placement is one of the essential conditions for successful performance of multiphonics. A tiny shift of the finger along the fingerboard, i.e., "playing out of tune", may lead to a change in the sound, and this is a real problem. Performance of unconventional flageolets (sometimes with quarter-tones) and with

an unexpected sounding result differing from the typical fourths and fifths, can create additional difficulties in orientation on the fingerboard, especially when a musical fragment is based on this technique exclusively.

2. *bow placement control (precise bow placement) relatively to fingerboard*

Usually players apply the bow position freely, using, for example, all the space of *ordinare.* The bow moves not only perpendicular to the neck, but also at an angle fully covering, for example, the area of *ordinare.*

Multiphonics require a different approach to bow-placement technique – developing the ability first to find the necessary place and then to keep the bow there without straying from this constant position. It is very important to take this into consideration, because performers usually underestimate the importance of this requirement. It is also important to keep the bow perpendicular to the fingerboard. Confronted with difficulties in reproduction of multiphonics, the performer frequently starts to bend the bow-hair sideward, touching a string. It is unnecessary to do so. Upon playing the chord, a slight shift in bow position along the string (beyond the given limits) is possible without degradation of the effect. But it is either quite difficult (due to instability) or altogether impossible to play a chord outside its given limits. That's why the initial playing of a chord requires following all the instructions given in the table.

3. *bowing pressure*

To simplify locating of chords, new particular designations are introduced. Exact observance of not habitual instructions regarding particular *bowing* pressure is a key to success. The pressure also has to be constant while playing.

4. *Bowing speed*

Designations of speed ("slow bow", "fast bow") are seldom heeded, but this factor can also influence the result, so when playing the chord is difficult, one can experiment with speed.

5. *Bow direction*

Sometimes, while acquainting oneself with chord techniques on cello, it is easier to achieve multiphonics with a descending bow movement. However, even at the very beginning of using the technique the most stable chords can be played equally well either with up- or down-bow movement.

No problem was encountered with bowing direction for successful chord playing on double bass. The only exception was the highest G-string, where it was easier to achieve the chord effect with a down movement.

6. *Rosin*

Rosin has to be applied on the bow.

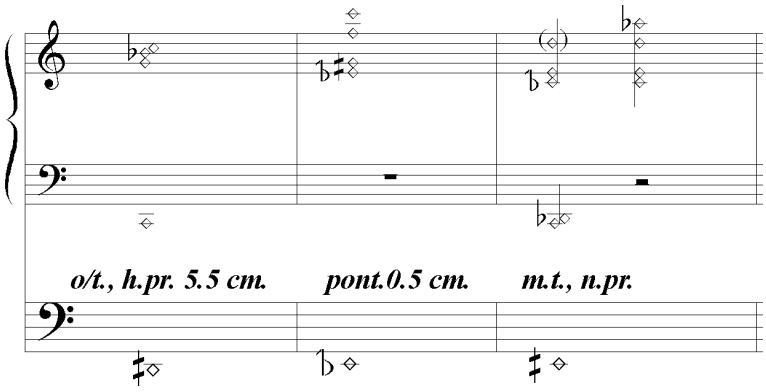
At first sight it seems that to succeed with multiphonics on any string it is enough to play same-position chords on adjacent strings while maintaining all playing conditions. The structure of the instrument is not always perfect even for the parallel fifth on adjacent strings. Therefore it is not always possible to perform multiphonics in the same position on adjacent strings.

Legato movement between strings from a flageolet-chord onto the same flageolet on an adjacent string (while using the same bow position on the string) brings forth the multiphonics in a better way, but is not guaranteed. For this reason, while creating the table, each of the string chords had to be analyzed individually, and only the most stable were included.

The easiest of chords on double bass and cello are on the third string (that is, G-string on cello and A-string on double bass). Therefore, the first acquaintance with multiphonics is preferable on these strings.

While the range of chords that can be generated is considerably larger, the most stable ones have been selected here. The next example shows a possibility for playing a chord from quarter-tones. (see ex. #10)

Ex. #10 Cello:



The placement of the bow

Many chords can be played in only one particular bow position, but some can be generated in other locations with certain differences in chord characteristics.

If the bowing is performed in different areas between the fingerboard and bridge, the chord effect changes accordingly. As a rule, lower overtones are shown in *tasto* and higher overtones are shown in *ponticello*. In practical terms, the three basic position descriptions [*tasto, ord., pont.]* are insufficient in themselves for successful performance of chords.

On the test **cello** with a 10 cm. length between the finger-board and the bridge, this has been divided into 7 sections of 1.4 cm. each, which is approximately the width of the bow. This unit of *a bow width* can be used as the basic unit of measurement and be applied to describe the place of bowing. The first unit, being the bow width closest to the bridge, is designated "*molto ponticello"* [*m.p.*] and the closest to the fingerboard – "*molto tasto"* [*m.t.*]. The other 5 from bridge up are designated accordingly as: "*pont.", "pont./ord.", "ord.", "ord./tasto" and "tasto"*.

The bridge-fingerboard distance varies considerably on different instruments.

Regardless of this fact, one can use the following tables as a basis. (see table #1):

Table #1 Cello:

PLACE OF BOWING	DISTANCE BETWEEN THE BRIDGE AND THE BOW
Molto ponticello /m.p./	0 cm.
Ponticello /p./	1,4 cm.
Ordinare /ponticello /o./p./	2,8 cm.
Ordinare /o./	4,2 cm.
Ordinare/tasto /o./t./	5,6 cm.
Tasto /t./	7 cm.
Molto tasto /m.t./	8,5 cm.

The highest placement corresponds to 8.5 cm., because in this position there is only 1.5 cm. remaining to the fingerboard. The upper bow edge almost touches the fingerboard.

On the test **double bass**, the distance between the bridge and fingerboard was 22 cm. (8,66 inches) Because the distance was measured between the bridge and the nearest (low) edge of

the bow (the hair of which is 1.5 cm wide), in the *m.t.* position the effective distance was 20.5 cm. This distance was subdivided into 7 segments of 3.15 cm. (see table #2):

Table #2:

PLACE OF BOWING	DISTANCE BETWEEN THE BRIDGE AND THE BOW
Molto ponticello	0 cm.
Ponticello	3. 15 cm.
Ordinare/ Ponticello	6. 3 cm.
Ordinare	9. 45 cm.
Ordinare / Tasto	12.6 cm.
Tasto	15.75 cm.
Molto tasto	18.9 cm.

In those cases where a chord can be performed in adjacent positions, e.g. "*pont.*" and "*ord./pont.*", bow position is marked as follows: "*pont.- o/p.*" or "*tasto.-ord.*"…
It is sometimes possible not to take small discrepancies (e.g., one millimetre) into account. The indicated specifications are absolutely precise only for the instruments identical, in size to the instruments described in this article, but this data is not hard to adapt to any instrument. When taking into account the size of a particular instrument, one should clearly delineate the boundaries of the seven positions.
And lastly - an accurate measurement system, up to tenths of a millimetre, is required in the process of mastering the technique while a musician is unaccustomed to operating under these new, more challenging conditions. In the future, indications like *o/p –ord.* might suffice.

Bow pressure

At first glance, one may think that a volume designation should be used instead a parameter "bowing pressure". However, in the case of multiphonics this concept - "bowing pressure" - is more accurate for portraying the character of playing chords as compared to volume, because in multiphonics the pressure is not in direct correlation to the volume.
the following designations are suggested for bow pressure:
Light pressure (l.pr.) - pressure approximately corresponding to ***pp***
Normal pressure (n.pr.) - pressure appr. corresponding to……***mf***
Heavy pressure (h.pr.) - pressure appr. corresponding to……***f***
Drilling pressure (dr.pr.) - pressure appr. corresponding to……***ff***

Bowing speed

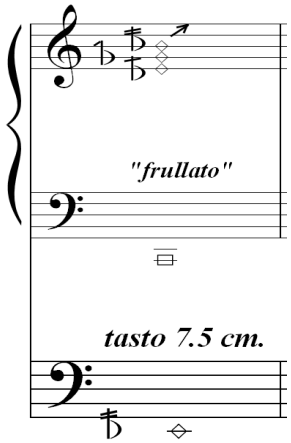
In those cases where a certain change of the bowing speed does not interfere with performing of a chord, speed designations are not applicable. Designations "slow bow" and "quick bow" appear when it is impossible or difficult to play a chord at a medium speed.
It is important to emphasize the necessity to take this parameter into account as something that could assist in reproducing a chord.

Arrows

Two types of arrows are introduced:
The first type:
An inclined arrow notation is used to assist performers in finding and reproducing the chord. A down-pointing arrow indicates that the bow should move slightly towards the bridge, and an

upwards arrow slightly towards the fingerboard. This corresponds to the real movements of the bow. (see ex. #11)

Ex. #11 Cello:



The second type: Horizontal arrow.
This points at the tone or tones which stand out in chord.
A horizontal arrow can help composers visualize the dynamic nuances within the chord. The fact is that not all of the tones comprising a chord resonate equally. Some of them stand out, as if highlighted, while others are distinguishable only on close listening. In those rare cases when all the tones are balanced, arrows are not required. If a tone is just slightly audible, it is put into brackets. (See ex. # 13, 15-18, 22)

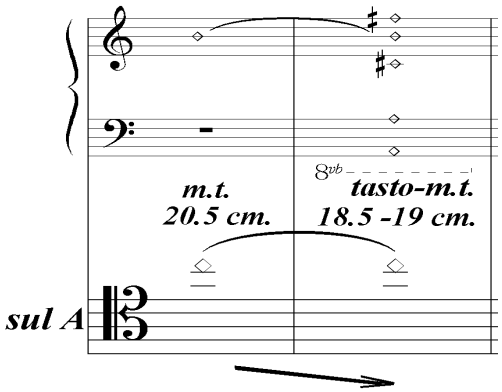
The Transformation of harmonics into a chord

It is easier to create multiphonics by starting to perform an individual flageolet, which, with a change of performing conditions, "disperses itself" into a chord - as though a chord "emerges" out of a flageolet. This can be reached by two ways:

1. **Changing the point where the bow touches a string.**

Starting from a position outside of the chord area, and moving the bow into a corresponding area, we gradually and more definitely move from flageolet to multiphonics. A change in bow position over the fingerboard results from simultaneously moving the bow perpendicular to the string and along its length. (see ex. #12)

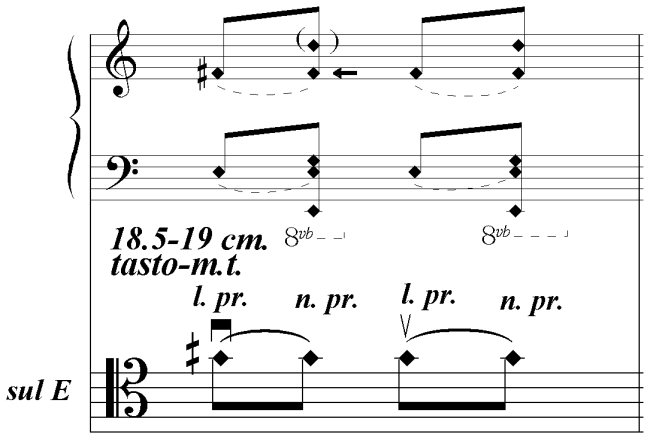
Ex. #12 Double bass:



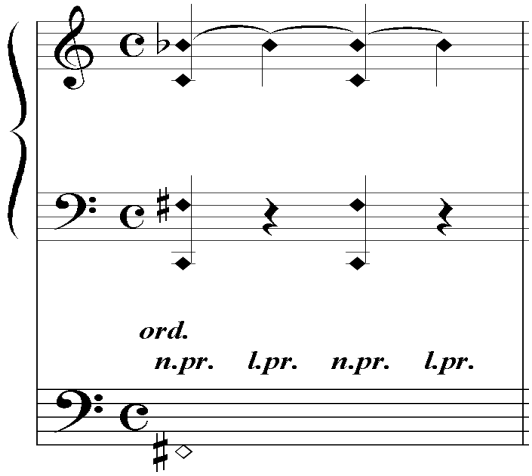
2. Applying additional pressure on the string.

In some cases the increasing the bow pressure can transform a harmonic into a chord effect. This technique is applicable when a pressure greater than "*light pressure*" is required for playing a chord. (see ex. #13 and #13a)

Ex. #13 Double bass:



Ex. #13a) Cello:



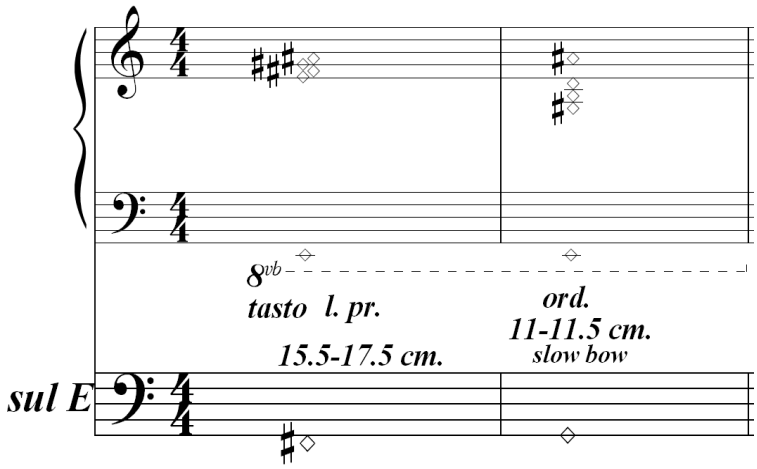
Transformation of a chord into a harmonic

This is a reverse case: of "dissolving" a chord into a single flageolet or its inversion. In the first case, one can get back to the original harmonic by shifting the bow up and down from the chord location to a non-chord location; in the second case, by weakening the bow pressure until the disappearing of chord. (see two previous examples)

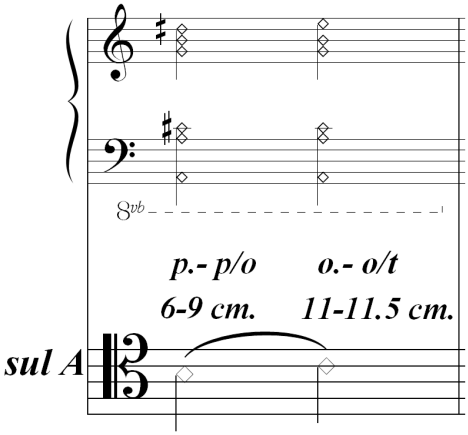
Comparison of the same string's chords on different natural flageolets

Comparing two or more chords produced on the same string helps to grasp their particularities and differences, since not only sonoristic but also melody-harmony factors of the chords become obvious. When played on the same string using different natural flageolets, multiphonics differ in their individual sets of overtones while effectively remaining variants of the same chord, whose basic tone corresponds to the tone of the respective string. (see ex. #14 and #14a)

Ex. #14 Double bass**:**



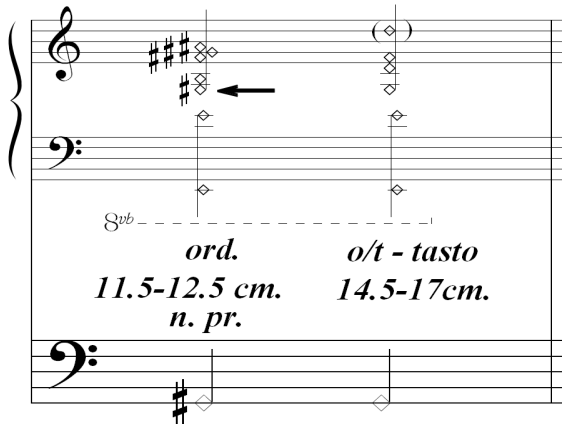
Ex. #14a) Double bass:



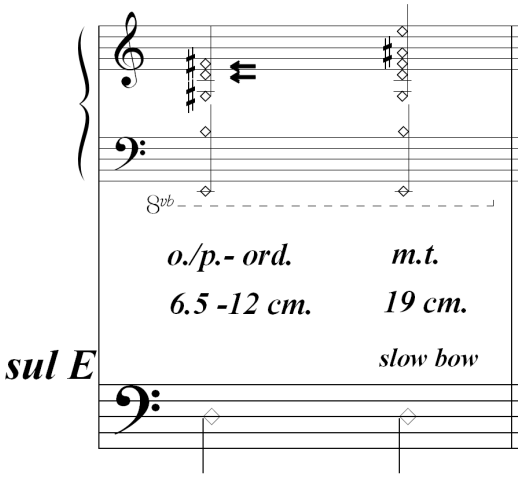
Different chords in one flageolet

As it has been mentioned, even within one flageolet is possible to perform different chords through use of a different placement of the bow. The set of overtones and the timbre (coloring) of a chord may be changed. Normally the higher overtones are produced in *molto ponticello* (*m.p.*), whereas when playing multiphonic chords one can hear higher overtones with *molto tasto* (*m.t.*). (see ex. #15 and #16)

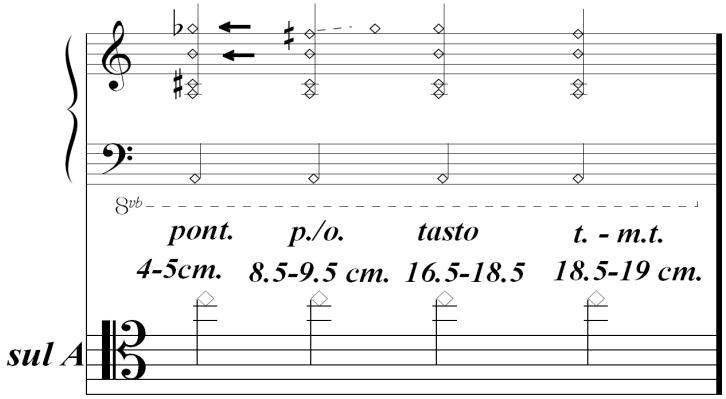
Ex. #15 Double bass**:**



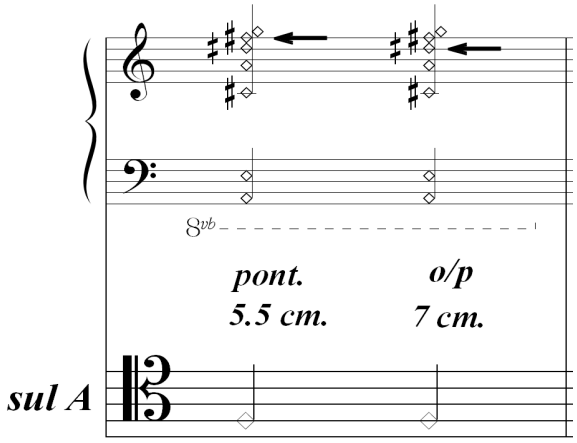
Ex. #16 Double bass**:**



Upper overtone can be made to shift. (see ex. #17)
Ex. #17 Double bass**:**



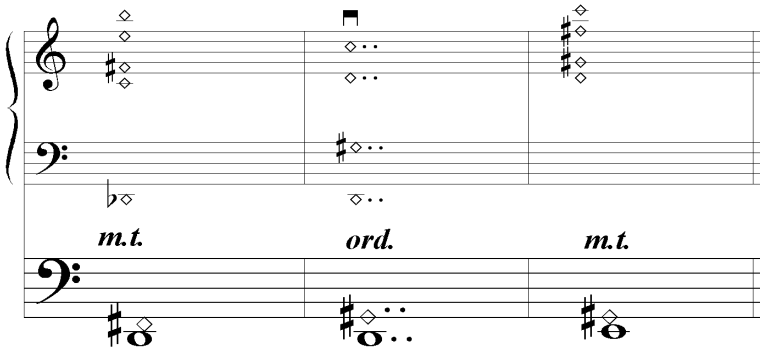
In the following example, with a vertical shift of a bow, different harmonics within a chord can be emphasized. (f#^{2} when the bow is 5.5 cm from the bridge, and a higher d^2 with a 7-cm shift). The content of the chord does not change.
The horizontal arrow is used for this. (see ex. 18)
Ex. #18 Double bass**:**



Multiphonics on artificial harmonics

All playing techniques presented here are applicable for use with the artificial harmonics of major seconds, minor thirds, major thirds and tritones. In comparing all useful flageolets

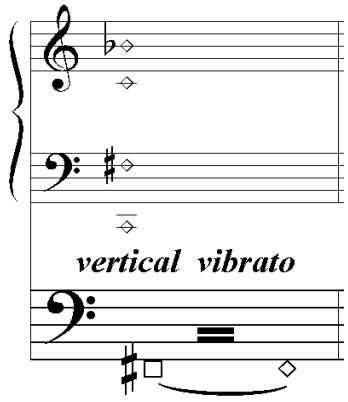
(natural and artificial) for the formation of chords, perhaps the major second ones are somewhat less stable. Other cases are not discussed here, but it is possible to produce sixth and even seventh harmonics in the high register. In the next example a way is shown to chain a succession of artificial flageolets by moving just one note: lower or upper. (see ex. #19)
Ex. #19 Cello:



Effects, which determine chord coloration

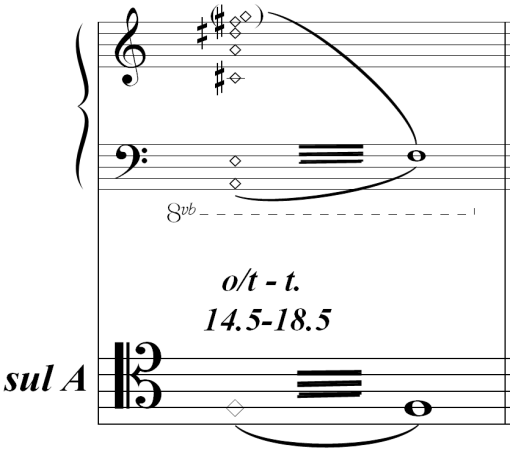
I *Vertical vibrato*

This technique (see p. 4) is applicable to chords as well. Vibrato brings a new dimension to the chord. However, at the same time, it creates certain performance complications. Different chords react differently to use of vibration. Some of them completely disappear. Furthermore, individual strings react to vibrato differently. On the 4th string, there is a better chance of sustaining the chord effect with vertical vibrato only when using strong bow pressure. On the third string, the vertical vibrato effect of the chord is audible even with light pressure. Vibrato should be handled gently, because the chord may simply disappear. (see ex. #20)
Ex. #20 Cello:



II *Vertical vibrato with touching of the fingerboard*

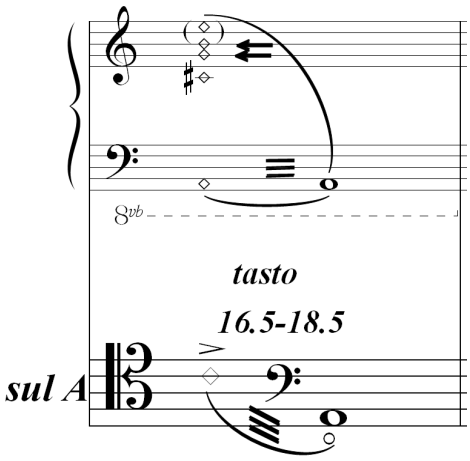
We can vary this effect by pressing a string all the way down to and touching the fingerboard. In such cases, in addition to the multiphonic chord, a "flickering" tone is produced corresponding to the point where the finger touches the fingerboard. There is an impression that the sounding of a chord has not been interrupted. (see ex. #21)
Ex. #21 Double bass:



III *Tremolo with open string*

A peculiar tremolo effect can be produced with a rapid finger movement whereby the player alternately touches a string and raises the finger. The chord in this tremolo is colored by a specific pulsation of the basic tone. (see ex. #22)

Ex. #22 Double bass**:**



IV *Playing simultaneously on two adjacent strings*

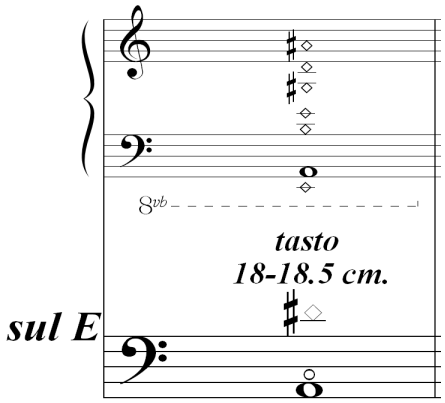
By incorporating the additional tone of an adjacent string, new colors may be added to a "safely tonal"-sounding chord.

This change may vary from a slight coloration to dissonance when both chord and flageolet are heard. Even a complete transformation of the timbre may take place.

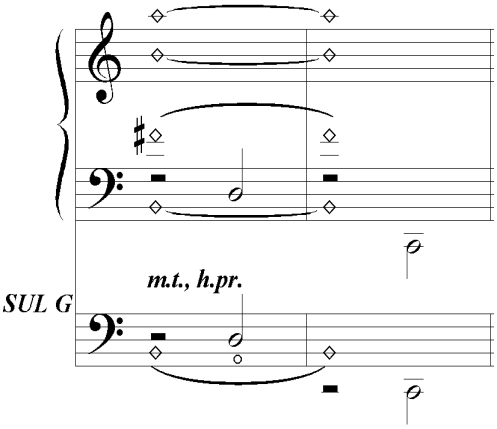
A) *The chord played together with an adjacent open string.*

The sound of an open string dynamically balanced with multiphonics produces a dark gloomy atmosphere. (see ex. #23 and #23a)

Ex. #23 Double bass**:**



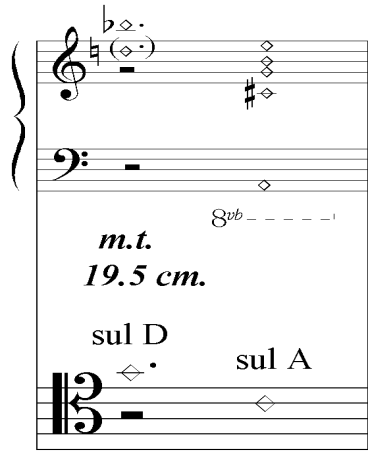
A difficulty in performing the next example is explained by the fact that the chord is not intended to dissolve into a flageolet, although the bow “rolls” around the periphery of the string, all the while touching the neighboring strings, both to the right and to the left.
Ex #23a Cello:



B) *Chord and flageolet*

A chord and a neighboring string flageolet can create a variety of sound combinations. In this example, the B-flat of the second octave joins in smoothly. Sometimes instead of b^{b2} we get d^{2}, so it is put in brackets. (see ex. #24)

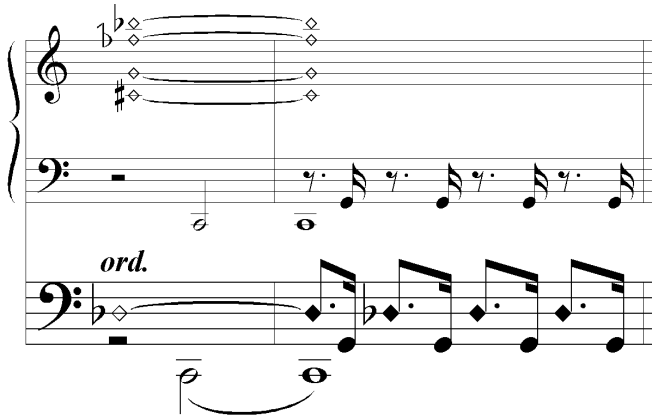
Ex. #24 Double bass**:**



C) Multiphonics simultaneously with an occasionally or periodically flickering open string and with an adjacent open string

This technique requires performing stability. The chosen multiphonics also need to be stable. To retain a chord effect, it is permissible to release flageolet only for a short instant. (see ex. #25)

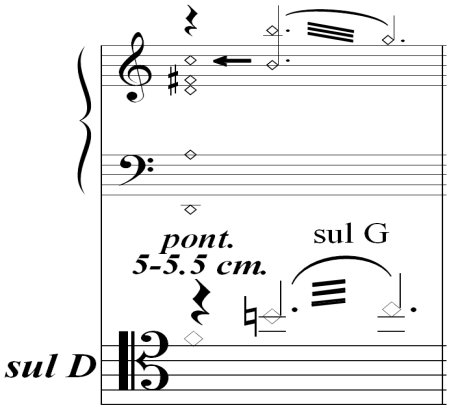
Ex. #25 Cello:



E) *Chord and harmonics with tremolo.*

Such a tremolo effect produces a variety of additional overtones. In *ponticello*, (as it was mentioned) even the slightest shift of the bow gives a new overtone, thus varying slightly the effect on each repetition. (see ex. #26)

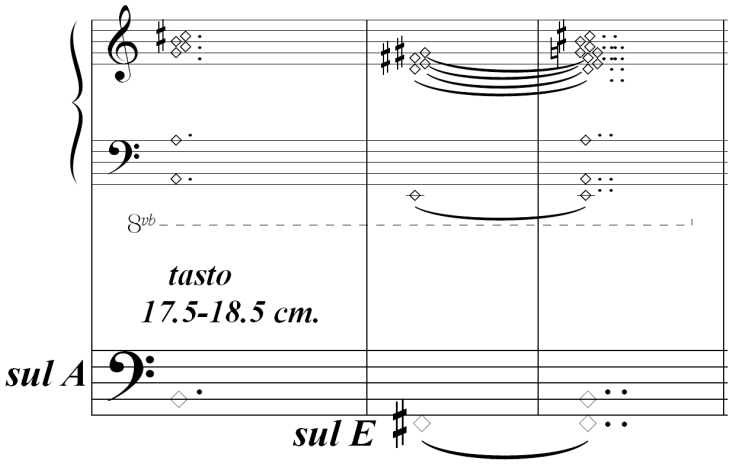
Ex. #26 Double bass**:**



F) *Two chords simultaneously*

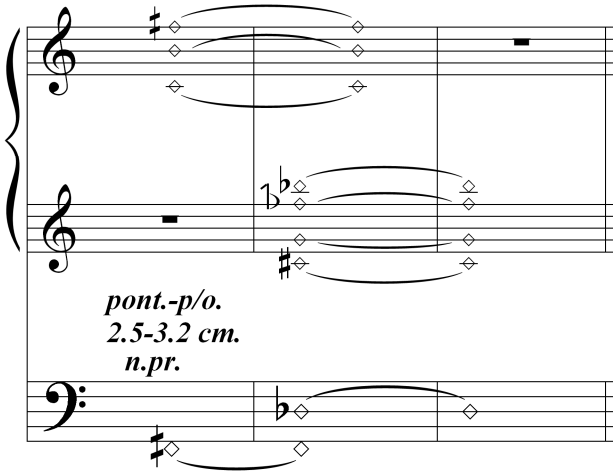
In order to simultaneously perform two chords, a musician needs to master the technique. Playing two multiphonic chords simultaneously requires a sharp and precise ear control. The performer must clearly hear the chords resonating from two adjacent strings. Even an extra flageolet may create a dissonance, hence complicating the sound with an erroneous perception of two multiphonics. For this reason it would be recommended (as shown in the example below) that the musician play the two chords in succession and only after that combine them. Also, this would allow both performer and listeners to better perceive the "color palette", better comprehend and appreciate this complex sonorous pattern. In this example, a very rich cluster-chord is given. (see ex. #27 and #27a)

Ex. #27 Double bass**:**



In the next example, one finds a different principle for merging of the chords: the second chord joins the already resonating first one; therefore its clear sounding appears. Its resonance is heard when the performer stops playing the first chord.

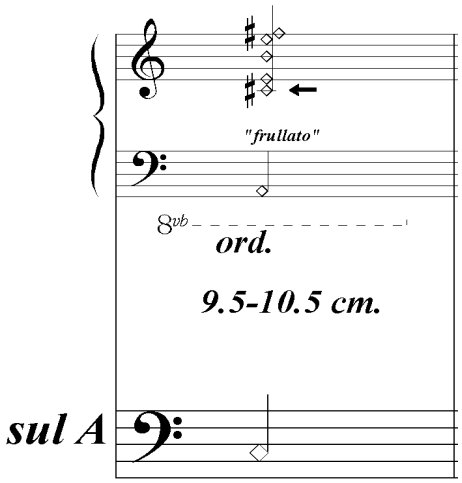
Ex. #27a) Cello:



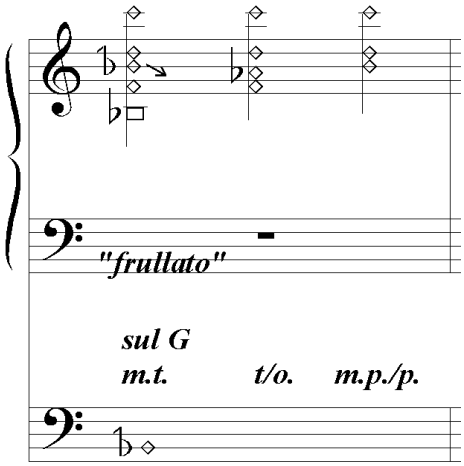
"Frullato"

Where low overtones intermingle, making precise fixation impossible, an effect resembling *frullato* on woodwind instructments may be produced. Thus, in such a chord there are additional sounds, and their presence is indicated by the designation *frullato.* (see ex. #28 and #29)

Ex. #28 Double bass:



Ex. #29 Cello:



Conclusion

This work describes various possibilities for applying, varying, and sophisticating the resource of multiphonics. This being said, one must clearly anticipate the results produced by applying the described techniques. Even a slight sonorous addition complicating the chord may destroy its specific character. On the other hand, an intentional, considered addition enriches the effect.

Experience obtained through application of this technique suggests that an unanticipated correlation of chords blurs their distinctions and complicates perception of timbral interplay. The chord technique should be applied with great precision.

Multiphonics constitute a very specific effect and should be applied only to the extent justified by artistic necessity, by the intended character of music.