УДК 78

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THE DUAL NATURE OF SOUND AS RAW MATERIAL OF MUSIC

The research and observation of the sound nature is the main objective of this article, since that is the raw material of music.

Wouldn't it be desirable for most research of music theory to have the nature of sound as the basis of its study?

Would it not be a more powerful and objective tool, if we learn the creative and subjective fact which is music, through the relationships and structures derived from sound that obey natural and objective laws?

My research and conclusions are based on the study of the natural harmonic series of sound. The Fundamental natural series is the main conclusion. Sound has a dual nature that best explains musical relationships.

Key words: *music theory, nature, sound, harmonic series, basic series, dual nature of the sound.*

1. The nature of sound as the basis for the study of music

Firstly, I think that music research should take a new direction. The knowledge of music theory is almost exclusively based on models with a certain mathematical logic (scales, modes or tonality, etc), (Sociedad Española de Acústica. *Journal of acoustics,* 2010)[1] extracted from musical practice, or the common practice period (Piston, 1941)[2]. But penetrating the secrets of the nature sound, (that is the raw material of music together with time), is the task in which we should necessarily devote our efforts.

I propose to study, observe and investigate the structures and characteristics of sound. My idea is to work from its natural resonance. Through a physical-acoustical description of this we can reach their derived mathematical models. All this will explain phenomena and sound relations generated in music, in a more objective way, which is clear, simple and transversal.

2. Description of the Natural Harmonic Series

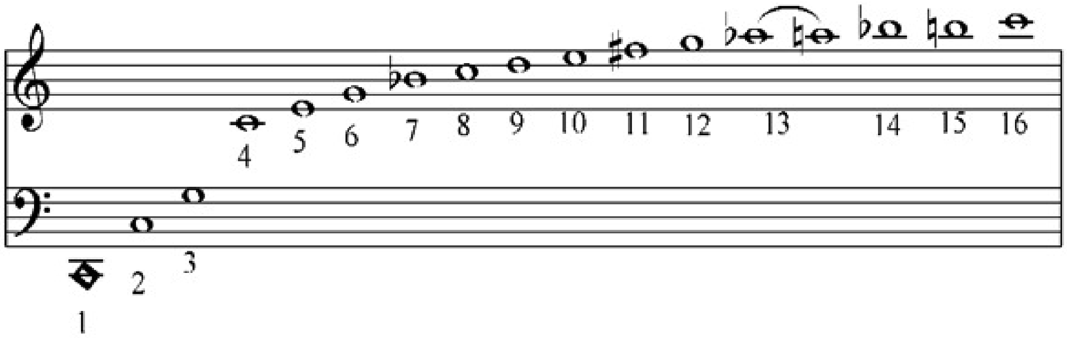

Figure 1. The Natural Harmonic Series

In this figure, we can see the traditional representation of the harmonic series of the frequency which has Do_1 (C_1) as its fundamental.

The series of resonance exceeding the range of sounds that accompany a fundamental sound so that these sounds are associated with a fundamental by a whole number of times is called the Natural Harmonic Series. If ***f*** is the frequency of the fundamental sound, also called first harmonic, the upper harmonics frequencies will be 2***f*** 3***f*** 4***f***, etc., we refer to them as second, third, fourth, harmonic etc.

The physical-harmonic phenomenon, which is a well-known principle by any musician for the significance that it has in musical theory and its application to the basic principles of harmony, has a well-known mathematical basis.

From the physical-acoustical point of view, it is defined by a succession of sounds of multiple integer frequencies of the fundamental frequency. From the point of view of music theory this would be represented in figure 1.

2.1 Features of the first harmonic:

As Antonio Calvo Manzano illustrates in his book Physical-Musical Acoustics. (1991)[3]:

The harmonics of a sound give the complex sound they form particular characteristics that define this complex and in which each of such harmonics, is important and plays a specific role. We thus have:

The First harmonic: has the greatest intensity and determines the height of the complex sound of which it is part.

The Second harmonic: Reinforces the feeling of height of the fundamental giving further precision. Their octaves, harmonic fourth, eighth and 16th reinforce the feeling of the second.

The Third harmonic: As we know, the third harmonic is a perfect fifth with the second, so its importance is decisive in the complex sound that it integrates. The corresponding octaves, i.e. the sixth and twelfth harmonics reinforce the importance of the third.

The Fifth harmonic: This harmonic is also of utmost importance to form, together with the third and first, the perfect major chord. The complex sound provides a warm, round Bell. The tenth harmonic intensifies the qualities of the fifth.

The Eleventh, Thirteenth and Fifteenth harmonic: These complex sounds give a rough appearance, especially the first two.

The intensity of the harmonics will decline with height, appearing after the fundamental in order of height, and disappearing in the reverse order, so that higher-order harmonics lose importance when it comes to conferring special features to the sound set up.

The first six harmonics have greater importance because they form a perfectly balanced whole.

I have added two things to this descriptive analysis:

a) **The Harmonic seventh:** is part of the balanced set of harmonics with higher importance. Therefore, I would say that numbers 6 and 7 form harmonics of this ad hoc group.

b) **We might call this balanced set a natural chord.**

This is what we would call a dominant seventh or 7^{th}.

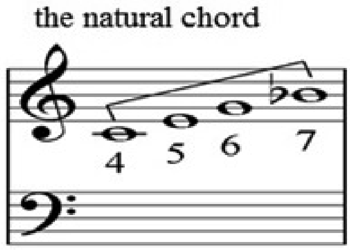

Figure 2. The natural chord

2.2 Conclusions of the observation of the harmonic series

We continue with Antonio Calvo Manzano's indications in his book physical-musical acoustics. (1991)[3]. My comments in this regard will appear in Parentheses and italics.

1. Intervals between each pair of successive harmonics become smaller.

As an example, 3-2 interval has 7.02 tempered semitones and the 4-3 is 4.98 tempered semitones.

2. Each octave has as many overtones as the number of orders on which it starts and the double of the previous octave. (*We could call this a harmonic cycle).*

For example the octave that begins in the harmonic 4 has four harmonics; 4, 5, 6 and 7. In addition, this octave has twice that of the previous, which only has two; 2 and 3.

3. All the fractions representing intervals between harmonics that are equivalent, i.e. their ratios are equal, represent the same interval.

For example 12/8, 6/4 and 3/2 intervals. These fractions are equivalent and therefore represent the same interval.

4. When the range is formed by two harmonics so that the numerator is divisible by the denominator, the ratio represents the number of order that the sharper sound would be in a harmonic series whose fundamental was the lowest sound.

They are harmonic 15-5. 15 is divisible by 5, and its ratio is 3. Furthermore, this means that the harmonic 15 would be 3 in a series in which the fundamental harmonic is 5. In the C scale, the 5th harmonic is E and the 15th harmonic is B. Consequently, when the scale begins in E the third harmonic is B.

(*The order of relationship of the sounds of the harmonic series is universal and independent of the fundamental choice between different series as in the interior of the same*).

5. Any sound can be harmonious from different series, logically changing the order number.

This conclusion is a consequence of the above that as we have seen the sound B was harmonious from two distinct series, also remaining so in other series. This circumstance is used by many wind instruments.

(*Derived from this same concept we can deduce and establish a second nature of sound. That of being a harmonic of all fundamentals*).

3. The natural resonance series of the common harmonic fundamentals as a conclusion derived from the harmonic series.

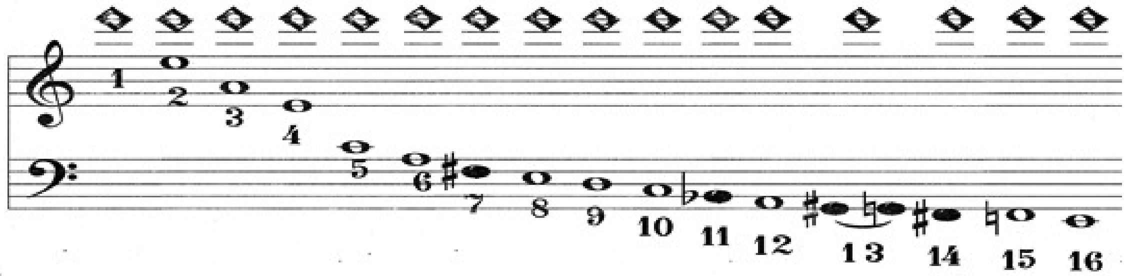

Figure 3. The fundamentals series

This series is defined and constructed from the common harmonic of all the fundamentals that can generate it.

This series is not the lower resonance series of a sound, which is based on the succession of sounds of less than one fundamental resonance. As Hugo Riemann postulated (general theory of the 1945 music)[4], Keeping the same intervals that are obtained in the harmonic series, but by reversing it. It is known that sound «echoes» only with harmonic superiors and never lower harmonics, which do not exist.

It is about grouping all the fundamentals that can generate the same harmonic but naturally in different orders.

It can be demonstrated with relative ease using the piano. If you move three keys lower than the lowest register, without sounding the notes corresponding to the famous perfect chord, for example, **A - C- E**, and the **E** of the higher octave is sounded, you will see that the hammered note, is now producing its sound on the three notes that we have not hammered. We can observe that the intensity of the resulting sound is notably stronger hitting all three at the same time than each separately.

4. FINAL CONCLUSIONS:

Derived from the natural harmonic resonance series, and the natural fundamental series from the same common resonant harmonic, we can deduce and establish two natures of sound. This dual nature of sound will depend on being the resonant or generator of the resonance. Therefore, all the sounds have this dual nature, being harmonic or fundamental and this leads to better explain the phenomena and sound relations that are generated in the music, in a more objective, clear, simple and transversal way.

For example:

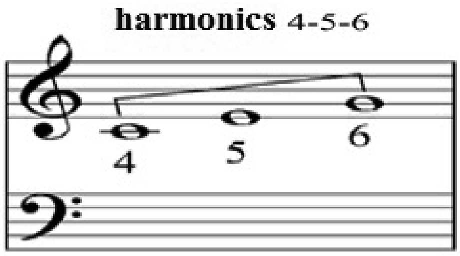

Figure 4. Harmonics 4-5-6 perfect major chord

We could say that the **harmonic series 4-5-6** form the **perfect major chord** in our music theory, while the **fundamentals 4-5-6 of the series of fundamentals** proposed form the **perfect minor chord**,

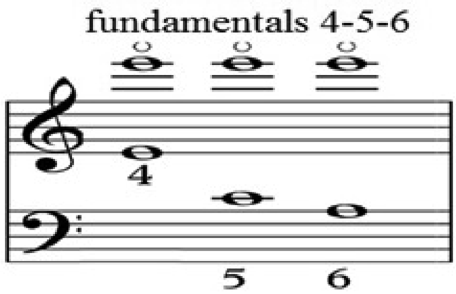

Figure.5. Fundamentals 4-5-6 perfect minor chord

demonstrating the harmonic convergence of the three fundamentals in a common harmonic. This concentration ratio is the closed auditive perception, which is melancholic or even sad which the minor chord generates as opposed to the open, extrovert or even joyful perception that the major chord generates by its divergence from a fundamental to three different harmonics.

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