

## **5. Laws of Sounds and the principles of Consonance & Dissonance:**

Music is a dual entity. It is a science as a matter of exigency and an art by nature. As a science it has to obey certain physical laws while as an art it creates its own forms and order so as to make a direct appeal to man's aesthetic instincts and enrich him emotionally. Truly good music cannot afford to sacrifice any of these aspects, indeed the two are inseparable. For music without aesthetic appeal is a meaningless tyranny however scientific it may be in the physical form, while a mere poetic call on the imagination has not the power to make the same direct and tender appeal, as and when it is accompanied by even a cursory melodic phrase. The process which infuses artistic and emotional values in music forms the aesthetics of music. Such values are often secured by extension of physical laws and in some cases by a deliberate departure from them.

To understand any system of music and the technique of its several forms of its expression, it is necessary to know these laws at the very outset. We may, therefore, state those physical laws first and consider the aesthetic principle later. To begin with, music finds an expression only through the medium of sound. Sound, which is musical, is pleasing to the ear while the noise is distinctly jarring. In a musical note, however, attentively we may listen to it we perceive no change or variation. The sensation is perfectly continuous and uniform. Also, all the musical sounds, whatever their origin, may be distinguished from each other by three different qualities, firstly by the loudness or the **intensity**, secondly by the pitch or the **frequency** and lastly by the difference in the peculiar quality or the **Timbre**. It is also known that the music judges two notes/swaras only by their mutual relation or by the musical interval between them. The musical interval is the ratio between their vibration numbers. It is a common experience that some intervals are consonant, while some others are dissonant in their effect.

The cause of dissonance between the two notes is the generation of beats. The range over which the dissonance due to the beats persists is different for different frequencies. It is small in lower octave and become greater with each higher octave. There is, however, an appreciable difference in numerical values of several dissonant ranges as obtained by different scientists. It, however, appears that the dissonance is maximum when the interval between the beating notes is near about a semitone and

becomes less as the interval increases and finally disappears when it amounts to a Minor Third.

It is well known that notes emitted by a stretched string are complex and contain, in addition to prime note, its harmonic upper partials. The partials completely blend in to prime and are found to bear simple and determinate ratios towards it. Thus beginning with prime note, the frequency ratio of the successive members of harmonic upper partials series may be represented by the series 1:2:3:4:5:6:7 etc. Here then is the key to determine the consonant or dissonant character of the two notes, sounded together.

Thus if the two notes have between them such simple ratios as 1:2:3 or 1:1/2:1/3 etc, either no beats at all will be generated or if generated they will give a note which will blend in to the prime note and enrich its quality. **Such exceptional cases are called consonances.** There are, however, degrees of consonance according to the degree of harmonic relationship between the notes. Thus when one of the notes happens to be the direct upper partial of the other, the consonance is absolute or the most perfect. Such consonance, therefore, is of the first order. If, however, neither happens to be direct harmonic partial of the other, but both of them are so related as to be harmonic partials of a third note serving as a common root, the consonance, though not absolute, is still perfect and belongs to be of the second order.

Again in harmonic series, the proper and the nearer harmonics are more consonant with the prime note than the more distant notes i.e. the harmonics related with the 1:2 is more consonant with the prime swara than the harmonics related with ratios 1:3 or 1:4 or 1:3/2 or 1:5/2 etc. **This is true for both the ascending and the descending orders. The present study is entirely based on this principle.** That is to say that the harmonics related with ratios 1:2 or 1:1/2 will be more consonant with the prime note than the harmonics related with the ratios 1:3 or 1:1/3. In other way it can be said that the degree of consonance in the harmonic series 1:2:3:4 will be same as that of 1:1/2:1/3:1/4 etc and the consonance level of harmonics so related will be in decreasing order.

Also, between themselves the harmonic upper partials are mutually out of beating distance up to the 7<sup>th</sup> partial only. After that the consonance is toned down and leads towards dissonance and is finally replaced by dissonance when the sixteenth partial is passed. But those higher partials are so feeble that they are hardly audible and hence do not invite any further consideration.

**Thus, it is clear that the nearer and more direct the harmonic relationship between the two notes the greater is the degree of consonance generated between them.**

Naturally, between the two notes there will be such relations as those of absolute consonance, perfect consonance, medial consonance, imperfect dissonance and complete dissonance etc. Though early members of harmonic series furnish between them all the consonant intervals upon which music is based, yet in practice it is impossible to restrict the music to higher harmonics.

The jump from the fundamental swara to the octave is very great and requires the introduction of other consonant notes in this interval. The study of harmonic series offers here a good precedent. In fact the consonant ratios 2:3, 3:4, 4:5 etc. given by first few harmonic partials may be judiciously used in introducing the required notes. Thus a set of notes, to be mutually consonant must employ one of these ratios between its individual members. This simplifies the work of choosing the consonant notes.

In practical music, however, it is not enough to take into consideration the relation between the two notes only in as much as melody or harmony (Western music) invariably consists of more than two notes. Thus there will be chords of three, four or more notes. (A chord however usually means a chord of three notes). And with the help of two such cords it is possible to derive chords with four or more notes. The two fundamentals chords are known as Major Chord and the Minor Chord respectively and form the key stone of Western system of music. Thus the three notes which have the vibration ratios of 4:5:6 form the Major chord, while the ratios of the notes of the Minor chord are 10:12:15.

**Indian music however does not directly employ either of these chords but brings out the relationship between the notes by referring them to the constant accompaniment of a drone which serves as a tonic chord of all music sung or played.**

**Theory of consonance:** The relationships of musical notes are of three categories, Identity (Samatva), Consonance (Samvada) and Dissonance (Vivada). The first kind of relationship is in popular usage, supposed to exist between one note and another which is eighth in degree above it. This would appear from the long established custom of calling these two notes by the same name; though, in a point of fact, one is higher in pitch than the other having two times (double) the number of vibrations.

As explained earlier the two notes are said to be also consonant to each other if they have a common upper partial perceptible to the ear. **The feeling of consonance is produced by common partial which, being in a sense identical with each of the two notes, serves as connecting link between them and produces an aesthetic satisfaction or pleasure by enabling the subconscious mind to connect the two notes with a common bond.**

There are altogether six relationships of consonance with the prime swara Sa. These according to the degree of their consonance with their respective ratios are;

- |      |                           |     |                                 |
|------|---------------------------|-----|---------------------------------|
| i)   | Fifth (i pe)              | 2:3 | (Perfect Consonance, Samvadi)   |
| ii)  | Fourth (pr f l)           | 3:4 | ( ---do--- )                    |
| iii) | Major Sixth (vk ùk'k'B)   | 3:5 | (Imperfect Consonance, Anuvadi) |
| iv)  | Major Third (vk ùk r'rh ) | 4:5 | ( --do-- )                      |
| v)   | Minor Third (y?h'rh )     | 5:6 | ( --do-- )                      |
| vi)  | Minor Sixth (y?k'k'B)     | 5:8 | ( --do-- )                      |

The notes Sa & Pa constitute one of the several pairs of notes having the relationship of fifth to each other. Taking 'Sa' to represent a note of 10 vibrations, Pa would be a note of 15 vibrations. The least common multiple of 10 & 15 is 30. This is the number of vibrations of the common upper partial of the two notes. This number having twice the number of vibrations of 'Pa' is its second partial, which is the Pa of the higher octave. It is likewise the third partial of 'Sa' as its vibration numbers is three times that of the latter note.

Similarly, the ratio numbers of the last of the above mentioned consonances are 5 & 8. The common upper partial in this case is, therefore, the eighth partial of the first note and the fifth partial of the second note. **The eighth, being the last of the partials perceptible to the ear, the minor Sixth is to be considered as the lowest of the consonances.** The six consonances may be divided in to the two groups of designated perfect and imperfect consonances. The first two in the list are included in the first group and remaining four in the second. There is a marked difference in the degree of consonance of these two groups. It is probably owing to this difference that in ancient India they were given separate names viz Samvadi (l òknh )and Anuvadi (vuòknh).

The third kind of relationship, called '**dissonance**' need no definitions as all relationships, which are neither those of identity nor those of consonance belong to this category. **Any relationship between the two notes, which the human ear cannot connect with each other, may be considered as dissonance.** It is, however, a well known fact that dissonance has no place in music. It is also a well known fact that the number of dissonant intervals in a scale is almost equal to that of consonance ones. **A noteworthy feature of every scale is that the two notes which are nearest to a particular note in the scale are both dissonant to it.** For example, 'Sa' & 'Ga' are both dissonant to 'Re'. All the consecutive notes in a scale are dissonant to each other. **Also the dissonant intervals are as frequent as consonance ones in melodic compositions.** The explanation of this, apparently paradoxical phenomenon, is that the notes of most of these intervals are related to each other indirectly through a common consonant note. The dissonant intervals so related have a special value in music and are termed related dissonance (लक्ष्य विषमता) in order to distinguish them from the remaining masses of dissonant intervals, which are useless for musical purposes.

There are four kinds of intervals between consecutive notes, namely Major Tone, Minor tone, Major semitone & Minor semitone as explained in Western Music. An interval having the ratio of 25:24 which is the difference between the 'Major Third' and the 'Minor Third' is used in some very popular scales found only in India. This interval is called a Small semitone. Another interval between the consecutive notes, which may be expressed by the ratio of 75:64, is also found in few scales and is called a 'Large Tone'. These are thus altogether six kinds of intervals between the consecutive notes of a scale. These intervals with their ratios are shown below in order of their size, the largest one being placed first. Large Tone 75:64, Major Tone 9:8, Minor Tone 10:9, Major Semitone 27:25, Minor Semitone 16:15 and Small Semitone 25:24.

Also, the notes separated by a major tone are indirectly related to each other through the note which is Fourth below the lower note and Fifth below the upper. The notes having a Minor tone difference between them may be related either through the note with fifth below the lower and major sixth below the upper note, or through the note/swara which is Minor third below the lower and Fourth below the upper note. The other intervals are also similarly related.

### **The Relations of sounds used in Melody & Harmony:**

‘Gounod’ once wrote that sounds alone can no more constitute music than words alone can constitute a language. Words can form a proposition, an intelligible sentence, only when they are associated in a logical sequence according to the law of intellect. This is also true of sounds which must obey certain laws of attraction and mutual response, by which is ruled their production successive or simultaneous, before they can become a musical reality, a musical thought.

The number of possible musical intervals is unlimited but, because of the limits of discrimination of our ears and of the consonance properties of some ratios, the number of intervals utilized in musical practice is limited. For a musical evocation, the simpler acoustic intervals are sufficient. Besides they appear so natural that without external help, it is vocally almost impossible to get away from them; **“the sounds which form consonances being the only ones that the human ear can accurately detect and that the human vocal organ can spontaneously utter”**.

If therefore, in musical practice, there can be utilized only a small number of intervals having between themselves definite ratios, it must be possible to divide the musical scale in such a way as to allow all the possible combinations of such ratios.

For our investigation, **musical interval appear under two aspects; one mathematical, of numbers and the logical ratios, the other symbolical and the psychological in which the relations of sounds, their harmony, awakens in us the feelings, ideas and precise visions. These two aspects obviously have their origin in the same principles.**

### **Fifth & Octave:**

According to the circumstances, to the time and to the role attributed to music, theorist have complied musical theories either from the point of view of expression or from that of numbers. In the first case the basis is generally the interval of octave and the relation of notes with a fixed sound, the tonic, giving birth to model /raaga music; in the second case, emphasis is given to the properties of the interval of the fifth and the succession of fifths, which leads to modulation and therefore harmony.

**The Harmonics and the consonance:** The sounds, the frequencies of which are simple multiples of the frequency of the primary or fundamental sound are called the harmonics of the fundamental sound. **The harmonics which are very near to the fundamental sound are the only one that the human ear can easily perceives and**

**appreciates.** They are those , whose relations appear to us more pleasing and which, normally form the element of musical system , because their correspondence with cosmic laws (macrocosm) and with physiologic data peculiar to man (microcosm) enable them to evoke for us ideas and images , of which these ratios are the simplified representation. **The more the harmonics are distant from the fundamental sound, the more they appear more complicated and dissonant to us.**

**Melody & Harmony** (The structure or musical sounds):In the musical systems in which the tonic is permanent and constantly present to the mind of listeners , each note by itself is a significance that is determined by the relation, which binds it to the tonic. The melody is thus composed of a succession of sounds with a perfectly definite meaning and therefore its significance is absolutely clear.

But if the tonic is not absolutely permanent no note can have significance, unless the ratio which measures its expression is given at the same time. This is why in every musical system where modulation is admitted, it can be asserted that no note and no melody can have a significance without the harmonic context which alone can establish the ratios necessary to define the meaning of each note and consequently of the entire melody.

The sounds utilized in the music generally have only one fundamental mode. The harmonies of this fundamental according to their relative intensity make the notes appear pure or nasal. When with the help of the different instruments, some of these harmonic sounds are reinforced, the quality of the basic sound is enhanced and its expressive value, which is different according to the reinforced harmonies, improved. **Thus is born the harmony which is the art of superimposed sounds.** If those sounds are successive instead of being simultaneous, as in melody, then for the notion of intervening time we have to call upon memory to establish the harmonic relationship, which alone gives to the melody its meaning.

**Mode:** This term is often used in Western music and sometimes confused with 'raaga' of Indian system. Mode is the nothing but the group of two or three fundamental chords which displays all the notes of the melody. The mode, being therefore a series of sounds having definite relations with a permanent tonic, can truly be said to represent the fixed harmonic basis of all melodic music, modulation being almost unknown in model music as the uncertainty it would create in the harmonic significance would last too long. The melodic figures turning within a fixed circle



and coming back frequently to certain notes create a harmonic complex, which gives its significance to the melody.

Like the forms in language, the musical modes are permanent marks of the tradition to which they belong.

**The relations between the notes which constitute a mode can be represented numerically. The mode is then with its complete significance, represented by a group of numerical relations; these relationships only have been used to define and find out the Inverse relationships in the various raaga patterns. Chords can also be represented in the same way. We will see that these mathematical relationships have been used to establish an inverse relationship in the Major and Minor Chords in Western music.**

### **Harmony and Discord**

Let us consider two tuning forks being sounded together and let us keep the pitch of one fork fixed at 261 Hz while the pitch of the other begins at 262 and is gradually raised. As the pitch raises the beats can be heard due to difference in the frequencies for a tone and then can no longer be discerned. The sound of the combined tones starts out by sounding pleasant to the ear and then it becomes gradually more unpleasant. The unpleasantness reaches a maximum at about 23 beats per second, and then begins to abate. The unpleasantness or discord declines only slightly and the discord remains at a fairly uniform level until the octave marking value of 522 Hz is reached, at which point the unpleasantness disappears.

If the experiment is repeated with violin strings, radically different results will be obtained. The discord does not stay at a uniform level but fluctuates erratically. It almost vanishes at an interval of Major third, and again at the intervals of Fifths & Octave. At the precise point at which the minimums of the unpleasantness occur; the frequency ratios of the variable to a fixed tone are found to have the values  $\frac{5}{4}$ ,  $\frac{4}{3}$ ,  $\frac{3}{2}$  &  $\frac{2}{1}$  etc.

**It has been observed that tones sound well together when the ratios of their frequencies can be expressed in terms of small numbers. The smaller are the numbers, the better is the consonance.** The following table lists the interval in order of increasing dissonance.



### **Interval Nomenclature and Frequency Ratios:**

<b>Interval (second)</b>	<b>Frequency Ratio</b>	<b>Largest Integer Occurring In the Ratio</b>
Unison	1:1	1
Octave	2:1	2
Fifth	3:2	3
Fourth	4:3	4
Major third	5:4	5
Major Sixth	5:3	5
Minor Third	6:5	6
Minor Sixth	8:5	8
Second	9:8	9

The further we go away from small numbers the more we encroach into the realm of discord. Pythagoras, one the greatest mathematician who gave us the famous Pythagoras theorem in Geometry, knew this fact more than 2500 years ago when he associated the consonance with the ratios of small numbers. The premise of the Pythagorean doctrine, “all nature consists of harmony arising out of numbers”, may be somewhat simplistic, but the Chinese philosophers in Confucius’s time also regarded small numbers 1, 2, 3, 4 as the source of all perfection.

The Swiss mathematician ‘Leonhard Euler’ adopted the psychological approach in declaring that the human mind takes pleasure in the Law and Order, particular in natural phenomena. His theory of harmony is this: the smaller the numbers required for expressing the ratios of the two frequencies, the easier it is to find this law and order, thus making it more pleasant to hear the combined sound. ‘Euler’ went so far as to propose a definitive measure of dissonance of a chord. His idea was to express the frequency ratio of a specific chord by a smallest number possible and then to find the common denominator for these frequencies. For example the frequency ratio of the common chord CEGC is 4:5:6:8. The least common denominator is 120, since it is the smallest number of which 4, 5, 6 and 8 are all factors. But, this theory falls apart when the same denominator is assigned to the

chord of CEFGB (Frequency ratios of 8:10:12:15) that turned out to be far more unpleasant to listen to.

### **The scale of the sound:**

We can here note that the fifty three intervals of the scale of fifths, if we want to utilize them musically i.e. sing them or play them by ear on a non keyed instrument , are automatically transformed into simpler harmonic intervals which are very much easier to appreciate, much more natural. **We might here ask that to sing without accompaniment the temperate scale is an undertaking above human capacities because we cannot , without external help , escape from harmonic intervals which alone are in accordance with the physical nature of the sounds and consequently, with the shapes and the possibilities of the organs by which we can emit and perceive sounds.**

Limited to simple ratios, the acoustic intervals in use among the different human or animal races, therefore, by the very nature of things, are limited in number. All the musical scales in the world have evolved using only the simple ratios as mentioned above.

In view of the above we can say that the basis of all that what is musical, whatever may be the system of music, is the concept of consonance & dissonance of various notes either with a common prime note or amongst themselves. The first principle makes the back bone of melodic (Indian) and the second that of Harmonic music (Western). If, therefore the principles of consonance and dissonance is understood and applied, all the system of the music in the world can be understood, this being a universal principle.

**This universal principle is the very back bone of the present study.**