Introduction

to

Indian Music

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Introduction to Indian Music

"One Drone to Rule them All"

and

"Your Drone will be your Reality"

  How does one even approach understanding and writing about Indian music? Not only is the tradition of Indian music thousands of years old, but there are also two separate, though overlapping cultures that one needs to come to terms with and understand. The music of northern India follows the **Hindustani** tradition, while the music of southern India follows the **Carnatic** tradition. There are as many different elements in each culture as there are common elements. Most importantly, both traditions are entirely drone based, almost always incorporating a Tanpura or two to play the drone.

  Put simply, Indian music is the most expressive **Just Intonation** music system the world has ever seen. All Indian instruments and music theory is the realization of playing perfectly in tune in **Just Intonation**. When there is a continuous drone playing, every note the solo performer plays is in relation to that drone. There is nothing more natural than tuning whatever note one is playing to sound the best and most in tune with the drone.

♦ Notes, Tetrachords, Parent Scales ♦

  When one sorts out all the music terms in the different Indian languages, it is very clear that the musical language shared by many cultures is all built upon the same foundation. The reason is that as human beings, no matter where or when we were born, we all respond the same way to musical stimulus and come to very similar musical solutions.

  Indian note names follow exactly the Sol-fa or Do Re Mi etc scale of Western music. In Indian music two notes or **Swaras** are immutable. They are **Sa** (**C**) and **Pa** (**G**). In Indian music there is no such thing as a **C#** or **Cb**, or **G#** or **Gb**. **Sa** (**C**) and **Pa** (**G**) are unchangeable.

  The rest of the note names can be altered by accidentals, but only in the following way:

<div align="center">

Db D   Eb E   F F#   Ab A   Bb B

</div>

  A scale, like in Western music, can only have each letter name once. In **Hindustani** music when we create a scale (using Western note names) we start with **C**, pick either **Db** or **D**, pick either **Eb** or **E**, pick either **F** or **F#**, pick **G,** pick either **Ab** or **A**, pick either **Bb** or **B**, and then of course end with the octave **C**.

  When we exhaust all the possible note combinations in **Hindustani** music we find we have exactly 32 possible scales. These are called "**Thaats**" or "**Parent Scales**" in **Hindustani** music.

The **Carnatic** music system also admits the notes **Ebb D#** and **Bbb A#**. When we exhaust all the possible note combinations in **Carnatic** music we find we have exactly 72 possible scales. These are called "**Melakartas**" or "**Parent Scales**" in **Carnatic** music.

Within the 72 "**Parent Scales**" are the 10 "**Thaats**" of **Bhatkhande**, though it is hard to know how all possible **Ragas** can only be classified using only these 10 "**Thaats**".

Like in Western music, we can divide the scale into two **tetrachords**, a lower **tetrachord** of the first four notes starting on **C**, and an upper **tetrachord** of the next four notes starting on **G**.

By creating a chart with all the possible lower and upper **tetrachords**, we arrive at all the possible "**Parent Scales**". It is a lot to come up with 72 different names for the "**Parent Scales**". An interesting system called "**Katapaydi Sankhya**" assigns syllables to numbers, and so helps with coming up with names for the 72 "**Parent Scales**". There is also a **Chakra** for each row.

♦ The 22 **Shrutis** ♦

Probably one of the most convoluted, misdirected and misleading topics in Indian music is the discussion on **Shrutis**. We will extensively analyze how we can make some sense of this.

When dealing with **Just Intonation** ratios, or **Shrutis** as they are called in Indian music, things can get super messy really quickly. Every note name or **swara** in Indian music has two possible **shrutis** or ratios, except the immutable **Sa** (**C**) and **Pa** (**G**), which have one **shruti** or pitch each. This gives a total of 22 **shrutis**, each with their own ratio or pitch.

The **Carnatic** musical system also includes four extra notes or **swaras**, being **Ebb, D#**, **Bbb** and **A#**, which fortunately are **enharmonic** to **D**, **Eb**, **A** and **Bb**, so they don't add to the number of **shrutis**. We will look at these later.

In Western music, pairs of **Just Intonation** pitches or ratios are tempered out to a single pitch. This leaves precisely 12 different pitches in the octave, the pitches dependent upon the temperament being used. **Just Intonation** however is a tuning system, not a temperament, and everything is calculated using rational ratios. The ratios of a temperament are all irrational numbers.

The first thing one can ask is, are the ratios of the 22 **shrutis** set and defined? It seems that yes, there is only one set of 22 **shrutis**, the ratios of which have been historically set down and fixed.

All Indian fretted instruments have 12 or less frets to the octave. The next question to ask is, of the 22 **shrutis**, which 12 pitches should we tune the 12 frets to? The pitches that are most in tune to the **Sa Pa** (**C G**) drone, which we will call the **Primary** ratios, are:

<u>C-1/1</u> **Db↑-16/15** D-9/8 **Eb↑-6/5** **E↓-5/4** F-4/3 **F#↓-45/32** <u>G-3/2</u> **Ab↑-8/5** **A↓-5/3** Bb-16/9 **B↓-15/8** <u>C-2/1</u>

That leaves 10 pitches or **shrutis** that we will call the **Secondary** ratios:

Db-256/243 **D↓-10/9** **Eb-32/27** **E-81/64** **F↑-27/20** **F#-729/512** **Ab-128/81** **A-27/16** **Bb↑-9/5** **B-243/128**

Besides the immutable **Sa Pa** (**C G**) ratios, we can see that every **secondary** ratio is a **Syntonic comma** (**81/80**) higher or lower than a **primary** ratio. A **syntonic Comma (81/80)** is 21.51 cents. Unlike Middle Eastern music, there are no quarter-tones in Indian music. All the **secondary** ratios are approximately 1/5 semitone shades, above or below, the **primary** ratios.

The 22 **shrutis** are also classified as **5 Limit** ratios, as the greatest prime factor of any of the above ratios is **5**, the **5 Limit** prime factors then being **2**, **3** and **5**.

Playing against the **Sa Pa** (**C G**) drone, the 12 **primary** ratios are the pitches that are the most in tune and settled with the drone. They are the pitches that produce the most consonant harmony with the drones.

How can we in any way sense make of the extra 10 **secondary** ratios? Some people seem to think that these **secondary** notes are expressive variations of the **primary** ratios. If we want to go with the expressive variation theory we can see that:

E-81/64 **F↑-27/20** **F#-729/512** **A-27/16** **Bb↑-9/5** **B-243/128**

are all sharper than their **primary** ratio counterpart. These **secondary** pitches can just be bent up, though why anyone would think leaving in tune, pleasing and consonant intervals for sharp, out of tune intervals is beyond me. Nobody in their right musical mind or ear would ever think that **E-81/64** is a restful, peaceful and in tune note to the drone, compared to **E↓-5/4**.

The **secondary** pitches:

Db-256/243 **D↓-10/9** **Eb-32/27** **Ab-128/81**

are all flatter than their **primary** ratio counterparts. It is not possible to bend notes downward on a fretted instrument, so the frets for these notes would have to be tuned to these **secondary** ratios, and we would then have to bend up to the **primary** ratio whenever we play the **primary** ratios, which is not very convenient to always have to do to be in tune. Unlike the **secondary** ratios that are sharp and harsh, flatter more depressed intervals actually can be expressive if we can play them!

The question is, whether singing, or playing on a **Sarod** without frets, can our ear even be accurate enough to distinguish notes that are a fifth of a semitone apart? I would say the answer is no, not at all. We need a measured instrument, that is, one with frets to be able make and recognize such fine microtonal variations.

So how else can we deal purposefully and musically, and make sense of the 10 **secondary** ratios? We will look at them from a few different angles.

♦

Starting simply.

Bb-16/9 tunes a perfect fourth (4/3) above **F-4/3**. If we want instead to tune a pure minor third (6/5) above **G-3/2** then we can use **Bb↑-9/5** instead. We are able to do this as we have **Pa** (**G**) to reference for tuning. Of course this begs the question, if the drone is **Sa Pa** (**C G**), how can we tune **Bb-16/9** in the first place? **Bb-16/9** is however a much better sounding note against the drone than the sharp **Bb↑-9/5**.

If we can differentiate between these two **Bb**'s then it will be absolutely no problem to bend ever so slightly **Bb-16/9** up to the sharper **Bb↑-9/5**. We can most likely here say than that **Bb↑-9/5** is actually an expressive variation on **Bb-16/9**, primarily because it can be measured and tuned to the **Pa** (**G**) of the **Sa Pa** (**C G**) drone.

We can extend this concept, by tuning **primary** ratios from **Pa** (**G**) instead of **Sa** (**C**). 9/8 above **G-3/2** gives us **A-27/16**, and 45/32 above **G-3/2** gives us **C#-135/128**. **C#-135/128** doesn't exist as a **shruti**, but has a very close **enharmonic** ratio of **Db-256/243**, which is only 1/50th of a semitone different. All the other **primary** ratios tuned from **G-3/2** give us the same ratios as **primary** ratios tuned from **C-1/1**.

Can we tune any of the remaining 7 **secondary** ratios to anything similar? Only if we change the drone.

♦

In Indian music the main drone is **Sa Pa** (**C G**). However, if the **raga** doesn't contain the **Pa** (**G**) **swara**, but does contain the **Ma** (**F**) **swara**, then the drone is usually changed to **Sa Ma** (**C F**).

When we change the drone from **Sa Pa** (**C G**) to **Sa Ma** (**C F**) then we can theoretically open up a whole new can of worms. No matter how we want to look at it, by changing the drone from **Sa Pa** (**C G**) to **Sa Ma** (**C F**) we are effectively changing acoustically the tonic from **C** to **F**, using Western terminology.

Of course in the west we would just simply change the movable **Do** to **F**, or any other new key we wanted to be in, and be done with it. In Indian music **Sa** remains **Sa** regardless. It makes no sense in Indian music to rename all the note names just because we change the drone to **Sa Ma** (**C F**), no matter if we want to believe we are in **F** tonic now or not.

If **Pa** (**G**) is missing from the **raga**, then **Pa** (**G**) can't be immutable if it doesn't even appear! It isn't then too far a stretch to make **Sa Ma** (**C F**) immutable! And if we do so, then our new scale, assuming **F** to be the new tonic, would have the **swaras** or note names:

F Gb G Ab A Bb B C Db D Eb E F

Everything is the same, except we have the forbidden note **Gb**. **G** (like **C**) is to be immutable and is not to admit of any alteration by sharp or flat to its existence. We will however work around that in a very clever way!

When playing a **Sa Ma** (**C F**) drone and re-evaluating the tonic as **F** we have to change a few ratios to be in tune in the same way as we are when the notes were tuned to the **Sa Pa** (**C G**) drone.

D-9/8 needs to be lowered to **D↓-10/9** to be a (5/3) ratio with **F-4/3**.

Eb↑-6/5 needs to be lowered to **Eb-32/27** to be a (16/9) ratio with **F-4/3**.

And what about the **Gb**? We can again take a page out of the "**Enharmonic Tunings and Temperaments**" chapter of the **Compendium Music**. As **Db↑-16/15** is the interval (16/15) above **C-1/1** when the drone is **Sa Pa** (**C G**), we need the **Gb↑** to be the interval (16/15) above **F-4/3** when the drone is **Sa Ma** (**C F**).

This gives us **Gb↑-64/45**, but there is no (64/45) **shruti**!? There is however the **enharmonic F#-729/512** which is only 1/50 of a semitone different, so for all extensive purposes almost identical to **Gb↑-64/45**! Of course **Gb↑-64/45** is not exactly **F#-729/512**, but they serve the same pitch function no matter how the pitch is written as a note name or **swara**.

No matter how we look at it we have to break one rule regardless. Either we allow there to be a **Gb** (almost identical in pitch, but with a slightly different ratio), or we allow a scale that has both **F** and **F#**.

The **swaras**, with the new adjusted ratios underlined, for the **Sa Ma** (**C F**) drone would now be:

F-4/3 Gb↑-64/45 G-3/2 Ab↑-8/5 A↓-5/3 Bb-16/9 B↓-15/8 C-1/1 Db↑-16/15 D↓-10/9 Eb-32/27 E↓-5/4 F-4/3
(F#-729/512)

This takes care of three more **secondary** ratios. We still have 4 more to try and explain!

♦

The **Carnatic** music system has more notes than the **Hindustani** music system. The **Carnatic** music system also has the **swaras Ebb, D#, Bbb** and **A#**. This is of course why there are 72 **Carnatic Melakartas** (Parent scales) and only 32 **Hindustani Thaats** (Parent scales).

We can assign **enharmonic** equivalents from the **shrutis** for the four extra **Carnatic swaras**:

<div align="center">

Ebb → **D↓-10/9** or **D-9/8**   D# → **Eb-32/27** or **Eb↑-6/5**

Bbb → **A↓-5/3** or **A-27/16**   A# → **Bb-16/9** or **Bb↑-9/5**

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Even so, whether the **Carnatic swaras** are **enharmonic** or not, there is still no reason to pick any of the lesser in tune ratios. We are starting to run out of options and justifications!

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But…if we look at a few fretted Indian instruments that have **Sa** (**C**) and **Pa** (**G**) strings and **Ma** (**F**) as the main playing string we can account for almost all of the 22 **shrutis**! We will though have to include the three extra optional ratios for the **Sa Ma** (**C F**) drone on the **Ma** (**F**) string.

Ma (**F**) **String**
F-4/3   F#↓-45/32   *(Gb↑-64/45)*   G-3/2   Ab↑-8/5   A↓-5/3   Bb-16/9   B↓-15/8   C-1/1   Db↑-16/15   *D↓-10/9*   D-9/8   *Eb-32/27*   Eb↑-6/5   E↓-5/4
                      F#-729/512

Pa (**G**) **Strings**
G-3/2   Ab-128/81   Ab↑-8/5   A-27/16   Bb↑-9/5   B↓-15/8   C-1/1   Db-256/243   D-9/8   Eb↑-6/5   E↓-5/4   E-81/64   F-4/3   F↑-27/20   F#↓-45/32
(G#↓-405/256)   (C#↓-135/128)

Sa (**C**) **Strings**
C-1/1   Db-256/243   Db↑-16/15   D-9/8   Eb↑-6/5   E↓-5/4   F-4/3   F#↓-45/32   G-3/2   Ab↑-8/5   A↓-5/3   A-27/16   Bb-16/9   Bb↑-9/5   B↓-15/8
(C#↓-135/128)

The only **shruti** or ratio missing in the above string chart is **B-243/128**! There is really no other way to justify it so we might just as well include it on the **Ma** (**F**) string as an expressive sharpened variation of **B↓-15/8**.

When the strings of an Indian fretted instrument are all tuned to either **Sa Pa** (**C G**) or **Sa Ma** (**C F**) the total number of **shrutis** that occur between the frets and strings is only 19.

The five tuning charts very clearly lay out how with only twelve frets there is no one possible perfect solution when adjusting the frets for tuning the pitches or **shrutis**. The tuning charts show both the position of the frets for the **primary** ratios for the **Sa Pa** (**C G**) drone, and the three adjusted pitches required to be in tune for the **Sa Ma** (**C F**) drone.

♦

We will look at one more defining parameter as concerning **shrutis**. We have above stretched the rules a little bit theoretically and introduced three **enharmonic** notes and their ratios which are only 1/50th of a semitone different to their related **shrutis**.

Keeping with rule that **Sa** (**C**) and **Pa** (**G**) are immutable, we can find all 22 **shrutis** by unfolding three levels of perfect fifths. The first level contains **Sa** (**C**) and **Pa** (**G**):

(no Gb) **Db-256/243 Ab-128/81 Eb-32/27 Bb-16/9 F-4/3 <u>C-1/1</u> <u>G-3/2</u> D-9/8 A-27/16 E-81/64 B-243/128 F#-729/512** (no C#)

and stops when we hit the inadmissible notes Gb and C#.

The second level of perfect fifths is a **syntonic comma** (**81/80**) higher, which also stops when it hits the inadmissible notes of Gb↑ and C↑.

(no Gb↑) **Db↑-16/15 Ab↑-8/5 Eb↑-6/5 Bb↑-9/5 F↑-27/20** (no C↑)

The third level of perfect fifths is a **syntonic comma** (**81/80**) lower, which also stops when it hits the inadmissible notes of G↓ and C#↓.

(no G↓) **D↓-10/9 A↓-5/3 E↓-5/4 B↓-15/8 F#↓-45/32** (no C#↓)

No matter how we relate this last way of looking at the 22 **shrutis** to the real musical world, as we have tried to do, it does present the easiest, most satisfying and most comprehensive layout of the 22 **shrutis** possible.

As an aside, in the same way as the very comprehensive **Partch** 43 note **Just Intonation** scale has nothing to do with the awesome 43 note **equal temperament**, so neither does the beautiful Indian **Just Intonation** system of 22 **Shrutis** have anything whatsoever or even remotely, to do with the awful sounding 22 note **equal temperament**, though some people always try to make some sort of correlation.

This analysis of the 22 **Shrutis** is about as far as I can go trying to explain and uncover its idea and implementation.

♦ <u>**Fretted Indian Instruments**</u> ♦

It is a common misconception that singers, and instruments without frets like the Sarod and Violin, are capable of singing or playing any scale possible. In actuality, the only scale they can sing or play is an irregular one, with notes that the ear deems to be in tune, in the context of the moment. No one can in real time sound an equal tempered scale or realize accurately the pitch nuances of two **shrutis** a **syntonic comma** (**81/80**) apart.

The ear can accurately realize a pitch that is a fundamental ratio (**1:1**, **2:1**, **3:2**, **4:3**, **5:3**, **5:4** etc) by the phenomena of the way the pitches vibrate and combine together. To find more complicated ratios requires some sort of method or measuring tool. Above, we can see that frets can be considered a measuring tool, as they allow us to accurately find **shrutis** that we wouldn't be able to find just by ear. Frets are also a tool that allows a pitch to be repeated accurately in real time over and over again. It takes time and various methods to set the exact position of the fret for the desired pitch, but once that has been done, one can be confident that every time we play that fret, it will produce the pitch we desire.

The first tuning chart deals with instruments that have strings tuned as **Sa** (**C**), **Pa** (**G**), **Sa** (**C**) and **Ma** (**F**) as the main playing string.

The second tuning chart deals with instruments that have their strings tuned **Sa** (**C**), **Ma** (**F**), **Sa** (**C**), **Ma** (**F**).

The third tuning chart deals with instruments that have their strings tuned **Sa** (**C**), **Pa** (**G**), **Sa** (**C**), **Pa** (**G**).

The fourth tuning chart deals with instruments that have their strings tuned **Pa** (**G**), **Sa** (**C**), **Pa** (**G**), **Sa** (**C**). The intervals between the strings here is exactly the same as the intervals between the strings of the second tuning chart. Tuning chart 4 is then an **Inversion** of tuning chart 2, though the position of the frets is different, and its **Sa** (**C**) is effectively a perfect fourth higher than the **Sa** (**C**) of tuning chart 2. In all the literature I have read about Indian music, nowhere have I read about how **Sa Ma** (**C F**) can be **inverted** to become **Pa Sa** (**G C**).

The fifth tuning chart deals with instruments that have their strings tuned **Ma** (**F**), **Sa** (**C**), **Ma** (**F**), **Sa** (**C**). The intervals between the strings here is exactly the same as the intervals between the strings of the third tuning chart. Tuning chart 5 is then an **Inversion** of tuning chart 3, though the position of the frets is different, and its **Sa** (**C**) is effectively a perfect fifth higher than the **Sa** (**C**) of tuning chart 3. In this case **Sa Pa** (**C G**) can be **inverted** to **Ma Sa** (**F C**).

All the tunings charts show both the **primary** ratios for the **Sa Pa** (**C G**) drone and the three adjusted ratios for the **Sa Ma** (**C F**) drone.

If one can decipher what the five tuning charts are trying to lay out, then one can intelligently make choices on how one would like to position the frets as concerning the tuning of the **shrutis**, their possibilities and limitations.

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In Indian music there is only one **Sa** (**C**) regardless of how high or low, for male voice or female voice, it is tuned. Pitch in Indian music is relative. In the Western world though, pitch is standardized, usually around **A-440**. So while an Indian musician will tune for example, a sitar relative to itself, a Western musician would say that the sitar is tuned around **concert C**, **C#** or **D**. Everyone still thinks of all the notes or **swaras** related to **Sa** or **C**, no matter how high or low it is tuned relatively or compared to Western pitch.

A number of charts show possible tuning ranges of a number of Indian instruments compared to Western pitches.

♦ <u>Ragas, Ornamentation, Rhythm, Aesthetics</u> ♦

From the "**Parent Scales**" the **Ragas** are derived. A **raga** is more than just a scale in Western terms. It has a mood, a time to be played, and different number of notes ascending and descending (and not always scale wise either). **Ragas** also have prominent notes that are focused on, and defining phrases and note combinations.

Many **ragas** may exactly the same notes as another **raga** of a different name, however their defining characteristics might be completely different. Not a single **raga** has been included in this treatise. There are hundreds and hundreds of **ragas**. One can easily nowadays look up any list of **Ragas**. It is not enough just to learn the note names of the **raga**. One has to learn what it is that defines a specific **raga**. This is only learned by osmosis and listening and understanding the personality of a **raga**, in the same way we slowly learn about a new friend. This is beyond the scope of any written treatise.

♦

Once we have settled on a **raga**, its notes aren't just played plainly like they are for the most part in Western music. The notes are played with a complex of possible ornamentations, like graces and glides and oscillations and so on. Individual **ragas** also have rules for which ornamentations are acceptable for each **raga**. **Hindustani** and **Carnatic** traditions have different, though related **Alankara**, meaning "ornament" or "decoration".

Again a written treatise cannot explain in words what is a lifelong study of a tradition that can only be learned by the ear and listening, studying and practicing. It is enough to explain that **Alankara** exist, that there are many, many possible kinds of ornaments, and that it is an integral, incredibly important facet of playing Indian music.

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 Improvisation is a huge, undeniable part of Indian music. Many improvisations start in a free rhythm which slowly solidifies its timing, until the percussionist(s) enter in a strict time. The rhythmic cycle established by the percussionist(s) is called a **Tala**, which can have any number of beats divided into any number of sub groups.

The complexity of Indian rhythms and the skill of the percussionists in playing the rhythms is incredible. Again this is a lifelong study, well beyond the scope of this **Introduction**.

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And finally, the **aesthetics** of what the performer is trying to convey and what the listener is emotionally responding to. No matter the culture, this part of music is its philosophy, spirituality and metaphysical existence that relates it to all time and the universe. Almost not possible to put into words, but words are the only way we can try to explain these ideas. Music is one of the ways we try to realize these concepts!

♦ <u>Hindustani and Carnatic Music</u> ♦

Once we have looked at everything above, there are still the different types of musical forms that are played and improvised and composed in. Words can no more convey their forms, traditions and styles than the words sonata or fugue can in anyway explain what those forms actually entail in Western music, and the huge variety that is possible under the umbrella of those terms.

Every single culture has many types and styles of music to be played for different functions and rituals. Naming them however tells us nothing of how different kinds of pieces sound and are played, and the variety contained even within the name. Only by becoming part of the musical tradition can we learn about, play and enjoy all the different styles of Indian music.

♦

This **Introduction** is but a road map, though **Shrutis** have been looked at with a huge amount of detail and depth. With a map to start with, one may journey forth on a real road, through a real field or forest, learning and experiencing and feeling for an entire lifetime!

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Note and Parent Scale Terms

| **Swar, Swara, Swaras** | **= note and note names** | -as with Western music there are seven note names |

		Shadja	Sa	*Do*	C
		Nishada	Ni	*Ti*	B
		Dhaivata	Dha	*La*	A
		Panchama	Pa	*So*	G
		Madhyama	Ma	*Fa*	F
		Gandhara	Ga	*Mi*	E
		Rishabha	Re *or* Ri	*Re*	D
		Shadja	Sa	*Do*	C

being exactly the same as Do Re Mi Fa So La Ti Do (Solfege)

Sargam = the short form of the note names
-the collection of these notes/syllables for singing
-the word is derived from the first four notes (Sa, Re/Ri, Ga, Ma)

Saptak = octave
-containing the gamut of "sapta" (seven) notes
Taar Saptak -upper octave (head) (dot over a note)
Madhya Saptak -middle octave (throat)
Mandra Saptak -lower octave (heart) (dot under a note)

Achala or Prakruti Swara = invariable notes
-the immutable fixed anchor notes Sa and Pa

Chala or Vikruti Swara = variable notes
-the remaining notes that are variable by accidentals

Komal, Shuddha, Tivra = flat, natural, sharp
-the Hindustani names for the accidentals
-Carnatic music uses different names for the accidentals

Swara Prakara = chromatic scale
-the twelve universal chromatic notes of the octave

Shruti = the pitch of a note
-there are 22 microtonal pitch variations for the 12 notes in the octave

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Thaat = Hindustani parent scale
-there are 32 Hindustani "parent" scales from which ragas are constructed

Melakarta = Carnatic parent scale
-there are 72 Carnatic "parent" scales from which ragas are constructed
  -**Melakarta** means "Lord of the Scale"
  -also known as "**Janaka raga**" (meaning "father raga"),
   from which "**Janya ragas**" (meaning "begotten ragas") are derived
  -also known as "**Asraya raga**" (meaning "shelter-giving raga"),
   from which "**Asrita ragas**" (meaning "sheltered ragas") are derived
  -groups of derived ragas in Carnatic music are called **Thaata**

Parameters for the parent scales
-Both **Thaat** and **Melakarta** "parent" scales have:
 -all seven notes of the scale (**Sa Re/Ri Ga Ma Pa Dha Ni**) and the upper octave **Ṡa**
 -can't contain both natural and altered version of the same note
 -are the same ascending and descending without any jumps or zig-zags
 -are used to derive ragas

Tetrachord Combinations

Hindustani and Carnatic Music Tetrachords

Perfect Fourth Lower Tetrachord

Major	2	2	1
	C	D	E	F

Minor	2	1	2
	C	D	Eb	F

Phrygian	1	2	2
	C	Db	Eb	F

Harmonic	1	3	1
	C	Db	E	F

Perfect Fourth Upper Tetrachord

Major	2	2	1
	G	A	B	C

Minor	2	1	2
	G	A	Bb	C

Phrygian	1	2	2
	G	Ab	Bb	C

Harmonic	1	3	1
	G	Ab	B	F

4 x 4 = 16 Scale Combinations

Augmented Fourth Lower Tetrachord

Major Tritone	2	2	2
	C	D	E	F#

Minor Tritone	2	1	3
	C	D	Eb	F#

Phrygian Tritone	1	2	3
	C	Db	Eb	F#

Harmonic Tritone	1	3	2
	C	Db	E	F#

Perfect Fourth Upper Tetrachord

Major	2	2	1
	G	A	B	C

Minor	2	1	2
	G	A	Bb	C

Phrygian	1	2	2
	G	Ab	Bb	C

Harmonic	1	3	1
	G	Ab	B	F

4 x 4 = 16 Scale Combinations

16 + 16 scales = 32 Thaats of Hindustani Music (North Indian)

Two matching sets   - 16 scales with Shuddha Madyama (F)
    - 16 scales with Tivra Madyama (F#)

A Thaat is a "Parent Scale" in Hindustani Music

Additional Carnatic Music Tetrachords

Perfect Fourth Lower Tetrachord

	1	1	3
C	Db	Ebb	F

	3	1	1
C	D#	E	F

Perfect Fourth Upper Tetrachord

	1	1	3
G	Ab	Bbb	C

	3	1	1
G	A#	B	C

(4 + 2) * (4 + 2) = 36 Scale Combinations

Augmented Fourth Lower Tetrachord

	1	1	4
C	Db	Ebb	F#

	3	1	2
C	D#	E	F#

Perfect Fourth Upper Tetrachord

	1	1	3
G	Ab	Bbb	C

	3	1	1
G	A#	B	C

(4 + 2) * (4 + 2) = 36 Scale Combinations

36 +36 scales = 72 Melakartas of Carnatic Music (South Indian)

Two matching sets   - 36 scales with Shuddha Madyama (F)
    - 36 scales with Prati Madyama (F#)

A Melakarta is a "Parent Scale" in Carnatic Music

Remaining Invalid & Unused Tetrachords

Augmented Fourth Lower Tetrachord

		2		3		1	
	C	D		(E#)		F#
		Ebb		F		(Gb)

		3		2		1	
	C	D#		(E#)		F#
		Eb		F		(Gb)

		1		4		1	
	C	Db		(E#)		F#
				F		(Gb)

		4		1		1	
	C	(Dx)		(E#)		F#
		E		F		(Gb)

4 Invalid Lower Augmented Tetrachords x
6 Upper Tetrachords = 24 Additional Scales

72 + 24 = 96 possible scales in total with
C and G fixed and immutable.

72 Melakarta "Parent Scales" of Carnatic Music   32 Thaat "Parent Scales" of Hindustani Music   10 Thaats of Bhatkhande

Chakras		Lower Tetrachords	Upper Tetrachords					
			P D$_1$ N$_1$ Ṡ G Ab Bbb C	P D$_1$ N$_2$ Ṡ G Ab Bb C	P D$_1$ N$_3$ Ṡ G Ab B C	P D$_2$ N$_2$ Ṡ G A Bb C	P D$_2$ N$_3$ Ṡ G A B C	P D$_3$ N$_3$ Ṡ G A# B C
I	Indu	S R$_1$ G$_1$ M$_1$ C Db Ebb F	01 - Kanakangi 1 = ka , 0 = na	02 - Ratnangi 2 = ra , 0 = na	03 - Ganamurti 3 = ga , 0 = na	04 - Vanaspati 4 = va , 0 = na	05 - Manavati 5 = ma , 0 = na	06 - Tanarupi 6 = ta , 0 = na
II	Netra	S R$_1$ G$_2$ M$_1$ C Db Eb F	07 - Senavati 7 = se , 0 = na	08 - Hanumatudi 8 = ha , 0 = nu **Bhairavi** (Phrygian)	09 - Dhenuka 9 = dhe , 0 = nu	10 - Natakapriya 0 = na , 1 = ka	11 - Kokilapriya 1 = ko , 1 = ki	12 - Rupavati 2 = ru , 1 = ?
III	Agni	S R$_1$ G$_3$ M$_1$ C Db E F	13 - Gayakapriya 3 = ga , 1 = ka	14 - Vakulabharanam 4 = va , 1 = ku	15 - Mayamalavagowla 5 = ma , 1 = ? **Bhairav**	16 - Chakravakam 6 = cha , 1 = kra	17 - Suryakantam 7 = su , 1 = ka	18 - Hatakambari 8 = ha , 1 = ka
IV	Veda	S R$_2$ G$_2$ M$_1$ C D Eb F	19 - Jhankaradhwani 9 = jha , 1 = ka	20 - Natabhairavi 0 = na , 2 = ra **Asavari** (Aeolian)	21 - Keeravani 1 = ke , 2 = ra	22 - Kharaharapriya 2 = ra , 2 = ra **Kafi** (Dorian)	23 - Gourimanohari 3 = go , 2 = ri	24 - Varunapriya 4 = va , 2 = ru
V	Bana	S R$_2$ G$_3$ M$_1$ C D E F	25 - Mararanjani 5 = ma , 2 = ra	26 - Charukesi 6 = cha , 2 = ru	27 - Sarasangi 7 = sa , 2 = ra	28 - Harikambhoji 8 = ha , 2 = ri **Khamaj** (Mixolydian)	29 - Dheerasankarabaranam 9 = dhe , 2 = ra **Bilaval** (Ionian)	30 - Naganandini 0 = na , 3 = ga
VI	Rutu	S R$_3$ G$_3$ M$_1$ C D# E F	31 - Yagapriya 1 = ? , 3 = ga	32 - Ragavardhini 2 = ra , 3 = ga	33 - Gangeyabhushani 3 = ga , 3 = ge	34 - Vagadheeswari 4 = va , 3 = ga	35 - Shulini 5 = ? , 3 = ?	36 - Chalanata 6 = cha , 3 = ?
VII	Rishi	S R$_1$ G$_1$ M$_2$ C Db Ebb F#	37 - Salagam 7 = sa , 3 = ga	38 - Jalarnavam 8 = ja , 3 = ?	39 - Jhalavarali 9 = jha , 3 = ?	40 - Navaneetam 0 = na , 4 = va	41 - Pavani 1 = ? , 4 = va	42 - Raghupriya 2 = ra , 4 = ?
VIII	Vasu	S R$_1$ G$_2$ M$_2$ C Db Eb F#	43 - Gavambhodi 3 = ga , 4 = va	44 - Bhavapriya 4 = bha , 4 = va	45 - Shubhapantuvarali 5 = ? , 4 = va **Todi**	46 - Shadvidamargini 6 = sha , 4 = vi	47 - Suvarnangi 7 = su , 4 = va	48 - Divyamani 8 = ? , 4 = vya
IX	Brahma	S R$_1$ G$_3$ M$_2$ C Db E F#	49 - Dhavalambari 9 = dha , 4 = va	50 - Nāmanarayani 0 = nā , 5 = ma	51 - Kamavardhini 1 = ka , 5 = ma **Poorvi**	52 - Ramapriya 2 = ra , 5 = ma	53 - Gamanashrama 3 = ga , 5 = ma **Marva**	54 - Vishwambari 4 = vi , 5 = ?
X	Disi	S R$_2$ G$_2$ M$_2$ C D Eb F#	55 - Shāmalangi 5 = ? , 5 = ma	56 - Shanmukhapriya 6 = sha , 5 = mu	57 - Simhendramadhyamam 7 = si , 5 = ma	58 - Hemavati 8 = he , 5 = ma	59 - Dharmavati 9 = dha , 5 = ma	60 - Neetimati 0 = ne , 6 = ti
XI	Rudra	S R$_2$ G$_3$ M$_2$ C D E F#	61 - Kantamani 1 = ka , 6 = ta	62 - Rishabhapriya 2 = ri , 6 = sha	63 - Latangi 3 = ? , 6 = ta	64 - Vachaspati 4 = va , 6 = cha	65 - Mechakalyani 5 = me , 6 = cha **Kalyan (Yaman)** (Lydian)	66 - Chitrambari 6 = chi , 6 = tra
XII	Aditya	S R$_3$ G$_3$ M$_2$ C D# E F#	67 - Sucharitra 7 = su , 6 = cha	68 - Jyotiswarupini 8 = jyo , 6 = ti	69 - Dhatuvardani 9 = dha , 6 = tu	70 - Nāsikabhushini 0 = nā , 7 = si	71 - Kōsalam 1 = kō , 7 = sa	72 - Rasikapriya 2 = ra , 7 = si

Katapaydi Sankhya

0 = na nu nā ne	1 = ka ko ki ku kra ke kō	2 = ra ru ri	3 = ga go ge	4 = va bha vi vya
5 = ma mu me	6 = ta cha sha ti chi tu tra	7 = se su sa si	8 = ha ja he jyo	9 = dhe jha dha

22 Shrutis   Just Third and Fifth Tuning   C = 1/1   All 5 Limit ratios calculated by Perfect Fifths and Syntonic Commas

Deviations +/- from 12ET in cents

22 Shrutis

				(no Gb↑)	**Db↑ 16/15**	11.73	**Ab↑ 8/5**	13.69	**Eb↑ 6/5**
									D# enh.
					Ab↑+		Eb↑+		(Bb↑+)
(no Gb)	**Db 256/243** -9.78	**Ab 128/81** -7.82	**Eb 32/27** -5.87	**Bb 16/9** -3.91	**F 4/3** -1.96		**C 1/1** 0.00		
	(C#↓ enh. 135/128) -7.82	(G#↓ enh. 405/256) -5.87	D#↓ enharmonic	A#↓ enh.					
				Ebb enh.		Bbb enh.			
			(no G↓)	**D↓ 10/9** -17.60	**A↓ 5/3** -15.64	**E↓ 5/4**			

12 Primary Ratios from Sa (C)   (Sa Pa drone and Sa Ma drone with primary ratios)

	Db↑ 16/15	11.73	**Ab↑ 8/5**	13.69	**Eb↑ 6/5**
Bb 16/9 -3.91	**F 4/3** -1.96		**C 1/1** 0.00		
			A↓ 5/3 -15.64		**E↓ 5/4**

12 Primary Ratios from Ma (F)   (Sa Ma drone with three adjusted ratios)

(Gb↑ 64/45) 9.78	**Db↑ 16/15** 11.73	**Ab↑ 8/5** 13.69
F# enh. 729/512 11.73		
Eb 32/27 -5.87	**Bb 16/9** -3.91	**F 4/3** -1.96	**C 1/1** 0.00
		D↓ 10/9 -17.60	**A↓ 5/3** -15.64	**E↓ 5/4**

Syntonic Comma = (81/80) = 21.51 cents
↑,↓ = Syntonic Comma sharp, flat

15.64	**Bb↑ 9/5**	17.60	**F↑ 27/20**	19.55	(no C↑)

A# enh.

	Ebb↑ enh.		Bbb↑ enh.			(Gb↑ enh. 64/45)	9.78

G 3/2	1.96	**D 9/8**	3.91	**A 27/16**	5.87	**E 81/64**	7.82	**B 243/128**	9.78	**F# 729/512**	11.73	(no C#)

(F+)　　　　　C+　　　　　G+

-13.69	**B↓ 15/8**	-11.73	**F#↓ 45/32**	-9.78	(no C#↓)

15.64

G 3/2	1.96	**D 9/8**	3.91

-13.69	**B↓ 15/8**	-11.73	**F#↓ 45/32**	-9.78

G 3/2	1.96

-13.69	**B↓ 15/8**	-11.73

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7 Swaras and 22 Shrutis

Swar, Swara, Swaras = note and note names
Sargam = the short form of the note names
Saptak = octave

Achala or Prakruti Swara = immutable fixed anchor notes Sa and Pa
Chala or Vikruti Swara = notes variable by accidentals
Swara Prakara = chromatic scale
Shruti = the pitch of a note

22 Shrutis

Sa Pa immutable (achala)
Sa Pa drone and Sa Ma drone
with primary ratios

Sa Ma drone with
three adjusted ratios

Hindustani Swaras
(North Indian)

Shuddha = Natural
Komal = Flat   Tivra = Sharp

Shadja	C Achala	Sa
Nishada	B↓ Shuddha	Ni
	Bb Komal	Ni
Dhaivata	A↓ Shuddha	Dha
	Ab↑ Komal	Dha
Panchama	G Achala	Pa
Madhyama	F#↓ Tivra	Mā
	F Shuddha	Ma
Gandhara	E↓ Shuddha	Ga
	Eb↑ Komal	Ga
Rishabha	D Shuddha	Re
	Db↑ Komal	Re
Shadja	C Achala	Sa

Carnatic Swaras
(South Indian)
(various different accidental names)

Shadja	C Achala	Sa S
Nishada	B↓ Kakali	Nu N₃
	Bb Kaishiki	Ni N₂	A#↓ Shatshruti	Dhu D₃
	Bbb Shuddha	Na N₁	A↓ Chatushruti	Dhi D₂
Dhaivata	→	→	Ab↑ Shuddha	Dha D₁
Panchama	G Achala	Pa P
Madhyama	F#↓ Prati	Mi M₂
	F Shuddha	Ma M₁
Gandhara	→	→	E↓ Antara	Gu G₃
	D# Shatshruti	Ru R₃	Eb↑ Sadharana	Gi G₂
Rishabha	D Chatushruti	Ri R₂	Ebb↑ Shuddha	Ga G₁
	Db↑ Shuddha	Ra R₁
Shadja	C Achala	Sa S

22 Shrutis table:

Primary Ratios	Secondary Ratios	4 Extra Carnatic Enharmonic Notes	Primary Ratios
C			C
	B		
B↓			B↓
	Bb↑	A# enh.	
Bb		A#↓ enh.	Bb
	A	Bbb↑ enh.	
A↓		Bbb enh.	A↓
Ab↑			Ab↑
	Ab		
G			G
	F#		* (Gb↑) = F# enh.
F#↓			
	F↑		
F			F
	E		
E↓			E↓
Eb↑		D# enh.	
	Eb	D#↓ enh.	Eb
		Ebb↑ enh.	
D		Ebb enh.	D
	D↓		D↓
Db↑			Db↑
	Db		
C			C

* (Gb↑) = F# enh.

Just Third and Fifth Tuning   C = 1/1

All 5 Limit ratios calculated by Perfect Fifths and Syntonic Commas

Syntonic Comma = (81/80) = 21.51 cents
↑,↓ = Syntonic Comma sharp, flat

If the Sa Pa drone had the unadjusted Sa Ma ratios

Primary Ratios (left column, top to bottom):
C / B↓ / Bb↑ / A / Ab↑ / G / F#↓ / F / E↓ / Eb↑ / D / ** (C#↓) = Db enh. / C

Names given by Śārṅgadeva	Primary Ratios	Secondary Ratios	Cents	+/- from 12ET	53ET	Ratio	Cents	+/- from Just	+/- from 12ET
Chandovatī	2/1		1200	0	2^(53/53)	2	1200	0	0
Mandā		243/128	1109.78	9.78	2^(49/53)	1.898064	1109.43	-0.34	9.43
Kumudvatī	15/8		1088.27	-11.73	2^(48/53)	1.873402	1086.79	-1.48	-13.21
Tīvrā		9/5	1017.60	17.60	2^(45/53)	1.801323	1018.87	1.27	18.87
Kṣobhinī	16/9		996.09	-3.91	2^(44/53)	1.777918	996.23	0.14	-3.77
Ugrā		27/16	905.87	5.87	2^(40/53)	1.687301	905.66	-0.20	5.66
Ramyā	5/3		884.36	-15.64	2^(39/53)	1.665377	883.02	-1.34	-16.98
Rohiṇī	8/5		813.69	13.69	2^(36/53)	1.601302	815.09	1.41	15.09
Madantī		128/81	792.18	-7.82	2^(35/53)	1.580496	792.45	0.27	-7.55
Ālāpinī	3/2		701.96	1.96	2^(31/53)	1.499941	701.89	-0.07	1.89
Sandīpanī		729/512	611.73	11.73	2^(27/53)	1.423492	611.32	-0.41	11.32
Raktā	45/32		590.22	-9.78	2^(26/53)	1.404996	588.68	-1.54	-11.32
Kṣhiti		27/20	519.55	19.55	2^(23/53)	1.350939	520.75	1.20	20.75
Mārjanī	4/3		498.04	-1.96	2^(22/53)	1.333386	498.11	0.07	-1.89
Prīti		81/64	407.82	7.82	2^(18/53)	1.265426	407.55	-0.27	7.55
Prasāriṇī	5/4		386.31	-13.69	2^(17/53)	1.248984	384.91	-1.41	-15.09
Vajrikā	6/5		315.64	15.64	2^(14/53)	1.200929	316.98	1.34	16.98
Krodhā		32/27	294.13	-5.87	2^(13/53)	1.185325	294.34	0.20	-5.66
Raudrī	9/8		203.91	3.91	2^(9/53)	1.124911	203.77	-0.14	3.77
Ratikā		10/9	182.40	-17.60	2^(8/53)	1.110295	181.13	-1.27	-18.87
Ranjanī	16/15		111.73	11.73	2^(5/53)	1.067577	113.21	1.48	13.21
Dayāvatī		256/243	90.22	-9.78	2^(4/53)	1.053705	90.57	0.34	-9.43
Chandovatī	1/1		0	0	2^(0/53)	1	0	0	0
→ → Sandīpanī		64/45	609.78	9.78	2^(27/53)	1.423492	611.32	1.54	11.32
** (C#↓) = Db enh. Dayāvatī		135/128	92.18	-7.82	2^(4/53)	1.053705	90.57	-1.61	-9.43

Carnatic Enharmonic Notes

Bb = A# enh.   A = Bbb enh.
Eb = D# enh.   D = Ebb enh.

B↓	B↓
15/8 ÷ 9/5 = 25/24	15/8 ÷ 16/9 = 135/128
A# enh.	A#↓ enh.

	Bbb↑ enh.
Bbb enh.	27/16 ÷ 8/5
5/3 ÷ 8/5 = 25/24	= 135/128
Ab↑	Ab↑

E↓	E↓
5/4 ÷ 6/5 = 25/24	5/4 ÷ 32/27 = 135/128
D# enh.	D#↓ enh.

	Ebb↑ enh.
Ebb enh.	9/8 ÷ 16/15
10/9 ÷ 16/15 = 25/24	= 135/128
Db↑	Db↑

Tuning and Frets 1
Sa Pa Sa Ma Tuning

22 Shrutis used in total

(all 5 Limit ratios calculated by Perfect Fifths and Syntonic Commas)

Syntonic Comma = (81/80) = 21.51 cents

↑,↓ = Syntonic Comma sharp, flat

Sitar, Sarod, Esraj, Dilruba - Sa Concert Pitch → C, Db, D	**Rudra Veena, Surbahar** - Sa Concert Pitch → F, F#, G, Ab, A

Sarangi (Pa Sa Ma) - Sa Concert Pitch → F to C
Violin - Sa Concert Pitch → E to B

Saraswati Veena - Sa Concert Pitch → Bb, B, C
(Tuning 2 Variation: Sa Ma Sa Ma → Sa Pa Sa Ma)

Frets for Sa Pa (C G) Drone and Sa Ma (C F) Drone with primary ratios (pr)

Frets for Sa Ma (C F) Drone with three adjusted ratios (ar)

(The Rudra and Saraswati Veena strings strung in the opposite direction to the Sitar and the Surbahar. The 4th playing string is closest to the ground)

Fret	pr/ar	4th String **Sa**	Ratio	Cents	+/- from 12ET	3rd String **Pa**	Ratio	Cents	+/- from 12ET	2nd String **Sa**	Ratio	Cents	+/- from 12ET	1st String **Ma**	Ratio	Cents	+/- from 12ET
						←3/2→				←4/3→				←4/3→			
0 / XII		C	1/1	0	0.00	G	3/2	701.96	1.96	C	1/1	0	0.00	F	4/3	498.04	-1.96
		(...bend Db up for primary ratio)				(...bend Ab up for primary ratio)				(...bend Db up for primary ratio)			(10935 / 8192 = 499.999 cents)	(angle fret for primary ratios, or...)			
I / XIII	pr	Db	256/243	90.22	-9.78	Ab	128/81	792.18	-7.82	Db	256/243	90.22	-9.78	F#↓	45/32	590.22	-9.78
I / XIII	ar	Db↑	16/15	111.73	11.73	Ab↑	8/5	813.69	13.69	Db↑	16/15	111.73	11.73	*(Gb↑)	(64/45)	609.78	9.78
										(4/3 = 498.045 cents)				(bend G↓ up for adjusted ratio)			
						(no good fret placement solution for A↓ for primary ratios)								(bend G↓ up for adjusted ratio)			
II / XIV	ar	D↓	10/9	182.40	-17.60	A↓	5/3	884.36	-15.64	D↓	10/9	182.40	-17.60	---(G↓)---			
II / XIV	pr	D	9/8	203.91	3.91	A	27/16	905.87	5.87	D	9/8	203.91	3.91	G	3/2	701.96	1.96
						(no good fret placement solution for Bb for primary ratios)								(bend Ab up for adjusted ratio)			
III / (XV)	ar	Eb	32/27	294.13	-5.87	Bb	16/9	996.09	-3.91	Eb	32/27	294.13	-5.87	Ab	128/81	792.18	-7.82
III / (XV)	pr	Eb↑	6/5	315.64	15.64	Bb↑	9/5	1017.60	17.60	Eb↑	6/5	315.64	15.64	Ab↑	8/5	813.69	13.69
						(bend Bb up to Bb↑ if desired to tune 6/5 with G)											
IV / XVI		E↓	5/4	386.31	-13.69	B↓	15/8	1088.27	-11.73	E↓	5/4	386.31	-13.69	A↓	5/3	884.36	-15.64
														(bend Bb up to Bb↑ if desired to tune 6/5 with G)			
V / XVII		F	4/3	498.04	-1.96	C	1/1	0	0.00	F	4/3	498.04	-1.96	Bb	16/9	996.09	-3.91
														Bb↑	9/5	1017.60	17.60
		(bend F#↓ up for adjusted ratio)	(16384 / 10935 = 700.001 cents)			(bend Db up for both ratios)	(10935 / 8192 = 499.999 cents)		(bend F#↓ up for adjusted ratio)								
VI / XVIII		F#↓	45/32	590.22	-9.78	Db	256/243	90.22	-9.78	F#↓	45/32	590.22	-9.78	B↓	15/8	1088.27	-11.73
		*(Gb↑)	(64/45)	609.78	9.78	Db↑	16/15	111.73	11.73	*(Gb↑)	(64/45)	609.78	9.78	B	243/128	1109.78	9.78
		(3/2 = 701.955 cents)				(4/3 = 498.045 cents)											
						(no good fret placement solution for D↓ for adjusted ratios)											
VII / XIX		---(G↓)---				D↓	10/9	182.40	-17.60	---(G↓)---				---(C↓)---			
VII / XIX		G	3/2	701.96	1.96	D	9/8	203.91	3.91	G	3/2	701.96	1.96	C	1/1	0	0.00
						(no good fret placement solution for Eb for adjusted ratios)											
(VIII) / (XX)		Ab	128/81	792.18	-7.82	Eb	32/27	294.13	-5.87	Ab	128/81	792.18	-7.82	Db	256/243	90.22	-9.78
(VIII) / (XX)		Ab↑	8/5	813.69	13.69	Eb↑	6/5	315.64	15.64	Ab↑	8/5	813.69	13.69	Db↑	16/15	111.73	11.73
														(bend D↓ up for primary ratio or angle fret)			
IX / XXI		A↓	5/3	884.36	-15.64	E↓	5/4	386.31	-13.69	A↓	5/3	884.36	-15.64	D↓	10/9	182.40	-17.60
IX / XXI		A	27/16	905.87	5.87	E	81/64	407.82	7.82	A	27/16	905.87	5.87	D	9/8	203.91	3.91
		(bend Bb up to Bb↑ if desired to tune 6/5 with G)								(bend Bb up to Bb↑ if desired to tune 6/5 with G)				(bend Eb up for primary ratio or angle fret)			
X / (XXII)		Bb	16/9	996.09	-3.91	F	4/3	498.04	-1.96	Bb	16/9	996.09	-3.91	Eb	32/27	294.13	-5.87
X / (XXII)		Bb↑	9/5	1017.60	17.60	F↑	27/20	519.55	19.55	Bb↑	9/5	1017.60	17.60	Eb↑	6/5	315.64	15.64
						(bend F#↓ up for adjusted ratio)											
XI / XXIII		B↓	15/8	1088.27	-11.73	F#↓	45/32	590.22	-9.78	B↓	15/8	1088.27	-11.73	E↓	5/4	386.31	-13.69
						*(Gb↑)	64/45	609.78	9.78								
XII / XXIV		C	1/1	0	0.00	G	3/2	701.96	1.96	C	1/1	0	0.00	F	4/3	498.04	-1.96

*(Gb↑)	(64/45)	609.78	9.78	=	F# enh.	729/512 / 611.73 / 11.73

Notes: -Sitar and Surbahar frets can be angled for tuning on the first and second strings.
-The intonation of the third and fourth string is usually so bad in the higher
 positions that exact fret placement on these strings, (caused by angling the
 frets for the first and second strings) is of no importance.
-Rudra Veena frets cannot be angled.

-Fret placement is dependent on whether the drone is Sa-Pa or Sa-Ma, which
 depends on the raga. There is no one perfect solution for all possibilities.

Tuning and Frets 2
Sa Ma Sa Ma Tuning

19 Shrutis used in total

(all 5 Limit ratios calculated by Perfect Fifths and Syntonic Commas)

Syntonic Comma = (81/80) = 21.51 cents
↑,↓ = Syntonic Comma sharp, flat

Sitar, Sarod, Esraj, Dilruba
- Sa Concert Pitch → C, Db, D

Rudra Veena, Surbahar
- Sa Concert Pitch → F, F#, G, Ab, A

Sarangi (Ma Sa Ma) - Sa Concert Pitch → F to C
Violin - Sa Concert Pitch → E to B

Saraswati Veena - Sa Concert Pitch → Bb, B, C
(Sa Ma Sa Ma = Tuning 4 Pa Sa Pa Sa "inverted")

Frets for Sa Ma (C F) Drone
with primary ratios (pr)

Frets for Sa Ma (C F) Drone
with three adjusted ratios (ar)

(The Rudra and Saraswati Veena strings strung in the opposite direction to the Sitar and the Surbahar. The 4th playing string is closest to the ground)

Fret		4th String	Ratio	Cents	+/- from 12ET	3rd String		Ratio	Cents	+/- from 12ET	2nd String		Ratio	Cents	+/- from 12ET	1st String		Ratio	Cents	+/- from 12ET
		Sa				**Ma**					**Sa**					**Ma**				
0 / XII		**C**	1/1	0	0.00	**F**		4/3	498.04	-1.96	**C**		1/1	0	0.00	**F**		4/3	498.04	-1.96
		(bend Db up for primary ratio)		(10935 / 8192 = 499.999 cents)					(16384 / 10935 = 700.001 cents)		(bend Db up for primary ratio)		(10935 / 8192 = 499.999 cents)						
I / XIII	pr	Db	256/243	90.22	-9.78	**F#↓**		45/32	590.22	-9.78	Db		256/243	90.22	-9.78	**F#↓**		45/32	590.22	-9.78
I / XIII	ar	**Db↑**	16/15	111.73	11.73	*(Gb↑)		('64/45)	609.78	9.78	**Db↑**		16/15	111.73	11.73	*(Gb↑)		('64/45)	609.78	9.78
				(4/3 = 498.045 cents)		(bend G↓ up for adjusted ratio)			(3/2 = 701.955 cents)					(4/3 = 498.045 cents)		(bend G↓ up for adjusted ratio)				
II / XIV	ar	D↓	10/9	182.40	-17.60	---(G↓)---					D↓		10/9	182.40	-17.60	---(G↓)---				
II / XIV	pr	**D**	9/8	203.91	3.91	**G**		3/2	701.96	1.96	**D**		9/8	203.91	3.91	**G**		3/2	701.96	1.96
					(bend Ab up for adjusted ratio)					(bend Ab up for adjusted ratio)										
III / (XV)	ar	Eb	32/27	294.13	-5.87	Ab		128/81	792.18	-7.82	Eb		32/27	294.13	-5.87	Ab		128/81	792.18	-7.82
III / (XV)	pr	**Eb↑**	6/5	315.64	15.64	**Ab↑**		8/5	813.69	13.69	**Eb↑**		6/5	315.64	15.64	**Ab↑**		8/5	813.69	13.69
IV / XVI		**E↓**	5/4	386.31	-13.69	**A↓**		5/3	884.36	-15.64	**E↓**		5/4	386.31	-13.69	**A↓**		5/3	884.36	-15.64
V / XVII		**F**	4/3	498.04	-1.96	**Bb**		16/9	996.09	-3.91	**F**		4/3	498.04	-1.96	**Bb**		16/9	996.09	-3.91
		(bend F#↓ up for adjusted ratio)								(bend F#↓ up for adjusted ratio)										
VI / XVIII		**F#↓**	45/32	590.22	-9.78	**B↓**		15/8	1088.27	-11.73	**F#↓**		45/32	590.22	-9.78	**B↓**		15/8	1088.27	-11.73
		*(Gb↑)	(64/45)	609.78	9.78						*(Gb↑)		(64/45)	609.78	9.78					
VII / XIX		**G**	3/2	701.96	1.96	**C**		1/1	0	0.00	**G**		3/2	701.96	1.96	**C**		1/1	0	0.00
(VIII) / (XX)		**Ab↑**	8/5	813.69	13.69	**Db↑**		16/15	111.73	11.73	**Ab↑**		8/5	813.69	13.69	**Db↑**		16/15	111.73	11.73
						(bend D↓ up for primary ratio)									(bend D↓ up for primary ratio)				
IX / XXI		**A↓**	5/3	884.36	-15.64	D↓		10/9	182.40	-17.60	**A↓**		5/3	884.36	-15.64	D↓		10/9	182.40	-17.60
		A	27/16	905.87	5.87	**D**		9/8	203.91	3.91	A		27/16	905.87	5.87	**D**		9/8	203.91	3.91
						(bend Eb up for primary ratio)									(bend Eb up for primary ratio)				
X / (XXII)		**Bb**	16/9	996.09	-3.91	Eb		32/27	294.13	-5.87	**Bb**		16/9	996.09	-3.91	Eb		32/27	294.13	-5.87
		Bb↑	9/5	1017.60	17.60	**Eb↑**		6/5	315.64	15.64	Bb↑		9/5	1017.60	17.60	**Eb↑**		6/5	315.64	15.64
XI / XXIII		**B↓**	15/8	1088.27	-11.73	**E↓**		5/4	386.31	-13.69	**B↓**		15/8	1088.27	-11.73	**E↓**		5/4	386.31	-13.69
XII / XXIV		**C**	1/1	0	0.00	**F**		4/3	498.04	-1.96	**C**		1/1	0	0.00	**F**		4/3	498.04	-1.96
						*(Gb↑)	(64/45)	609.78	9.78	=	F# enh.		729/512	611.73	11.73					

Tuning and Frets 3
Sa Pa Sa Pa Tuning

19 Shrutis used in total

(all 5 Limit ratios calculated by Perfect Fifths and Syntonic Commas)

Syntonic Comma = (81/80) = 21.51 cents
↑,↓ = Syntonic Comma sharp, flat

Sitar, Sarod, Esraj, Dilruba
- Sa Concert Pitch → C, Db, D

Rudra Veena, Surbahar
- Sa Concert Pitch → F, Gb, G, Ab, A

Sarangi (Pa Sa Pa) - Sa Concert Pitch → Eb to Bb
Violin - Sa Concert Pitch → D to A

Saraswati Veena - Sa Concert Pitch → Ab, A, Bb
(Sa Pa Sa Pa = Tuning 5 Ma Sa Ma Sa "inverted")

Frets for Sa Pa (C G) Drone and
Sa Ma (C F) Drone with primary ratios (pr)

Frets for Sa Ma (C F) Drone
with three adjusted ratios (ar)

(The Rudra and Saraswati Veena strings strung in the opposite direction to
the Sitar and the Surbahar. The 4th playing string is closest to the ground)

Fret			**4th String** Ratio	Cents	+/- from 12ET		**3rd String** ← 3/2 → Ratio	Cents	+/- from 12ET		**2nd String** ← 4/3 → Ratio	Cents	+/- from 12ET		**1st String** ← 3/2 → Ratio	Cents	+/- from 12ET
			Sa				**Pa**				**Sa**				**Pa**		
0 / XII			**C** 1/1	0	0.00		**G** 3/2	701.96	1.96		**C** 1/1	0	0.00		**G** 3/2	701.96	1.96
I / XIII			**Db↑** 16/15	111.73	11.73		**Ab↑** 8/5	813.69	13.69		**Db↑** 16/15	111.73	11.73		**Ab↑** 8/5	813.69	13.69
			(bend D↓ up for primary ratio)								(bend D↓ for primary ratio)						
II / XIV			D↓ 10/9	182.40	-17.60		**A↓** 5/3	884.36	-15.64		D↓ 10/9	182.40	-17.60		**A↓** 5/3	884.36	-15.64
			D 9/8	203.91	3.91		A 27/16	905.87	5.87		**D** 9/8	203.91	3.91		A 27/16	905.87	5.87
			(bend Eb up for primary ratio)				(bend Bb up to Bb↑ if desired to tune 6/5 with G)				(bend Eb up for primary ratio)				(bend Bb up to Bb↑ if desired to tune 6/5 with G)		
III / (XV)			Eb 32/27	294.13	-5.87		**Bb** 16/9	996.09	-3.91		Eb 32/27	294.13	-5.87		**Bb** 16/9	996.09	-3.91
			Eb↑ 6/5	315.64	15.64		Bb↑ 9/5	1017.60	17.60		**Eb↑** 6/5	315.64	15.64		Bb↑ 9/5	1017.60	17.60
IV / XVI			**E↓** 5/4	386.31	-13.69		**B↓** 15/8	1088.27	-11.73		**E↓** 5/4	386.31	-13.69		**B↓** 15/8	1088.27	-11.73
V / XVII			**F** 4/3	498.04	-1.96		**C** 1/1	0	0.00		**F** 4/3	498.04	-1.96		**C** 1/1	0	0.00
			(16384 / 10935 = 700.001 cents)				(bend Db up for primary ratio) (10935 / 8192 = 499.999 cents)				(16384 / 10935 = 700.001 cents)				(bend Db up for primary ratio)		
VI / XVIII	pr		**F#↓** 45/32	590.22	-9.78		Db 256/243	90.22	-9.78		**F#↓** 45/32	590.22	-9.78		Db 256/243	90.22	-9.78
VI / XVIII	ar		*(Gb↑) (64/45)	609.78	9.78		**Db↑** 16/15	111.73	11.73		*(Gb↑) (64/45)	609.78	9.78		**Db↑** 16/15	111.73	11.73
			(3/2 = 701.955 cents)				(4/3 = 498.045 cents)				(3/2 = 701.955 cents)						
			(bend G↓ up for adjusted ratio)								(bend G↓ up for adjusted ratio)						
VII / XIX	ar		---(G↓)---				D↓ 10/9	182.40	-17.60		---(G↓)---				D↓ 10/9	182.40	-17.60
VII / XIX	pr		**G** 3/2	701.96	1.96		**D** 9/8	203.91	3.91		**G** 3/2	701.96	1.96		**D** 9/8	203.91	3.91
			(bend Ab up for adjusted ratio)								(bend Ab up for adjusted ratio)						
(VIII) / (XX)	ar		Ab 128/81	792.18	-7.82		Eb 32/27	294.13	-5.87		Ab 128/81	792.18	-7.82		Eb 32/27	294.13	-5.87
(VIII) / (XX)	pr		**Ab↑** 8/5	813.69	13.69		**Eb↑** 6/5	315.64	15.64		**Ab↑** 8/5	813.69	13.69		**Eb↑** 6/5	315.64	15.64
IX / XXI			**A↓** 5/3	884.36	-15.64		**E↓** 5/4	386.31	-13.69		**A↓** 5/3	884.36	-15.64		**E↓** 5/4	386.31	-13.69
			(bend Bb up to Bb↑ if desired to tune 6/5 with G)								(bend Bb up to Bb↑ if desired to tune 6/5 with G)						
X / (XXII)			**Bb** 16/9	996.09	-3.91		**F** 4/3	498.04	-1.96		**Bb** 16/9	996.09	-3.91		**F** 4/3	498.04	-1.96
			Bb↑ 9/5	1017.60	17.60						Bb↑ 9/5	1017.60	17.60				
							(bend F#↓ up for adjusted ratio)								(bend F#↓ up for adjusted ratio)		
XI / XXIII			**B↓** 15/8	1088.27	-11.73		**F#↓** 45/32	590.22	-9.78		**B↓** 15/8	1088.27	-11.73		**F#↓** 45/32	590.22	-9.78
							*(Gb↑) (64/45)	609.78	9.78						*(Gb↑) (64/45)	609.78	9.78
XII / XXIV			**C** 1/1	0	0.00		**G** 3/2	701.96	1.96		**C** 1/1	0	0.00		**G** 3/2	701.96	1.96
											*(Gb↑) (64/45) 609.78 9.78	=	F# enh. 729/512 611.73 11.73				

Tuning and Frets 4
Pa Sa Pa Sa Tuning

19 Shrutis used in total
(Tuning 2 Sa Ma Sa Ma "Inverted" = Pa Sa Pa Sa perfect 4th higher)

(all 5 Limit ratios calculated by Perfect Fifths and Syntonic Commas)

Syntonic Comma = (81/80) = 21.51 cents
↑,↓ = Syntonic Comma sharp, flat

Sitar, Sarod, Esraj, Dilruba
- Sa Concert Pitch → F, Gb, G

Rudra Veena, Surbahar
- Sa Concert Pitch → Bb, B, C, Db, D

Sarangi (Sa Pa Sa) - Sa Concert Pitch → Bb to F
Violin - Sa Concert Pitch → A to E

Saraswati Veena - Sa Concert Pitch → Eb, E, F
(Pa Sa Pa Sa = Tuning 2 Sa Ma Sa Ma "inverted")

Frets for Sa Pa (C G) Drone and
Sa Ma (C F) Drone with primary ratios (pr)

Frets for Sa Ma (C F) Drone
with three adjusted ratios (ar)

(The Rudra and Saraswati Veena strings strung in the opposite direction to the Sitar and the Surbahar. The 4th playing string is closest to the ground)

Fret			4th String — Ratio	Cents	+/- from 12ET	← 4/3 →	3rd String — Ratio	Cents	+/- from 12ET	← 3/2 →	2nd String — Ratio	Cents	+/- from 12ET	← 4/3 →	1st String — Ratio	Cents	+/- from 12ET
0 / XII			**Pa** G 3/2	701.96	1.96		**Sa** C 1/1	0	0.00		**Pa** G 3/2	701.96	1.96		**Sa** C 1/1	0	0.00
I / XIII			Ab↑ 8/5	813.69	13.69		Db↑ 16/15	111.73	11.73		Ab↑ 8/5	813.69	13.69		Db↑ 16/15	111.73	11.73
			(bend D↓ up for primary ratio)												(bend D↓ up for primary ratio)		
II / XIV			A↓ 5/3	884.36	-15.64		D↓ 10/9	182.40	-17.60		A↓ 5/3	884.36	-15.64		D↓ 10/9	182.40	-17.60
			A 27/16	905.87	5.87		D 9/8	203.91	3.91		A 27/16	905.87	5.87		D 9/8	203.91	3.91
III / (XV)	(bend Bb up to Bb↑ if desired to tune 6/5 with G)		Bb 16/9	996.09	-3.91	(bend Eb up for primary ratio)	Eb 32/27	294.13	-5.87	(bend Bb up to Bb↑ if desired to tune 6/5 with G)	Bb 16/9	996.09	-3.91	(bend Eb up for primary ratio)	Eb 32/27	294.13	-5.87
			Bb↑ 9/5	1017.60	17.60		Eb↑ 6/5	315.64	15.64		Bb↑ 9/5	1017.60	17.60		Eb↑ 6/5	315.64	15.64
IV / XVI			B↓ 15/8	1088.27	-11.73		E↓ 5/4	386.31	-13.69		B↓ 15/8	1088.27	-11.73		E↓ 5/4	386.31	-13.69
V / XVII			C 1/1	0	0.00		F 4/3	498.04	-1.96		C 1/1	0	0.00		F 4/3	498.04	-1.96
	(bend Db up for primary ratio)		(10935 / 8192 = 499.999 cents)				(16384 / 10935 = 700.001 cents)		(bend Db up for primary ratio)		(10935 / 8192 = 499.999 cents)						
VI / XVIII	pr		Db 256/243	90.22	-9.78		F#↓ 45/32	590.22	-9.78		Db 256/243	90.22	-9.78		F#↓ 45/32	590.22	-9.78
VI / XVIII	ar		Db↑ 16/15	111.73	11.73		*(Gb↑) (64/45)	609.78	9.78		Db↑ 16/15	111.73	11.73		*(Gb↑) (64/45)	609.78	9.78
			(4/3 = 498.045 cents)				(3/2 = 701.955 cents) (bend G↓ up for adjusted ratio)				(4/3 = 498.045 cents)				(bend G↓ up for adjusted ratio)		
VII / XIX	ar		D↓ 10/9	182.40	-17.60		---(G↓)---				D↓ 10/9	182.40	-17.60		---(G↓)---		
VII / XIX	pr		D 9/8	203.91	3.91		G 3/2	701.96	1.96		D 9/8	203.91	3.91		G 3/2	701.96	1.96
			(bend Ab up for adjusted ratio)												(bend Ab up for adjusted ratio)		
(VIII) / (XX)	ar		Eb 32/27	294.13	-5.87		Ab 128/81	792.18	-7.82		Eb 32/27	294.13	-5.87		Ab 128/81	792.18	-7.82
(VIII) / (XX)	pr		Eb↑ 6/5	315.64	15.64		Ab↑ 8/5	813.69	13.69		Eb↑ 6/5	315.64	15.64		Ab↑ 8/5	813.69	13.69
IX / XXI			E↓ 5/4	386.31	-13.69		A↓ 5/3	884.36	-15.64		E↓ 5/4	386.31	-13.69		A↓ 5/3	884.36	-15.64
			(bend Bb up to Bb↑ if desired to tune 6/5 with G)												(bend Bb up to Bb↑ if desired to tune 6/5 with G)		
X / (XXII)			F 4/3	498.04	-1.96		Bb 16/9	996.09	-3.91		F 4/3	498.04	-1.96		Bb 16/9	996.09	-3.91
							Bb↑ 9/5	1017.60	17.60							Bb↑ 9/5	1017.60	17.60
	(bend F#↓ up for adjusted ratio)									(bend F#↓ up for adjusted ratio)							
XI / XXIII			F#↓ 45/32	590.22	-9.78		B↓ 15/8	1088.27	-11.73		F#↓ 45/32	590.22	-9.78		B↓ 15/8	1088.27	-11.73
			*(Gb↑) (64/45)	609.78	9.78						*(Gb↑) (64/45)	609.78	9.78				
XII / XXIV			G 3/2	701.96	1.96		C 1/1	0	0.00		G 3/2	701.96	1.96		C 1/1	0	0.00

*(Gb↑) (64/45) 609.78 9.78 = F# enh. 729/512 611.73 11.73

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Notes: -Not only can the Saraswati Veena frets not be angled like the Sitar frets can,
           they can't even be moved. The tuning and frets to the left present an unobtainable
           ideal that the Saraswati Veena is not possible to even remotely reach.

          -The tuning of the Saraswati Veena is dependent entirely on the position of
           the fixed frets and the bridge placement for intonantion, and will never be able to
           be play exactly in tune in Just Intonation.

Tuning and Frets 5
Ma Sa Ma Sa Tuning

19 Shrutis used in total
(Tuning 3 Sa Pa Sa Pa "Inverted" = Ma Sa Ma Sa perfect 5th higher)

(all 5 Limit ratios calculated by Perfect Fifths and Syntonic Commas)

Syntonic Comma = (81/80) = 21.51 cents
↑,↓ = Syntonic Comma sharp, flat

Sitar, Sarod, Esraj, Dilruba
- Sa Concert Pitch → G, Ab, A

Rudra Veena, Surbahar
- Sa Concert Pitch → C, Db, D, Eb, E

Sarangi (Sa Ma Sa) - Sa Concert Pitch → Bb to F
Violin - Sa Concert Pitch → A to E

Saraswati Veena - Sa Concert Pitch → Eb, E, F
(Ma Sa Ma Sa = Tuning 3 Sa Pa Sa Pa "inverted")

Frets for Sa Ma (C F) Drone
with primary ratios (pr)

Frets for Sa Ma (C F) Drone
with three adjusted ratios (ar)

(The Rudra and Saraswati Veena strings strung in the opposite direction to the Sitar and the Surbahar. The 4th playing string is closest to the ground)

Fret			Ratio	Cents	+/- from 12ET			Ratio	Cents	+/- from 12ET			Ratio	Cents	+/- from 12ET			Ratio	Cents	+/- from 12ET
		4th String		← 3/2 →			**3rd String**		← 4/3 →			**2nd String**		← 3/2 →			**1st String**			
		Ma					**Sa**					**Ma**					**Sa**			
0 / XII		F	4/3	498.04	-1.96	C	1/1	0	0.00	F	4/3	498.04	-1.96	C	1/1	0	0.00
		(16384 / 10935 = 700.001 cents)				(bend Db up for primary ratio)	(10935 / 8192 = 499.999 cents)			(16384 / 10935 = 700.001 cents)				(bend Db up for primary ratio)			
I / XIII	pr	F#↓	45/32	590.22	-9.78	Db	256/243	90.22	-9.78	F#↓	45/32	590.22	-9.78	Db	256/243	90.22	-9.78
I / XIII	ar	*(Gb↑)	(64/45)	609.78	9.78	Db↑	16/15	111.73	11.73	*(Gb↑)	(64/45)	609.78	9.78	Db↑	16/15	111.73	11.73
		(bend G↓ up for adjusted ratio)				(3/2 = 701.955 cents)				(4/3 = 498.045 cents)	(bend G↓ up for adjusted ratio)			(3/2 = 701.955 cents)			
II / XIV	ar	---(G↓)---				D↓	10/9	182.40	-17.60	---(G↓)---				D↓	10/9	182.40	-17.60
II / XIV	pr	G	3/2	701.96	1.96	D	9/8	203.91	3.91	G	3/2	701.96	1.96	D	9/8	203.91	3.91
		(bend Ab up for adjusted ratio)								(bend Ab up for adjusted ratio)							
III / (XV)	ar	Ab	128/81	792.18	-7.82	Eb	32/27	294.13	-5.87	Ab	128/81	792.18	-7.82	Eb	32/27	294.13	-5.87
III / (XV)	pr	Ab↑	8/5	813.69	13.69	Eb↑	6/5	315.64	15.64	Ab↑	8/5	813.69	13.69	Eb↑	6/5	315.64	15.64
IV / XVI		A↓	5/3	884.36	-15.64	E↓	5/4	386.31	-13.69	A↓	5/3	884.36	-15.64	E↓	5/4	386.31	-13.69
V / XVII		Bb	16/9	996.09	-3.91	F	4/3	498.04	-1.96	Bb	16/9	996.09	-3.91	F	4/3	498.04	-1.96
						(bend F#↓ up for adjusted ratio)								(bend F#↓ up for adjusted ratio)			
VI / XVIII		B↓	15/8	1088.27	-11.73	F#↓	45/32	590.22	-9.78	B↓	15/8	1088.27	-11.73	F#↓	45/32	590.22	-9.78
						*(Gb↑)	(64/45)	609.78	9.78					*(Gb↑)	(64/45)	609.78	9.78
VII / XIX		C	1/1	0	0.00	G	3/2	701.96	1.96	C	1/1	0	0.00	G	3/2	701.96	1.96
(VIII) / (XX)		Db↑	16/15	111.73	11.73	Ab↑	8/5	813.69	13.69	Db↑	16/15	111.73	11.73	Ab↑	8/5	813.69	13.69
		(bend D↓ up for primary ratio)								(bend D↓ up for primary ratio)							
IX / XXI		D↓	10/9	182.40	-17.60	A↓	5/3	884.36	-15.64	D↓	10/9	182.40	-17.60	A↓	5/3	884.36	-15.64
		D	9/8	203.91	3.91	A	27/16	905.87	5.87	D	9/8	203.91	3.91	A	27/16	905.87	5.87
		(bend Eb up for primary ratio)								(bend Eb up for primary ratio)							
X / (XXII)		Eb	32/27	294.13	-5.87	Bb	16/9	996.09	-3.91	Eb	32/27	294.13	-5.87	Bb	16/9	996.09	-3.91
		Eb↑	6/5	315.64	15.64	Bb↑	9/5	1017.60	17.60	Eb↑	6/5	315.64	15.64	Bb↑	9/5	1017.60	17.60
XI / XXIII		E↓	5/4	386.31	-13.69	B↓	15/8	1088.27	-11.73	E↓	5/4	386.31	-13.69	B↓	15/8	1088.27	-11.73
XII / XXIV		C	1/1	0	0.00	C	1/1	0	0.00	F	4/3	498.04	-1.96	C	1/1	0	0.00

*(Gb↑)	(64/45)	609.78	9.78	=	F# enh.	729/512	611.73	11.73

Instruments at Concert Pitch

Sitar, Sarod, Esraj, Dilruba

Tuning 1

Sa	Pa	Sa	Ma
D	A	D	G
Db	Ab	Db	Gb
C	G	C	F
(IV	III	II	I)

Tuning 2

Sa	Ma	Sa	Ma
D	G	D	G
Db	Gb	Db	Gb
C	F	C	F
Pa	Sa	Pa	Sa

Tuning 4 = T2 "Inverted"

Tuning 3

Sa	Pa	Sa	Pa
D	A	D	A
Db	Ab	Db	Ab
C	G	C	G
Ma	Sa	Ma	Sa

Tuning 5 = T3 "Inverted"

Rudra Veena, Surbahar

Tuning 1

Sa	Pa	Sa	Ma
A	E	A	D
Ab	Eb	Ab	Db
G	D	G	C
F#	C#	F#	B
F	C	F	Bb
(IV	III	II	I)

(Rudra Veena fourth string
lowest to the ground)

Tuning 2

Sa	Ma	Sa	Ma
A	D	A	D
Ab	Db	Ab	Db
G	C	G	C
F#	B	F#	B
F	Bb	F	Bb
Pa	Sa	Pa	Sa

Tuning 4 = T2 "Inverted"

Tuning 3

Sa	Pa	Sa	Pa
A	E	A	E
Ab	Eb	Ab	Eb
G	D	G	D
Gb	Db	Gb	Db
F	C	F	C
Ma	Sa	Ma	Sa

Tuning 5 = T3 "Inverted"

Saraswati Veena

Tuning 1 "Variation"

Sa	Pa	Sa	Ma	←
C	G	C	F	
B	F#	B	E	
Bb	F	Bb	Eb	
(IV	III	II	I)	

(fourth string lowest to the ground)

Tuning 2 = T4 "Inverted"

Sa	Ma	Sa	Ma
C	F	C	F
B	E	B	E
Bb	Eb	Bb	Eb
Pa	Sa	Pa	Sa

Tuning 4

Tuning 3 = T5 "Inverted"

Sa	Pa	Sa	Pa
Bb	F	Bb	F
A	E	A	E
Ab	Eb	Ab	Eb
Ma	Sa	Ma	Sa

Tuning 5

Sarangi   (approximate range dependent upon string guages)

Tuning 1

Pa	Sa	Ma
G	C	F
F#	B	E
F	Bb	Eb
E	A	D
Eb	Ab	Db
D	G	C
C#	F#	B
C	F	Bb
(III	II	I)

Tuning 2 = T4 "Inverted"

Ma	Sa	Ma
F	C	F
E	B	E
Eb	Bb	Eb
D	A	D
Db	Ab	Db
C	G	C
B	F#	B
Bb	F	Bb
Sa	Pa	Sa

Tuning 4

Tuning 2 = T5 "Inverted"

Pa	Sa	Pa
F	Bb	F
E	A	E
Eb	Ab	Eb
D	G	D
Db	Gb	Db
C	F	C
B	E	B
Bb	Eb	Bb
Sa	Ma	Sa

Tuning 5

Violin   (approximate range dependent upon string guages)

Tuning 1

Sa	Pa	Sa	Ma
B	F#	B	E
Bb	F	Bb	Eb
A	E	A	D
Ab	Eb	Ab	Db
G	D	G	C
F#	C#	F#	B
F	C	F	Bb
E	B	E	A
(IV	III	II	I)

Tuning 2 = T4 "Inverted"

Sa	Ma	Sa	Ma
B	E	B	E
Bb	Eb	Bb	Eb
A	D	A	D
Ab	Db	Ab	Db
G	C	G	C
F#	B	F#	B
F	Bb	F	Bb
E	A	E	A
Pa	Sa	Pa	Sa

Tuning 4

Tuning 3

Sa	Pa	Sa	Pa
A	E	A	E
Ab	Eb	Ab	Eb
G	D	G	D
Gb	Db	Gb	Db
F	C	F	C
E	B	E	B
Eb	Bb	Eb	Bb
D	A	D	A
Ma	Sa	Ma	Sa

Tuning 5 = T3 "Inverted"

Raga Terms

Raga   **= melodic framework for improvisation**   -the literal meaning of Raga is to "colour, tinge, dye", so to
     "colour the mind" of the listener with emotion and feeling
-each Raga has an emotional significance or mood (**Rasa**),
     and an association with a time (**Samay**), and season (**Ritu**)
-there are four three hour **Prahars** for the daytime cycle of Ragas (**Purva Bhaag**),
     and four for the evening cycle of Ragas (**Uttar Bhaag**).
-there are also Ragas for dawn **Praatahkaalin**, (where Shuddha Madhyama is important),
     and Ragas for dusk **Saayamkaalin**, (where Tivra Madhyama is important),
     which are known as **Sandhi Prakash** (Joining Light) Ragas.
-the six seasons are **Vasant = Spring**, **Grishma = Summer**
     Varsha = Monsoon, **Sharad = Autumn**, **Hemant = Late Fall**, **Shishir = Winter**
-**Sarv-Kalik** ragas can be played at any time
-a Raga is an array of melodic structures and motifs,
     each with their own melodic personality
-each **Thaat** or **Melakarta** "parent" scale can contain several Ragas

♦♦♦

Arohana   **= ascending scale notes of the raga**   -ascending and descending scale forms can omit different notes
Avarohana   **= descending scale notes of the raga**

Vakra Swaras   **= crooked, twisted or zig-zag notes**   -the ascending and descending scales are not always strictly so

Varjya Swaras   **= forbidden notes**   -notes excluded from a Raga, also known as **Vivadi swaras**

Jati   **= system of classifying ragas**   -Jati means "collection" or "caste"
-based on the number of notes in each of the Arohana and Avarohana scales

(???   **= scale with 3 notes to the octave)**   -16 possible Jati raga classifications with 4,5,6 or 7 scale notes, for example:
Surtara   **= scale with 4 notes to the octave**   **Audava - Surtara**   (5 note ascending - 4 note descending scales)
Audava   **= scale with 5 notes to the octave**   **Sampurna - Sampurna**   (7 note ascending - 7 note descending scales)
Shaadava   **= scale with 6 notes to the octave**   etc.
Sampurna   **= scale with 7 notes to the octave**

-Sampurna means "complete"

♦♦♦

Adhara Shadja	**= beginning and end of the octave**	-pitch level chosen by the performer
Adhista	**= dividing note of the octave**	-either Ma or Pa dividing the octave into two parts (anga)
Uttaranga	**= upper part of the octave**	
Purvanga	**= lower part of the octave**	
Vadi	**= most prominent note of the raga**	-in either upper or lower anga (part)
Samvadi	**= second most prominent note**	-consonant with the Vadi and in the opposite anga
Anuvadi	**= neither emphasized or de-emphasized note**	
Durbal	**= de-emphasized note**	

♦♦♦

Upanga Ragas	**= ragas strictly derived from the parent scale**	-Carnatic music terms
Bhashanga Ragas	**= ragas with notes external to the parent scale**	-these foreign notes are called "**Anya**" swara
Vivadi	**= dissonant note**	-in Hindustani music all the notes that do not belong to the Arohana and Avarohana of the raga. These though sometimes can be skillfully introduced to add colour to the interpretation.
Pakad	**= defining phrase or characteristic of a raga**	-also called **Swarup** or **Mukhya-Ang**
Alankar	**= note combinations of a raga**	-literally meaning "jewels", notes following a particular pattern like an ornament
Vishranti Sthan	**= resting notes of a raga**	-good consonant resolving notes to end a phrase or improvisation on

♦♦♦

Avirbhav	**= the original form of the Raga**	-making the raga and its distinguishing features visible
Tirobhav	**= deviating from the original form of the Raga**	-showing glimpses of a nearby Raga

♦♦♦

3 Raga Bhed (Types)	**-Shuddha Raga**	-a single Raga unique to itself
	-Chayalaga Raga	-a Raga that is similar and closely related to other Ragas
	-Sankeerna Raga	-a Raga that is a combination of two or more Ragas

Ornamentation Terms

Alankara	**= musical ornamentation**	-literally means "ornament" or "decoration"
		-also called **Palta** in Hindustani music
		-general term for any type of musical ornamentation or adornment
		-**Alankara** can be either irrational, which belong between the notes
		of a scale, or rational belonging only to scale notes
		-irrational **Alankara** are covered in the theory of **Gamakas**

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Gamaka	**= a pitch variation of a note**	-means "ornamented note"
		-pitch variation includes oscillations and glides between notes
		-each raga has specific rules for the types of "gamakas" used
		-there are 15 or more types of "gamakas" in Carnatic music
		-Carnatic and Hindustani music have different kinds of "gamakas"

Terms for Hindustani vocal and instrumental music

Kan-swar	**= a short grace note**	-can be sung or played before or after a note
		-extended Kan-swar become **Meends**
Meend	**= a glide from one note to another**	-on fretted instruments the string is bent or pulled across the fret
Andolan	**= a very slow pitch oscillation**	-around a specific note depending on the raga
Gamak	**= an emphasised note with oscillation**	-singing the note with force produces the rapid oscillation
Khatka	**= an ornamental cluster of notes**	-ornamenting a single main note
Murki	**= swift light cluster of notes**	-like a trill, mordent or turn
Taan	**= a rapid melodic improvised passage**	-used in vocal music and sung to a single vowel
Zamzama	**= a long complex cluster of notes**	-rendered in progressive combinations and permutations
		-like a complex **Taan** with sharp Gamaks

etc!

Terms for Carnatic vocal and instrumental music

Jaaru	**= a glide from one note to another**	-on fretted instruments the string is bent or pulled across the fret
Kampitam	**= a pitch oscillation between notes**	-moving between notes with a wavy pitch
Janta Swaras	**= double or repeated notes**	-the second note is slightly forced and glides up from a lower pitch
Spuritam	**= a very quick vibration**	-exactly like the Janta Swaras but very fast

etc!

Rhythmic Terms

Matra	**= beat**	
Vibhag (Ang)	**= a group of beats**	-like the Western bar, but each bar or **Vibhag** can have a different number of beats -each **Vibhag** is specially designated by a clap or a wave of the hand
Avartan	**= a rhythmic cycle**	-each repeated cycle of a **Tala**
Sam or Samam	**= the first beat of a cycle**	-means to "conjoin" or "come together" -point of resolution or beginning, a pivotal point -the transition point between soloists

♦♦♦

Tala or Taal	**= rhythmical grouping of Matras** (beats) **and Vibhags** (bars)	-means literally "clapping of the hands" -there are **Talas** with rhythmic cycles between 3 and 108 beats -there are over 100 **Talas**, 30 known and 10-12 commonly used
Tali	**= Clap of the hand (c)**	-Applies to the first beat of strongly stressed **Vibhags**
Khali	**= Wave of the hand (w)**	-Applies to the first beat of moderately stressed **Vibhags**

Talas	Beats	Vibhags and Matras
Ardh Jhaptal	=5	= 2c + 3c
Dadra / Khempta	=6	= 3c + 3w
Rupak	=7	= 3w + 2c + 2c
Tivra	=7	= 3c + 2w + 2c
Pashtu	=7	= 3c + 2c + 2c
Kaherava	=8	= 4c + 4w
Matta	=9	= 2c + 2c + 2w + 3c
Jhaptal	=10	= 2c + 3c + 2w + 3c
Sultal	=10	= 2c + 2w + 2c + 2w + 2c
Sawari	=11	= 2c + 2c + 2w + 2c + 1.5c +1.5c
Chautal / Dhrupad	=12	= 4c + 4c + 2c + 2c
Ektal	=12	= 2c + 2w + 2c + 2w + 2c + 2c
Jai	=13	= 2c + 2c + 2w + 2c + 2w + 1c + 2c
Adha-Chautal	=14	= 2c + 2c + 2w + 2c + 2w + 2c + 2w
Dipchandi / Jhumra	=14	= 3c + 4c + 3w + 4c
Dhammer	=14	= 5c + 2c + 3w + 4c
Pancham Sawari	=15	= 3c + 4c + 4w + 4c
Teen-Tal / Sitarkhani / Tilwada	=16	= 4c + 4c + 4w + 4c
etc!		

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Bols	**= mnemonic syllables**		-represent the various strokes on the Tabla, Pakhawaj etc
Theka	**= a common arrangement of bols**		-the convention of playing certain **bols** patterns for certain **talas**
			-usually following the pattern of **Vibhags**
			-usually based on a pair of slightly different symmetrical structures
Prakar	**= a variation of a Theka**		

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Vilambit Laya	**= in a slow tempo**		-**Laya** means meter
Madhya Laya	**= in a medium tempo**		-most styles start at one tempo and then speed up
Drut Laya	**= in a fast tempo**		

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Layakiri or Kala	**= rhythmic subdivisions**		-of 4, 2 or 1 **Matras**
	Single time	**4 strokes over 4 matras**	-Ekgun or Barabar
		5 strokes over 4 matras	-Kuadi or Savai
		6 strokes over 4 matras	-Adi-Lay or Derdh
		7 strokes over 4 matras	-Biadi-Lay or Paune dugan
	Double time	**4 strokes over 2 matras**	-Dugan
		5 strokes over 2 matras	-Mahakuadi
		6 strokes over 2 matras	-Mahaadi or Tigun
		7 strokes over 2 matras	-Mahabiadi
	Quadruple time	**4 strokes over 1 matras**	-Chaugun
		5 strokes over 1 matras	-Panchgun
		6 strokes over 1 matras	-Chehgun
		7 strokes over 1 matras	-Satgun
		8 strokes over 1 matras	-Aathgun

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Carnatic Talas	**Chapu**	**4 or 5 Talas**	-various mathematical constructs to organize the **Talas**
	Chanda	**108 Talas**	
	Melakarta	**72 Talas**	
	Suladi Sapta Talas	**35 Talas**	

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Aesthetic Terms

Nada = musical or cosmic sound
-the manifestation of reality and the entire cosmos through the energy of vibrations
-the metaphysical aim of the composer/performer

Ahata Nada = struck and audible sound
Anahata Nada = unstruck and inaudible sound
-The two types of sound, physical and metaphysical
-**Anahata** is the basis of all existence and the principle of all manifestation

Bhava = an emotional state that procedes Rasa
-a state of mind and being
-the process of becoming
-**Bhava** is the flower, **Rasa** is the fruit
-**Bhava** is what is embodied, **Rasa** is what emerges

Rasa = emotional flavour or aesthetic of a work
-literally means "essence, nectar, taste"
-**Rasas** are created by **Bhavas**
-an emotional feeling that can't be described connecting performer and listener

Nine Moods -example: the **Affect** of **Humour** is the **Emotion** of **Laughter**

Bhavas	Affect	Rasas	Emotion	Colour
Rati	Pleasure	Shringara	Love	Light Green
Hasa	Humour	Hasya	Laughter	White
Krodha	Anger	Raudra	Rage	Red
Shoka	Sorrow	Karuna	Compassion	Grey
Jugupsa	Disgust	Beebhatshya	Loathing	Blue
Bhaya	Fear	Bhayanaka	Terror	Black
Utsaha	Perseverence	Veera	Valour	Saffron
Vismaya	Amazement	Adbhuta	Wonder	Yellow
Shanta	Peace	Shanta	Tranquility	White

Hindustani Music

Hindustani Music   **= Music from the north of India**   -more improvisation than composition

Gharana   **= Hindustani lineage and tradition of musical style**   -typically of a single musical family or court

Brij Bhasa   **= a dialect of Hindi**   -most common language for Hindustani compositions

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Hindustani Music Forms or Styles of Singing and Compositions

-Dhrupad, Khayal, Chaturang (Tarana, Sargam), Dhamar, Hori, Thumri, Tappa, Ragasagar, Ghazal

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Dhrupad   -The oldest (12th century) and grandest form of Hindustani vocal music.
-A poetic form presented in an extended style, with precise and orderly elaboration of a **Raga**.
-Long composition of four parts: **Alap**, **Jod**, **Jhala** and **Bandish** (or **Cheez** or **Gat**)

First Unmeasured and Unpatterned Movement
-Alap = Introduction or Invocation   -Means "dialogue" or 'talk", and is a free melodic improvisation introducing and developing the Raga
-Jod = Formal section   -Means "pair", where a simple and steady unpatterned pulse is added to the music
-Jhala = Conclusion   -Means "web", where the unpatterned pulse or tempo greatly increases, and
     the rhythmic element overtakes the melodic element.

Second Measured Movement
-Bandish = Fixed Composition   -Means "binding together", and is a fixed composition with a specific raga, tala and words.
   -Sthayi = first part   -Emphasising the lower octave and first tetrachard of the middle octave. "Sthayi means an "octave".
   -Antara = second part   -Emphasising the second tetrachard of the middle octave and the higher octave.
   -Sanchari = third part   -Development section typical in Dhrupad Bandishes
   -Aabhog = fourth part   -Concluding section typical in Dhrupad Bandishes
   -(Bhoga = possible fifth part)

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Khayal   -Literally means "imagination, thought, reflection" and is the most prominent romantic style of singing
-18th century popular form combining Hindu and Persian traditions
-Based on a brief text elaborated with **Bol-Taans** and **Taans** (rapid vocal passages with or without words of the text)
-**Bada Khayal** = First part, usually in a slow tempo (**Vilambit Laya**)
-**Chota Khayal** = Second part, usually in a medium to fast tempo (**Madhya** or **Drut Laya**)
-When two soloisits in co-operation divide the improvisation between them it is called **Jugalbandi**

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Chaturang
-Song composition in four parts: fast **Khayal, Tarana, Sargam** and a **Paran** with Pakhawaj or Tabla
-**Khayal** = singing the words or **bols** of the composition
-**Tarana** = rapid improvised singing to nonsense syllables
-**Sargam** = singing passages using note names or **swaras**
-**Paran** = singing the sound syllables or **bols** used for the Pakhawaj or Tabla
-A **Chaturang** without the **Khayal** is called a **Trivat** (meaning three parts or colours)

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Dhamar
-A song in **Dhrupad** style, utilizing the **Dhamar Tala** of 14 beats played on the Pakhawaj or Tabla.
-Light, gentle, romantic music concering the antics of **Krishna** teasing the milkmaids during **Holi**.

Hori
-Semi-classical song popular in Uttar Pradesh and Bihar.
-Also called **Dhamar** and **Hori/Dhamar**, sung during the **Holi** Spring Festival of Colours.

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Thrumi
-Romantic and erotic form of singing dealing with the subjects of Love, Separation and Devotion.
-Sung in slower tempos, lighter ragas and simpler talas.
-Closely related is **Dadra** which has more verses and is in **Dadra Tala** (six beat rhthym cycle in 3+3 beats).

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Tappa
-Short folklore compositions written in Punjabi based on the **Shringara Rasa** (Love and Passion).
-However not sung in the Punjab! Sung in Varansi, Gwalior and the Bengal region.
-Developed in the late 18th century from the folk songs of camel riders.

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Ragasagar
-Vocal composition with lyrics set to 8 to 12 different ragas.

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Ghazal
-Poetic form originating in 10th century Iran.
-Never exceeds 12 couplets with 7 couplets on average.
-Began developing in India in the 12th century under Mughal influence.

Carnatic Music

Carnatic Music   **= Music from the south of India**
-main emphasis on vocal music
-equal importance to both composition and improvisation, complementing each other and taking turns, as a prelude to a song or extending it
-most compositions are sung in Telugu or Sanskrit

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Varnam
-Performed at the beginning of a recital revealing the features of a **Raga.**
-A very complex form which is usually quite lively.
-Different types include **Taana**, **Pada**, **Daru** and **Ragamalika** Varnam

Sub-sections
-Pallavi — -the first section of a **Varnam** sung with lyrics
-Anupallavi — -a recapitualtion sung with lyrics
-Muktaayi or Ettugade — -sung completely with syllables or swaras (except **Pada Varnam** can have lyrics)
-Sometimes the first three sections are repeated at a faster tempo
-Charanam — -sung with lyrics
-Chitta Swara or Ettugadda Swaram — -sung completely with syllables (except **Pada Varnam** can have lyrics)
-Anubandham — -the epilogue of a **Varnam**
-some **Varnams** have extra parts that lead back to earlier sections

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Kriti
-A longer song format that is the backbone of any **Carnatic** concert
-A highly evolved song set to a particular **Raga** and **Tala**, usually in a three part form.

Sub-sections
-Pallavi — -the refrain of a **Kriti**
-Anupallavi — -the second verse (sometimes optional)
-(Chittaswara) — -(optional section sung completely with syllables or swaras)
-Charanam — -the final and longest verse that concludes the song
-the last line usually inludes the composer's **mudra**, which is a specific group of words

♦♦♦

Ragam Tanam Pallavi	-A very complex form of singing that allows the performer to improvise to the greatest extent.
	-The most complete form of Indian music, demonstrating the skill and depth of knowledge of the performer.
	-Includes **Ragam**, **Tanam**, **Pallavi** and can include **Niraval**, **Kalpanaswaram** and **Tani Avartanam**.
Alapana or Ragam	-Means to "speak, address, discourse, communicate".
	-A pure form of melodic improvisation, creating the mood of the **Raga**, and laying down the foundation of the composition.
	-A journey of exploration of the **Raga**, unfolding slowly without rhthym, and can last up to 45 minutes.
	-Three parts include: **Akshipthika** - Introductory section giving the performer free reign to creatively express themselves
	Ragavardhini - Step by step elaboration on each **swara** of the **Raga**
	Magarini - Concluding section with rapid passages across the range of the **Raga**
Tanam	-An improvisation expanding the Raga with the syllables "a-nam-tam".
	-Performed as a rhythmic variation of Alapana but without a specific **Tala**, and usually not elaborately.
Pallavi	-Made up of three syllables: **Pa** for Pada (words), **La** for Laya (rhythm) and **Vi** for Vinyasam (variations).
	-A one line composition, equivalent to a refrain, set to one or more cycles of a **Tala**, played on the Mridangam and Ghatam.
	-The **Pallavi** line has two halves, **Purvangam** and **Uttarangam**, and is expanded into the **Niraval** and **Kalpanaswaram** sections.
Niraval	-An advanced improvisation, repeating the text of the **Pallavi** repeatedly, with melodic elaborations at various multiple tempos,
	maintaining the original patterns of duration and relation to the **Tala**.
	-Performing the **Pallavi** in three different tempos with the same **Tala** is called **Trikalam**.
Kalpanaswaram	-Like **Niraval**, except the performer improvises using **swara** names.
	-The **Kalpana swaras** improvisations should always end in the same place of the rhythmic cycle of the **Tala**.
	-The **swaras** can be sung at different multiple speeds.
Tani Avartanam	-Pure rhythmic improvisation for the percussionists, exploring intricate aspects of a **Tala**.

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Ragamalika	-Means a "Garland" of Ragas, being a composition where different sections are set to different Ragas.
Talamalika	-Means a "Garland" of Talas, being a composition where different sections are set to different Talas.
Ragatalamalika	-A special kind of **Ragamalika** composition that incorporates a range of **Talas**.