

# Aum: The Primordial Signal

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**Sai Venkatesh Balasubramanian**

Sree Sai VidhyaMandhir, Mallasandra, Bengaluru-560109, Karnataka, India.

[saivenkateshbalasubramanian@gmail.com](mailto:saivenkateshbalasubramanian@gmail.com)

## Abstract

Motivated by the increasing significance of Indian Spirituality and its cornerstone, the Pranava Aum, the present article explores the results of a signal based nonlinear analysis of Aum recital. Aum is seen to possess a rich frequency profile, with an array of integral and non-integral harmonic components. The phase portrait of Aum is rich, dense and ornamental, typical of chaotic systems. Polar plots of Aum show a remarkable uniformity in phase distribution. The bispectrum shows ordered pattern of scintillations, ruling out random processes. Quantitative analyses of Aum assert the presence of chaos, while also revealing a high degree of uncertainty, instability and self-similarity in the underlying process. In comparisons with chaos observed in solar cell open circuit output voltage, the similarities between Aum and solar processes become apparent. It is hoped that the results discussed in the present article throw light on Aum, as an audio signal, helping to understand the underlying features and characteristics of this primordial signal. The chaotic nature of Aum speaks volumes about the intricacies and complexities underlying the universal primordial sound, suggesting that it indeed possesses the necessary complexity to be the universal wave function. The similarity with solar cell based signals indicates the ubiquity of this primordial chaos in natural systems, further accentuating the omnipresent nature of Aum.

## 1. Introduction

To the modern world, Indian Spirituality or ‘Sanaatana Dharma’ needs no introduction. With an ever-growing interest in Hindu philosophy, terms like ‘Karma’, ‘Nirvana’, and the practice of Yoga, as witnessed in ‘International Yoga Day’ celebrations, Indian Spirituality is indeed becoming more accessible and interesting to the Westerner [1,2].

While other mythologies and cultures evolved during the same time, such as Greek, Egyptian, Sumerian and Meso-American have largely been reduced to mere museum artefacts, Indian Spirituality is a true juggernaut (the term itself being derived from Indian Lord Jagannatha), still followed and practiced regularly and with fervor in a country with more than a billion people, and its neighbors in the subcontinent [1].

For a monumental example to observe how alive Indian Spirituality is, look no further than Varanasi in Uttar Pradesh, the ‘Spiritual Capital’ of India – a city with a population of more than a million. Known for eons as Kashi, and referenced in nearly all major Sanskrit geography related texts, since time immemorial, this place, as the most purified by Ganga, and as the capital of Vishwanatha Shiva, is characterized by extremely narrow and dark alleys, an explosion of people along the Ganges ghats,

cremations and rituals for the dead pushing them towards direct Moksha, free acceptance of the homeless, the aged, the handicapped and the renounced, and a really complex and intricate way of life that a foreigner at first glance would describe as ‘chaotic’. The city has remained this way for hundreds, if not thousands of years, and is set to be so for ages to come. Even the Puranas say so – this is the only city that remains undestroyed, even during the Pralaya, or cosmic deluge [3].

Central to such a robust, alive and strong Indian Spirituality is the Sanskrit language. Linguistic debates and controversies aside, this language is thousands of years old, and is very well-known for its systematic grammatical, lexical and syntactic structures, including an elaborate number-case-gender declension system and a system of developing verbs, adjectives and nouns alike using roots or ‘Dhaatus’. The ‘perfect’ structure of Sanskrit has even attracted studies from NASA, which have concluded that this language is most suited for developing computer algorithms and scientific methods, thanks to its clear structure, flexibility and unambiguous nature [4].

From a spiritual perspective, these observations indeed make sense, since it is clearly understood that Sanskrit, unlike most other natural languages, was not born out of grunts, growls and distortion of ‘proto’ languages. Rather, Sanskrit took thousands of years to develop, with the basis being that each of its 51 alphabets, or ‘Aksharas’ represent the sound form of a fundamental concept of the universe. This is so that, when a word such as ‘Agni’ meaning fire is constructed from constituent Aksharas, it is an arrangement and structure of not only the sounds but the concepts, such that when one recites Agni multiple times with focus and concentration, one can actually materialize the constituent concepts and invoke fire without any material requirements. This is the principle behind Mantras and Bija Aksharas, abound in Indian Spirituality [5,6].

I had carried out experiments earlier to verify the potent power of Sanskrit Aksharas. Using a crude home-made cymatic setup (‘tonoscope’), each of the 51 Akshara sounds were uttered onto a vibrating membrane, with particles of salt sprinkled over it [7]. The sound vibrations of the membrane caused the particles to arrange themselves in certain ‘cymatic’ patterns, and it was observed that for each of the 51 Aksharas, the cymatic pattern corresponded with the shape of the Akshara, as written in the Brahmi script. The 51 observed patterns, and a listing of the concept associated with each Akshara are presented in the appendix, for reference [6,7].

The Hindu texts, such as the Maha Nirvana Tantra, Mundaka and Mandukya Upanishads, assert that the 51 Aksharas, themselves arose as derivatives of a single sound. This sound is ‘Aum’, the cosmic mantra, the primordial vibration. Pervading the entire universe both as Aahata (struck) and Anaahata (unstruck and unheard) sound, Aum (Omkaara) is revered in Hinduism as the ‘Naada Brahma’. This undivided primordial sound is beyond boundaries of space and time and is eternal; however, it lends itself to the play of Maya and at each point of space and time, gets tinted with one of the three Gunas, or characteristics – Sattva, Raajasa and Taamasa [8-11].

*“The word which all the Vedas proclaim, That which is expressed in every Tapas (penance, austerity, meditation), That for which they live the life of a Brahmacharin, Understand that word in its essence: Om! that is the word. Yes, this syllable is Brahman, This syllable is the highest. He who knows that syllable, Whatever he desires, is his.” — Katha Upanishad, 1.2.15-1.2.16*

The Maitrayaniya Upanishad in sixth Prapaathaka discusses the meaning and significance of Om. The text asserts that Om represents Brahman-Atman. The three roots of the syllable, states the Maitri Upanishad, are A + U + M. The sound is the body of Soul, and it repeatedly manifests in three: as gender-endowed body - feminine, masculine, neuter; as light-endowed body - Agni, Vayu and Aditya; as deity-endowed body - Brahma, Rudra and Vishnu; as mouth-endowed body - Garhapatya, Dakshinagni and Ahavaniya; as knowledge-endowed body - Rig, Saaman and Yajur; as world-endowed body - Bhūr, Bhuvah and Svaḥ; as time-endowed body - Past, Present and Future; as heat-endowed body - Breath, Fire and Sun; as growth-endowed body - Food, Water and Moon; as thought-endowed body - intellect, mind and psyche [8-11].

Given its omnipresent, eternal nature, the modern physicist might think of Omkara as the Universal Wave Function proposed in Quantum Mechanics – the single all-pervading space-time-varying state vector that can describe the position and details of every single entity in the universe. In this context, in an earlier work, I had taken the E8 ‘Theory of Everything’, and using chaotic quantum interpretations, meta-homeo-morphism and computational universe principles, I had shown how one can visualize the entire universe as the interplay of three fundamental ‘information’ signals – these signals verily are the distributing and varying nature of the three Gunas [6,12].

It is no surprise then that the supreme nature of Omkara has attracted the attention of scholarly studies in multiple disciplines worldwide. Significant among them are two observations:

1. The ‘music’ of the sun, as an audio recording/conversion of solar magnetic field, has been reported to sound eerily similar to Aum [13].
2. The cymatic pattern corresponding to Aum has been reported as a Sri Yantra (Fig. 1), which in Indian Spirituality is the single most complex and potent geometrical pattern, describing and symbolizing the creation and dissolution of the universe, in the form of the Universal Mother, Shri Lalitha Maha Tripura Sundari [6, 14].

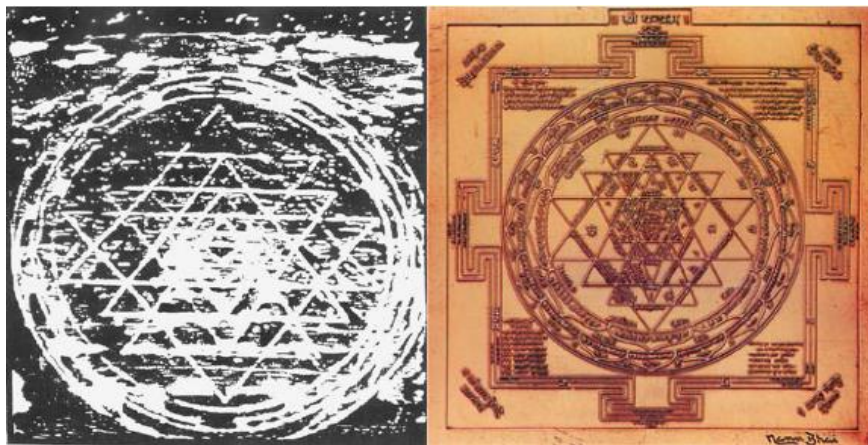


Figure 1 Aum pattern in a Tonoscope, compared with Sri Yantra

With all this background the objective of this article is to present and discuss the results of a nonlinear analysis of the Aum, viewed as an audio signal. The intent is to uncover more features and clarity on the nature of the Aum, than can be revealed by conventional linear analysis. It is seen from the results that the

Aum is characterized as a signal pertaining to deterministic chaos – characterized by deterministic nature and an extremely sensitive dependence on initial conditions, which are reflective of the extreme complexity and intricate nature of the system underlying the Aum sound.

Following this, the various results of nonlinear analyses of Aum are compared with corresponding counterparts from the open circuit voltage of a solar cell that I had analyzed in my earlier work [15]. It is seen that many properties depicting a highly intricate chaotic system are shared between Aum and Solar cell output further confirming the similarity suggested by the NASA studies.

It is hoped that the results discussed in the present article throw light on Aum, as an audio signal, helping to understand the underlying features and characteristics of this primordial signal. The chaotic nature of Aum speaks volumes about the intricacies and complexities underlying the universal primordial sound, suggesting that it indeed possesses the necessary complexity to be the universal wave function. The similarity with solar cell based signals indicates the ubiquity of this primordial chaos in natural systems, further accentuating the omnipresent nature of Aum.

## 2. Pre-Requisites

### A. Source Data

The input used for the nonlinear analysis discussed in this paper is a 5-second clip of a single Aum chant obtained from the recitation available in <https://www.youtube.com/watch?v=1jqMUkoFqwA>. This 2-channel audio signal is converted into .wav format, with a sampling frequency of 44.1 kHz. The resulting 1-D vector is used as the basis for all the nonlinear analysis.

### B. An understanding of Chaos

The advancement of computer based visualization and simulation technologies in recent times have exposed to scientists the dynamics and mechanics underlying most natural and man-made systems. These have been uncovered by observing graphs and charts plotting the trajectories of values systems take upon evolution of time, and studying the intricacies and regions of stability therein.

What has emerged from such understanding is the rise of the discipline of nonlinear science, whose hallmark is the development of chaos theory. Chaos, in the scientific sense is a behavior of systems characterized by determinism and an extremely sensitive dependence on certain initial conditions [16,17]. A classical example is the weather. Though, the mechanics underlying weather can be described by a set of thermodynamic differential equations, there are a lot of air currents, movements, atmospheric gases and materials, as well as human activity that act as initial conditions, and it is virtually impossible to know all of them accurately.

As a consequence of the nonlinear nature of chaos, even a small inaccuracy in the initial conditions leads to drastic differences in the final observed results, after a certain evolution of time. This is aptly depicted in the butterfly effect: a butterfly flapping its wings in a certain location, gives rise to air movements and causes by nonlinear effects and evolution of time, a tornado in another location, half the globe away.

While most understanding of chaotic systems stem from descriptions of iterative maps, which essentially describe varying states of a chaotic system depending on values of ‘control parameters’, it is not always possible to have a firm understanding or access the source and initial conditions of natural systems. Thus, in recent times, methods have been developed to understand and characterize chaotic nature of systems by examining their output signals, and it is these methods that are used in the present work.

### 3. Nonlinear Analysis and Results

The Aum signal is read into MATLAB using which various analyses are performed. As a starting step, the waveform, which shows variations in the values with progress in time, is plotted in Fig. 2.

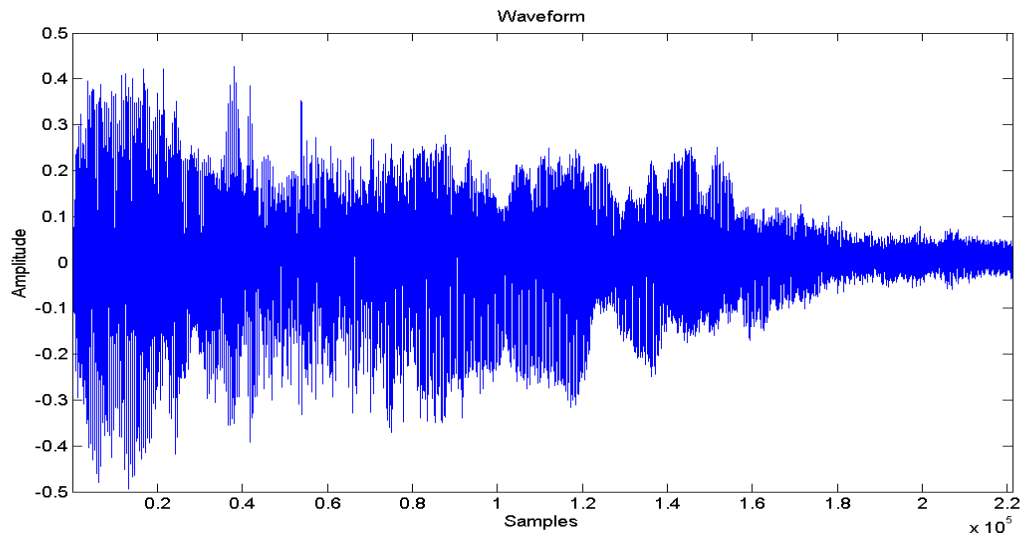


Figure 2 Aum waveform

While the waveform shows general dynamics and intensity variations of the signal as seen by the gentle tapering down of intensity as ‘A’ changes to ‘u’ and finally to ‘m’, a better understanding of the nature of the signal can be obtained by the fourier spectrum.

The Fourier spectrum stems from the Fourier Transform, which essentially decomposes a function of time (a signal) into the frequencies that make it up, similarly to how a musical chord can be expressed as the amplitude (or loudness) of its constituent notes. Thus, for a signal  $x(t)$ , the frequency dependent spectral distribution  $X(f)$  is given as  $X(f) = \int_{-\infty}^{\infty} x(t)e^{-2\pi ift} dt$ .

For a discrete sampled signal, as used in this case, the spectrum is obtained using the Fast Fourier Transform (FFT) algorithm. The absolute spectrum,  $|X(f)|$  is plotted in Fig. 3.

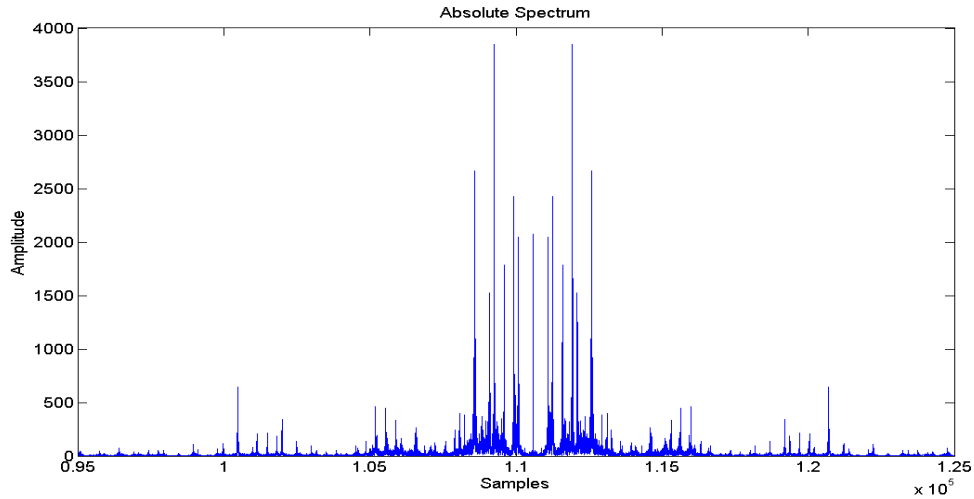


Figure 3 Absolute Spectrum of Aum

The spectrum shows a rich array of frequencies, with the central frequency (DC component) moderate and lower in value than surrounding low frequency components. Apart from the presence of regular harmonics (integral multiples of fundamental frequencies) at regular intervals, one also observes a lot of mixed frequencies, and frequencies at fractional multiples of the fundamental. One also observes a ‘grass’ of frequencies near the fundamental, slowly dying out at higher frequencies. In summary, the Aum signal shows richness in spectral profile that is difficult to explain using purely linear processes.

One of the classical tools used in nonlinear analysis is the phase portrait. This is a plot of the signal  $x(t)$  against its time derivative  $dx(t)/dt$ , which essentially captures the trajectory of the system underlying Aum as it evolves in time. Phase portraits, which are a qualitative assessment of sensitivity and ergodicity (non-repetitive nature), typically appear in chaotic systems as ornamental, dense patterns of loops and whorls, with fixed and easy to recognize outlines. The phase portrait of Aum is shown in Fig. 4.

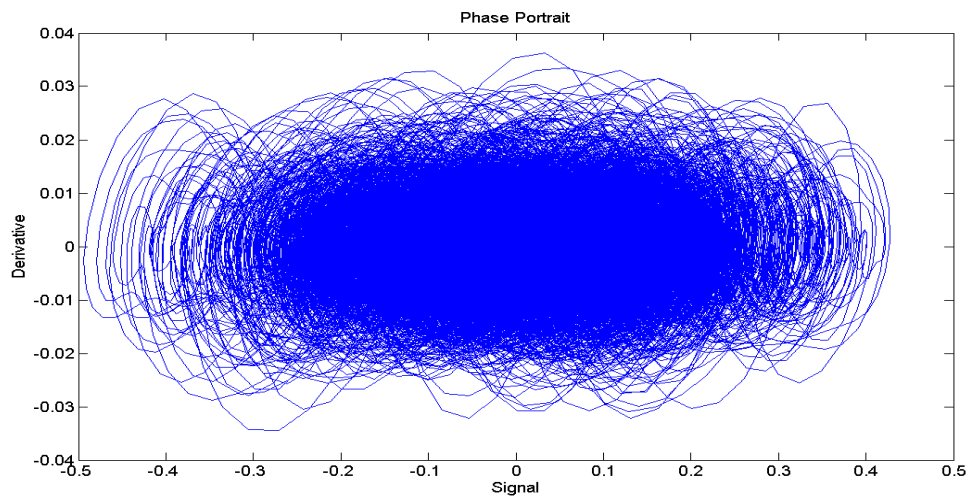


Figure 4 Phase Portrait of Aum

It is seen from the phase portrait that the trajectory of evolution creates a thick, dense pattern of loops, with a polarized (along  $x(t)$ ) orientation. This appearance is a clear indicator of nonlinearity and chaos underlying Aum.

The polar plot, plotted by taking  $x(t)$  and  $t$  as Cartesian ordinates and converting them into polar magnitude-angle ( $r-\theta$  form, where  $t = r\cos\theta$  and  $x(t) = r\sin\theta$ ) values highlights the phase distribution of the signal, corresponding to spatial harmonics. In other words, the plot indicates whether intensity of the signal is uniform along all phases, and whether there are particularly noticeable coherences and phases of high/low intensity. This plot is illustrated for Aum, for normal and  $1/1000x$  scaled values of  $t$ , in Fig. 5 and 6.

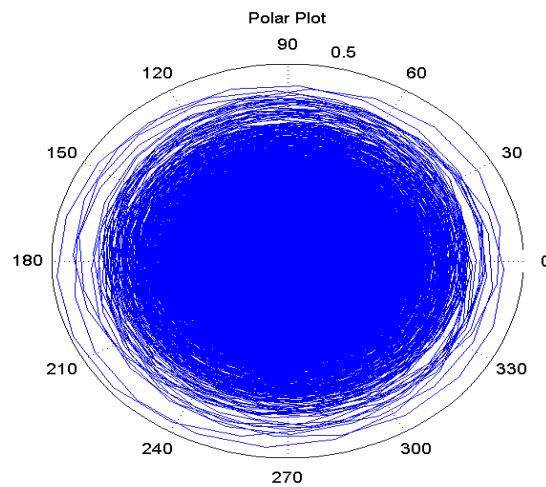


Figure 5 Polar plot of Aum signal

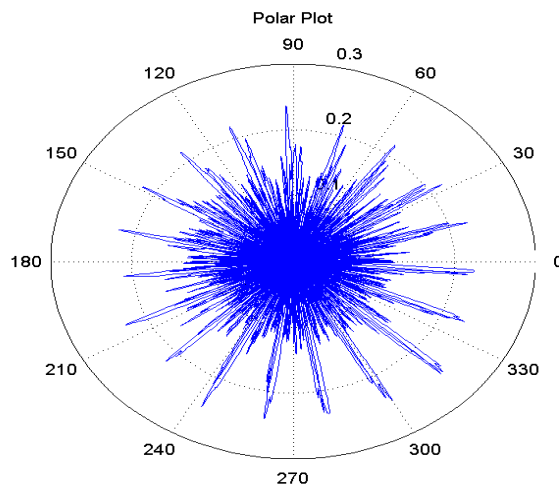


Figure 6 Polar plot of Aum signal – scaled down 't'

In the first polar plot, one observes concentric rings, indicating that each vibration (or motion about zero value) in the Aum sound covers entire phase cycle of 360 degrees, showing a uniformity in phase distribution, as opposed to ‘lop-sided’ polar plot patterns of certain antennas for example, which are designed to transmit and receive in only certain phase directions.

In the second polar plot, the intent of scaling t down by a factor of 1000 is to observe whether the phase uniformity seen in Fig. 5, still holds over multiple vibrations of Aum. The pattern of Fig. 6, resembling the rays of a sun, show intensity peaks (the ‘rays’) well spread out in equal intervals across all 360 degrees, confirming the phase distribution uniformity.

In order to study the effects of frequency mixing and other related nonlinearities such as inter modulation and cross modulation in the mechanics underlying Aum, the bispectrum is plotted. The bispectrum is essentially the spectrum obtained from the third order cumulant, and for every pair of frequencies f1 and f2 in the signal, the plot gives a contour representing the coupled components of the form f1+f2. The bispectrum of Aum is shown in Fig. 7.

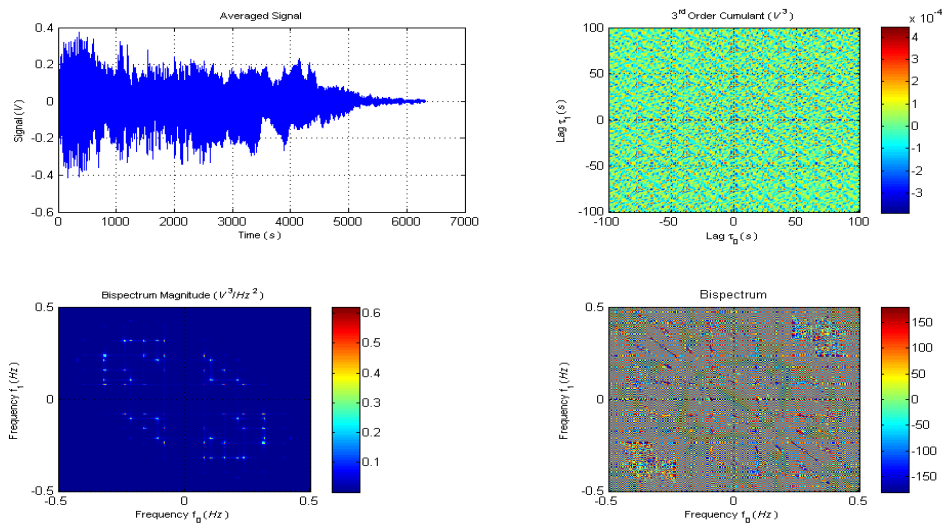


Figure 7 Bispectrum of Aum

From the plot, especially the bispectrum magnitude, one observes multiple scintillations arranged into a hexagon-like pattern, suggesting not only that mixed frequencies exist, but also that they are in closely related ratios and values forming a definite pattern. This observation essentially rules out any speculation that the processes underlying Aum are purely random. A similar arrangement of patterns can be observed in the phase bispectrum, albeit a bit fainter.

The main premise in the concept of distance plot is that most natural processes possess recurrent behavior in the form of periodicities and irregular cyclicities. Here, a recurrence is defined as a condition where states in the system are arbitrarily close after some time of divergence. On this concept, the distance plot (DP) is defined as follows: For a discrete signal with N samples denoted by x(n), n<=N, the distance between the ith and jth point D(i,j) is given by ||x(i)-x(j)||.



The collection of all the distance points  $D(i,j)$  for all  $i,j < N$  form the Distance Matrix  $D$ , a contour plot of which is termed the Distance Plot (DP). It has been shown that certain dynamical invariants such as the Correlation Dimension, Kolmogorov Entropy and Mutual Information can be derived from distance plots. The key advantage of distance plots is that these plots provide useful information about the chaotic nature even for short term and non-stationary data.

The distance plot of Aum is obtained as in Fig. 8.

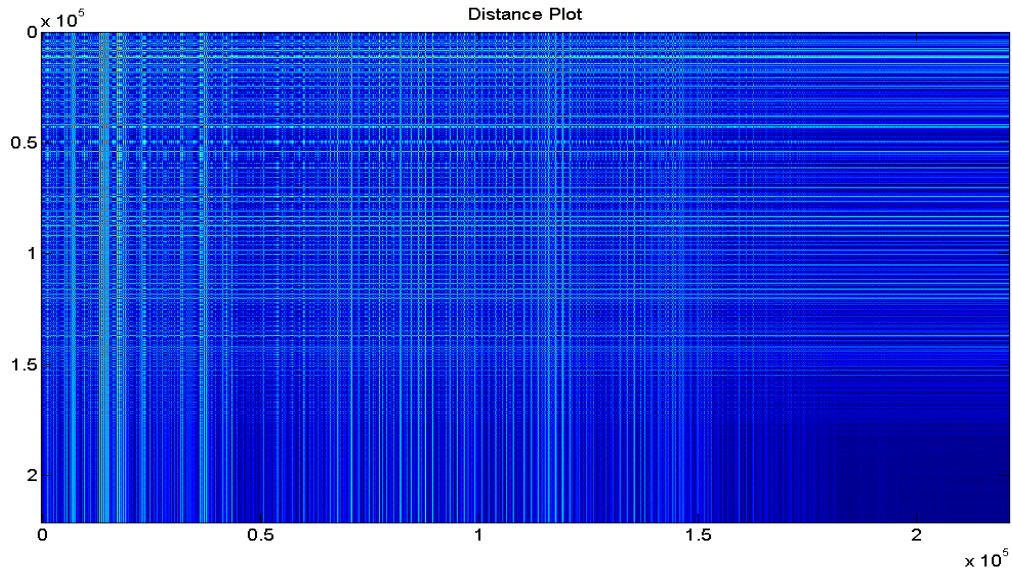


Figure 8 Distance Plot of Aum

The plot clearly illustrates lines of varying widths and intervals, highlighting the irregular periodicities, and coinciding with the observations of rich spectrum and dense phase portrait.

In addition to the qualitative nonlinear assessment discussed thus far, there exist three quantitative measures which assertively confirm the presence and characterize the nature of chaos in Aum signal.

Paramount among them is the Lyapunov Exponent, which essentially quantifies the sensitive dependence of a system on initial conditions, a key aspect of chaotic behavior. The maximal Lyapunov Exponent, denoted as the MLE refers to the largest Lyapunov Exponent value obtained and determines a notion of predictability of a dynamical system. A positive value of MLE asserts the presence of chaos.

Methods such as the Rosenstein's Algorithm exist to determine the Lyapunov Exponent from a time series. Specifically, an evolution time  $\Delta t$  is defined and the  $i$ th sample of the divergence  $d$  for the  $j$ th trajectory is expressed as a function of  $\lambda$  as  $d_j(i) = C_j e^{\lambda_i(\Delta t)}$ , where the  $\lambda$ 's denote the Lyapunov Exponents and denote normalization constants.

In a typical chaotic system such as the Lorenz attractor, the initial time is considered, where a group of very closely separated points are taken. In due course, the same points are noted after letting the system evolve for some time. What were once closely separated points are now scattered wildly, and the scattering of the points indicates the sensitivity. The largest Lyapunov exponent is the final measure of

sensitivity obtained. Though the calculation of Lyapunov exponent requires the actual system to evolve over a period, modern techniques such as the Rosenstein algorithm can be effectively used to obtain the Largest Lyapunov exponent from the time series directly. If the MLE is positive, chaotic nature dominates (that is, the complexity of the system is high).

The MLE is obtained as 6.5660, asserting the chaotic nature of Aum.

Secondly, the Kolmogorov entropy (K2), measured in information units of bits per symbol denotes the entropy and thus the uncertainty present in the signal, and large values indicate more dynamic and unpredictable behavior.

The number of times that the time series of the signal crosses a particular value is seen as the empirical probability of that value occurring in the sample space. In other words, the time series of the data is mapped onto a probability space. Then, the Kolmogorov entropy, denoted as K2 is defined as the uncertainty associated with the probability space, with an equi-probable case possessing highest possible value of K2.

For the Aum signal, an entropy of 4.87 bits/symbol is obtained, signifying the complexities in the signal giving rise to an apparent certainty, that can easily be mistaken for a truly random process.

The last quantitative parameter is the fractal dimension (D2).

A fractal is a system in which “any part of the system resembles the whole”. Most chaotic signals are fractal. Typically, very simple systems, after four or five self-similar iterations, end up with a complex and ornamental looking structure. It is called a fractal, since each iteration develops on a fraction of the original. The significance of the final pattern is that each part of the final pattern is a miniature version of the whole. This property is known as ‘selfsimilarity’. The fractal dimension of a space denotes the degrees of freedom of a particle to move around that space. For instance, a particle in a square can move in two directions: up/down, and left/right. Thus the dimension is two. For fractal structures, since a fraction of the whole is being chewed off every time, the dimension ends up as a fraction such as 0.7 or 0.4. Thus D2 is a measure of the dimensionality of the signal. A high fractal dimension such as 0.9 or 0.8 indicates more instability than lower dimensions such as 0.6 or 0.4. Various methods and techniques have been proposed to calculate the fractal dimension of a signal. One of the famous methods is the box counting algorithm whose result is called the ‘Minkowski Bouligand Dimension’.

For the Aum signal, a fractal dimension of 0.957 is obtained, indicating the level of instability, complexity and self-similarity in the underlying mechanics of Aum.

Finally, it is noted that the Mandukya Upanishad enumerates fourfold etymological roots of the syllable "Aum". It states that the first element of "Aum" is A, which is from Aпти (obtaining, reaching) or from Adimatva (being first). The second element is U, which is from Utkarsa (exaltation) or from Ubhayatva (intermediateness). The third element is M, from Miti (erecting, constructing) or from Mi Minati, or aṗīti (annihilation). The fourth is without an element, without development, beyond the expanse of universe. In accordance with this principle, it would be interesting to observe differences in the three (A, u and m) components of the Aum signal. By demarcating the three signals roughly at 0.4e5

and  $1.4 \times 10^5$  sample indices, the three components of Aum are taken and the spectra are plotted as in Fig. 9.

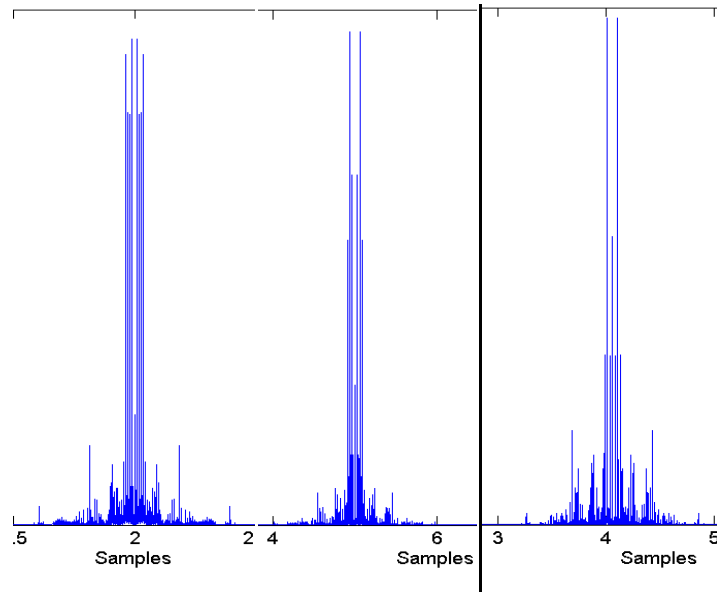


Figure 9 Fourier Spectra of A, u and m

#### 4. Similarities with Solar Cell Output

In an earlier work, I had analyzed the fluctuations of the signal accompanying the DC offset of a solar cell (photovoltaic) open circuit output voltage [6,15]. This was achieved by using a 6V, 50mA polysilicon photovoltaic cell connected to an oscilloscope, recording the time varying signals in various levels of illumination (bright sunlight, room-light and dark), and performing nonlinear analyses on the signals, which indicated the presence of chaos therein. The intent of such a study was to understand better the wild and unstable solar cell output fluctuations, usually written off as ‘noise’, and also to investigate whether these fluctuations respond to atmospheric, celestial and cosmic phenomena.

By observing the fluctuating signals, which deviate markedly from avalanche breakdown diode statistics, along with observations that the spectral profiles of the signals showing good response to the presence and dominance of solar flares, it is noted that the underlying mechanism behind the observed chaos is indeed dependent on the sun, atmosphere and cosmic effects, and not the diode mechanics.

The results of nonlinear analysis performed on solar cell signal are plotted in Fig. 10.

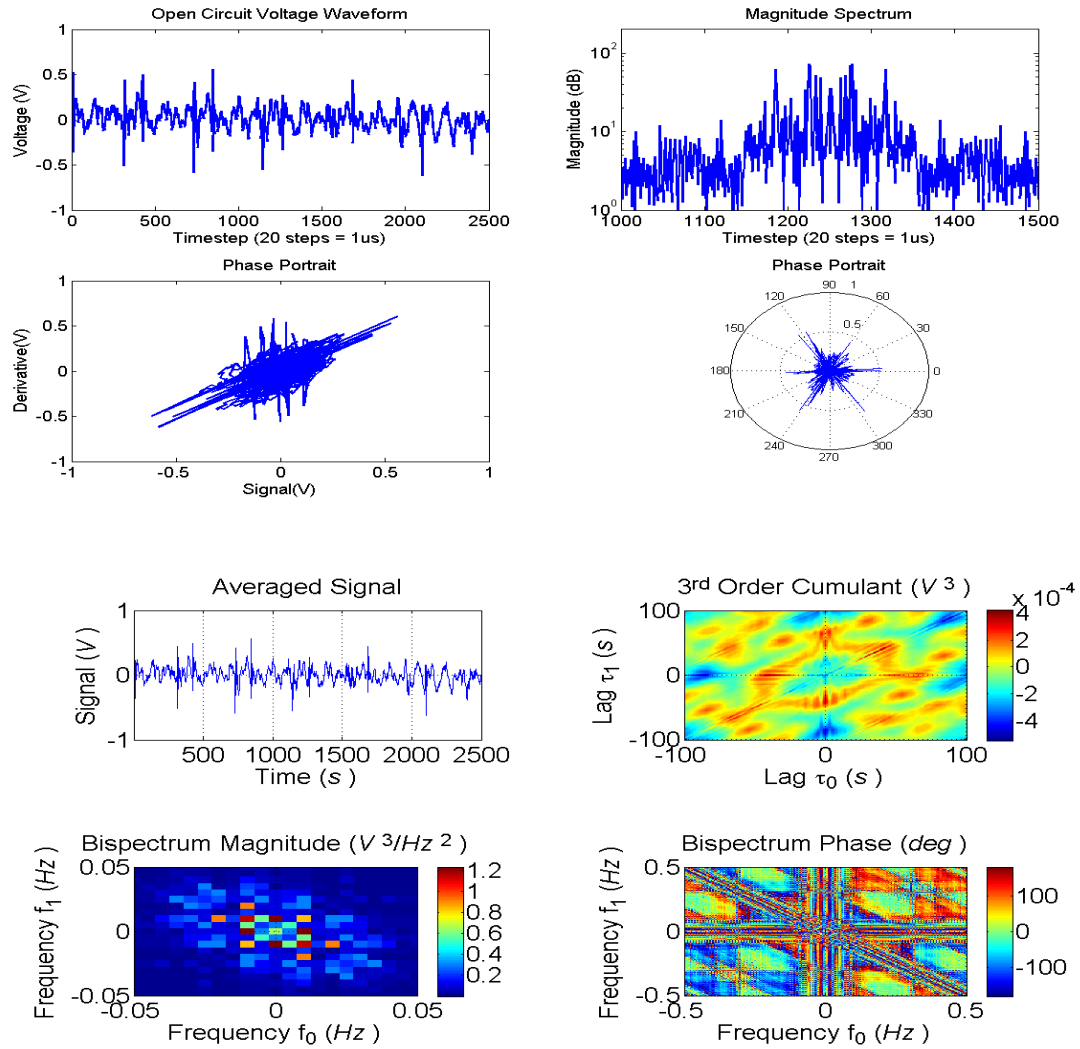


Figure 10 Nonlinear Analysis of Solar Cell fluctuations

As can be seen from the plots, the Spectral profile of Fig. 10, with a moderate central frequency, dominating fundamental, and various integral and fractional harmonic components, seems to resemble the one in Fig. 3, albeit with a higher noise floor and more pronounced ‘grassy’ frequency distribution, which can be attributed to the atmospheric noise accompanying the solar chaotic signal.

While the phase portrait of solar and Aum signals show comparable richness and density, the polar plot of the solar signal shows a phase uniformity lower than the Aum signal.

However, the underlying similarities between Aum and Solar chaotic signals are comprehensively captured in the similarity of scintillations and hexagonal patterns in the magnitude bispectrum plot.

This observation of similarity is in accordance with NASA studies of similarity between the ‘music’ of solar cell with Aum.

## 5. Conclusion

Having understood the increasing significance of Indian Spirituality and its cornerstone, the Pranava Aum, the present article explores the results of a signal based analysis of Aum recital. Specifically, nonlinear analyses are performed on the Aum signal, and the following are the key inferences:

1. Aum possesses a rich frequency profile, with an array of integral and non-integral harmonic components. Aum shares this property with observed solar cell chaotic output.
2. The phase portrait of Aum is rich, dense and ornamental, typical of chaotic systems.
3. Polar plots of Aum show a remarkable uniformity in phase distribution.
4. The bispectrum shows ordered pattern of scintillations, ruling out random processes.
5. Distance plots show a wide array of varying cyclicities and periodicities, another typical signature of a chaotic system.
6. Aum possesses high complexity and uncertainty, as seen from a high entropy value.
7. A positive MLE value of obtained for Aum, asserting chaos presence.
8. A high fractal dimension is obtained, indicating high instability and self-similarity.

In comparisons with chaos observed in solar cell open circuit output voltage, the similarities between Aum and solar processes become apparent, especially in the bispectrum plots. These observations point to an underlying oneness in the mechanisms responsible for both signals, and that this chaotic nature has a well defined presence everywhere, probably identifiable in other natural and cosmic systems as well.

It is hoped that the results discussed in the present article throw light on Aum, as an audio signal, helping to understand the underlying features and characteristics of this primordial signal. The chaotic nature of Aum speaks volumes about the intricacies and complexities underlying the universal primordial sound, suggesting that it indeed possesses the necessary complexity to be the universal wave function. The similarity with solar cell based signals indicates the ubiquity of this primordial chaos in natural systems, further accentuating the omnipresent nature of Aum.

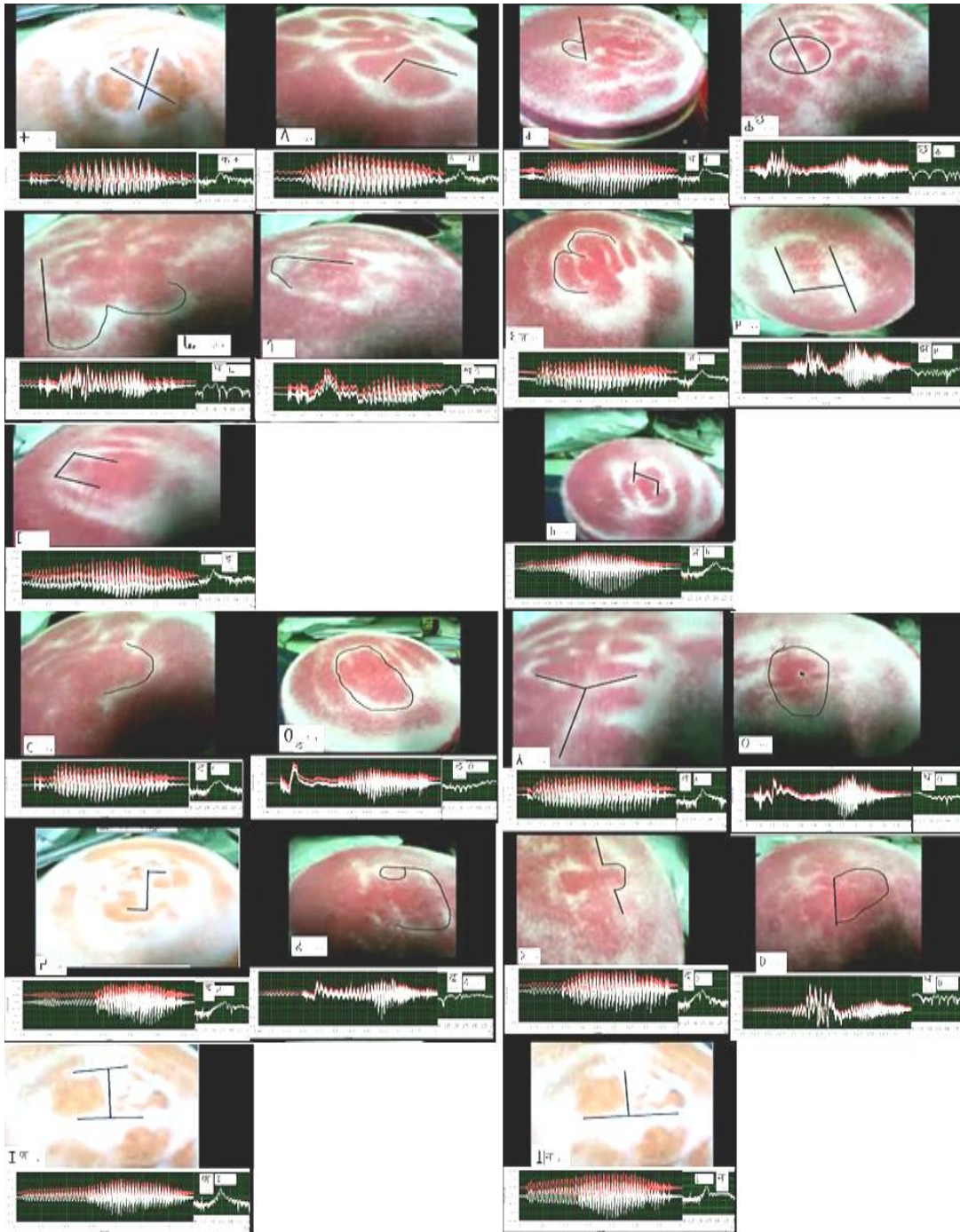
This article concludes by noting that the similarity between solar processes and Pranava Aum is not a new observation. In fact, ages ago, Brahmarishi Vishwamitra recorded this very similarity and ubiquity of Aum in the Gayatri Mantra, the single most powerful Mantra of Sanatana Dharma, and the crux of Sandhyavandanam, the oldest extant liturgy:

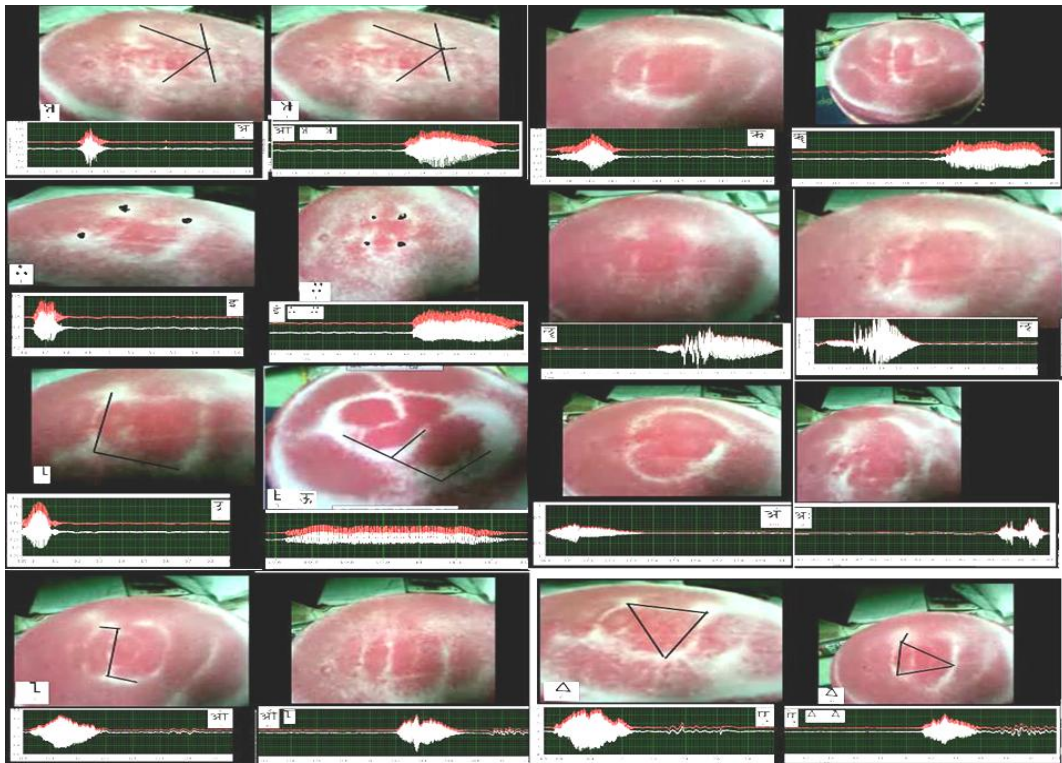
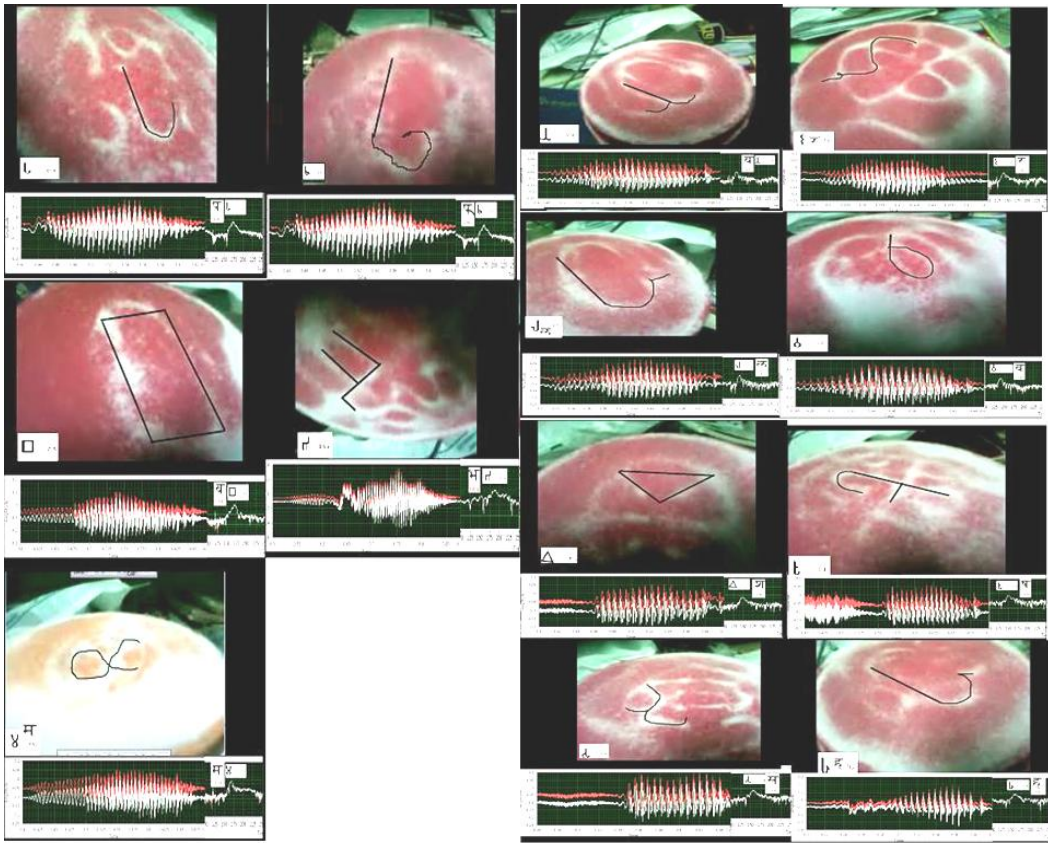
*“om bhūrbhuvahsvah; tatsavitúrvāreṇ(i)yaṃ bhārgodevāsya dhīmahi; dhíyoyónaḥ prachodayat”.*

*‘Om is the Earth, atmosphere, heaven. Let us think on that desirable splendor of Savitr, the Inspirer. May he stimulate us to insightful thoughts.’ — Rig Veda III.62.10.*

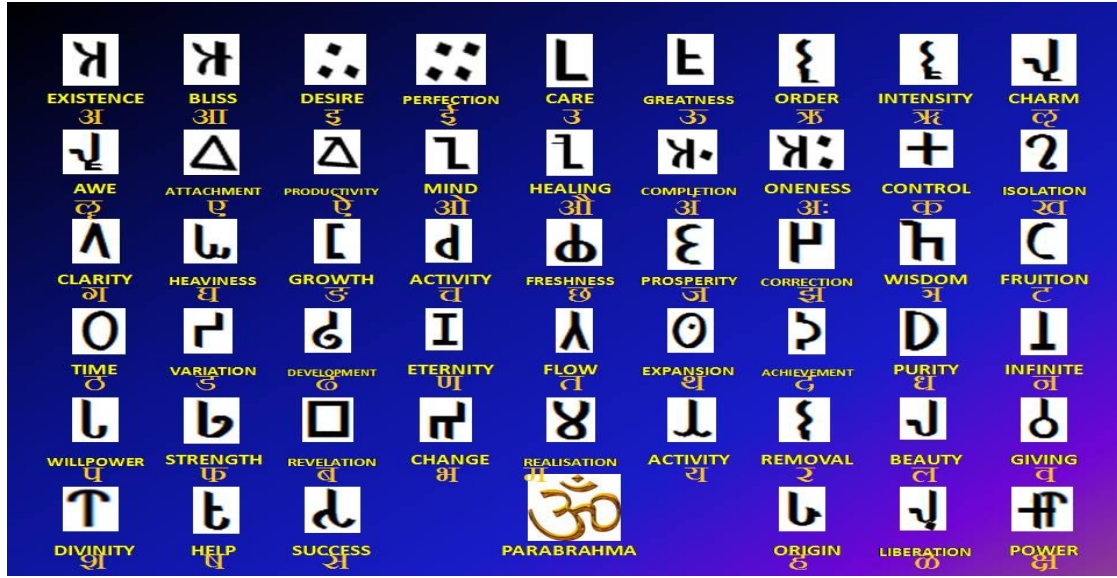
## Appendix

### A. The observed Cymatic Patterns for the 51 Aksharas





## B. The Concepts represented by the 51 Aksharas of Sanskrit



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