Cosmographiko

A three dimensional, spatial audio, algorithmic, generative and musical synthesis and composition of abstract harmonic astronomy.

Control Levels

Control0:
A simple Euler Identity circle x,y (real, imaginary), on the 3D plane with a spin and synchronous rotation to control1, having as rotation axis (quaternion) the sum of the three rotation axis vectors of control1.

Control1:
Silver star (Astrum Argentum) a 6D moving and modulated array of Spherical coordinate in the 3D form of y=1/x graph across the 3D plane with independent axis of rotation (quaternion) for each x, y, z axis.

Control2:
Control array, an array of Spherical coordinated in golden angle distribution modulated by spherical harmonics, according to their order, and mapped to control1 coordinates via *neighboring point logic* and its proximity range.

Neighboring point logic:

```
        //////localization areas on the sphere array
        (
{~points = ~az.collect({ |az, i|Spherical(1, az, ~el[i]);})}.value;);

        (
{var n=1.neg,neighbors;
~neighbors=[];
(360).do{n=n+1;
~center = Spherical(1, ~az.[n], ~el.[n] );

~threshold =   0.5;////////////////////////////////////////////////////proximity range

neighbors = ~points.select { |pt|
Quaternion(0,pt.x,pt.y,pt.z).distance(Quaternion(0,~center.x,~center.y,~center.z)) < ~threshold};

~neighbors=~neighbors.add(neighbors);
}}.value;);

~thetaArray = ~neighbors.collect(_.theta);
 ~phiArray = ~neighbors.collect(_.phi);
```

Control3:
Material arrays, again mapped as before, to the control array via neighboring point logic, they are arrays of Spherical point coordinates with magnitude iterations in order to have depth, and various wrappings in their forms, in order to represent cosmographically astral objects like atomic clouds, stars (first suns) and supermassive black holes, galaxies, suns and black holes, planets.
Each material array forms a different viewpoint on the cosmos during the same timeline. This means that the values these arrays create, which are the final values passed on several arguments of the synths, are passed via an order of cosmographic viewership which happens according to the following principle, that of location.

Through the layers of mappings from the cycle, to the silver star, through the control array to the material arrays, the location chosen corresponds to a specific point on the cosmic material cloud initially, as this cloud is morphed to create first stars, a location can be a star, which in turn has its own spherical locations, as such stars collapse and form galaxies, a location can correspond to a galaxy which in turn has its own spherical locations being suns or simply cloud matter. Following the suns have their own spherical locations corresponding to their structure and possibly the sun locations can be planets, with in turn their own structure, as each suns potentially corresponds to a solar system.

In order to structure this viewership and state of auditory information, Routines come in play. Control0 via and Control1 set an initial location proximity which is then used by specified Routine for each astral object. A master Routine and Task specify the astral object used and viewed throughout the timeline of the cosmographic and locational level of the composition. The musical synthesis of the composition regarding concepts like rhythm, melody, chords timing and tempo are partly independent from locational data, something that will further described and explained at a later part of this document.

Returning to the master Routine and Task, these create a composition framework in the choice of astral object data used, according to the state of the universe cosmography temporaly.

This means that for example at an initial state, the only possible material array corresponding to the location data from previous control levels is that of the cloud matter. Once first suns appear, there is a probability that a chosen location is a star. At that moment a star Routine is initiated where location data are mapped to the stars coordinate structure and consequent synth argument values.

This part of the timeline can be compositional and have a specific period, after which, and according to the universe timeline, new possible routines and their respective material arrays emerge, like the one of a galaxy, or subroutines to these corresponding to further material arrays like those of suns and planets.

All these data, routines and task follow a cosmographic timeline cycle which defines the lifecycle of the universe with corresponding modulation values of every type of array argument.

A simplified version of the above described cosmographic timeline composition would be to place the viewer at only the direct perception of one level of macrocosm/ microcosm the different material arrays point. This especially helpful for diffusion and panning, as the VBAP location could follow only eg. galaxy location data, regardless of the oscillator arguments, thus placing the viewer at a constant space and not making things too complex to perceive, by zooming in and out to different astral objects.

To make thing clearer on the above layering and time based triggering of different routines and subroutines in a task, one can visualize each material array being a different tonal argument on the oscillator structure or a morphing of its tonal argumentation. For example when a location is chosen through the control layers, the tonal arguments this coordinate values create corresponding to each material array, are different. For example, if the location, throughout the layers of the material array routines, corresponds to a galaxy, and a sun on this galaxy, then the tonal arguments on the oscillator include both those created by the galaxy as a location, the sun as a location on the galaxy and a point on the sun structure as a location on the sun, so three levels and types of argument control. These levels are therefore present according to the presence of material arrays at a specified location through the timeline. Furthermore, each material level array can correspond to a different range of tonal musical temperament (confluence) in order 12,56,992… and fundamental
multiplier.

As stated before, for the sake of simplicity this time based inter-wiring of arguments concerns only the tonal arguments of the synth oscillator and not the panning of the synth. The pan locations (VBAP) remain in that sense one dimensional and at one level of material array viewership., for example these spatial sound locations can correspond only to chosen galaxies/stars, or have a more abstract nature and be simply locations of the control array, thus not concerning cosmographic materiality, and being purely abstract and mathematical in its geometric aesthetic.

Array structures

- Silver star (as in astrum argentum.scd file has 6D modulation whereas each of the axis of the 3D exponential graph star has an independent rotation axis (rotation via quaternion), These rotation axis are wrapped in the range of azimuth: 0-90 angle degrees and elevation 0-90 angle degrees.
- Control array as in choice array.scd file is a sphere with coordinate point distribution driven by golden angle azimuthal and elevation intervals, has depth through magnitude iteration of some interval >1, eg. square root of two or any interval of choice times a sawtooth sequence L, that is L is an iteration sequence L=L+1, so magnitude=interval*L. The control array is modulated via spherical harmonics at certain LFO speeds, spread of harmonic (elliptic or spherical bubble) and at certain ambisonic order according to the composition cosmographic timeline (big bang to heat death period).
- Material array as in material arrays files, has as its structure basis the same coordinate point creation as the control array, only this time, via the silver ratio and the total spherical object is to represent a certain astral object or situation, or collection of astral objects eg. a galaxy. This means the spherical object is shaped accordingly to form the respective object and its modulation is spin (VBAP panning of azimuth and elevation) and a Bessel function as a form of rippling
  Bessel:

```
~magxx = ~magx.collect { |val, i|
        var waveSpeed = 1;
        var waveFreq = 6;
        var amp=0.4;
        var theta = ~az[i].degrad;
   var phi = ~el[i].degrad;
  // var wave = sin(waveFreq * theta + waveFreq * phi - waveSpeed * t);
        var wave = amp*sin(waveFreq * theta + waveFreq * phi - waveSpeed * t);
   val * wave.postln;
};
```

Geometric interpolation of arrays

A gradual mapping (according to cosmographic timeline) via neighbor point logic and its proximity limit as argument. Each of the arrays, *controls,* gradually, shift from or to, their spherical point distributions towards a specified platonic solid or polytope, with maybe the addition of in between symmetrical distributions like geodesies and Goldberg polyhedra.

The *contol0* cycle shifts towards specified polygons like a single line, a triangle, a square etc., if we consider its initial state before a shift being a total cyclic and tight distribution like via the golden angle, or simply many gradient cyclic points via a +1 degree angle azimuthal shift or even smaller degree. The control array shifts towards a tetrahedron, with its respective rotation, spin and spherical harmonic modulations.

Regarding the material arrays, each astral object type follows a different such geometric interpolation, and symbolized as such via the respective polygon. The monadic general spatial could matter shifts towards a cube or from an octahedron. If we consider compound polytope geometries a cube is a hull and a octahedron a core, thus the cube can be a final state of universal heat-death, following a spatiotemporal collapse and end of one universal cycle, following a new big bang, geometrically interpolated and symbolized via the core nature of the octahedron (z axis is the birth line of big bang and the azimuthal square x,y of the octahedron being its sudden burst of expansion). In a similar fashion of symbolism, at the state of heat-death and hull cube interpolation state.

A first sun (star) and consequent galaxies (supermassive black hole) are interpolated to a rhombic dodecahedron (hull) and a cuboctahedron (core) respectively. Suns, black holes and planets (a state between a sun and a black hole) are interpolated as polytope compounds via the rhombic triacontahedron (hull) and the icosidodecahedron (core), respectively.

Time

Silver star remains in the synthesis a constant modulation source and seed array for music related data like rhythm, chords and melody sequencies.

The **control array's** modulations and arguments change throughout the timeline of the cosmographic composition period. Arguments like the spherical harmonic oscillation speed, the spherical harmonic order as well as the overall geometric interpolation towards a tetrahedral distribution are such realms of change.

The **material arrays** change through the timeline also through their respective geometric interpolations, but also in their lifecycle as astral object through initiation from respective routines to their different states, for example a sun that collapses to a black hole. Other forms of change include the ripple Bessel effect oscillations they process, as well as in detail their change of form while in a particular routing state, like in the case of a star growing in size, a galaxy growing, or a planet being born. All these latter forms of change happen on the same material array type and are not termed as changes of one material array to the other. To be concrete a star is a different array than a galaxy and also a different array from a sun or a cosmic matter cloud. These different arrays are interchanged via routines and sub routines that set a different array as data source, not via array specific modulators.

Tonality and space

Silver Star is an abstract object and particle system array which lies at the bottom levels of the control layers, before the control array object, and is responsible, apart from setting the initial azimuth and elevation values for the spatial argument chain of the composition, mainly responsibly for the factors that render the algorithmic synthesis to a musical composition.

Silver star is essentially a y=1/x starry form of the 3D axial system, where each axis can rotate independently on the the 3D plane via quaternion rotation and a rotation axis, thereas named a 6D system six axis come into play (in complex terms three real and three imaginary, or more philosophically three spatial and three temporal), three coordinate axis and three rotation axis. This objects forms starry constellation and symbolizes free will as an underlying factor of the universe.

As a choice of coordinate on the silver star is initiated the coordinate is mapped to the control array which in turns generates the musical values. This is achieved through three types of arrays whose values are derived from the silver stars particle coordinate choice. Each point has a 3D coordinate of x,y,z as a Spherical object.

When the magnitude of this Spherical objects, through iteration of the whole control array, is set to be a power of 2, then a sequence of [x0,y0,z0,x1,y1,z1…] derived from the silver star coordinate choice sets a rhythmic pattern of three beats per bar. The amount of bars per rhythmic cycle is determined by the control array and its geometric interpolation. The magnitude when for example 1 then the rhythmic time signature is ¾, when four then the time signature is 3/1. For the sake of simplicity and quick adaptation to different rhythmic musical patterns one can set the creation of the rhythmic pattern directly from a pure tetrahedron array, or any other solid, without the need of interpolating the control array to such geometries, and keeping things seperate.

Form of modulation would be in this case, as similarly in the case of the silver star, rotation and spin of the seed polyhedron for the rhythmic pattern array. For example one cycle could be one position of the tetrahedron with four bars, then for the next bar a different position of the tetrahedron on the 3D plane can be used, creating thus variating rhythmic according to specified patterns derived from the polyhedron rotation. Of course, the seed polyhedron and its array can remain static throughout the composition, entailing thus a stable rhythm where only form of modulation would be the overall tempo via the SC TempoClock. Essentially the silver star works as a frame of choice, which then maps to the control array, from which the musical data arrays are derived, modulated further by the control arrays modulators.

Another musical realm the silver star, through the control array, is responsible for is the creation of melodies. Again in the same manner as the above described rhythmic pattern, a tone array is created, from the x,y,z sequences that each particle coordinate create, only this time the applied Spherical object that exports these x,y,z data based on the silver star point coordinates, must have a tonality related magnitude, this would be an octave of range of musical temperament to the formula 2.pow(x / order of musical temperament), with possible numbers of 12, for classical 12 tonic system or larger numbers for bigger amounts of microtonality, like 56 from number 28, 992 from the number 496 etc according to perfect number sequence. The magnitude exports x,y,z, according to the musical temperament range and then the final value for the tonal array sequence is derived through the tonal musical temperament formula 2.pow(n/12) for x,y and z respectively.

As described in a previous chapter, the choice of musical temperament can depend on the material array present, or simply be a constant throughout the timeline and any involved material array objects. Again, as before in the case of rhythmic patterns, periodic modulation of the silver star through rotation and spin, can create periodic change of the melody pattern and geometric interpolation to a tetrahedral distribution, helps create clear 4 bar ¾ melodic pattern periods.

Final musical parameter is that of chords. The above described sequences of coordinated on each bar and period of modulation can also form a chord of three tones and not a sequence of three chords. This parameter can works through the logic of assigning the tonal values to three parallel oscillators.

One can make different setups with this concept, either playing at one bar duration a three note sequence, and on another bar a chord or both a chord and a three note sequence via two separate synths, or having the chord of each bar being one tonal argument and the tree note sequence of the bar a second, temporal argument of tone on the same three oscillators of the chord.

For the sake of CPU usage economy and being able to have faster tempos and longer decays without the use of more than one server to run the code of the composition, something cumbersome both for production and recording, in essence any other application other than real time playback, where again separating the composition in various serves is a tedious task on its own, the way of using one server is chosen. For this reason, having three oscillators for every note played is too heavy for the CPU, especially when the later described addition of additive synthesis via the spherical points that form the depth of the spherical object at an azimuth and elevation coordinate, are added to the synth oscillator bank.

Therefore for the sake of this composition it will follow to use two separate synths. The first one with one basic oscillator forming the three note tonal sequences and a second synth with three oscillators, forming only chords from the specified coordinates, not at every but at some periodic or semi-periodic interval or some kind of boolean sequence of presence or non presence like an L-System (Figure1). Note that the duration of the chord as a note played follows a sum of the correspondent coordinate rhythmic x,y,z sequence, lasting thus a whole bar, at this duration argument a variable can be added which randomly increases or decrease a bit this duration, thus creating extra variance and lack of or more reverberance on the chord progressions.

About the additive synthesis. As described before the control array gains depth as spherical object by iteration of its fundamental magnitude in a saw-tooth manner towards a maximum via an n=L*interval; L=L+1; logic whereas interval is an interval of choice with value higher than 1, eg. 3/2, or the square root of two, each can give different timbre.

Furthermore, all these above mentioned tonal and musical properties derived from coordinates are described on the control level of the silver star and the control array, for the sake of simplicity in description. In fact the coordinates are mapped through all layers of control, from the silver star, through the control array, to each respective material arrays where, through this mapping via neighbor point proximity logic the final coordinate data are derived. These data are the final values used in the synth for the fore-mentioned algorithmic music formulas and sequencies. In this manner also respective to the material array type and form in hand according to location and universe timeline, ranges to the additive synthesis iterations are set, musical temperament ranges and magnitude of coordinates which is to be another yet tonal argument derived from a coordinate.

To sum up, coordinates chosen on the silver star level and mapped up to the material array, derive a rhythmic pattern array, a tone/melody pattern array, a respective chord for each coordinate, a magnitude of coordinate tonal scalar and fundamental for the depth related additive sawtooth synthesis (overtone), and finally a VBAP coordinate for panning the sound source of the tone played, which as described before, for the sake of simplicity is kept on an abstract level on one level of control, the silver star. Spectatorship on the auditory level is easier that way as it is not really possible to derive a specific material array from its VBAP information, therefore the journey of mappings through the control levels concerns all arguments other than VBAP coordinates.

Concluding, final note on the oscillator arguments other than frequency (all these tonal variables happen on a specified fundamental frequency) are the amplitude and the phase. The amplitude is defined by the product of reciprocal tonal arguments (in musical temperament value format) and phase is defined from the coordinate data by adding x,y and z raw values when mapped linearly from 0..1 to 0..2pi. Other modulators include those on the panned VBAP location which essentially are no extra LFOs but derive from the modulation of the silver star. Note here that

although reading a seed coordinate on the silver star is a musical contract and follows a systematic period, the modulation of the silver star is independent, therefore, while each oscillator related value change happens at specific intervals, the VBAP location is a continuous panning modulation with no intervals and bars.

Lindenmayer's original L-system for modelling the growth of algae.

variables : A B

constants : none

axiom : A

rules : (A → AB), (B → A)

which produces:

$n = 0$: A

$n = 1$: AB

$n = 2$: ABA

$n = 3$: ABAAB

$n = 4$: ABAABABA

$n = 5$: ABAABABAABAAB

$n = 6$: ABAABABAABAABABAABABA

$n = 7$: ABAABABAABAABABAABABAABAABABAABAAB

Figure 1

Choice

As fore-mentioned an index of the silver star array is chosen in sequence corresponding to the specified coordinate which in turns moves all the argument gears of the composition. A different level of, more or less, modulator gears ‘state of being’ gears and other arguments, not so much related to music, but to the cosmographic timeline are defined by the timeline itself and its corresponding overall envelope task and routines. Such arguments, as mentioned before, include the state of the material arrays form, their modulation characteristics, spherical harmonic oscillations orders and spreads, Bessel ripples and other automata, that are more or less automata and do not depend on some choice or interface and are defined purely through the chapters of progression in the universal timeline and randomness, eg. on each different cosmic period these automata may give different values at different phases. Their nature stands before the eyes of the beholder but they are not beholden in any other way from the viewer or composer other than algorithmic oscillation and noise.

Back to the silver star, reading of the index on the array can be linear from bottom to top and some preference in this does not affect the concept of choice in a composing manner in any way, as the actual variance is created by the silver star being an automaton and modulated object, not by how its array of values are red. The same path of index reading can return different values for the chosen coordinates at different phases of modulation, therefore musical variance melodies and rhythms that have difference and repetition are achieved without the need of further specifying the array reading index order or scrambling it. Possible only inversion of the array order is a possible reading alternative, if a Mobius strip loop is desirable for the composition musical sequences.

Therefore to escape the clutches of this automaton, where essentially the only means of synthesis control is the dialing of the oscillation knobs of the silver star’s modulators, a further interface to the silver star is needed, and thus a final and bottom line level of control.

Before the introduction of this level a view words and abstractions are needed on the silver star nature, what is behavior is and what it means to choose a point from its cluster. As all other arrays in higher control levels have a geometric interpolation towards or away from a polyhedron and polytope, the silver star does not have a geometric interpolation towards or away from anything other than itself. This means that the interpolation is essentially how zoomed in or zoomed out from our perception its object form lies. Like breaking the fourth wall in a sense. The silver star object and consequent coordinates array are therefore either very zoomed out, being formally very close to having no coordinates like the 3D axis themselves, near the axis, and a very thin halo of points on the cycle of rotation of each axis. On the other hand, very zoomed in means that we see the center of the star limit up close, the 3D axis are there but the underlying sphere is visible and the axis rotation halos are kinda lost from visibility through the noise especially if the interdependent 3D axiai are modulated as oscillating really fast or chaotically in relation to each other.

In any case, no matter the realm of perception of the silver star, and consequent array values in relation to the origin, the choice interface is always there. This is to be described as simply a cycle, a one dimensional ring of sorts that floats in 3D space with the same center of

origin as the silver star, and has spin around any possible rotation axis vector on the 3D plane coming from the origin outwards, unlike the silver star where all three rotation axis for x axis, y axis and z axis respectively, are wrapped in the quarter area of the hemisphere of azimuth 0..90 degrees and elevation 0...90 degrees.

This interface cycle therefore can rotate around any axis and spin around any axis around the origin. For example in visual terms if this cycle was spinning really fast and its rotation axis was spinning also really fast, we would not see a cycle floating any more, but a sphere, because our eyes would not be able to distinguish the frames.

Choosing a point on the silver star can be described via a 2D analog as choosing a point on the y=1/x graph, or if lamdoma (Figure 4) intervals are used, the graph y=(x+a)/x (Figures 2 and 3). In that choice the further the coordinate is from an equilibrium y=x, the more x increases its overtone value and y its subharmonic value, and in analogy, according to trigonometry, complex number theory and the Euler Identity *exp(Complex(0,1)*angle)* (Figure 5), the more the y overtone value is increase, the more the x subharmonic value is increased. Similarly this happens on the silver star, according also to its specific point distribution which is increments of one degree for elevation and increments of the silver ratio for its azimuthal coordinates, these happening for each axis and +/- orientation, creating thus a silver star.

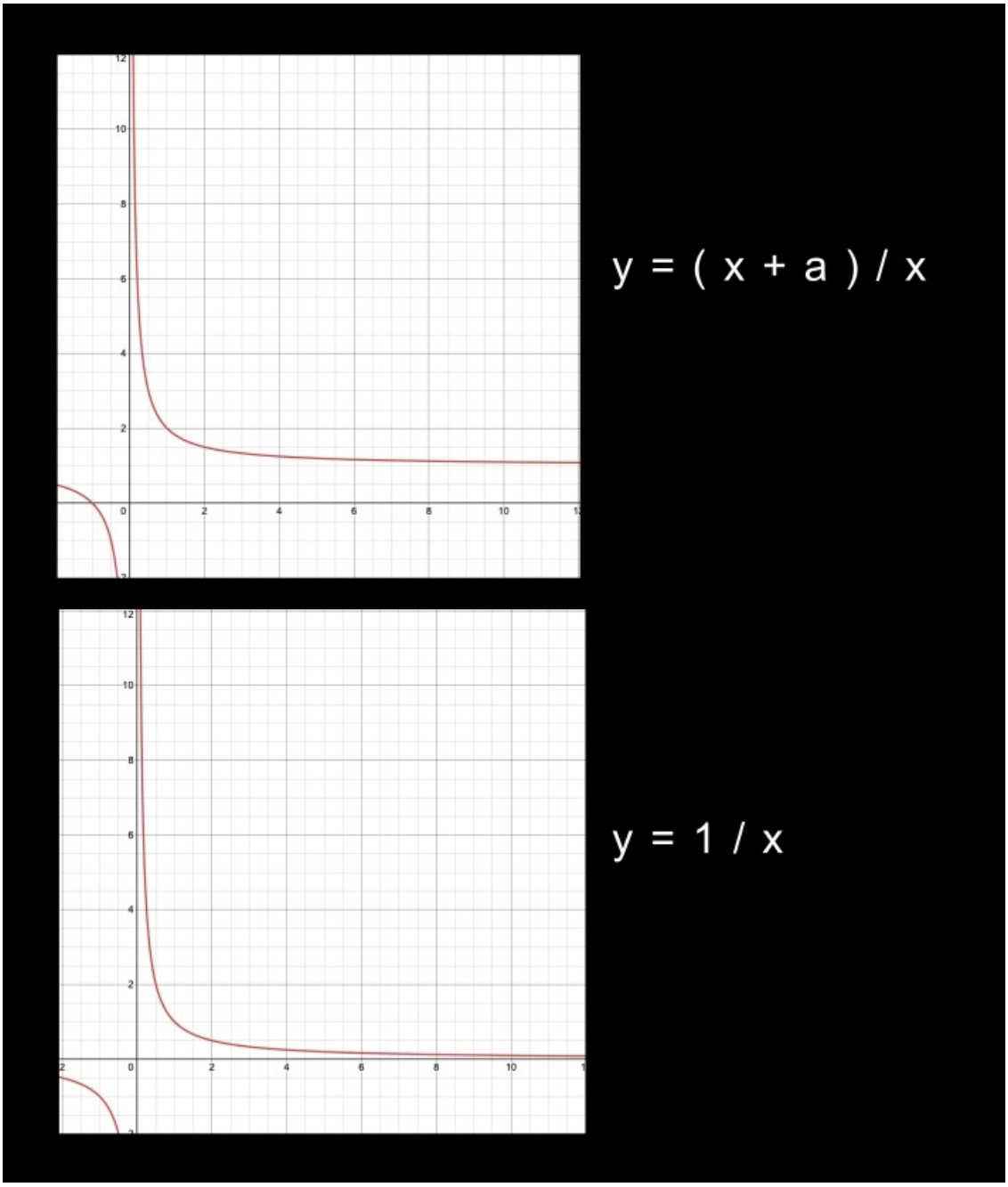


Figure 2

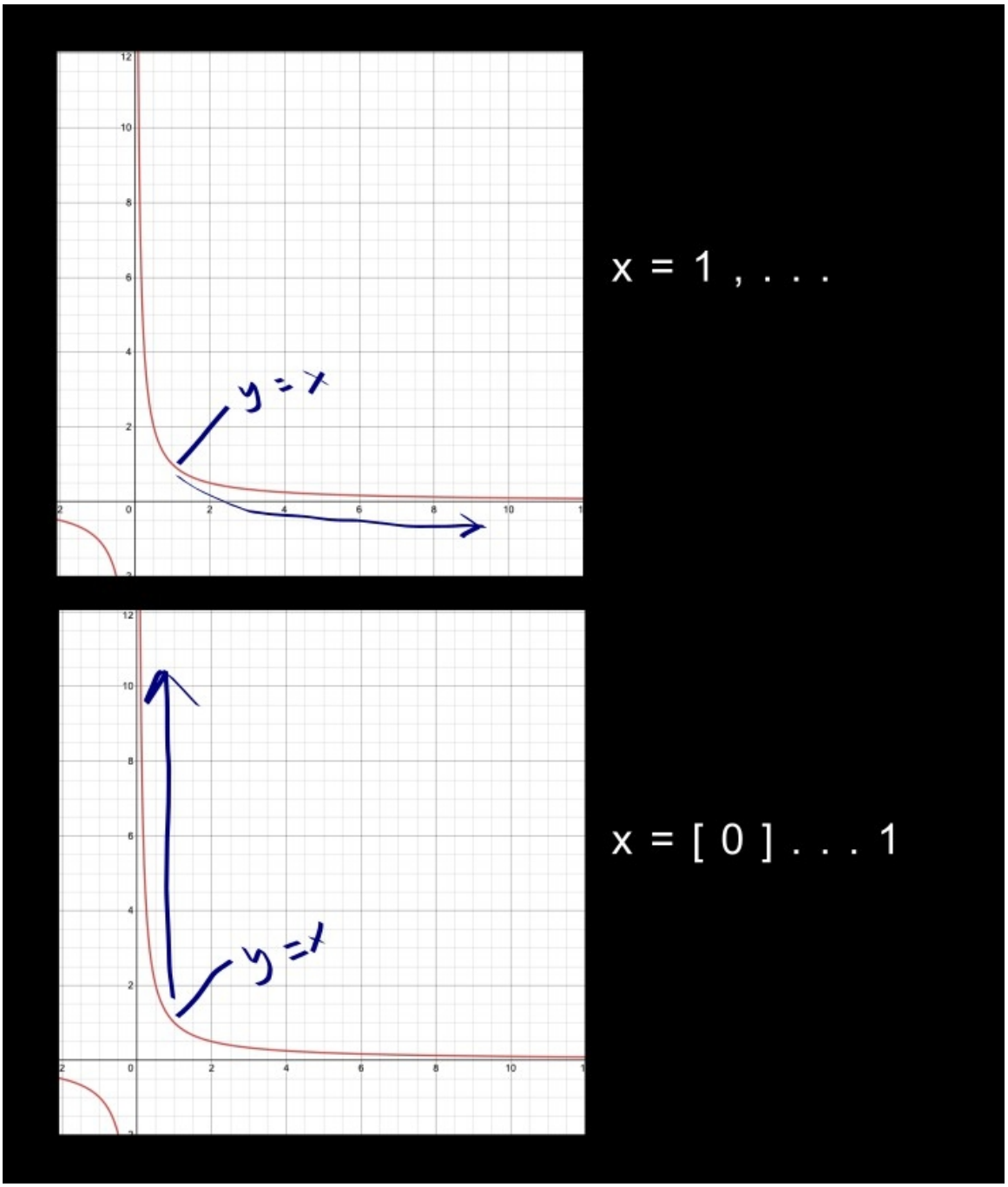


Figure 3

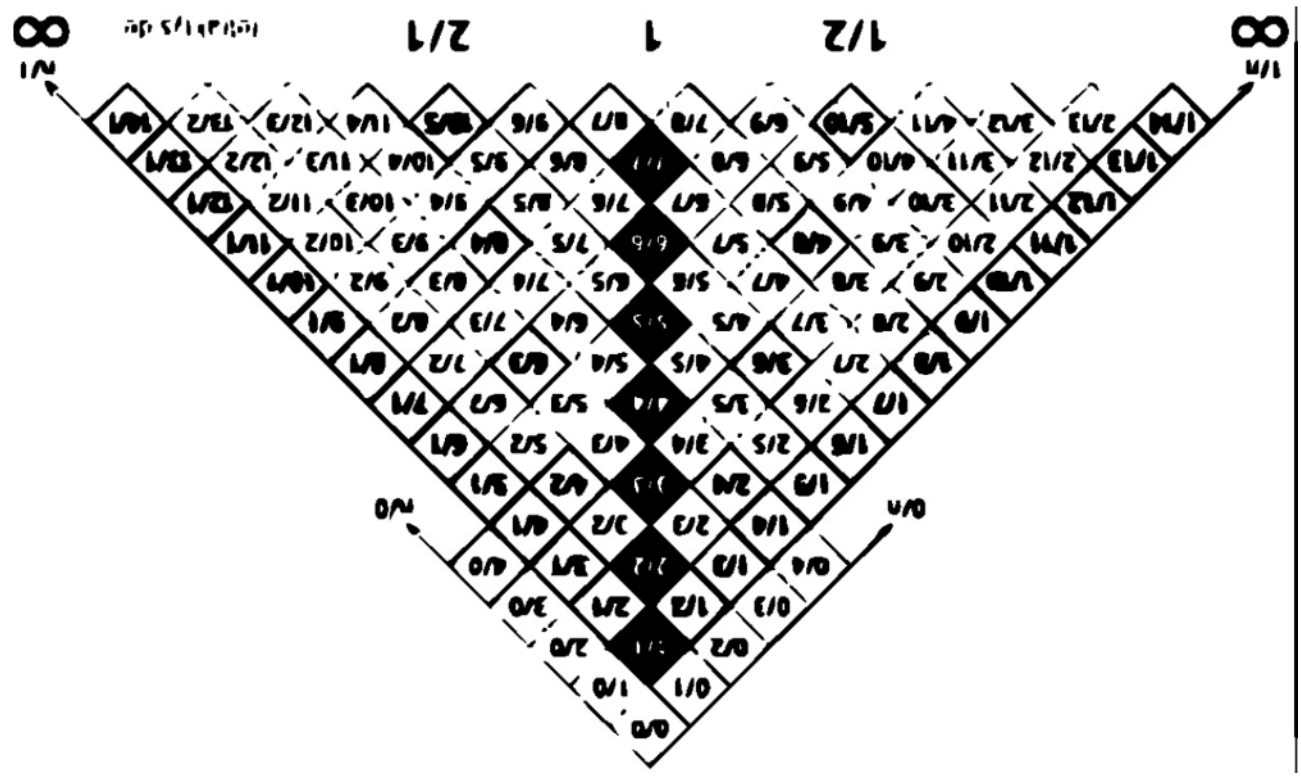


Figure 4

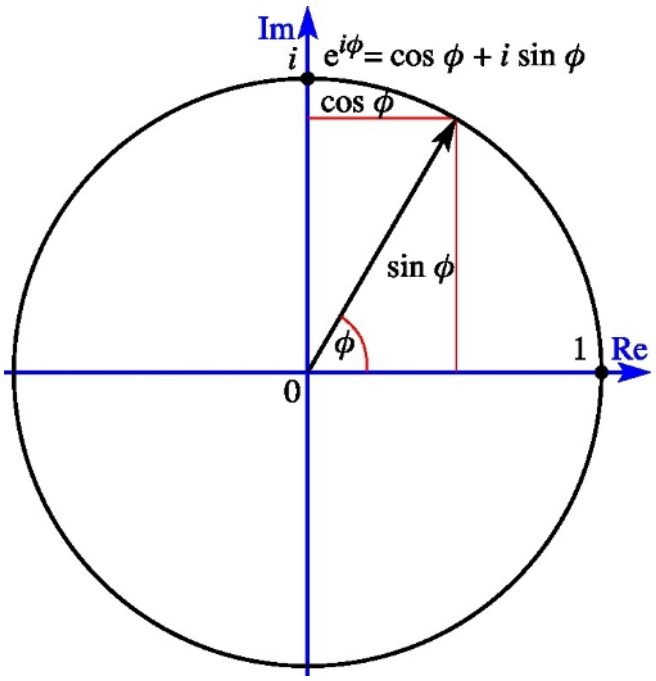


Figure 5

Moving back to the free floating cycle on the 3D plain, interface to the choice of point on the silver star. Having described the nature of the cycle as an object abstractly, in detail it is an azimuthal iteration of angular increments with constant elevation eg. elevation=0. Via quaternion product an any rotation axis this azimuthal ring can be placed on any orientation and spin around any axis, spin would be a modulation of the object in that case as in any other similar case of spherical object modulation of its array. The angular increments for creating the cycle can be a simple 360 times iteration with 1 degree increments, or infinite limit points via golden angle increments (the one ring to rule them all), or simply a polygon, like a line, a triangle, a square etc., Or every further, including temporality and the cosmographic timeline in mind the cycle structure can also take part in this generative composition and be subject to change in its form, like from some distribution to an other such as geometric interpolation of a golden angle ring, to a polygon.

The logic of choice, of this cycle as an interface to the silver star is simple. Similarly as in previous control arrays, the cycle object array index is red at a specific rate, some tempo, and the modulation automaton responsible for the spin and rotation of the cycle does the rest by choosing a location on the silver star, again via neighbor point and proximity logic.

Essentially this means that the whole composition, algorithm, synthesis and generative artwork, contains randomness only where needed and aesthetically reasonable and by choice, and any controls are reduced to one interface of a 2D cycle on the 3D plane, a ring.

Its controls are the tempo of reading through its array index values, which feeds the values for all other control levels and finally the synth arguments, and the speed of spin around a chosen axis, a modulation which created variance in the array values read in ordinance to their mapping to the silver star. So, tempo and two modulators, speed of spin, and oscillation (panning) of rotation axis. For the sake of simplicity this rotation axis of the cycle can be sync to the modulation of the silver star, in particular the oscillation of its three rotation axis, by being the sum of theses rotation axis as vectors. This sync would also wrap the probable locations of the cycle rotation axis to the same quarter hemisphere area as the rotation axiai of the silver star, but there is no reason why not to further develop its range keeping the sync intact. Meaning, the rotation axis of the cycle interface control level can be the sum of the silver star rotation vectors, but itself as a vector itself, can mirror its location to any other quarter hemisphere, becoming thus ever present on the 3D plane as initially defined while keeping a sync to the silver star as modulated objects.

Concluding, master controls of the whole composition through the cycle interface (Figure6) are its array index reading routines, its spin speed and where on the 3D plane its rotation axis is mirrored, with initial state the sum of rotation vectors of the silver star.

Finally to harmonize the cycle as an interface, according the lamdoma matrix, a mathematical state and most basic symbol and matrix of intervals and harmony, across arts and sciences, the following calibrations must be made:

the cycle object having a linear azimuthal increment in its creation defined as az and its magnitude defined as mag, then when magnitude is 0 then only azimuth and elevation values can be passed to the silver star and therefore the magnitude information of the cycle which would complete the definition of spherical coordinate mapping to the silver star must be defined through a random number, as 0 is no point at all, or because of the latter reason, as a lack of mapping, a gap in the sequence, silence and pause in musical terms. If mag is lamdoma interval factor following a formula of mag=(Complex(x,(x+a)/x)).rho*silver star zoom factor, where silver star zoom factor is the scaling of the silver star object in relation to the origin and when a=0 then the cycle mag is the square root of two, forming thus the equilibrium of x=y at that point, then the lamdoma matrix and interval logic is incorporated to the cycle interface as a variable. Thus the control cycle has a speed

of spin, an interval of magnitude and an orientation on the 3D plane, or three controls defining a point on the silver star under a tempo, and setting the whole thing described so far in a generative motion, for as many cosmic cycles as possible.

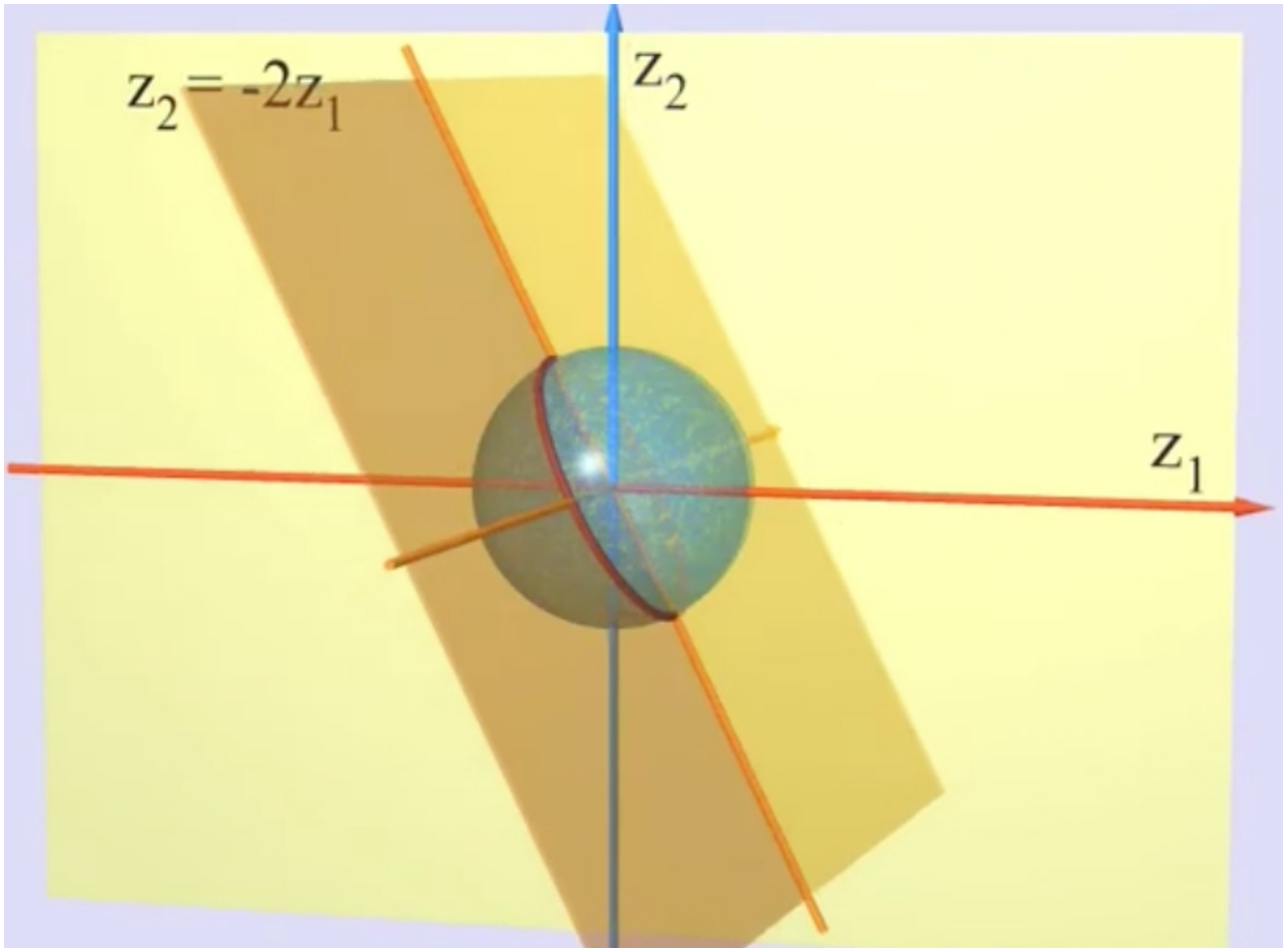


Figure 6

Variation and the time-based cosmographic structure

A so called ‘big bang’ works a percussive starting state and from for the timeline, with first and only of material array used and shaped being that of the matter cloud. The first shape of this initial state follows the geometric interpolation of an octahedron and a similar to the silver star distribution logic, with cloud point state throughout the 3D plane, very close to the 3d axis system. Nonetheless, the minuscule moment of cosmic birth, the ‘big bang’ itself, after the previous cosmic cycle, heat-death collapse, are the octahedron vertices vectors of the 3D plane axis, themselves.

The faces of this octahedron, as points, are no other than a growing cubic interpolation, starting its growth after the big bang, developing gradually, the entire spectrum of matter to a cubic interpolation, which when a limit is reach, that of the cube, the cosmic cycle ends and the universe collapses to itself, initiating thus a new big bang, from this force. Its cosmic cycle follows this same logic and general envelope, but each time the exact points of ant distribution in the material spectrum is different.

In terms of variance in matter, and transitioning from one material array to the other, the following guidelines are set, also according to the previous described cuboactahedral structural and death and rebirth. The cube vertices which gradually grow in magnitude from the origin forming finally the collapse cube, can be seen throughout their growth as not a perfect cubic distribution of points but a noisy one, not only in terms of modulation of the actual magnitudes involved, but also because of their coordinate variance from a perfect cubic interpolation, coming from the inter-layered mapping of coordinate values throughout the control level layers via neighbor point and proximity boolean logic. That is to say that if the control cycle chooses one point on the silver star and, in order, a third coordinate is mapped, from the silver star to the material array as a cubic growth with noise depth. Of course there can be a state where mappings sync or are out of sync, therefore the final spherical array values fro the synth can differ in index number amount.

Coming back to the time base cosmographic structure description, if we consider the matter cloud array, during the ‘big bang/ period, a similar state to the silver star, this distribution is morphed via a cubic interpolation, thus points start to expand not only at the xy, xz and yz planes but also, towards the diagonals of a cubic interpolation from the point of origin, growing thus throughout the whole 3D plane. This expansion may follow a cubic vertices vector architecture but the actual form is less perfect than a cube, modulated, noisy, spherical and includes depth, hence a matter cloud. In spherical harmonic terms this cubic tendency of the matter cloud array can be structured and modulated via third order ambisonics and their corresponding ‘bubble’ spread. That is following if we consider this order’s geometry and intuitively deduce that a 2nd order would be the octahedral form of the ‘big bang’ and the silver star when in no modulation and perfect symmetry to the 3D axiai, 1st order the essence of modulation itself and zero order, the atemporal and aspatial plane, or the realm of the control cycle, eg. the soul.

On every of the eight central regions of the cubic interpolated growth of the matter cloud array, a star is gradually born (first suns), these when collapse, create in geodesic order or also possibly through other polytopes forms, further expansion and creative space of next generation stars, and they the first themselves become, not necessarily in perfect symmetry or phase, the first supermassive black holes and their adjustment galaxies.

These series of floating symmetrical and asymmetrical, periodic and aperiodic expansions, mass fusions and collapses result in a vast network of galaxies, adjacent matter clouds and void. For reference, bellow are some scientific visuals regarding cosmography and astral structure (Figures 7, 8). I am sure you can find plenty and more accurate ones or closer to your interest, at public libraries, museums, universities, labs, exhibitions and astronomy forums.

Considering this structure, each galaxies contains its own ecosystem of suns and planets, solar system, clouds, void matter clusters. At a certain point in the timeline of one cosmic cycle, when the cubic interpolation growth of the generic matter cloud array reaches a point of spherical coherence of its imaginary cubic vertices to the imaginary octahedral planes of the 3D plane, as described before, an octahedral structure. The paradigm shifts, and the cubic growth speed up, not only because of the gravitational momentum built by the fore-mentioned material and astral network growth but also on the grounds of ever growing amount of collapses stars and suns, to various magnitudes of black hole masses. After this tipping point so to say, although spatially distances expand, the distribution of the network expands at one hand, the number of possible astral objects and coordinates shrinks, on the other, as more and more matter and black masses get gravitational sucked in to stronger ones. The stronger being the imaginary vertices of the cubic

interpolation, ever growing and moving towards being real vertices of the expansion as cubic interpolation. As e perfect cube is achieved in theory, or in practice when only eight coordinates and astral masses remain, their gravitational equilibrium leaves them nowhere to expand further, the universe reaches its limit, and in some aphasia or perfect symmetry, if one prefers, these final black holes masses and their immense gravitational pull, orders them to do what their nature involves, draw one another to theirselves. This act collapses the so far created universe, space and time, and this collapse back to the point of origin, containing the whole sum of cosmic energy and momentum, makes the point of origin, again a source of ‘big bang’, initiating thus a new cosmic cycle. Each cycle is a variant and generative repetition of a cosmic lifecycle as musical synthesis. The gap between collapse and new cosmic lifecycle can be arbitrary, depending on installation needs of the sound synthesis on different speaker setups, art spaces, aesthetics and environments.

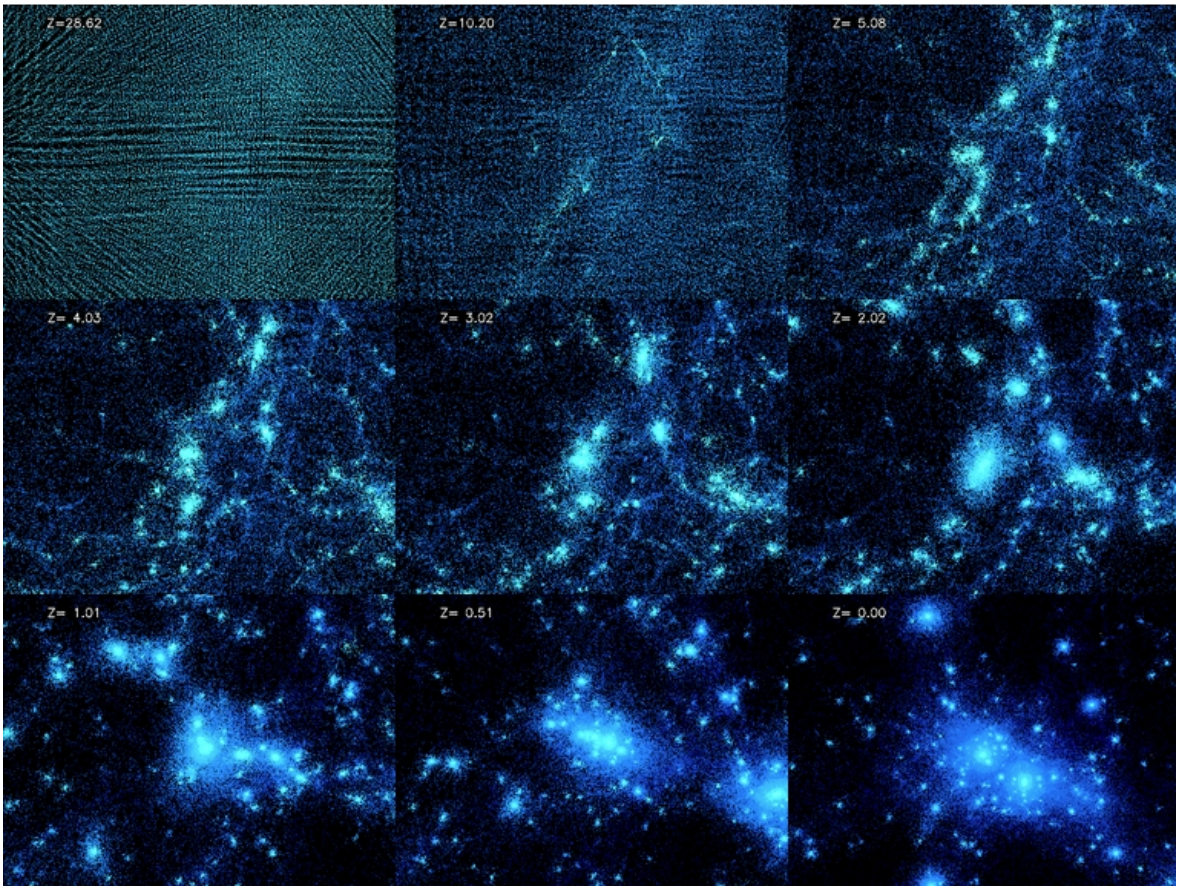


Figure 7

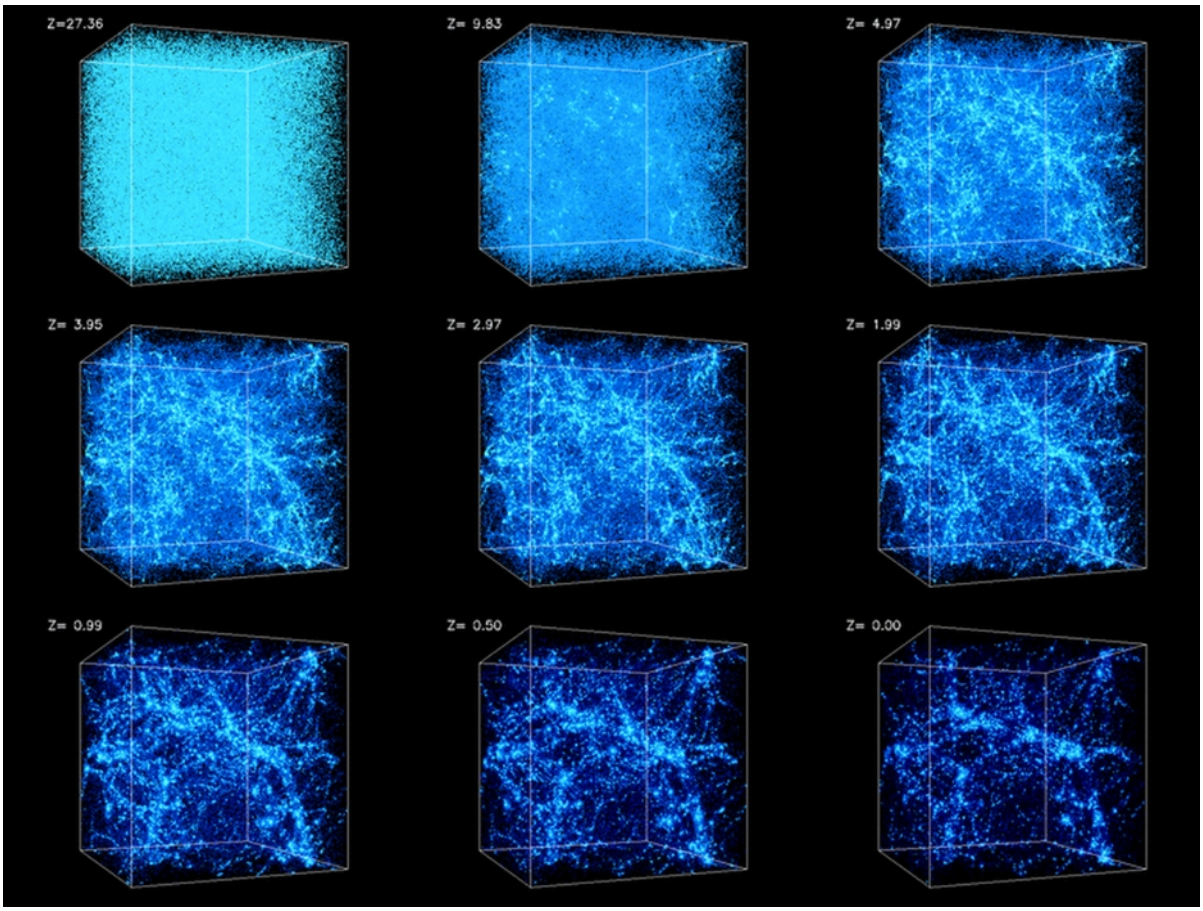


Figure 8

The movie stills pictured above illustrate the formation of clusters and large-scale filaments in the Cold Dark Matter model with dark energy. The frames show the evolution of structures in a 43 million parsecs (or 140 million light years) box from redshift of 30 to the present epoch (upper left z=30 to lower right z=0). The simulation was performed at the National Center for Supercomputer Applications by Andrey Kravtsov (the University of Chicago) and Anatoly Klypin (New Mexico State University).

Conclusion and the ghost in the shell

So far, one level and paradigm of the matarial array structres of the cosmographic composition is discribed, that of the cube and the octahdern. If we follow a self similarity logic and the mathematical structures of polytope compounds, further creative conclusion can be drawn for geometrically structure the rest of the material arrays, the first stars and galaxies, the suns and the planets, at a fairly abstract manner, as may have notices throught the graphic nature of this thesis and algorithmic composition conceptual manual, to the repository, synthesis SuperCollider code bundle files.

Self semilarity, partly refers to the fact that as the so called nfirst stars collapse and create gallactic networks, others galaxies, in similar manner later suns collapse or are generated with adjuscent planets and cloud matter. For the sake of simplicity and keeping a linear layering fashion to the routine and subroutine interchange and structure of the composition as a cosmographic timeline, planets are not to be considered as in conventional science but rather a possible state as sun mass cluster can take rather than becoming an actual star or collapsing to a black holes. Therefore planets are more or less states the sun array can morph to, either before its collapse tipping point as a sun, or before it becomes a sun altogether. To sum up a bit, there are the following certain types of material arrays, cloud matter array and its morphs and modulations, first star/ galaxies and their morphs and modulations, and suns/ planets and their morphs and modulations. The could matter array is a collection of point and coordinates tha morph, from the bigbag state to cosmic collapse, as described in the previous chapter, stars and gallaxies are a first nesting and gravitational fusion and collection of regions of the matter cloud array, and finally suns and planets are a second type nesting on the galaxies themselves and its regions.

The cloud matter array follows, under the polytope compound trail of thought (Figure 9), two tetrahedra, meaning a cube hull (magnitude growth guide and collapse state) and an octahedron core (coordinate and cosmic tipping point guide and ‘big bang’ birth state as axis). In order first stars and galaxeis follow a cube and octahedron complex, with a rhombic dodecahedron hull being the stars collapse state and a cuboctahedron core which describes the birth of the star but also the geometric interpolation of its potential galaxy after its collapse to a supermmasive black hole. Finally a sun, complex of the dodecahdron and an icosahedron, has as its geometric interpolation to an otherwise more abstract and chaotic geometric, coordinate point array distribution, a rhombic triacontahedron hull which structures its collapse limit into a black hole or other astral derivatives of sun fusion collapse, and an icosidodecahedron core which terms the sun as a stable materail array form. By planets being in between states of the previously described sun array structure, is meant the following. The icosidodecahedron has 30 vertices and the rhombic triacontahedron has 32, so any polytope state between these amount of vertices or before the icosidodecahedron polytope vertices count, eg. a 26 vertice polygon, can be a morphing of the arrae termed as a planet, or some other astral object. The type of this or a planet ‘s as a distinct form, is irrelevant for the porpuses of this composition as only one polytope and variant of the sun will be chosen, for the sake of coding and musical simplicity.

It is evident that the universe is cosmopgraphically described through gemotric interpolations of semi-chaotic cloud point distributions based on irrational number spherical angle intervals, through compound of all platonic solids, throught all levels of material arrays. The silver star, a level bellow, is a state of ‘big bang’ at its very first moment, frozen in time as a control method, for 6D modulation of coordinate choice on every higher control level material array. Tha is to say, that the y=1/x state of each 3D axis rotates indipendently and in free will to other axia via three also indipendently moving vektors as quaternion rotation axis. Hence 6D system. Three axis forming the object (real), three axis forming its rotation axis frame (imaginary).

Finally we come to the bottom and most crucial level of control, before the silver star in mapping order. The control cycle, as described before in previous chapters. Cosmographically this cycle represents in the realms of the composition, free will itself, roaming and floating on the and in the 3D plane through material entropy. The cycle as a form of control is both an automaton, as any other part of the composition, as well as an interface. Its automaton arguments are its in sync to the silver star rotation vector and its interface argument its spin, two arguments that make the choice of coordinate and through all levels all control and synth the final auditory outpur. The second interface is simply the tempo. The relation between the tempo and the spin are essentially the instrument of the synthesis and the only and simple musical control of this algorithmic sound

automaton. Chords and spatial audio location are set by coordinates, melody and rhythm are set by coordinate [x,y,z] sequencies. Calibration of the instrument other than specifically ordering VBAP and speaker setups, noise and randomness, musical scales and temperaments, frequency spectrum bands and other parts of the automaton algorithm, more significantly for the purposes of making and exhibiting generative instrument through this instrument, is a third parameter on the interface level, which is the polytope of choice for the rhythm and melody sequences.

This interface part essentially is a choice of 3D musical motive, eg. simply the tetrahedron. On this terms the tetrahedron with no modulation, rotation etc. is a sequence of four coordinates, each coordinate is a rhythmic or a melodic sequence [x,y,x], according to the scale of the coordinate's magnitude variable as a Spherical object. Any modulation or rotation of this solid of choice elongates the sequence in time through variance repetition and in harmony mathematically, as all coordinates are inscribed to a sphere, a cyclic quadrilateral. The place of this choice as an interface and a control level is optional, as its purpose is mainly to incorporate musical symmetry to the composition, so its use is rather an aesthetic choice than a nescessary part of the synthesis and the overall algorithm as an instrument. If chosen as an option and level of control, its application should lie as a layer between the cotrol cycle array and the silver star array. Thus a mapping would occur, when possible and according to the proximity range of the applied neighbor point scan, from the control cycle to the solid pattern of choice, eg. the tetrahedron, and then that coordinate mapped to the silver star, the rest is as follows in the previous chapters. Note that some mucisians might prefer a different ordering sequence eg. for the case of tetrahedron not four bars of three notes [x1, y1, z1], [x2, y2, z2], [x3 y3, z3], [x3, y3, z3], but an order of three bars with four notes each, following [x1,x2,x3,x4], [y1,y2,y3,y4], [y1,y2,y3,y4]. To my view this is a miniscule difference in terms of jamming if one is skilled enough, but to be honest, under my scope and theoretically in terms of harmnony, being according to Socrates the appeal of mathematically simple auditory intervals to the ear hoewer complex the music may be, following the first paradigm of having four bars of three notes, seems closer to the soul.

RocknRoll!

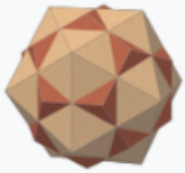
Dual compound	Picture	Hull	Core	Symmetry group
Two tetrahedra (Compound of two tetrahedra, stellated octahedron)		Cube	Octahedron	*432 [4,3] O_h
Cube and octahedron (Compound of cube and octahedron)		Rhombic dodecahedron	Cuboctahedron	*432 [4,3] O_h
Dodecahedron and icosahedron (Compound of dodecahedron and icosahedron)		Rhombic triacontahedron	Icosidodecahedron	*532 [5,3] I_h

Figure 9

Notes

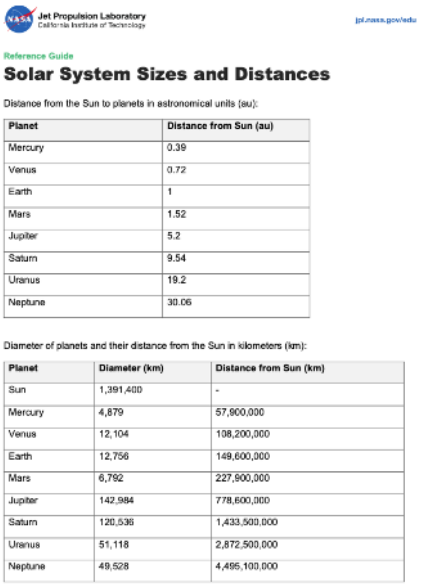
- Important to mention, that one can use external instruments, synths, sequencers and oscillators, via MIDIout information and the .cpdmidi method, in order to improve the timbre of the computer instrument or even incorporate additional arpeggios melodies and riffs, to any event.

- A tetrahedral speaker setup with whole spectrum speakers and high quality amplifiers is proffered for musical purposes, when the third mentioned interface argument is in use, that is. Any other multichannel setup would suffice for other sound art uses. Of course stereo mixdown in production or at real-time performance and installation is an option using encoding tools of choice, like Ambisonics, FFT Analysis or simple stereo mix of the VBAP output channels.

- Following the 'music of the heavens' gnostic paradigm, one can conceptualize sound as gravity theorizing this composition, not a sensible but intuitive roar of the spheres. As Kepler would have put it, we are born in gravity, thereof we do not perceive its absence as an actual phenomenon, unless of course we let things fall.

- Regarding further cosmographic abstraction and astronomic information one can utilize contemporary distances/ intervals between bodies in the solar system as a form of wavetable information, for use on the synth oscillator, variating thus from the simple sine form. Another option would be to scratch the option of morphing the sun location and sun array to as being a planet and only incorporate some points as planets, with corresponding distances (Figure 10) from the central sun object, to the sun array. These locations could serve as independent drones when their coordinate matches that of the synthesis chosen coordinate through the layers of mapping, via separate dedicated synths, only triggered when these locations are an event. This might prove interesting, but potentially it might prove to complex in terms of the synthesis as harmonic composition and disorient the viewer, as spatial sound is a
crucial factor. In any case, a solar system cosmography abstraction could be an interesting concept for a generative composition in its own account, considering contemporary astronomical data, and following similar synthesis logic patterns control levels and mapping as for the 'Cosmographico'.

- Another set of possibly useful information for the composition automaton and signification cosmography would be the frequency of orbits of planets around the sun and of the sun around the galaxy. These, according to contemporary data, approximate to: 0.24 years for Mercury around the sun, 0.62 years for Venus, 1 year for Earth, 1.88 years for Mars, 11.86 years for Jupiter 29.46 years for Saturn, 84.01 years for Uranus, 164.8 years for Neptune and 248 years for Pluto. The sun orbits the galaxy at a period of 225-250 million years and has completed 20 galactic orbits since the formation of the earth.



Jet Propulsion Laboratory
California Institute of Technology

Reference Guide

Solar System Sizes and Distances

Distance from the Sun to planets in astronomical units (au):

Planet	Distance from Sun (au)
Mercury	0.39
Venus	0.72
Earth	1
Mars	1.52
Jupiter	5.2
Saturn	9.54
Uranus	19.2
Neptune	30.06

Diameter of planets and their distance from the Sun in kilometers (km):

Planet	Diameter (km)	Distance from Sun (km)
Sun	1,391,400	-
Mercury	4,879	57,900,000
Venus	12,104	108,200,000
Earth	12,756	149,600,000
Mars	6,792	227,900,000
Jupiter	142,984	778,600,000
Saturn	120,536	1,433,500,000
Uranus	51,118	2,872,500,000
Neptune	49,528	4,495,100,000

Figure 10

- Regarding the bottom line control level of the composition and the parameters of tempo, cycle spin and rotation axis spin (sync to silver star rotation axis vector sum speed), three seeds can be used, for controlled repetition and harmonic chance on the adjacent controls or modulators/ generators. A thread with randomness seed integers from the Fibonacci sequence (golden ratio) can be used for the speed of spin, seed integers from the Pell numbers sequence (silver ratio) can be used for tempo, and finally a seed of integers from the perfect number sequence (best approximation sequence using the Archimedean approximation method for π) can be used for the rotation axis oscillation.

Or any other configuration of the three transcendental numbers φ,s,π sequences, that you prefer. For example spin of rotation axis and of rotation can be automata via golden ratio and silver ratio randomness, and tempo being a musical temperament value based on the perfect number sequence octaves. The same can apply for the overall fundamental frequency along with maybe a 9/8 scalar. Or differently, having a stable tempo, choosing spin via a π, perfect number randomness, etc. Or setting the three independent rotation axis of the silver star following each a different randomness type of the fore-mentioned, their vector sum being the control cycle rotation axis and the spin some user dependent chosen ‘performative’ value under some tempo, returning back to the initial musical instrument format.

Any alterations and explorations on such configurations are welcome. Concluding, the third irrational number sequence gen of π can be used as simply the wavetable formant of the synthesis, golden as spin, silver ratio as rotation ratio, all under stable tempo. Hve Fun.

-Creating an analog wave in SuperCollider, via wavetable and AM, with the musical temperament sequence generates a minor sound, and with the lamdoma method a major sound. This oscillator method scratches previous mentioned additive synthesis methods and renders them only relevant as partials of spatial sound events in terms of multi coordinate events (a concept more handy for stereo applications and FFT synthesis via audio files). That is because the oscillator now, being analog, when low pass filtered to the oscillator frequency it produces a sine and when this filter frequency tends towards high, the waveform shifts towards sawtooth variation, according to the oscillator structure, temperament, lamdoma or other (eg. sawtooth).

This means that additive synthesis (in terms of oscillator harmonics) does not occur by adding oscillators of additive frequency on a fundamental, derived from the depth location data of an array, but simply from the magnitude of a coordinate, from the point of origin. This magnitude is used as a value for the oscillator low-pass filter multiplier, and thus the correspondent waveform is achieved.

```
////musical temperament method
(
~n=1.neg;~array=16256.collect{~n=~n+1;2.pow(~n/16256)};
~a=(0-(pi/8128)); ~ph=16256.collect{~a=~a+(pi/8128);};
~bufferSize = 4096*8;
~signalSize = 2048*8;
)

/////lamdoma method
(
~n=0;~array=512.collect{~n=~n+1;(~n+1)/~n};
~a=(0-(pi/256)); ~ph=512.collect{~a=~a+(pi/256);};
~bufferSize = 4096*8;
~signalSize = 2048*8;
)

(
Buffer.freeAll;
~w= Buffer.alloc(s,~bufferSize);
                    {
        var signal,wt;
```

```
        signal=Signal.sineFill(~signalSize,~array,~ph);

wt = signal.asWavetable;
~w.loadCollection(wt);
signal.plot;
                }.value;
)


(
var freq=6*32, b=1,amp=1/10;
{Out.ar(0,LPF.ar((Osc.ar(~w.bufnum,freq,phase:0.degrad,mul:100).abs*SinOsc.ar(freq,phase:0.de
grad)),freq*64,amp))}.play;
{Out.ar(1,LPF.ar((Osc.ar(~w.bufnum,freq,phase:90.degrad,mul:100).abs*SinOsc.ar(freq,phase:90.
degrad)),freq*64,amp))}.play;
)
```

- Composition dramaturgy:

Matter cloud array:

Array flattens through time, as pan spin increases. Regions start to form (gravitas file) with lighter particles (few harmonics) growing towards the center creating gradually the sun, heavier particles, form their own centers and groupings of other bodies like planets. This in case of solar system array.

In case of star matter array, general cloud matter cloud follows this order to create collections of stars. Which when collapse create the galaxy matter cloud around the supermassive black hole core, with new cloud matter groupings in these galaxies, following the solar system creation logic, or other forms like free floating meteorites, void, or systems with two or more suns.

So coming back to the cloud matter array, as generic material array of the timeline, big bang to heat-death, the geometrically interpolated points form the masse centers of clouds that create stats, which nested inside are independent clouds hosting systems.and gravitas modulation, travels towards greater masses.

After the timeline tipping point so to say, galaxies start to shrink, and their systems grow, until only the mass remains, which in turn according to cosmic interpolation

In terms of distribution, if a cloud is a generic chaotic distribution of irrational number interval, an ordering galaxies follows two parameters, the geometric interpolation of platonic points, according to system level, and a network parameter which not only influences (along with temporal parameters) the interpolation mapping limit but also its modulation and noise.
Eg. a solar system as it gravitationally, moves away from the cloud, to a certain amount of bodies, including cloud matter and the center sun, it has for once a certain independent order (modulator) for each body, in terms of panning ans other stuff, along with asymmetric and several temporal parameters which render the general geometric interpolation time-based, semi-periodic and in line with a dramaturgy of the composition or in other terms generative timeline.

- An alternative for the use of a coordinate as a threefold x,y,z harmony may not be a chord of oscillators, but having one oscillator with a modulated BPF sweep across its spectrum, via three such sweeps with corresponding x,y,x speeds. So essentially one oscillator with a 3-pole band pass, or 3-pole BPF and 3-pole BRF, for inverse band sweep as well.

- Before, a method of using an algae L- system sequence is refereed for determining the rest of events sequence (silence). The rest time value depends on amount of subsequent 0 (A=[0,0..]) of the binary L-system array. A silent event may, apart the setting case of chord presence, a presence of void (silence), as the neighborhood point logic mapping, always converges towards the coordinate of a point and not empty space.

- In terms of perspective for the composition synthesis and timeline, we can think of all the arrays are six vanishing point 3D objects. Determining a perspectives is to set tetrahedron scope on these six vanishing points. Determining as one of the vanishing points as the point of view and its negative (horizon), this points acts as one vertex of the tetrahedron scope, and the tetrahedron quaternion rotation axis, and the rest three vertices the vanishing points, of a triangular scope surface. As axis are independent (silver star), the view-point can be any angle, on the 3D plain, as well as the scope surface, in relation to the view axis angle (offset of horizon line to view direct, frontal axis).

In terms of the composition this entails that although as generative sound, tensor coordinates are set through the fore-described layers, modulators and processes, in case of a visual animation, the tetrahedral scope is to be applied to view each coordinate from a selected angle and horizon. In spatial auditory terms this process can be mapped conceptually, to the virtual listeners position being a flyby from one coordinate to the other. That is, that although tonal properties and panning may jump from one coordinate to the other, there is an additional panning and filtering and reverb, maybe, modulator that entails the tetrahedral scope. That is, for example in the case of panning, a transition from coordinate a to b, takes into account an initial viewing position (tetrahedral scope), and the next viewing position, although scoping a new coordinate, the change in viewer position in relation to the horizon must be a continuous shift, as if there is a 'pilot' parameter to the listening, from one event to the next. For example, without such a scope, the panning locations are simply VBAP points on spherical coordinates, corresponding to the control array. Adding the tetrahedral scope would mean that only coordinates on the triangular scope surface are audible as frontal, and the rest are reverberated and psycho-acoustically altered to be our of focus, on the auditory periphery of the listener, on rear perception, back, up and down.

The shift of the scope's viewpoint can be a totally independent modulator and tempo from the overall composition, and the horizon, an automaton mapping offset to the viewpoint, in terms of the spaceship aesthetic one requires to set. If this scoping modulator is to be incorporated in the control layer of the composition, it can simply be the tetrahedral geometric interpolation of the control array.

This scope for the control array is handy, also for structure sub routines for the material arrays, via dedicated control arrays. This essentially means that when the pilot 'listener' locks on a location to the first control array, this area, can be a second control array, and so on. This is helpful for navigating from macrocosm to microcosm, both for panning, and musical presence in the composition, throughout the automaton timeline period. Eg. the composition can travel from a cosmic view, to a galaxy view, to a solar system view, and inversely. This latter control aspect, along with maybe the tempo, and the control cycle spin, can manual controls or interaction sensor inputs in the case of a sonic arts installation.

- Considering and contextualizing heat-death and big-bang terms, for this composition, one can think that as the universe expands location distances grow towards a lim, which in sonic terms means greater amplitude, thus lower frequency, hence at the lim, heat-death. Correspondingly, at the big bang state, distances are smaller, thus higher frequencies.

Therefore one can conceptualize the fundamental of the composition, shifting from higher to lower timbre, throughout the cosmographic timeline. This, along with temperament range, according to level of material location, cosmic to solar system, are the main generic tonal properties that depend from the overall synthesis and not individual locations as coordinates.

- A simpler way to visualize the virtual listeners point of view, is two vanishing points on the spherical VBAP, that are orthogonal to each other and in relation to a listening cubic space. That is, these vanishing points have a proximity range neighborhood point mapping of half the distance to each other, creating thus a listening area on the VBAP plane, according to piloting setting described before.

- A simpler approach that encapsulates also the vanishing points concept is to pan the four, two on each of the same cube side, vertices of the two tetrahedra, that geometrically structure the cube, to a quad setup. That is having a VBAP output of 8 channels, and drawing four to physical speaker lines in a bipolar orthogonal panning shift or a quad mix-down of the cubic 8 channels to quad.

- Cosmographically, this setup, conceptualizes the heat-death of the universe as an actuallistic, semi-periodic and asymmetric abstraction. That is, during the final stage of the cosmic cloud and consequent 8 final masses of its cubic interpolation, the cube is no platonic perfect and its asymmetry collapses it to a tetrahedron, with the in-pair less distant masses colliding. This tetrahedron in turn collapses also because of its asymmetry and parallel tendency towards symmetry and forms a line between two masses, which in turn collapses, shutting thus the door to everything spatiotemporal and begetting and new cosmic period and big-bang, via its collapse on itself against the total void.

For a quad setup spatialization van be as the following example:

```
(
Server.default = s = Server.local;
////server setup
(
s.options.numWireBufs = 1024*4;
s.options.numOutputBusChannels=4;
s.options.numInputBusChannels=0;
TempoClock.default.tempo_(1);
s.options.memSize = 8192*4;
//s.options.sampleRate= 44100;
);

s.waitForBoot{
	Buffer.freeAll;
	(
~n=1.neg;~array=16256.collect{~n=~n+1;2.pow(~n/16256)};
~a=(0-(pi/8128)); ~ph=16256.collect{~a=~a+(pi/8128);};
~bufferSize = 4096*8;
~signalSize = 2048*8;
);
	(
Buffer.freeAll;
~w= Buffer.alloc(s,~bufferSize);
		{
	var signal,wt;
	signal=Signal.sineFill(~signalSize,~array,~ph);

wt = signal.asWavetable;
~w.loadCollection(wt);
signal.plot;
		}.value;
);
(
~az1=[45.degrad,135.neg.degrad,45.neg.degrad,135.degrad];
~el1=[35.264390.neg.degrad,35.264390.neg.degrad,35.264390.degrad,35.264390.degrad];
);
/////tetrahedron2
(
~az2=[45.degrad,135.neg.degrad,45.neg.degrad,135.degrad];
~el2=[35.264390.degrad,35.264390.degrad,35.264390.neg.degrad,35.264390.neg.degrad];
);

(
~a1 = VBAPSpeakerArray.new(3, [[~az1.[0], ~el1.[0]], [~az1.[1], ~el1.[1]], [~az1.[2], ~el1.[2]],
[~az1.[3], ~el1.[3]]]);
	~b1 = Buffer.loadCollection(s, ~a1.getSetsAndMatrices);
```

```
	);

	(
~a2 = VBAPSpeakerArray.new(3, [[~az2.[0], ~el2.[0]], [~az2.[1], ~el2.[1]], [~az2.[2], ~el2.[2]],
[~az2.[3], ~el2.[3]]]);
	 ~b2 = Buffer.loadCollection(s, ~a2.getSetsAndMatrices);
	);

({
var
sig,out1,out2,pan1,pan2,phase1,phase2,equlibrium,p_amp1=0.5,p_amp2=0.5,sph,phase,freq=220
,f=1,amp=1;

sph=Spherical(2pi,45.degrad,90.degrad);
phase=Complex(exp(Complex(0,1)*sph.theta).real,exp(Complex(0,1)*sph.phi).imag).theta;
sig=LPF.ar((Osc.ar(~w.bufnum,freq,phase:phase,mul:100).abs*SinOsc.ar(freq,phase:phase)),freq*f
.round(1),amp);
//sig=SinOsc.ar(440,phase,mul:0.1);

equlibrium=90.degrad;
phase1=0.degrad; phase2=equlibrium;
pan1=SinOsc.ar(freq/32,phase:phase1,mul:p_amp1);
pan2=SinOsc.ar(freq/32,phase:phase2,mul:p_amp2);

out1=Out.ar(0,VBAP.ar(4,sig,~b1.bufnum,sph.theta.raddeg,sph.phi.raddeg,72)*pan1);
out2=Out.ar(0,VBAP.ar(4,sig,~b2.bufnum,sph.theta.raddeg,sph.phi.raddeg,72)*pan2);

}.play)}
)
```

And for a stereo or 2.1 setup as the next example:

```
(
Server.default = s = Server.local;
////server setup
(
s.options.numWireBufs = 1024*4;
s.options.numOutputBusChannels=2;
s.options.numInputBusChannels=0;
TempoClock.default.tempo_(1);
s.options.memSize = 8192*4;
//s.options.sampleRate= 44100;
);

s.waitForBoot{
	Buffer.freeAll;
	(
~n=1.neg;~array=16256.collect{~n=~n+1;2.pow(~n/16256)};
~a=(0-(pi/8128)); ~ph=16256.collect{~a=~a+(pi/8128);};
~bufferSize = 4096*8;
~signalSize = 2048*8;
);
	(
Buffer.freeAll;
~w= Buffer.alloc(s,~bufferSize);
		{
	var signal,wt;
	signal=Signal.sineFill(~signalSize,~array,~ph);
```

```
wt = signal.asWavetable;
~w.loadCollection(wt);
//signal.plot;
                    }.value;
);
(
~az1=[45.degrad,135.neg.degrad,45.neg.degrad,135.degrad];
~el1=[35.264390.neg.degrad,35.264390.neg.degrad,35.264390.degrad,35.264390.degrad];
);
/////tetrahedron2
(
~az2=[45.degrad,135.neg.degrad,45.neg.degrad,135.degrad];
~el2=[35.264390.degrad,35.264390.degrad,35.264390.neg.degrad,35.264390.neg.degrad];
);


({
var
sig,out1,out2,pan1,pan2,phase1,phase2,equlibrium,p_amp1=0.5,p_amp2=0.5,coordinate=0,angle,
pan_az,pan_el;
var pos1,pos2,sph,phase,freq=220,f=1,amp=1,sph1,sph2,angle1,angle2,az,el;

equlibrium=90.degrad;
phase1=0.degrad; phase2=equlibrium;
pan1=SinOsc.ar(freq/32,phase:phase1,mul:p_amp1);
pan2=SinOsc.ar(freq/32,phase:phase2,mul:p_amp2);

                    az=SinOsc.ar(1/2,0.degrad,pi);
                    el=SinOsc.ar(1/4,90.degrad,pi/2);

//sph1=Spherical(1,(~az1.[coordinate]+az).wrap(pi.neg,pi),(~el1.[coordinate]+el).wrap((pi/2).neg,
(pi/2)));
//sph2=Spherical(1,(~az2.[coordinate]+az).wrap(pi.neg,pi),(~el2.[coordinate]+el).wrap((pi/2).neg,
(pi/2)));

sph1=Spherical(1,(az),(el));
sph2=Spherical(1,(az),(el));

angle1=Complex(exp(Complex(0,1)*sph1.theta).real,exp(Complex(0,1)*sph1.phi).imag).theta;
angle2=Complex(exp(Complex(0,1)*sph2.theta).real,exp(Complex(0,1)*sph2.phi).imag).theta;

angle=Complex(exp(Complex(0,1)*angle1).real,exp(Complex(0,1)*angle2).imag).theta;

pos1=exp(Complex(0,1)*angle).real;
pos2=exp(Complex(0,1)*angle).imag;

sig=LPF.ar((Osc.ar(~w.bufnum,freq,phase:angle,mul:100).abs*SinOsc.ar(freq,phase:angle)),freq*f.
round(1),amp);

out1=Out.ar(0,Pan2.ar(sig,pos1)*pan1);
out2=Out.ar(0,Pan2.ar(sig,pos2)*pan2);

}.play)}
)
```