Article

The Origin of Time in Mandelbrot Cosmology

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Abstract

The very beginning of the universe is a mystery to physicists and cosmologists are forced to speculate about the dynamics at the Planck scale, without the basis for a clear picture of the phenomenology. This is one area where the Mandelbrot Set offers profound insights, because using the Mandelbrot Mapping Conjecture we can chart what happens in the first few instants, and see how geometrization leads rapidly to an inflationary phase and then to baryogenesis, if we assume octonionic embedding. We chart how time began, and discuss how cosmological evolution works to create the present-day arrow of time, according to the Mandelbrot Set and its extended family of associated figures.

Keywords: Origin of time, space-energy, unification, geometrization, Mandelbrot Set.

Introduction

The origin of time is hotly debated in Physics, with many differing opinions on whether time is fixed or flexible, primal or derivative, and so on. But time's origin is unavoidably connected with the origin of the cosmos, and thereby to Cosmology, but also to high-energy and/or Particle Physics. It is broadly or widely assumed that the first instant or instants involved energies so high that none of the particles we can directly observe using today's accelerators and colliders could have formed yet. I will make no attempt to review or summarize the vast amount of literature on this topic.

Much of it is speculative, and my focus here will be to present what the Mandelbrot Set tells us about the Planck epoch and the onset of Inflation, where $\mathcal{M}$ in the complex domain (2-d) is assumed to be the projection or shadow of a higher-dimensional figure. This is based on the Mandelbrot Mapping Conjecture (or MMC) [1], which states that we can map physical processes to locations in $\mathcal{M}$, where the highest-energy processes near the Planck scale are represented by the cusp at (0.25,0*i*), and absolute zero temperature is seen at (-2,0*i*). This paper focuses solely on the initial arc, and it is intended as a letter to introduce the reader to this line of reasoning rather than a technical treatise on the subject, which offers full explanations.

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What the Mandelbrot Set tells us closely mimics much of what physicists already know about the early universe. But as covered in several recent papers [2]; what $\mathcal{M}$ depicts closely resembles theories that assume a higher-dimensional origin for the cosmos, or a higher-dimensional precursor universe – from which our present-day cosmos was born. So a broader context must be assumed, than the standard or concordance model of Cosmology, to include alternative theories of gravitation and Quantum Gravity theories, as well as formulations arising in the study of Particle Physics. But what we see represented in $\mathcal{M}$ gives us insights into areas that have barely been touched upon by theorists, because we do not possess the detailed knowledge of particle interactions at such high energies, nor are we likely to ever get there in the laboratory. Perhaps an advanced culture, having already built a Dyson sphere around their native sun, could construct on its surface an accelerator large enough to probe those energies …almost.

Therefore, anything useful we can learn about the universe's origin from $\mathcal{M}$ is likely to be unobtainable using conventional sources. However; it is freely acknowledged that what is displayed in $\mathcal{M}$ is an archetypical and abstract representation of ideal processes that physical forms can only approximate. We can iterate points in regions of interest in $\mathcal{M}$ to extremely high values using available software on desktop computers. We imagine structures on the boundary (in the repeller sets) with high iteration counts represent high energies, but we cannot assume nature had arbitrarily high energies to work with.

On the other hand; if we can probe what would happen at even higher energies than the universe can muster, we can gain insights into how physical structure emerges from pure energy. There appears to be a ratcheting effect at the outset, where energy directly pushes out the boundary of spacetime in waves of descending period, until enough space is created for seminal fermionic particles to appear and baryogenesis to commence. We see this represented in the Mandelbrot Butterfly, which appears if we color in locations where the iterand magnitude shrinks monotonically for three iterations. We will also turn the Mandelbrot Set inside out, and use other novel ways to represent the features we are looking to highlight. It is shown that $\mathcal{M}$ gives us a unique window on the early universe, which allows us to see the context for a broad range of existing theories, and provides direction for future work.

The Early Universe in $\mathcal{M}$

While it is often assumed that symmetry groups and other mathematical invariants are important to understanding Physics; few look to the Mandelbrot Set for insights about the physical universe and its laws. The Mandelbrot Set appears to be a law unto itself, and a self-contained universe with attributes which are purely abstract rather than physical. But the author's discovery 30 years ago of the Butterfly figure [3], and subsequent conversations with Benoit Mandelbrot, left me convinced there was something to explore. This came just after taking a course in Cosmology and Astrophysics, where my immediate reaction was that it depicted the Big Bang. Seeing later it was not a precise match led to setting the idea aside for a number of years. But the turn of the century brought a revolution in Cosmology making this notion seem far more plausible. Then over time; descriptions of what was observed and the connections to physical law were made more and more precise.

In recent years; I found out that the theoretical Physics community has already explored many of the same dynamics that are spelled out visually in $\mathcal{M}$, or by the Mandelbrot Butterfly figure and its family of related forms. However what I discovered was not merely a new figure, but a new methodology for exploring the Mandelbrot Set and its family of associated objects, including the Julia Sets [4], so many unexplored avenues remain. In Fig. 1 below, the cardioid portion of the Mandelbrot Butterfly is shown to represent the cosmology of the early universe.

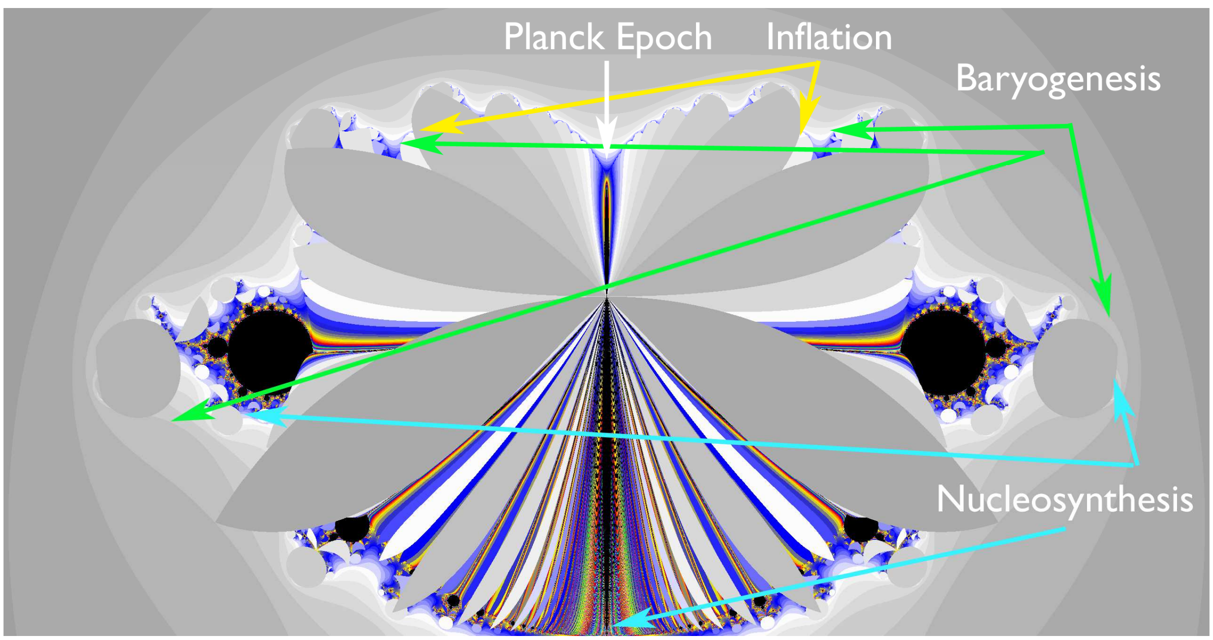

Fig. 1. The cardioid region of the Mandelbrot Butterfly shows the progression of cosmological eras in the early universe, tracing the periphery from the cusp at (0.25,0*i*) to the antipode at (-0.75,0*i*).

Perhaps the most striking feature of the above diagram is the Janus-like feature where the same progression unfolds along the left and right edges of the periphery, suggesting two opposing directions of time. This grows to 14 directions assuming octonionic embedding for $\mathcal{M}$, with seven pairs of opposing timeline branches, where each branch is a CPT mirror of the opposing branch. Charge is associated with positive or negative imaginary values applied to features with a given characteristic period. Chirality is discerned as a geometric property associated with forms around branching Misiurewicz points, and in the vicinity of mini-$\mathcal{M}$s dotting the periphery, so

Parity is seen in oppositely chiral features. The thermodynamic arrow of Time dictated by entropy is associated with the global asymmetry of the Mandelbrot Set, and it is projected on its parts through self-similarity.

The bifurcation diagram for the Mandelbrot function over the reals splits where the boundary of $\mathcal{M}$ doubles back on itself and it shows the progression to chaos when transiting from a value of 0.25 to -2.0. Entropy is therefore seen to progress moving from the cusp of $\mathcal{M}$ to the tip of its main antenna or spike at the far end. A similar progression is observed as we look outward from any bulb along the periphery of the cardioid. And instead of one branch splitting into two, there are 3, 4, 5, or higher numbers of branches for each splitting – at a range of Misiurewicz points. But conveniently; the largest mini-$\mathcal{M}$ on the branches extending from each bulb points in the primary direction of entropic flow for its basin of attraction.

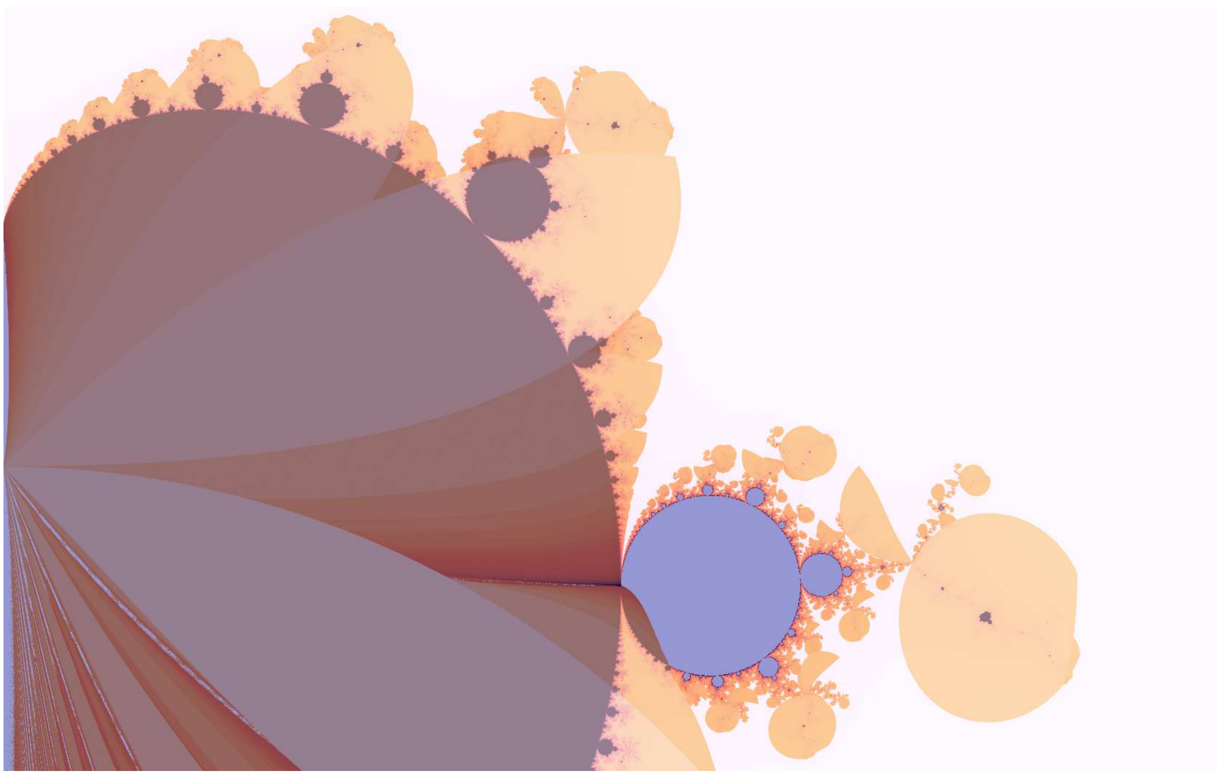

Fig. 2. In this semi-transparent view of the Butterfly, we can see the mini-$\mathcal{M}$s pointing in the direction of increasing entropy and showing us the thermodynamic arrow of time. (Image by Paul Bourke)

So far we have talked only about general features, but we can examine the very first moment and hence the origin of time with this model. Accordingly; looking back to a time before familiar particles could exist, we expect to learn how space emerges and how space and time came to be a single entity or became intertwined. Indeed what we see is that; in the initial phase of the universe's unfoldment, bands of energy press on the fabric of space, moving it toward volumetric expansiveness. This can be explained easily in the context of the octonions. Because the Mandelbrot Set in the complex numbers is the faithful projection of a higher-dimensional figure in the quaternions and octonions, it is imagined that it encodes information about these spaces. I have shown in previous work [5] that the overall shape of $\mathcal{M}$ duplicates Cartan's rolling ball analogy for Lie group G_2 symmetries, where G_2 is the smallest exceptional Lie group (F_4, E_6, E_7, and E_8 being the others), and all of these arise from the octonions.

Papers by Joshi with Griffin [6] and Kricker [7] show how the Mandelbrot Set can also help delineate non-associative regimes of the octonionic quadratic domain. The behavior of the Mandelbrot function $z \rightarrow z^2 + z_0$ along the real axis is the same for the quaternions and octonions as for the complex. But if we assume octonionic embedding, some of the familiar features of $\mathcal{M}$ have a new meaning, because in higher dimensions they take on properties of those spaces. The fact positive real values greater than .25 grow so quickly therefore provides a mechanism for Inflation.

The very first moment of time is presumed by scientists to occur at the Planck scale, and in this model that instant corresponds with the cusp at (0.25,0*i*). The primal instant is represented by a pure positive real, with no imaginary components, even in the octonion domain with seven imaginaries. But this indicates that the Planck scale is defined primarily as a minimum unit of time – or as a minimum time extent, the Planck time – and then this unit's attribute of duration is projected onto space by the action of energy. The arrow of time is initially associated with the real component, and space-like attributes arise by adding imaginary components, because imaginary values represent a specific amount of variation, and variation from a straight line is required to create space.

A sufficient positive real extent was required to set time moving in a forward direction, in this analogy, and then the power of variation inherent in imaginary dimensions moved the process forward. In the octonions; we observe sequential evolution, combining cyclical and stage-wise composition of processes. Alain Connes has stated emphatically "Noncommutative measure spaces evolve with time!" [8] and P.C. Kainen has further explained [9] that the non-associative octonions exhibit an even stronger form of this evolutive behavior, which should be considered a blessing instead of a curse. In this case; having a function that grows rapidly on iteration for even a small positive value, where adding the right number of imaginary dimensions causes spaces to evolve on their own, creates a fertile setting for octonionic Inflation.

If we consider properties of higher-dimensional spheres; it can be shown that something like Inflation arises without having to add in scalar fields, additional particles, or other provisions, in higher dimensions. If we rearrange the terms in Einstein's equation for mass-energy equivalence to read $c^2 = E/m$ and then let $m \to 0$, we see the speed of light becomes unconstrained in the matter-free regime [10]. A very similar phenomenology arises in a recent paper by Afshordi and Magueijo [11]. The matter-free state can occur both before the appearance of massive particles in the early universe, and in higher-dimensional domains where the properties of space allow 3-dimensional knots to be untied.

The non-associative geometry in some higher-d spaces does not admit stable containing structures. Here we assume that unique properties of 3-d space or 4-d spacetime which make it possible to construct continuous knots that cannot be untied are an essential condition for the existence of fermionic particles. Thus it is seen that these particles do not persist in a higher-dimensional bulk – which we expect contains energy as radiation – but are forced to the periphery of the hypersphere where they can exist in its volumetric hypersurface. If we are guided by the fact that 5-d spheres have the largest hypervolume for spheres of any dimension [12], and so assume that the early universe reached its maximum extent in 5-d; then its hypersurface was a 4-d spacetime where familiar particles could safely reside.

The phenomenology described in the last paragraph is graphically depicted in the Mandelbrot Butterfly figure. The discs around the periphery show basins of attraction for the mini-Mandelbrots that reside beyond a Misiurewicz point, which is the edge of that basin. Each has a characteristic period, and they resolve before features in the repeller sets beneath, or the outline of the mini-$\mathcal{M}$. That is; the features of the Butterfly figure require fewer calculations to resolve than points in their neighborhood using the standard algorithm. We see that the discs in the periphery show us attracting regions surrounding mini-$\mathcal{M}$s that are bracketed by branching and terminal Misiurewicz points. This is seen to represent regimes where forms congeal rather than fly apart. Accordingly; it shows the emergence of particles and nucleosynthesis, as one progresses around the edge of the cardioid from the cusp. The wings that emanate from the center are therefore seen to represent creation/annihilation operator paths involved in matter-energy exchanges.

In figure 3 above; we see that the wings press directly on the periphery and exclude the appearance of discs beyond their reach. If these features represent the action paths of creation/annihilation operators elsewhere in $\mathcal{M}$, and the initial action of these energy bands is to press out the boundaries of space; we can conclude they are assisting in space creation, and that space and energy are directly coupled in the early universe. Therefore; some form of space-energy unification is shown to be a factor in geometrogenesis and the creation of space using the above assumptions. Briefly stated; a geometric setting for particles to exist must be created, in the form of volumetric spaces with properties that persist in time, before any massive particles can emerge. Then this gives way to a dense plasma phase where quarks and gluons begin to form, but are immediately subsumed in the energetic flow until sufficiently large spaces are opened up to allow those forms to emerge. In figure 4; we see what lurks behind the wings, when the 5 lowest-order solutions are suppressed. This shows the power of using this algorithmic approach to study archetypical behaviors.

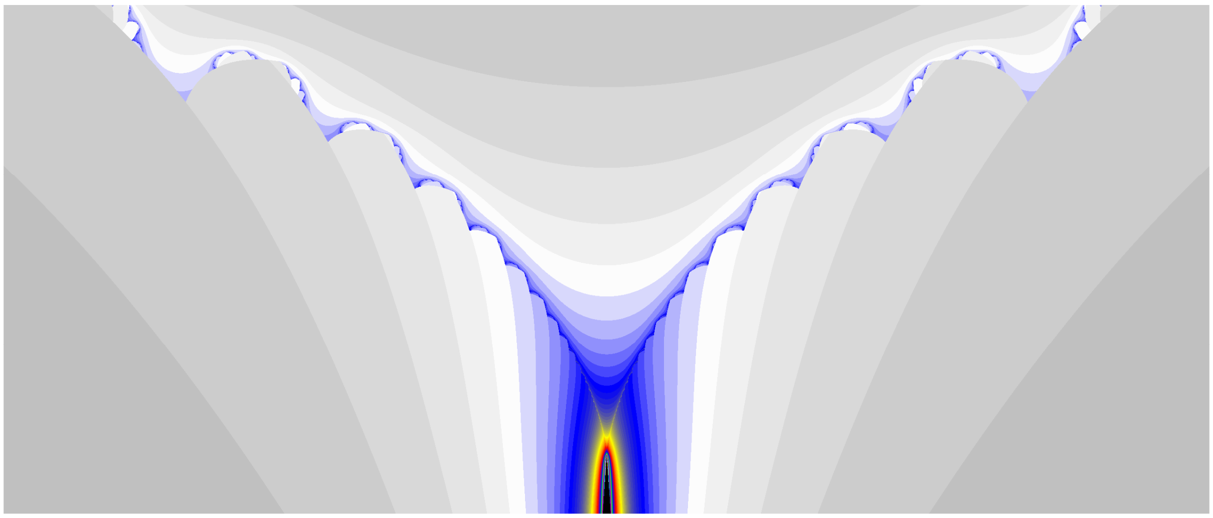

Fig. 3. Bands of energy are seen to push against the fabric of space, ratcheting outward in descending period, and seminal particles in a quark-gluon plasma begin to appear on the outermost edge.

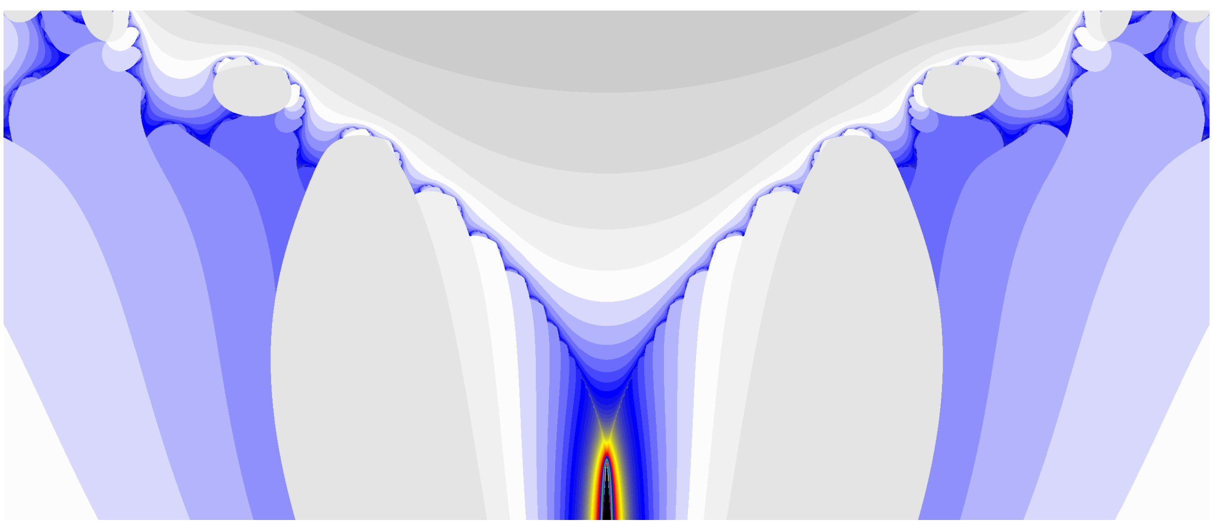

Fig. 4. Five layers are removed by suppressing lower-order solutions, to reveal the forming particles and quark soup behind the energy bands that are paths of creation/annihilation operators.

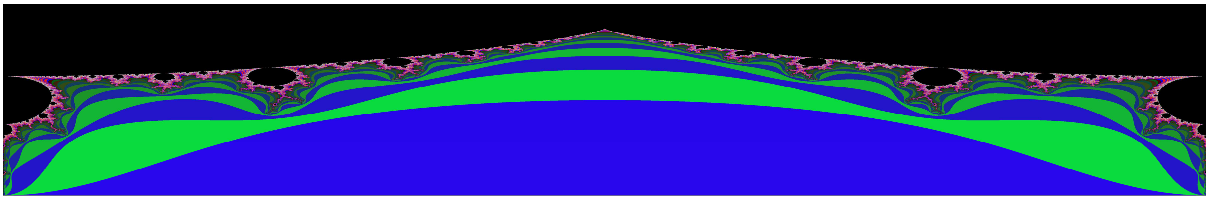

Fig. 5. The Mandelbrot Set, where concentric circles about (0,0*i*) are mapped to rows of pixels, shows that a ball dropped on the top would roll either left or right along an optimal curve, illustrating how time's direction is split.

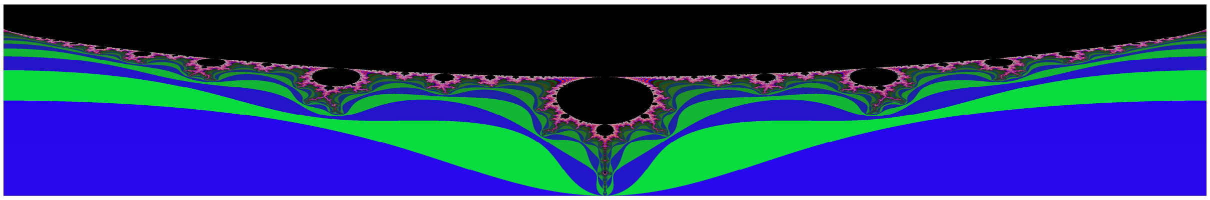

Fig. 6. The same image rotated 180 degrees places our present-day universe in the center to illustrate the resemblance of the Mandelbrot Set in its entirety to Anti de Sitter space.

The last point to emphasize is the fundamental asymmetry of the Mandelbrot Set. Not only is it maximally asymmetric, where both ends point toward the tail, but it optimally contains that asymmetry. We see in Fig. 5 the surface encountered by an expanding circle or sphere impacting the Mandelbrot Set, as it is normally seen. We imagine the primal fireball of pure energy in the early universe would be spread on impact and separated into bands of successively diminishing energy as the fabric of space opened up to allow them to expand outward. And this is what we see depicted in the Mandelbrot Butterfly as shown in Fig. 3.

However space has expanded to a tremendous degree by this point, and has cooled enough so energy has decoupled from both space and matter. This is clearly observed in the Butterfly figure, as it is seen below in Fig. 7, where the analogy to a cosmic thermometer is annotated, and the location corresponding to our current cosmological era is highlighted. The present-day universe is in the center of Fig. 6 above, illustrating the resemblance of $\mathcal{M}$ to Anti de Sitter space, and showing the prior universe is like a cup emptying into our 4-d spacetime. This shows there is a unique exit from octonionic inflation and matter-energy coupling in the prior cosmos. As discussed in prior work [13], this transition resembles what is seen in DGP gravity [14] and extensions like cascading DGP [15], and also the black hole in 5-d → 4-d white hole and spacetime bubble scenario, which was proposed by Pourhasan, Afshordi, and Mann [16], and by Poplawski [17].

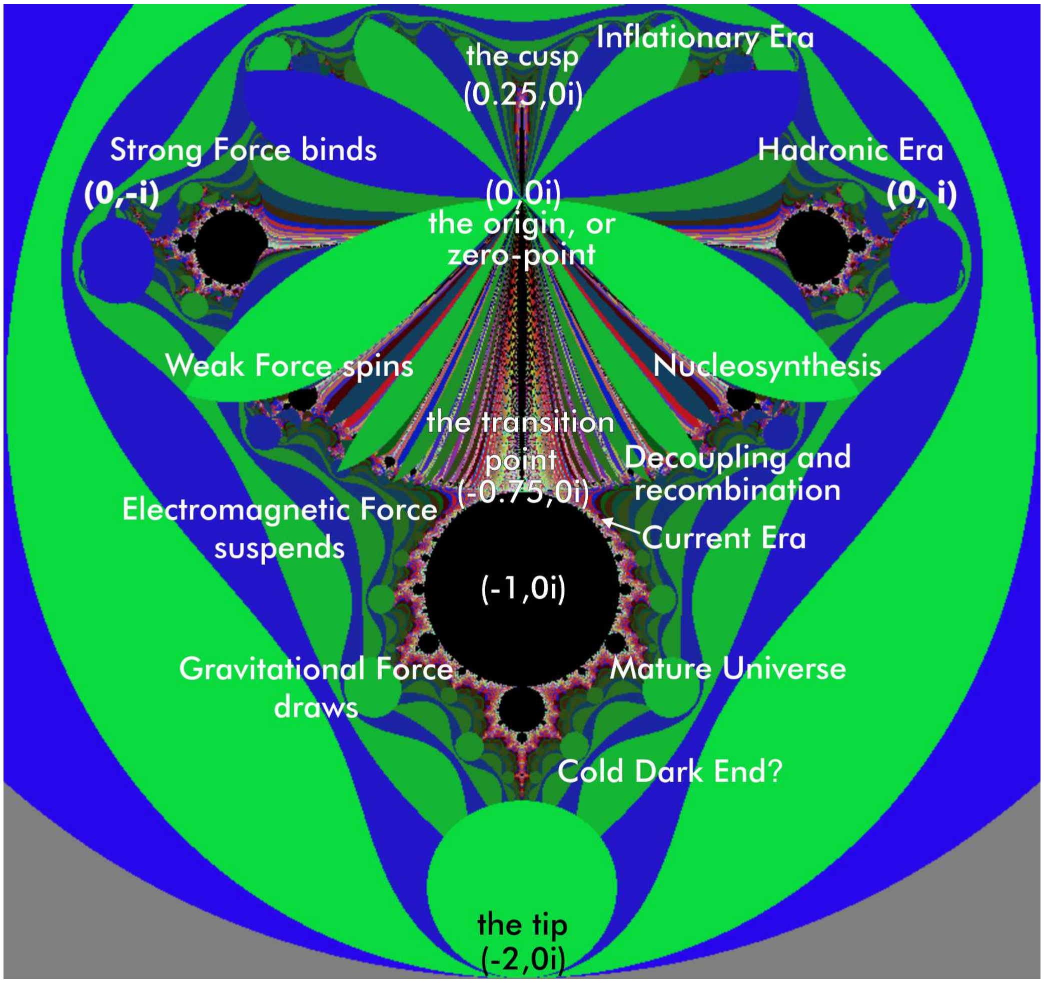

Fig. 7. The Mandelbrot Butterfly is annotated here to show the analogy with a thermometer suggested by the Mandelbrot Mapping Conjecture, and colored so that structures with odd (blue) and even (green) period can be distinguished.

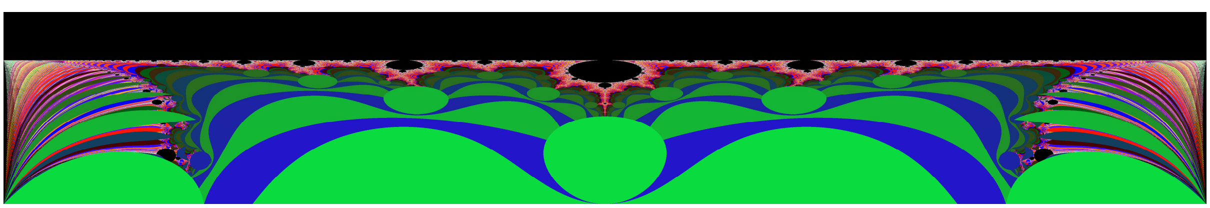

Fig. 8. The Mandelbrot Butterfly, where concentric circles about (-1,0*i*) are mapped to rows of pixels, shows the asymptotic flatness of 4-d spacetime, massive objects in gravitational potential wells, and the early universe inside-out from the present-day cosmos.

Reflection and Conclusions

We seem far removed in the current era from events that happened when the universe was young, but those events shape and dictate the flow of time today. Time appears to move on inexorably, driven both by processes at the microscale and by the continuing evolution of the cosmos as a whole. The Mandelbrot Set is unique because it can inform us both about what occurs in the extreme microscale and at energies only present at the universe's inception, and also about the macroscopic extreme of the expanding cosmos – because it describes the universe's entire evolutionary arc. This analogy is imagined to work mainly because $\mathcal{M}$ traces process evolution and displays the interplay of perfect symmetry in every flavor against a background that is asymmetric to which it must conform. This interplay between symmetry and asymmetry was first noted by Tan Lei [18] at the Misiurewicz points and she observed that this property extends into the Julia Sets for these locations. But along its length; $\mathcal{M}$ displays symmetry-breaking analogies and structures in every flavor. A recent paper [19] suggests one can draw an analogy to the AdS/CFT correspondence with the boundary between the cardioid and the circular disc located at (-0.75,0i), where symmetries preserved on one side (in the 5-d precursor) are broken on the other side (our 4-d spacetime).

The current state of the universe is the product of many symmetry-breaking events, if we assume the fundamental forces were once unified. But the Mandelbrot Set suggests that cosmological events such as the 5-d $\rightarrow$ 4-d transition described above served as gauge fixing mechanisms helping to set the relative strength of the natural forces, where this explains the weakness of gravity, relative to the other forces. However; this also means we cannot run the clock backward on physical processes without supplying at least as much energy (and as much information) as they dissipated. As with Sisyphus; even if we roll or lift a stone all the way to the top of the mountain, natural forces will roll it back down again, because it is energetically favorable for it to roll down.

Likewise; something that is heated will cool back down again, once the energy source is removed. And nothing can go back further than decoupling/recombination, or before the 5-d $\rightarrow$ 4-d transition where a black hole in the precursor universe becomes a white hole feeding our own. I do not imagine that one could go backwards through a wormhole, which is emptying into our space. And the universe we live in continues to evolve. So we are caught up in a web of irreversible processes by which energy is expended, but luckily we live in a kind of Goldilocks zone, where things have cooled enough for objects of molecular matter to form and persist, but still warm enough for biological processes to happen. So we can watch processes unfold.

In the present-day universe; the cosmological and thermodynamic arrow of time are perhaps the greatest determining factors to time's progression in our universe. However; it is a process-driven progression or evolution now, to every bit as great a degree as it was near the beginning of cosmological time. The proper conditions must be created before the next step in completing a process can be undertaken, or the next stage of evolution can be properly begun.

We see this in everyday situations like baking a cake or building a house, where things must be added in a certain order, and then one stage of the process leads to the next, until the job is done. But mathematicians know the octonions require similar attention to the order of steps during each calculation, and to the sequential staging of steps in the evaluation process, to obtain the correct result. And this forced ordering of elements is very strict, where although there are alternate octonion multiplication tables [20], the choice of any one table forces us to use the same ordering for all ensuing calculations. In many ways; the forced ordering of elements is what marks the passage of time.

But the non-associativity of the octonions, which gives them evolutive properties, must give way to a more stable condition for familiar forms to exist and endure. The property of duration, which was first conferred to space, is possessed by all sub-atomic particles. We perceive them as having a half-life (where half of the particles in a given sample will decay) because their duration maps to intervals of time only relativistically. But we see in the Mandelbrot Butterfly initially particle-like forms are only partly exposed, but as pockets of space open up they become free standing, and we imagine the first particles to form are very short-lived while long-lived particles come after, so the descriptions agree. But it should also be noted that being in combination with time, as spacetime, is what allows space itself to be persistent or enduring.

This is apparently connected with both the associative rule and the commutative rule being in effect for common relations, which allows reversibility and repeatability to manifest. So the fact these properties have emerged out of non-associative geometry in the early universe (assuming a higher-d origin) is what give the physical objects in our universe duration. Figure 6 shows the view from our universe, where our location is about one fourth of the way from the left edge of the boundary, and the timeline goes straight from left to right until the center. From the right; we see the CPT mirror of our universe, which appears paradoxically to exist both before the beginning and after the end of time – from our perspective. This jibes well with the conditions and predictions cited in a recent paper by Boyle, Finn, and Turok [21]. However the Mandelbrot Set shows that besides the CPT mirror of a reverse-time 4-d branch, there was also a 5-d precursor phase to our universe, as with DGP, and it proves these models can coexist.

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