Theories of Quantum and Analog Gravity represented in the Mandelbrot Set

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The Inherently Quantum Nature of ℳ Explains why Gravity is Quantum Mechanical

How spacetime arises is often modeled using the tools of continuous spaces, although we imagine the origin of spacetime and gravity must be quantum mechanical. The Mandelbrot Set is inherently and manifestly quantum mechanical, where every structure associated with it has a discrete period because it resolves after a definite (integer) number of iterations. Since the familiar 2-d representation of ℳ in the complex numbers is a shadow or projection of a higher-dimensional figure; it gives us insights into the progression of forms defining the dimensionality of the universe. Emergent evolution happens automatically in the context of octonionic embedding, but this is seen as part of an overall progression where the emergence of spacetime gave it an upper and lower limit for *D* in the seminal early universe, which converged on a specific dimensionality during or by the current cosmological epoch.

If we examine the form at the periphery of the Butterfly figure; we find a pattern that depicts the emergence of matter and the progression in the morphology of the spacetime fabric. We note here that the 'skin' or hyper-surface of a higher-dimensional sphere is volumetric, so a 5-d volume has a 4-d bounding surface. Spin is locked into the 4-d spacetime background in the early universe as topological torsion which encodes forms with increasngly higher intrinsic spin, such as nuclei of heavy and super-heavy elements. But the 5-d → 4-d transition leaves many of the heaviest elements and highest-energy particles in the parent or precursor universe, in this theory, along with sterile neutrinos and other particle species which are native to spaces of 5-d or higher. This is clearly represented in ℳ and in its family of associated figures, but is also implied by Physics.

Abstract

The Mandelbrot Set displays features of the 5-d → 4-d transition in DGP gravity and in theories where a 5-d black hole gives rise to a 4-d white hole and spacetime bubble which is our present-day cosmos at (-0.75,0*i*). The ratio of radii here is 3:1 in imitation of Cartan's rolling ball analogy for Lie group G_2 symmetries. Holographic dualities are displayed across the boundary, linking the quantum mechanics in the precursor universe with the astrophysical realm in the current era, which we discuss. Then we examine the Misiurewicz point at about (-1.543689,0*i*) where is clearly depicted an analogy of BEC formation and Schwarzschild black hole event horizons, which forms an important part of the analog gravity program. The fact both of these dynamics are displayed in the same object indicates that the theories are not mutually-exclusive and could coexist in nature.

Keywords: AdS/CFT, 5-d → 4-d, Lie group G_2, Mandelbrot Set, BEC analog gravity

Representation of Gravity Analogs in ℳ make it a Useful Tool to Study Analog Gravity

As a catalog for symmetry-breaking phenomena; the Mandelbrot Set adds a lot to the toolkit for analog gravity researchers. On the whole; it is asymmetrical, but it displays a remarkable interplay between local symmetry and global asymmetry at the branching Misiurewicz points, which occur at all of the bulbs or bays surrounding the cardioid, and around the entire periphery of ℳ. These points appear perfectly symmetrical and exactly resemble their Julia Set counterparts at the centers, but conform to the asymmetrical background at the edges, as was first observed by Tan Lei. But the Misiurewicz point $M_{3,1}$ is of special interest to gravity researchers, because it is the 0^{th} order or ground state point representing archetypal features that extend to all of the other branching or inflecting Misiurewicz points in ℳ. The scale factor goes to zero at all Misiurewicz points, and increases thereafter if it is not a terminal point.

At the point designated $M_{3,1}$; we observe a phase inversion for the self-similar forms entering and leaving it. Since $M_{3,1}$ has only one avenue of entrance and exit; this is similar to what is seen at the event horizon of a Schwarzschild black hole, ***but*** it is also analogous to the quantum critical point of BEC formation. This gives us unique insights into the dynamism of analog gravity by allowing us to peer behind the event horizon boundary algorithmically, and to see the process of condensation dynamically. Since we can examine this in an archetypical setting in ℳ; we have the ability to proceed past any impasse impeding progress. And with the understanding that ℳ in the complex numbers is the shadow or projection of a higher-dimensional figure in the quaternions and octonions; we can see how quantum and analog gravity can coexist, or are compatible.

It was observed by the author 32 years ago that there is a link or map between the Mandelbrot Set and Cosmology. The Mandelbrot Mapping Conjecture (or MMC) asserts the cusp shows the highest energy and earliest processes near the Planck scale, and the farthest extent of ℳ (-2,0i), processes at 0°K. In this way; ℳ is seen to show us both the beginning and end of our cosmos. It does not exactly match the Big Bang with Inflation, and so was put on the shelf for a time.

The discovery of accelerating expansion and recent theories make the story told by ℳ match predictions of the Physics mainstream more and more often. The MMC appears to have its greatest utility in theories of gravitation because ℳ is asymmetrical on the whole, even though it contains many beautiful symmetries. In ℳ we see the interplay of local symmetry and global asymmetry displayed as a symmetry-breaking catalog, index, or table of contents with a Julia for each spot in ℳ.

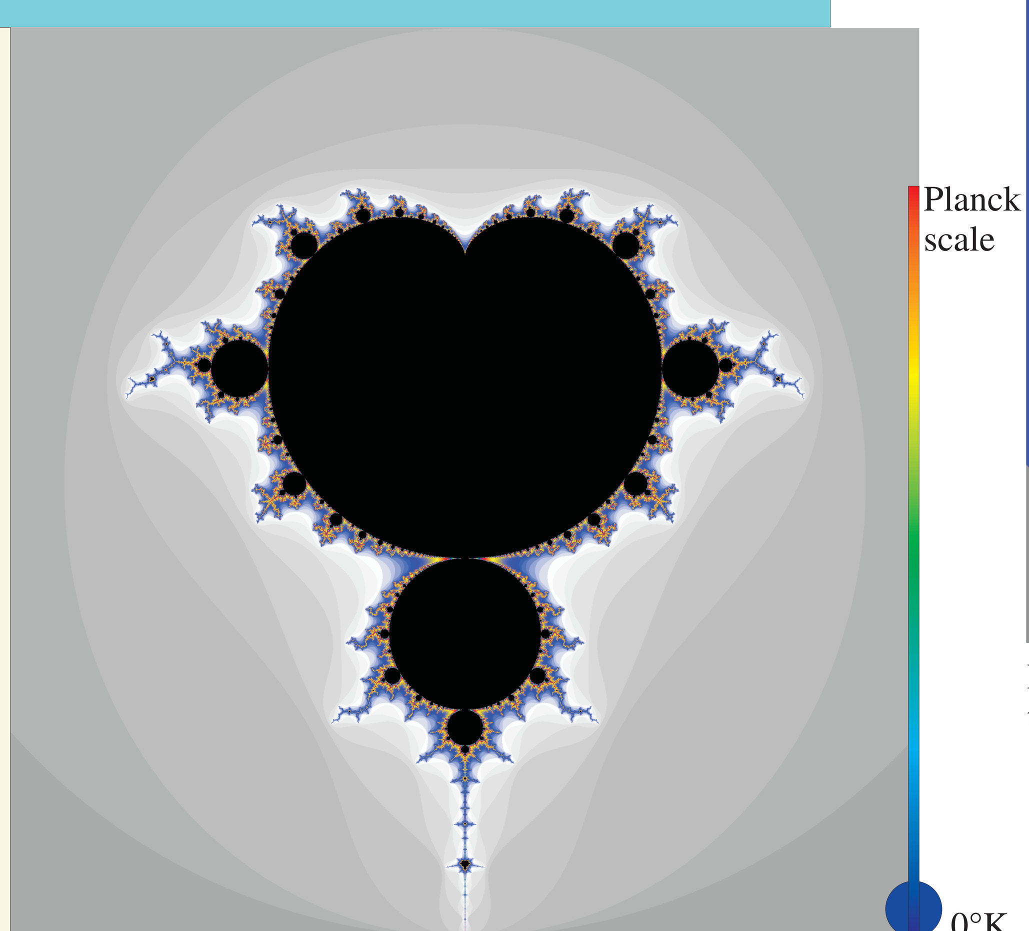


Fig. 1 - The Mandelbrot Set as it is normally seen, but rotated so (-2,0i) is at the base. This 2-d representation is the shadow or projection of a higher dimensional object which exists in the quaternions and octonions.

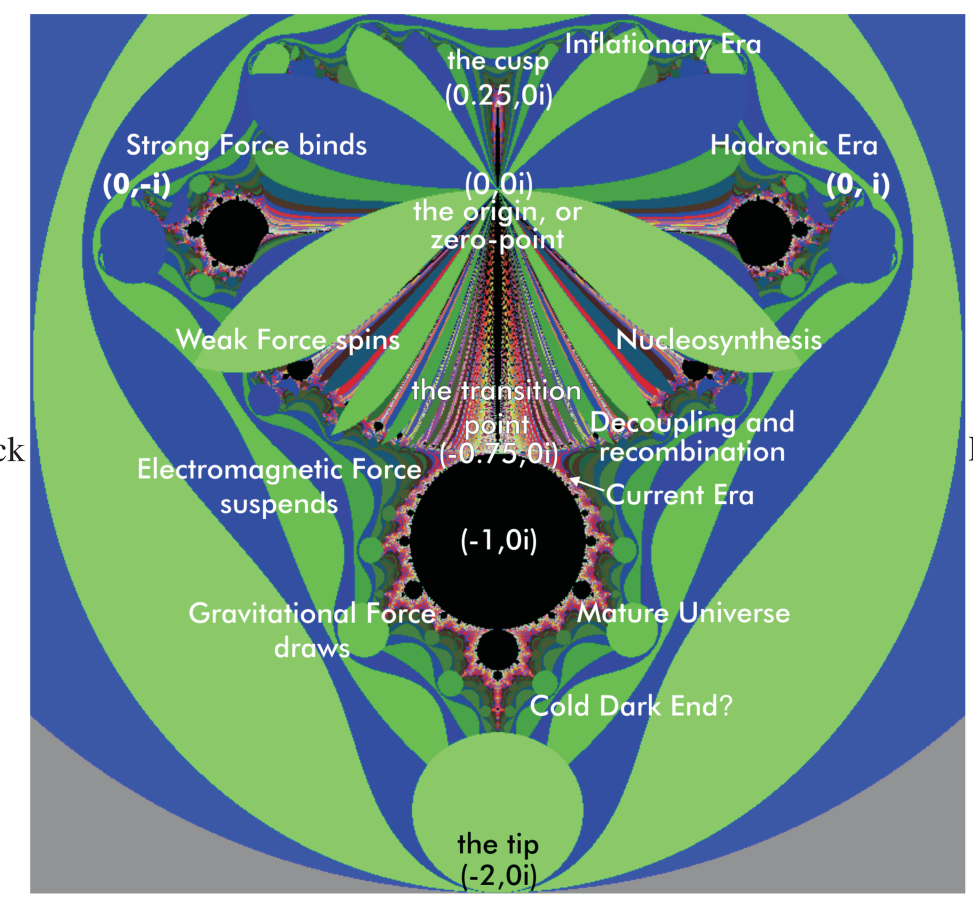


Fig. 2 - The Mandelbrot Butterfly annotated to show how it maps the cosmological eras and fundamental forces.

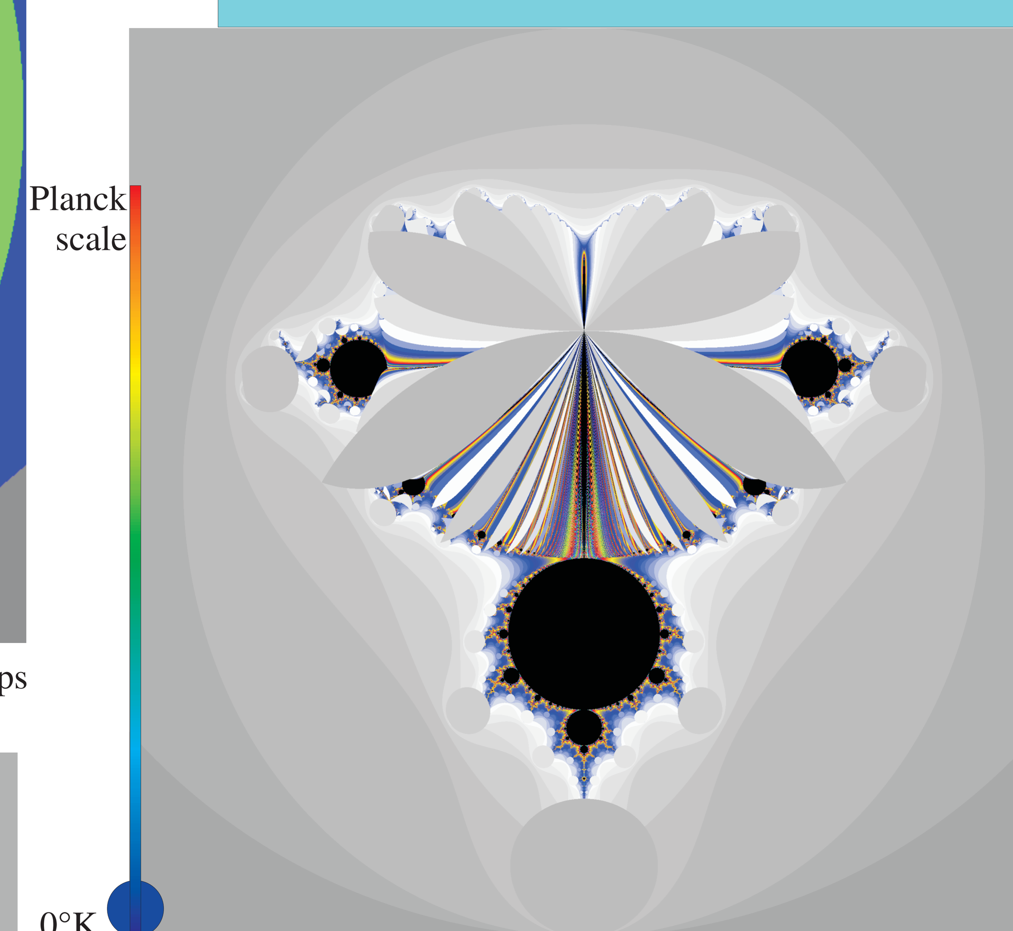


Fig. 3 - The Mandelbrot Butterfly appearing when one colors in points where the iterand magnitude diminishes monotonically over three calculations maps symmetry-breaking in Physics.

The most prominent features of the Mandelbrot Butterfly are its wings and the discs that populate the periphery of the figure. The wings are seen to represent creation/annihilation pathways, while the discs are the forms that congeal out of the energy soup. In the cardioid section we see the early universe evolving sub-atomic particles and then nuclei as it unfolds to a 5-d volume. Then in the circular region that is our 4-d bubble, aggregate objects give way to black holes. The theory predicts slower spinning BHs will come to predominate over time.

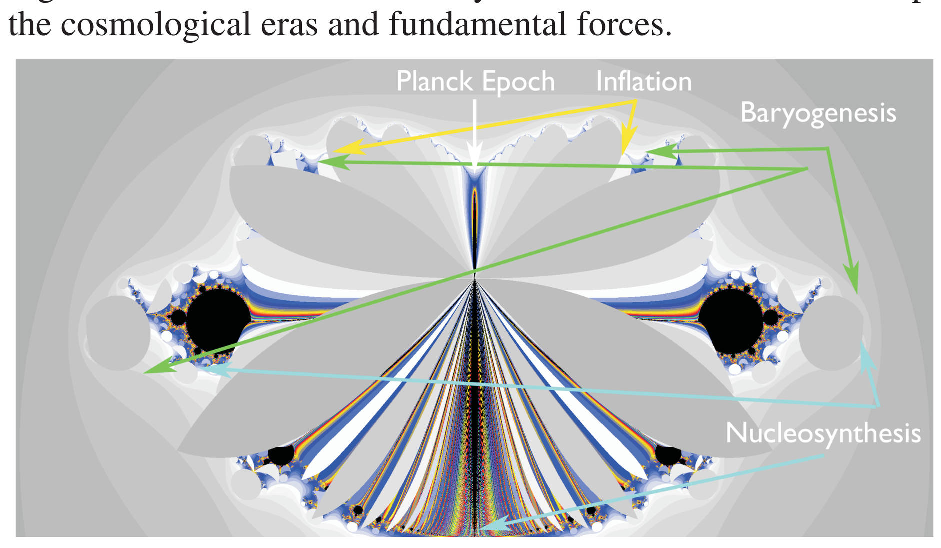
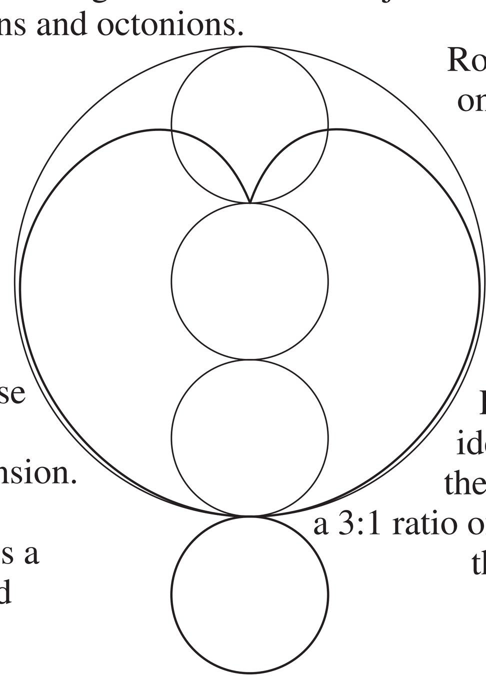


Fig. 4 - This view of the Butterfly illustrates how it represents the evolution of form in the early universe. Inflation is seen to proceed spontaneously, with bi-directional time as in the work of Carroll and Chen, with each branch a CPT mirror of the other.



Rolling one circle on another yields the cardioid.

Early universe evolves to a higher dimension.

Current era is a bubble of 4-d spacetime.

Placing another identical circle at the apex results in a 3:1 ratio of radii, framing the Mandelbrot-G_2 conjecture.

Fig. 5 - The major geometry of the Mandelbrot Set is constructed by rolling a circle on a circle, and this recreates Cartan's rolling ball analogy for G_2 symmetries, when ℳ is regarded as a higher-dimensional figure.

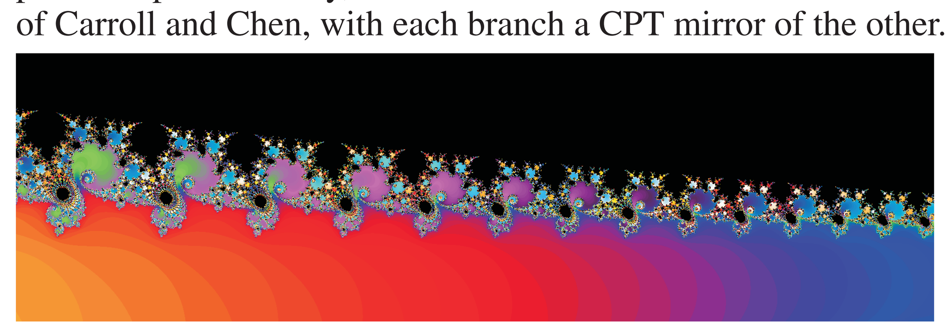


Fig. 6 - A section of the Mandelbrot Set approaching the transition point at (-0.75,0i), where the spiral eyes are left uncolored, shows tidal force deformation due to increasing Weyl tensor values near the end of the 5-d parent or precursor universe. Pockets of spin trapped in the spacetime fabric thus create topological torsion.

The Misiurewicz point $M_{3,1}$ is relevant to the study of gravity because it shows how trajectories converge at a gravitational horizon or quantum critical surface. It permits an exact solution because it satisfies the equation $((c^2+c)^2+c)^2+c=(c^2+c)^2+c$.

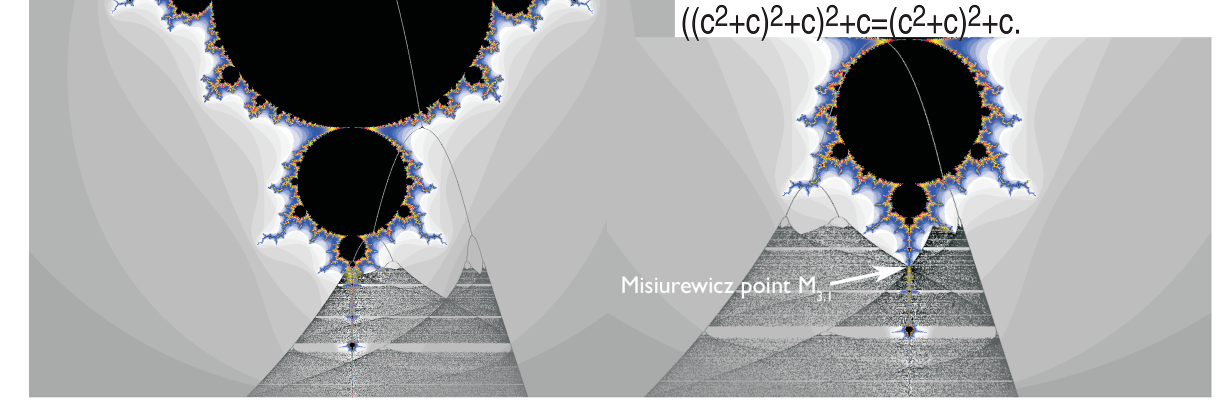


Fig. 7 - The bifurcation diagram for $c=c^2+c$ over the reals splits everywhere the boundary of the Mandelbrot Set folds back on itself, but a range of points from each splitting all converge at the Misiurewicz point $M_{3,1}$, which shows how maximal complexity is connected to the action of gravity at a critical point.

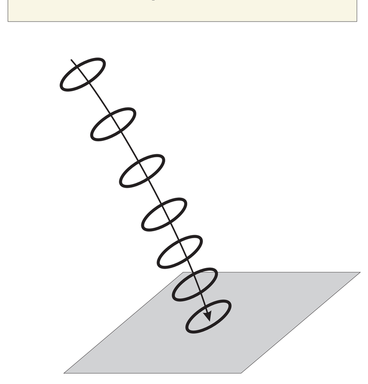


Fig. 8 - Gravitons settle to lie flat on a condensing surface or horizon, following gravitational field lines, in a scenario like Dvali and Gomez' theory where a Schwarzschild black hole is a graviton condensate.

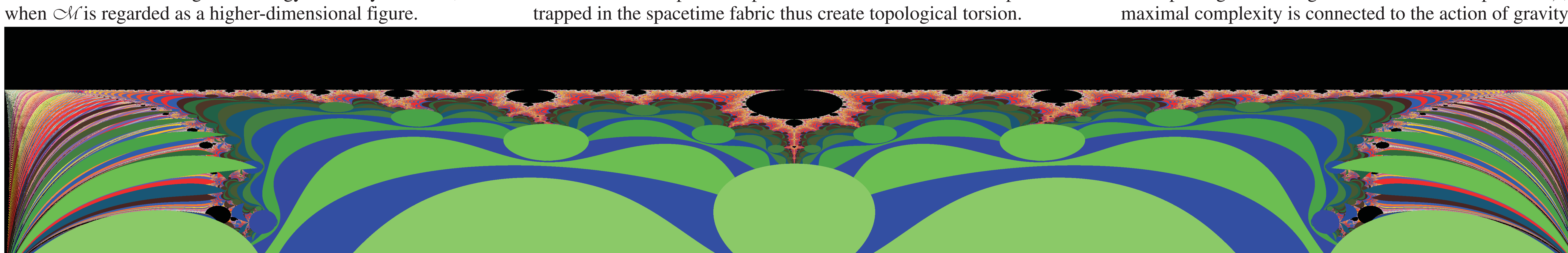


Fig. 9 - The Mandelbrot Butterfly, as seen above where concentric circles around (-1,0*i*) are mapped to rows of pixels, illustrates the asymptotic flatness of space, where UV completion is seen on the far edges and IR completion is represented at the center top. We also see gravitation depicted below that as macroscopic masses (green discs) lying at the bottom of potential wells. $M_{3,1}$ is at very center.

A general pattern?

$$\mathbb{O}\supset\mathbb{H}\supset\mathbb{C}\supset\mathbb{R}$$

Eqn. 1 - hierarchy of the division algebras shows the reals are a condensate.

$$Sm\supset Top\supset Meas$$

Eqn. 2 - also hierarchy of *Smooth*, *Topological*, and *Measurable* objects/spaces.

$$Gas\supseteq Liq.\supseteq Sol.$$

Eqn. 3 - to a degree; the phases of matter follow the same pattern where what is free to vary gives rise to more definite forms.

This document combines and extends the material presented on my poster for GR21 in NYC, in my talk at FFP15 in Orihuela, and detailed in several recent publications in *Prespacetime Journal*. It includes numerous insights from the author's essays which were a finalist in recent FQXi contests, and findings from his paper submitted to this year's Gravity Research Foundation awards competition. It also incorporates ideas from the recent work of friends/colleagues, whose specific insights or contributions will be enumerated in a paper with the same title as this poster. The accompanying paper will be published in *Prespacetime* just before this event, detailing some of the most relevant findings that are sketched on this poster.

Poster for GR22/Amaldi13
Valencia Spain, July 2019
Session D4 - Quantum fields in curved spacetime, semi-Classical gravity, Quantum gravity phenomenology, and theoretical aspects of analogue gravity.

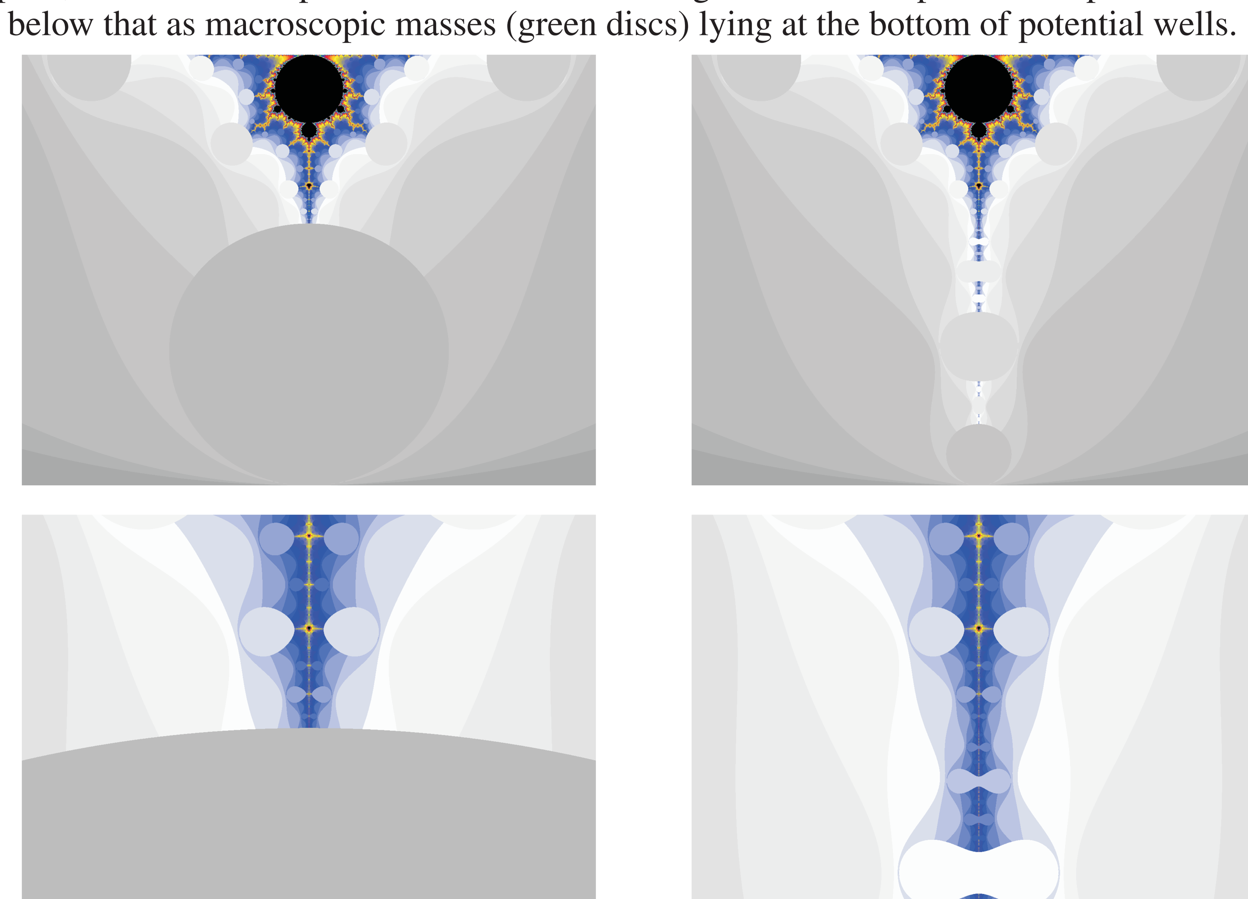


Fig. 10 - The disc at the base of the Butterfly, between $M_{3,1}$ and the tail at (-2,0i), seen below magnified at $M_{3,1}$ on left. The same location on right with one layer removed by suppressing the lowest order solution illustrates condensation.

Coexistence

The fact that various theories of Quantum and BEC Analog Gravity are simultaneously represented in the Mandelbrot Set shows that they can coexist or are compatible possibilities, and not mutually-exclusive options. This allows us to contemplate how the pieces fit together, by seeing visual representations of the relationships between processes in ℳ. We observe at (-0.75,0*i*) features of the 5-d → 4-d transition in DGP gravity (for Dvali, Gabadadze, and Porrati) and explained phenomenologically as a black hole in a prior universe feeding a white hole and bubble that becomes our cosmos, in the work of Pourhasan, Afshordi, and Mann – as well as Poplawski and a few others. Knowing the details of this transition can provide deep insights into the AdS/CFT correspondence among other things.

But at Misiurewicz point $M_{3,1}$; we find a remarkable confluence of representations, because it depicts a Schwarzschild event horizon, the quantum critical point or surface for BEC formation, and the place of maximal complexity. In addition to recent work by Dvali and Gomez; there is a wealth of research linking gravity to BEC formation, going all the way back to Sakharov in '67, then Sudarshan, and later Chapline and Laughlin among others. At this point; Barceló, Liberati, and Visser cite hundreds of researchers working in this area. But remarkably; this connects to a broad spectrum of theories involving emergent or entropic gravity, and especially to recent work by Susskind on complexity at an event horizon. We find all of these examples vividly represented in ℳ and its associated figures.