Does the Mandelbrot Set offer Clues to the Cosmological Evolution of Form?

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Brief Abstract:

The Mandelbrot Set is one of the most complex objects known, and its diverse array of beautiful forms is a diversion for many. It may also be a cosmological roadmap that reveals the entire progression of cosmic form, from the Planck epoch to the fate of the universe. The evolution of Spiral Galaxies is specifically examined.

Extended Abstract:

Like a shining orb hanging in space, the Mandelbrot Set (or M) is both an absolute entity and an unattainable ideal. M is arguably something which has always existed in theoretical space, or resides beyond time and space. Does this unique mathematical object offer us clues to the history and fate of the universe? My research indicates that it may in fact offer us a roadmap of sorts. While searching for computational shortcuts (over 20 years ago), I found instead a whole family of figures spawned by the process that generates M. When the first one I explored appeared on the screen, I immediately noted a resemblance between the progression of forms on its periphery, and the cosmological epochs I had just learned about in Astrophysics. Seeing on closer inspection that what M displayed was not quite true to Big Bang theory, I put this idea on the shelf, but the revolution in observational cosmology has made my theory far more plausible.

Research by Pietronero and his team put the idea of the large-scale fractal distribution of matter on a solid footing and the work of Baryshev, Teerikorpi, and others made Fractal Cosmology a respectable topic, if not yet mainstream. But in theoretical cosmology we see many appearances, and they begin early on. Fractals arise at the ultra-large scale, in Andrei Linde's self-reproducing inflationary universe theory, and in other flavors of 'new' inflation. They appear in the ultra-small realm, near the Planck scale, in Causal Dynamical Triangulation theory, in Quantum Einstein Gravity, and in other theories of quantum gravity. This all shows that fractals are relevant in cosmology, and helps to establish the plausibility of my theory. However, my work is substantially different.

My theory considers the Mandelbrot Set to be a primal object which can be coaxed to tell us something about the progression of forms in the universe, because as a powerful attractor, it aided in shaping the universe's unfoldment. Thus, my ideas have something in common with the recent work of Garrett Lisi with E8, and Edward Witten's work with the Monster group and Black Holes, in that they show how mathematical objects may be far more than a curiosity or diversion. It appears, in fact, that fundamental properties of the real world may be quite well represented by objects (thought to be) existing only in theoretical space.

After a brief description of my theory, I will devote the remainder of my presentation to a discussion of Spiral Galaxy shapes, and the manner in which they arise and evolve over specific reaches of M (between -0.75, 0i, and -1, 0.25i or -1, -0.25i). I will compare this with what we know about the shapes of the earliest galaxies in the known cosmos, the observed varieties of spiral galaxy shapes, and the evolution of galaxy shapes over time. Finally, I will attempt to contrast the main differences between my Cosmology derived from the Mandelbrot Set, and the adjusted Big Bang or Lambda CDM's views and predictions.

Overview of Theory:

The Mandelbrot Set is a rich source of inspiration to those who are its explorers. Many have plumbed its depths, or rather the intricately detailed form surrounding its periphery, for artistically beautiful images. For more than 20 years now, I have been exploring its relevance to Physics, and especially its profound relationship with Cosmology. The progression of its forms, from the cusp near the origin along either edge to the tail, appears to depict the full range or spectrum of forces we observe, and the entire span of cosmological time. Accordingly, it also provides us with a clear rationale and mechanism for symmetry breaking, as a way of giving the fundamental forces their separate faces.

What revealed this pattern were, in part, the unique algorithms I used to highlight patterns of change in the magnitude of the dynamical variable of M, over succeeding iterations. The form I have called a Fractal Butterfly emerges when one colors in areas where the magnitude of the iterand diminishes, with successive calculations. Seeing that form for the first time prompted an immediate reaction that it looked like the Big Bang. What was at first a vague notion that such a resemblance exists, became a search for specific parallels with the fundamental forces and the progression of cosmic form, and later an attempt to find ways to validate or refute the apparent isomorphism between the cosmos and the Mandelbrot Set.

At some point; it became clear that this involved finding the region of M corresponding with the local universe, or with the current stage in the evolution of the cosmos, and thus with the observed range of large scale structure. What I observed is that while the object harbors sunburst and spiral shapes of all descriptions, the region where one can find 'grand design' spirals, along either edge, is limited in range. This allows us to determine, through the observed range of galaxy types in the local cosmos, an approximate location along the periphery of M that we could call home.

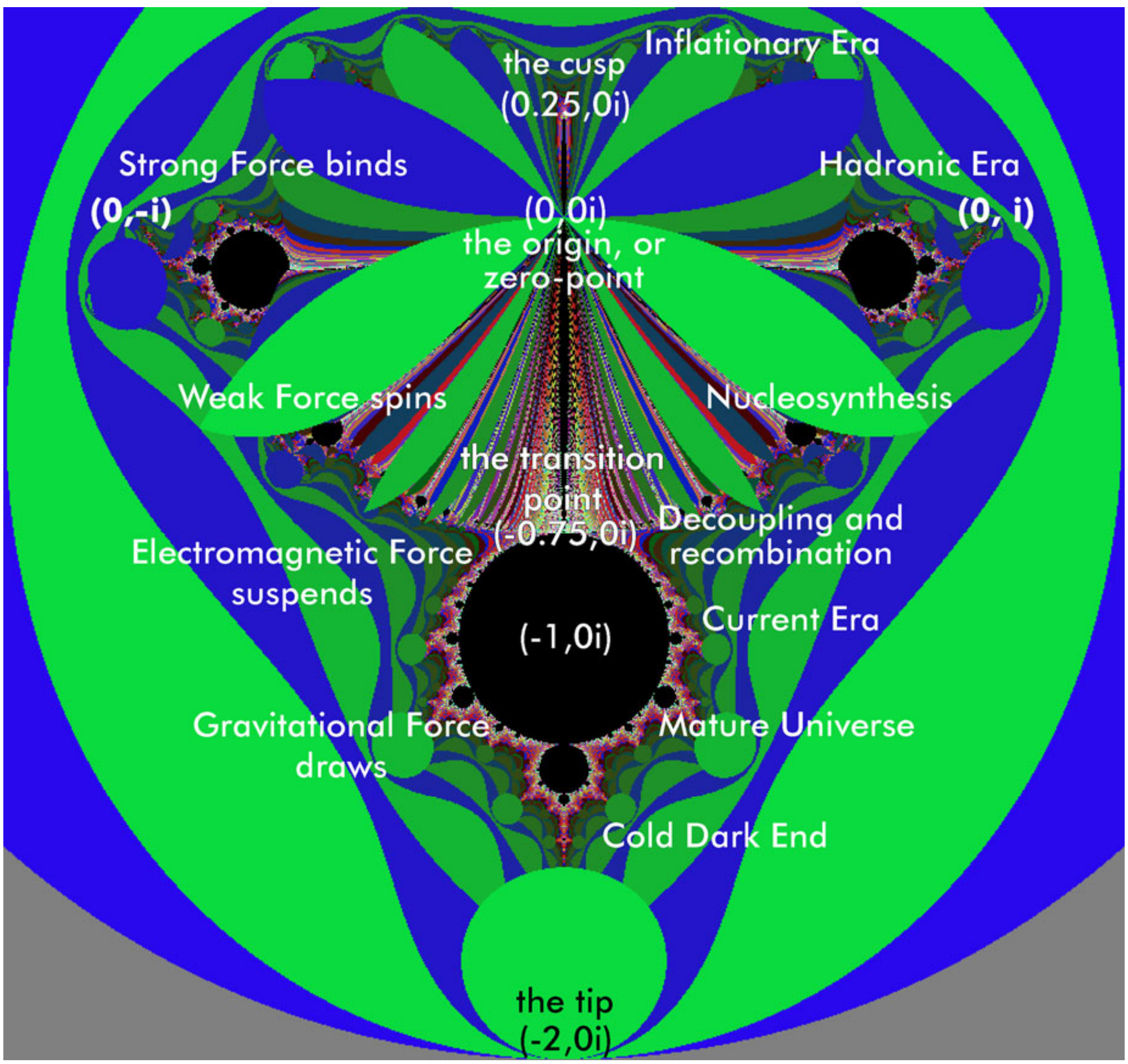

Fig 1 - Mandelbrot Fractal Butterfly
annotated to show an overview of theory

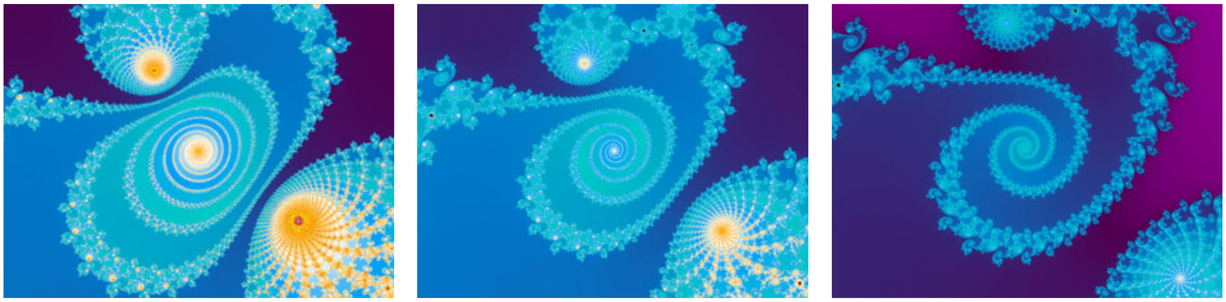

Fig 2 – squashed, tight, and looser spirals from the unadorned Mandelbrot Set

Fig 3 – GALEX image of M81, a 'grand design' spiral galaxy

Spiral Galaxies - their origin and evolution:

Spiral galaxies in the cosmos are thought to arise through an interplay of forces, with the dominant player being gravity. The observation that most, if not all, of the well-defined spirals contain super-massive objects (possibly black holes) at their cores, makes some scientists wonder whether a particular galaxy has created a black hole, or if the black hole has attracted the material for a galaxy to form around it. But some feel that the action of electromagnetic forces is also an important player, which is too often overlooked when considering why two clouds of gas might be attracted, and spiral toward each other in the first place.

If we imagine the fundamental forces were once unified, the birth of hadrons indicates when the strong-force congealed out of the energy soup, and the process of nucleosynthesis brought the weak force into expression, or gave it a separate nature. The next force to separate out would be the electromagnetic. And the event by which it occurred is known as decoupling or recombination (a misleading term in my opinion). But the obvious implication is that this makes EM a dominant player, at a point in the cosmological process when many in the mainstream would discount its importance, and perhaps makes it important to this day.

All of what is discussed in the last two paragraphs is aptly represented by the Mandelbrot Set and its family of related figures. On the annotated Mandelbrot Butterfly figure above, one can clearly see the progression of cosmological eras and fundamental forces. But if we examine the unadorned Mandelbrot Set in the region corresponding to the current era, a progression of spirals can be seen which clearly resemble 'grand design' spiral galaxies. A closer examination reveals that each such spiral is flanked by other figures, with radiating lines that resemble the lines of force near the poles of a magnet or an electric potential. In M this is all one continuous form, but we can wonder if the connecting streams would be visible, were a configuration of forms like this to occur in the cosmos.

Note that this is depicted happening in the region of M believed to pertain to the electromagnetic force, on the butterfly figure. This characterization was based upon the discs around the periphery of the circle about (-1, 0i) being neatly situated in 'waves' of appropriate size, suggesting motion. Examining the spirals in the same region of the unadorned M, we find tightly squashed spirals near (-0.75, 0i) and more loosely wound spirals as we progress along the edge. For the most tightly wound, the figures on either side are nearby and almost on a line with the spiral, and the radiating lines of force are pronounced. Unwound spirals are seen where these figure have moved away, to where the spiral is no longer between them.

When we examine the local universe through telescopes, we see a range of spiral galaxies, some rather tightly wound, and others less so. But there are definite limits to the observed range. Galaxy Spirals in the Mandelbrot Set range from incredibly tight to completely unwound, turning them into a gentle S-curve. The only place we see galaxies completely unwound in the cosmos is in remnants that have had a close brush with a larger galaxy, and become tidal streams of stars. But if the universe continues to expand at an accelerating pace, as many cosmologists believe is occurring, this could ultimately cause large spiral galaxies to unwind more and more over time. The Mandelbrot Set seems to indicate that this is indeed the direction galactic evolution will take. Conversely, earlier galaxies should be more compact.

Contrasting M-set predictions with LCDM:

While this theory shows broad areas of agreement with the Big Bang and/or Inflationary Universe theory, it reveals some of the assumptions of LCDM to be naïve, if it is true. First off; this theory supports the idea that, rather than homogeneity at large scales, we will find continuing evidence of large scale voids and clustering, out to whatever range of scale we can eventually measure. That we can detect walls and voids as large as we have observed in recent galaxy surveys is already curious, based upon the assumption that we are observing the distant past, and it is very lumpy considering the cosmologically short time it would have to get that way, if the universe at decoupling started out homogeneous.

The idea that the universe is fractal is viewed by the mainstream as an artifact of measurement, or an abstraction about how the universe is measured, rather than a statement about how it was constructed. Fractals are seen as an intrusion of roughness into the smooth theoretical predictions of LCDM. They are seen as arising from essentially random forces, as a distraction from the main story. This theory takes the opposite approach that the universe is observably fractal because it is actually based upon a fractal, or has an underlying space-time structure that is fractal as a basis. Ergo; it also asserts that fractals ***are*** the main story, or are the one essential piece of the puzzle which makes all the other pieces fit together so nicely.

A cosmology based on M seems to clearly show the beginning of the cosmos, but offers alternate endings. While the form in M and it family of figures is consistent with a cold dark end, the theory by no means requires it, but instead suggests that the universe is somehow cyclical and will continue. It decidedly does not call for a singularity to occur, if or when the universe is at its smallest. It suggests that instead of a singularity, there would or will be a bounce, as is also suggested by Martin Bojowald's loop quantum cosmology. The M-based theory strongly suggests a scenario similar to the spontaneous inflation theory of Sean Carroll and Jennifer Chen, where time can or does flow both ways, in greatly separated areas of the universe.

Foremost, this theory predicts that there will be the continuous progression or evolution of forms in the universe, and also an endless succession of similar forms, or variations on a theme. The theory even appears consistent with the idea of a succession of bubble universes, but the bubbles seen on the periphery of M could be simply a depiction of the cosmic voids and bubbles we already see. My research suggests that the potential for much of the form we observe may have had a seed in the forms present in the Mandelbrot Set. But the operative idea here is that this wonderfully complex mathematical object shows us not only static form, but also the nature of processes, and the stages in an unfolding process. And the grandest process of all, the unfolding evolution of the universe, may likewise be revealed thereby.

Does the Mandelbrot Set offer clues to the cosmological evolution of form? Yes, I must assert that it does offer such clues. Indeed, it offers both insights and answers for those who explore it with an open mind, and ask the right questions. Fractals are seen to be common in nature, once you know what to look for, and the Mandelbrot Set will show you all of their many qualities, again and again, in endless variations. When I have looked for answers in M, for questions in cosmology, I have usually gotten much more than I bargained for. As with String Theory/M-Theory, a cosmology based on the Mandelbrot Set seems to show us a wider range of possibilities than pertain to our specific universe, and this raises questions about how nature chooses.

My quest for answers to cosmological questions has been full of lessons and surprises, and when I have searched M for insights it has often left me awestruck at the sheer volume of possibilities that are mapped out on the shores of that figure. It may turn out to be a sort of road map to cosmology and the spectrum of natural forces, or it might be even bigger than a guide to the universe, being instead a catalog of all possible universes. Or this mathematical object that exists beyond time and space in the realm of theoretical absolutes might be just an inspiration for unending complexity, and an unattainable mathematical ideal. Perhaps Oldershaw said it best, in suggesting that the Mandelbrot Set is a wonderful metaphor for the universe.

Whatever its import, I shall look forward to my next journey to its shores, and I advise you to also check out the universe of form you can find there. Your visit is likely to be wonderful fun, and it is almost certain to tell you something interesting about the universe we live in. May the endless complexity of this profound mathematical object inspire you. It has certainly done this for me.

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