Exploration

How Simple Can Gravity Be?

Jonathan J. Dickau*

Abstract

Gravity is phenomenologically simple but hard to explain within the framework explaining the other forces. If gravity is not fundamental; avenues for unifying Physics exist, but new approaches are needed. The Mandelbrot Set offers insights. Maximally asymmetric and complex; the 2-d setting is a cross-section of quaternion and octonion figures notable to Physics. Features of DGP gravity emerge, because M mimics Cartan's rolling-ball analogy of G2 symmetry at (-0.75, 0*i*). A 5-d maximum ending octonionic inflation gives rise to a 4-d spacetime bubble. M also models BEC formation and Schwarzschild event horizons, first linked by Sakharov and recently studied by Dvali and colleagues – near (-1.543689, 0*i*), a Misiurewicz point. This suggests M offers a simple way to unify gravity with the rest of Physics.

Keywords: Gravity, Mandelbrot Set, quaternion, octonion, Cartan, spacetime.

Introduction

Perhaps to simplify our study of gravity, we need to turn the universe inside out, or acknowledge that it is that way. The Mandelbrot Set suggests exactly this analogy, when considering its relevance to Physics. In the scenario suggested by Pourhasan, Afshordi, and Mann [1] a 5-d black hole ended its life in the early universe, and ushered in our 4-d spacetime through a white hole. This fulfills conditions proposed by Dvali, Gabadadze, and Porrati [2] for what is called the DGP model of gravity. A quite similar scenario is suggested by the Mandelbrot Set, or M, in Mandelbrot Gravity Theory (or MGT). We observe that at (-0.75, 0*i*) the boundary of M folds back on itself, turning inside-out. In the higher-dimensional case, with M embedded in octonionic space (8 dimensions), very interesting things happen. We expect octonionic inflation to maximize area before volume, then result in a 5-d expanse with no further to go because five dimensions provide maximum hypervolume for spheres [3]. It is anticipated that G2 symmetries then come into play, because of simile in M at (-0.75, 0*i*) to Cartan's rolling-ball (in 3:1 ratio) analogy. Cartan's analogy is also most precise in 5-d, so there is a natural synergy between the two geometric constructions. Cosmologically, this is identical to a scenario where a 5-d black hole gives rise (through a white hole) to a 4-d spacetime bubble.

* Correspondence: Jonathan J. Dickau, Independent Researcher/Science Writer, 8 Lynn Road, Poughkeepsie NY 12603.
E-mail: jonathan@jonathandickau.com Note: This is an Essay written for the Gravity Research Foundation 2017 Awards.

The relevance of M to Physics [4] is expressed by the Mandelbrot Mapping Conjecture, or MMC, which states that the full spectrum of physical states and processes has a corresponding place in M. One can view M as a great thermometer. In this analogy; the highest-energy processes in the universe are modeled by forms near (0.25, 0*i*) and the lowest energy possible, 0°K absolute zero, is represented at (-2.0, 0*i*). A place of interest to gravity research is the Misiurewicz point at about (-1.543689, 0*i*), satisfying the equation $((c^2+c)^2+c)^2+c=(c^2+c)^2+c$, representing 3 and 2 iterations of the Mandelbrot formula on the left and right hand side respectively. This spot clearly models the quantum critical point where BEC formation is observed, but it also represents the event horizon of a Schwarzschild black hole – an object defined by gravitational forces alone. An analogy of gravity with Bose-Einstein condensation was first suggested by Sakharov [5], but the BEC-EH connection is the subject of multiple recent papers by Dvali and colleagues [6]. I have been investigating this for about 30 years. Coloring in areas of M where iterand magnitude monotonically diminishes (over 3 iterations), reveals features including basins of attraction beyond the branching Misiurewicz points. The largest such basin is a circular region between (-1.543689, 0*i*), where Bose-Einstein condensation and event horizon formation are clearly represented, and (-2.0, 0*i*) the tip of the figure's tail.

What is Gravity?

At High School back in the '70s, one of my most valued references was Eddington's "Space, Time, and Gravitation," [7] which contains insights about subtle differences between Relativity theory and Newtonian gravity. My friends and I used the highest technology of the day (an HP programmable calculator), to calculate gravitational radii for common objects ranging from the sub-atomic to planet-sized. We knew that relativistic gravity does not attract trajectories down to a point (as with Newton) and were curious to learn the difference, but the significance of such insights was not apparent – even to many physicists – at the time. One arena where this is seen to be especially significant is Black Holes, but what we thought were absolutes turned out to be approximations of reality. The book by Hawking and Ellis "The Large Scale Structure of Space-Time" [8] first published in '75 is a benchmark, but both authors have since revised their positions (in the chapter on Exact Solutions…) regarding the true nature of Black Hole event horizons [9,10] after new insights. This appears to be suitably represented by M, and in its family of associated figures, however.

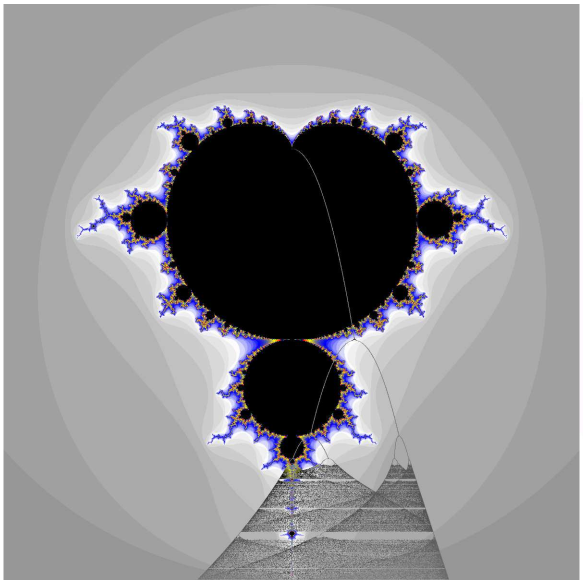

Figure 1 – Mandelbrot Set with its bifurcation diagram

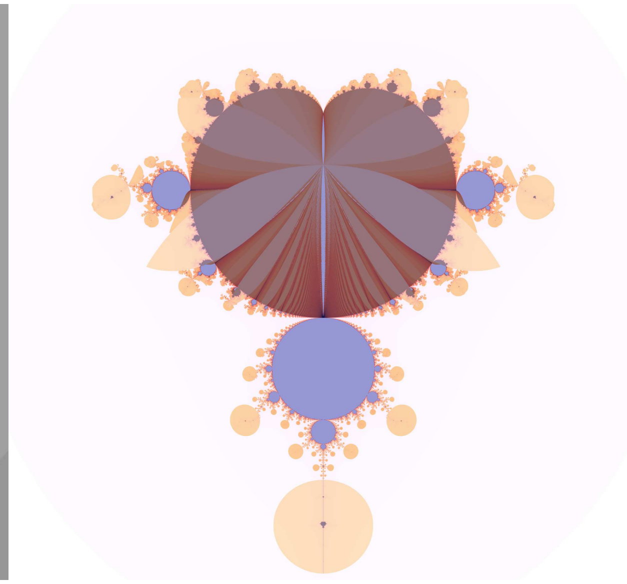

Figure 2 – Mandelbrot Set with diminishing iterands colored in

If the Mandelbrot Set can simplify the study of gravity, it is largely because the role of asymmetry in Physics is too often overlooked. Not only is it one of the most complex objects in Mathematics, but it is also maximally asymmetric. Simply squaring and adding recursively yields the greatest complexity and variety, while all higher-order polynomials give us simpler and more symmetrical figures. However; this means that what M provides is a map of how symmetry is broken – which has many applications for Physics. The recent book by Padmanabhan [11] gives extensive attention to how including asymmetry helps us make sense of gravitation. But the work of Jacobson [12], Verlinde [13], and others exploring thermodynamic or entropic explanations for gravity, all depend on the idea that the universe is asymmetrical with respect to time. In this context; gravity is treated as a residual of the other forces and a sink for their sources. The great success of symmetry in Physics cannot be disputed, but the failure of physicists to unify the pictures from Relativity and Quantum Mechanics may be because gravity arises from asymmetry. What M teaches is how local symmetries are balanced against a global asymmetry, which yields analogies with physical processes. With these insights, it suggests that studying symmetry alone does not yield the full picture of gravity. Both for physicists and for explorers of M, symmetrical structures get the most attention, but it is the interplay with asymmetry that drives the evolution and spawns the complexity of those structures.

Condensation is a natural consequence of thermodynamic cooling that also arises in the context of emergent gravity theories. Sakharov observed in 1967 that an analogy can be made of gravity with Fluid Mechanics and Condensed Matter Physics [14] later seen as observable in Bose-Einstein condensation. Several papers by Dvali and colleagues [15] treat a Schwarzschild event horizon as a quantum critical point for BEC formation of a graviton condensate. Because it is describable solely in terms of gravitational forces, a Schwarzschild BH allows gravity to be studied apart from other influences. But an analogy with BECs brings our studies into the laboratory! This BH/BEC analogy can be clearly observed in M at about (-1.543689, 0*i*), if points are colored in when iterands diminish monotonically over 3 iterations. In addition; layers can be algorithmically peeled back to reveal underlying features in higher-order solutions. This could provide a valuable window into BH Physics, allowing us to peer behind the BH event horizon. But it appears to imply that graviton condensation is the mechanism holding the space at R_G open, be it the event horizon of a black hole or the spherical shell at the gravitational radius of an ordinary object. At the critical point, quantum mechanical forces pressing outward match the forces of contraction which would collapse it further, so this could be the simple factor unifying gravity with the other forces and making our calculations in High School relevant. Gravitons occupy space at the boundary, forming a hollow shell at the gravitational radius and preventing objects with mass from shrinking to a point – while holding the drain open.

Conclusions

While it is not expected that the process of carrying these ideas forward to create robust solutions will be easy or automatic, what was presented is a way forward – past the impasse preventing gravity and quantum mechanics from being united. A full description of MGT also weaves in massive gravity, because the graviton is a spin triplet. This is beyond the scope of this essay, but will appear in future papers. Something involving the octonions, higher-dimensional inflation, a 5-d black hole evolving into a 4-d white hole, and other exotic concepts, appears anything but simple. But if the reality revealed after all the difficult Math is done can be distilled into something any bright High School student can learn, I will have accomplished my purpose. Bose-Einstein condensates were once quite exotic, and thought for a long time to be impossible to create – even in a laboratory. But now; BECs are easy and commonplace, where the main apparatus is well-known and can be purchased for a few thousands of dollars – within the reach of almost any College Physics lab. Now that demonstrations are attainable it's easier to show the relevance of BEC analogies to gravitation. So concepts that were too abstract or theoretical now have a tangible basis. Gravitons have long been assumed to exist. Even if we lack the means to detect them at this point, being able to show they play a role in gravitation by holding space open helps our greater understanding of the universe. This appears to be one of the insights imparted by the Mandelbrot Set also. And it may make gravity simple to understand.

Received November 27, 2017; Accepted December 31, 2017

References

1 - Pourhasan, R.; Afshordi, N., Mann, R., Out of the White Hole: a holographic origin for the Big Bang, *Journal of Cosmology and Astroparticle Physics*, Volume 2014, April 2014, arXiv:1309.1487

2 - Dvali, G.; Gabadadze, G.; Porrati, M., 4D Gravity on a Brane in 5D Minkowski Space, *Physics Letters B* **485**: 208-214, 2000, arXiv:hep-th/0005016

3 - Weisstein, Eric W. "Ball." From *MathWorld*, http://mathworld.wolfram.com/Ball.html

4 - Dickau, Jonathan J., Charting trends in the Mandelbrot Set and showing their significance for Cosmology, *Prespacetime Journal*, **7**, 9, pp. 1319-1332, June 2016

5 - Sakharov, Andrei D., Vacuum Quantum Fluctuations in Curved Space and the Theory of Gravitation, *Doklady Akademii* Nauk SSSR, vol. 177, No. 1, pp. 70–71, November 1967

6 - Dvali, G.; Franca, A.; Gomez, C.; Wintergerst, N., Nambu-Goldstone Effective Theory of Information at Quantum Criticality, *Phys. Rev. D* **92**, 125002, 2015, arXiv:1507.02948; Dvali, G.; Panchenko, M., Black Hole Type Quantum Computing in Critical Bose-Einstein Systems, arXiv:1507.08952; Dvali, G.; Gomez, C.; Lüst, D., Classical Limit of Black Hole Quantum N-Portrait and BMS Symmetry, *Physics Letters B*, **753**, 10, February 2016, pp. 173–177

7 - Eddington, Arthur S., “Space, Time and Gravitation: An Outline of the General Relativity Theory” Cambridge University Press, 1920

8 - Hawking, S.R.; Ellis, G.F.R., “The Large Scale Structure of Space-Time,” Cambridge University Press, 1973

9 - Hawking, S.W., Information Preservation and Weather Forecasting for Black Holes, 2014, arXiv:1401.5761

10 - Ellis, G.F.R., Astrophysical black holes may radiate, but they do not evaporate, 2013, arXiv:1310.4771, Ellis, G.F.R.; Goswami, R.; Hamid, A.I.M.; Maharaj, S.D., Astrophysical Black Hole horizons in a cosmological context: Nature and possible consequences on Hawking Radiation, *Phys. Rev. D* **90**, 084013, 2014, arXiv:1407.3577

11 - Padmanabhan, T., “Gravitation: Foundations and Frontiers,” Cambridge University Press, 2010.

12 - Jacobson, Ted, Thermodynamics of Spacetime: The Einstein Equation of State, *Phys.Rev.Lett.***75**, pp. 1260-1263, 1995, arXiv:gr-qc/9504004

13 - Verlinde, Erik P., On the Origin of Gravity and the Laws of Newton, *J. High Energy Phys.* (2011) 2011: 29, arXiv:1001.0785

14 - Ibid Ref. 5; Visser, Matt, Sakharov's induced gravity: a modern perspective, *Mod. Phys. Lett. A* **17** (2002) 977-992, arXiv:gr-qc/0204062

15 - Ibid Ref. 6