ISSN: 2994- 9459

Research Article

Current Research in Statistics & Mathematics

African Fractal Geometry as a Novel Approach to Understanding Supersymmetry: A Comparative Analysis with Calabi-Yau Manifolds

Precious Mamotingoe Lesupi*

Independent Researcher, South Africa

***Corresponding Author**
Precious Mamotingoe Lesupi, Independent Researcher, South Africa.

Submitted: 2024, Nov 18; **Accepted**: 2024, Dec 17; **Published**: 2025, Jan 02

Citation: Lesupi, P. M. (2025). African Fractal Geometry as a Novel Approach to Understanding Supersymmetry: A Comparative Analysis with Calabi-Yau Manifolds. *Curr Res Stat Math, 4*(1), 01-03.

Abstract
We investigate the potential parallels between African fractal geometry, particularly in Adobe architecture, and the mathematical structures underlying supersymmetry and Calabi-Yau manifolds. Our explorations extend to how the recursive scaling properties of African fractals, described by the power law scaling dimension $D = \frac{\log N}{\log r}$, might offer new insights into extra dimensions proposed by supersymmetry. We then compare the self-similarity of African fractals with the complex geometry of Calabi-Yau manifolds, characterized by the Ricci-flat condition $R_{ij} = 0$. Thus, developing a novel mathematical framework that maps African fractal patterns onto higher-dimensional spaces, utilizing the supersymmetry algebra ϱ_{α}, $\varrho_{\beta} = 2(\gamma_{\mu})_{\alpha\beta}P_{\mu}$. This approach aims to provide a unique perspective on the geometric foundations of supersymmetry and potentially uncover new mathematical tools for visualizing and understanding higher-dimensional spaces.

Keywords: African Fractal Geometry, Supersymmetry, Calabi-Yau Manifolds, Power Law Scaling Dimension, Supersymmetry Algebra, Self-Similarity, Ricci-Flat Condition

1. Introduction

African fractal geometry has been explored by a few authors including Eglashn Mandelbrot and Yau & Nadis among others. In this paper, the core research question guiding us is: Can the recursive scaling properties of African fractal geometry provide new ways to understand the extra dimensions proposed by supersymmetry, and how do these fractals align with the recursive properties of Calabi-Yau manifolds? As Eglash observes, fractals are characterized by repetition of similar patterns at ever-diminishing scales [1-3]. African fractal geometry presents a striking model of indigenous mathematical insight with significant implications for modern scientific understanding. Fractals – self-replicating geometric structures – exist not only as abstract mathematical entities, but as practical frameworks within African cultural practices. These fractal characteristics can also be seen in African textiles, paintings, sculptures, masks, religious icons, cosmologies and social structures [4]. In this paper, we show the potential parallels between indigenous African fractal geometry and the mathematical structures underlying supersymmetry and Calabi-Yau manifolds. We introduce the conceptual and mathematical mapping of these African fractals to mirror how Calabi-Yau manifolds compactify dimensions.

2. Fractal Geometry

Fractal geometry, introduced in the 20th century by mathematicians such as Mandelbrot, and continued to be improved by a lot more capable mathematicians such as Eglash, Okere and more, provides a groundbreaking way to understand complex, self-similar structures that defy the constraints of traditional Euclidean geometry. Unlike conventional shapes with integer dimensions (1D lines, 2D squares, 3D cubes), fractals occupy fractional, or non-integer dimensions, reflecting on their complexity and intricacy at multiple scales. This unique property allows fractals to model patterns that recur throughout nature, from the branching of trees and river networks to the rugged surfaces of mountains and coastlines. Fractals serve as a mathematical link between natural phenomena and human-made designs, especially those emphasizing recursion and self-similarity [5]. A defining feature of fractals is self-similarity – a property where parts of a structure resemble a whole. For example, the Koch snowflake curve demonstrates this properly by recursively adding triangular segments to each side of a triangle, creating infinitely detailed boundary [6]. The applications of fractals extend beyond cultural artifacts. They provide a framework for visualizing highdimensional spaces. Here, fractals model the compactified spaces of Calabi-Yau manifolds, which are integral to higher-dimensional theories of supersymmetry. These manifolds possess fractal-like properties in their recursive, self-similar structures, allowing them to contain vast spatial information within bounded dimensions. The power law scaling dimension, $D = \frac{\log N}{\log r}$, commonly observed in African fractal designs can serve as an adaptable tool for analyzing the structural properties of high-dimensional spaces.

3. African Fractals and Calabi-Yau Manifolds

The recursive and self-similar properties of African fractals bear remarkable similarities to the structure of Calabi-Yau manifolds. These multi-dimensional shapes rely on recursive structures to define their geometry in a way that maximizes symmetry and minimize curvature [7]. These recursive designs in Calabi-Yau spaces also share an aesthetic and mathematical kinship with African fractals, particularly in their representation of symmetry and scaling across dimensions. Supersymmetry relies on a recursive algebra where particle interactions are described by self-similar transformations that mirror the nested arrangements in fractals [8].

4. Scaling Law in African Fractals

In this section, we will use the notion of power law scaling dimension to map properties of African fractals to those of Calabi-Yau manifolds.

$D = \frac{\log N}{\log r}$ *Calculates fractal dimensions*

D: the fractal's scaling dimension representing how the fractal's detail changes with scale

N: The number of self-similar units, indicating how many smaller, identical shapes make up the fractal

r: the scaling factor, or the ratio by which each dimension of the fractal is reduced at each step

5. Ba-Ila Village Layout

5.1. Conceptual Mapping

The patterns found in African architecture like the Ba-ila village layouts in Zambia also show this self-similarity. The way these patterns repeat themselves at different scales is like how the extra dimensions in Calabi-Yau manifolds are curled up.

5.2. Mathematical Mapping

Assume the village is made up of N = 16, self-similar huts arranged in a grid pattern. The scaling factor r = 4, represents the ratio by which the layout is scaled down at each recursive level.

1. Take the logarithm of N = 16

$$\log(16) = 1.20411998266$$

2. Take the logarithm of r = 4

$$\log(4) = 0.60205999132$$

3. Compute scaling dimension (D)

$$D = \frac{\log(16)}{\log(4)} = \frac{1.20411998266}{0.60205999132} = 2$$

The result, D = 2, indicates that the Ba-ila village layout exhibits self-similarity in two dimensions. This means that the pattern of huts repeats itself at different scales, a characteristic of fractal structures.

NB: This is a simplified example to illustrate the concept. Real-world Ba-ila village might have more complex patterns.

6. Kente Cloth

6.1. Conceptual Mapping

The Kente cloth has intricate patterns that repeat at different scales. You can see a small pattern; you'll find smaller versions of the same pattern. This self-similarity is a key feature of fractals.

6.2. Mathematical Mapping

Assume:

The number of self-similar units (N). In a section of a Kente cloth, assume 27 self-similar motifs (e.g. diamond shapes repeated in pattern).

Scaling factor (r). The size of each motif shrinks by a factor of 3 when moving from one scale to the next (eg the large diamond splits into smaller diamonds, each 1/3 of the size).

Take the logarithm of N = 27

$$\log(27) = 1.43136376416$$

Take the logarithm of $r = 3$

$$\log(3) = 0.47712125473$$

Compute Dimension D

$$D = \frac{\log(27)}{\log(3)} = \frac{1.43136376416}{0.47712125473} = 3$$

The scaling dimension of the recursive cube is D=3, proving that the fractal pattern now occupies 3D space. This reflects how Kente inspired patterns, when mapped recursively onto a 3D cube, demonstrate a fractal scaling consistent with 3D geometry. The 3D fractal structure of the Kente cloth example, with its scaling dimension of D = 3, serves as a powerful conceptual model for understanding the recursive compactification and symmetry inherent in Calabi-Yau manifolds.

7. Conclusion

These findings suggest that African fractal geometry, with its recursive scaling properties, can provide a meaningful lens for interpreting the extra dimensions proposed by supersymmetry. By aligning the recursive patterns observed in Kente-inspired fractals and Ba-ila village layouts with the properties of Calabi-Yau manifolds, we can successfully bridge cultural mathematics and high-energy physics, opening pathways for innovative approaches to understanding higherdimensional spaces [9-20].

Funding

This project was self-funded.

Availability of Data and Materials

I, as the sole author of this article confirm that no datasets were used or generated during the preparation of this paper.

Declarations

Conflict of Interest

I, as the sole author of this article declare that there is no conflict of interest.

Ethical Approval

Not applicable

References

1. Eglash, R. (1999). African fractals: Modern computing and indigenous design.
2. Davey, A., Karasaki, K., Long, J. C. S., & Landsfeld, M. (1991). Mandelbrot, BB, 1982. The Fractal Geometry of Nature. REFERENCES WH Freeman and Company, New York, 468 p. Barker, J., 1988. A generalized radial-flow model for Orbach, R., 1986. Dynamics of fractal networks. Science, pumping tests in fractured rock. Water Resour. Res., v. 231, p. 814-819. v. 24, no. 10, p. 1796-1804. Polek, J., 1990. Studies of the hydraulic behavior of. *Earth SciencesDivision, 40*.
3. Yau, S. T., & Nadis, S. J. (2010). *The shape of inner space: String theory and the geometry of the universe's hidden dimensions*. Il Saggiatore.
4. Eglash, R., & Odumosu, T. B. (2005). Fractals, complexity, and connectivity in Africa. *What mathematics from Africa, 4*, 101-9.
5. Falconer, K. (2013). *Fractal geometry: mathematical foundations and applications*. John Wiley & Sons.
6. Von Koch, H. (2019). On a Continuous Curve without Tangents Constructive from Elementary Geometry. In *Classics on fractals* (pp. 24-45). CRC Press.
7. Brian, G. (1999). *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory*. WW Norton.
8. Polchinski, J. (2005). *String Theory, Volumes 1 & 2*. Cambridge University Press.
9. Aras, A. (2020, 01). Persistent Homology for Image Analysis.
10. Ascher, M. (2017). *Ethnomathematics: A multicultural view of mathematical ideas*. Routledge.
11. Feder, J. (1988). Fractals Plenum Press, N.
12. Glimps, P., & Ford, T. (2012). Fractals in African American Culture: Representations and Mathematical Analysis. *Journal of African American Studies*, 644–661.
13. Joseph, G. G. (2011). *The crest of the peacock: Non-European roots of mathematics*. Princeton University Press.
14. Mavhunga, C. C. (2018). *The mobile workshop: The tsetse fly and African knowledge production*. MIT Press.
15. Motaung, L. (2023). *Web of Hair*. The Melrose Gallery, Johannesburg. Retrieved 2024, from https://www.artsy.net/artwork/lebohang-motaung-web-of-hair
16. Motaung, L. (n.d.). *Formation*. Johannesburg.
17. Mouhtare, T. (2014, September 09). *African weavers are mathematicians*. Retrieved from https://www.lafriquedesidees.org/african-weavers-are-mathematicians/
18. Okere, B. I. (2005). African Cosmology and the Universe. *Journal of African Studies,* 30-45.
19. Purnomo, K. D., Sari, N. P. W., Ubaidillah, F., & Agustin, I. H. (2019, December). The construction of the Koch curve (n, c) using L-system. In *AIP Conference Proceedings* (Vol. 2202, No. 1). AIP Publishing.
20. Witten, E. (1998). Magic, mystery, and matrix. *Notices of the AMS, 45*(9), 1124-1129.