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Visualization of Zetabulbs: Mandelbulbs Associated With the Riemann Zeta Function

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Amidst the rich tapestry of the natural world, we encounter a myriad of imperfect geometric shapes. Geometry equips us with potent tools to articulate and formalize the innate symmetries governing these shapes. These fundamental symmetries encompass rotation, translation, and reflection, providing us with a framework to comprehend the harmony in nature, from intricate snowflake-like patterns to bilateral symmetry seen in many creatures.

We uncover an intriguing subset of natural phenomena defying traditional categorization within these established symmetries. For instance, consider the intricate branching of trees, which lacks rotation, translation, or reflection symmetry. Yet, zooming in on a single branch reveals a striking resemblance to the entire tree, a phenomenon known as scale symmetry. This concept extends across various natural structures, from Romanesco cauliflower spirals to mountain silhouettes, river meanders, and coastal contours.

In mathematics, we honor these scale-symmetric structures called fractals. While some fractals, like Sierpinski's triangle or Menger's sponge, ignite our imagination and lend themselves to artistic expression, others pose computational challenges. A prominent example, the Mandelbrot set exhibits an astonishingly intricate boundary, captivating mathematicians for decades, as evidenced by numerous scientific publications in the Clarivate Analytics Web of Science database.

The Mandelbrot set's significance transcends mathematics; it finds practical application in computer graphics, creating realistic and fantastical landscapes for visual storytelling and cinema.

Further exploration of fractals introduces the Mandelbulb, a 3D counterpart to the Mandelbrot set. Due to the non-existence of a 3D analog of the 2D space of complex numbers, the absence of a canonical three-dimensional Mandelbrot set led to new techniques employing spherical coordinates to construct the Mandelbulb. Moreover, by combining fractals, figures, and surfaces, we may produce novel hybrid fractal structures.