

Explaining Time's Passage

The flow of time reexamined

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Dedication

This talk is dedicated to the memory of
my departed friends and colleagues
Ray B. Munroe and Greg H. Kirk

They both emphasized the need to
develop a top-down approach to
Maths for Physics, to complement the
conventional bottom-up methodology

Motivations for this talk

- A conversation with Tevian Dray at GR21 affirmed the unavoidability of using NCG and NAG in various Physics settings
- Alain Connes first sparked my interest in intrinsic or modular time evolution in 2000
- Recent work by Tejinder Singh, the theory of Aikyons, increased that interest
- Carlo Rovelli's book "Reality is not What it Seems," and his paper in *FoundPhys* **48**, 5 showed me the impact and profound need for Philosophy to do good Physics

The How and Why of Time

There are age-old questions

- How do we perceive time?
- How do we measure time?

and

- Why does time exist?
- Why does it only move forward?
- Why do our choices accumulate?

But now also

- Why does the GW signal arrive earlier?

Reconciling Viewpoints

- Ancient and modern philosophers
- Common or everyday experience
- Scientific knowledge and theories
- Common standardized clock time
- Newton's common river of time
- Universal or cosmological time
- Relativity with 4-d block time
- Quantum-mechanical time
- Intrinsic time?

Accumulation of Experiences

- Stepping lightly in Anaximander's stream
- Painters and bakers must follow the rules
- Some everyday decisions can't be undone
- Observations and decisions ratchet action
- Real-life moves us inexorably forward
- An observation is a participation or action
- We must live with whatever we see or do
- There is no going back to a past condition
- Experiences and choices accumulate

Accumulation of Determinations

- Every measurement is a construction
- Determination is a process with two faces
- Determination takes time for triangulation or bracketing/estimation iteratively
- Choices of what to observe, and which elements are added first, accumulate
- Similar rules apply for the order of maneuvers by pilots in flight
- 4-d spacetime is non-commuting!

Non-commutativity and Time

“Noncommutative measure spaces evolve with time!” – Alain Connes

- Higher-dimensional spaces
- Quantum-mechanical spaces
- Infinite degrees of freedom (implies?)

What is modular or intrinsic time?

- Tomita-Takesaki theory of modular Hilbert algebras reveals evolutive properties
- Connes utilized this knowledge to develop a new kind of differential geometry

Chinese Philosophers Agree

- The doctrine of Wu-Ji in Taoist Chinese teachings echoes the view of Connes...
- Wu-Ji is the unformed essence
 - Beyond and before distinctions or polarity
 - Neither light nor dark, large nor small, ...
 - Variations come first, and conditions later
 - Wu-Ji is evolution before appearance of form
 - Tai-Ji is the creation from opposite polarities
 - And the Chinese word for Physics is Wu-Li
 - Physical reality is seen as a process

Non-commutative Time Maths

- Infinite-dimensional Hilbert space can be mapped to finite spaces to create QFTs
- As degrees of freedom approach infinity evolutive properties become automatic
- Connes offers the following relation

$$\delta : \mathbb{R} \rightarrow \textit{Out}(M)$$

where $\textit{Out}(M) = \textit{Aut}(M) / \textit{Int}(M)$

modular time evolves through KMS EQ states

- Conjugate spaces combine iteratively

The Island of Familiar Maths

- We live in a Goldilocks zone physically
- Ordinary Maths suffice for everyday stuff
- There is fierce pressure not to go “beyond the reef” because there are dangers
- But we must explore what lies beyond, if we hope to reconcile QM and Relativity
- Understanding the origin and flow of time may be the essential puzzle piece
- Quantum-mechanical and thermodynamic arrows of time must mostly match

How we got to this Island

- If we examine the normed division algebras

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

- If we compare classes of objects & spaces

$$\textit{Smooth} \supseteq \textit{Top} \supseteq \textit{Meas}$$

- By analogy, comparing the phases of matter

$$\textit{Gas} \supseteq \textit{Liquid} \supseteq \textit{Solid}$$

- This is a map or a set of directions to the
‘Island of Familiar Maths’ where rules apply
- Most people don’t know what lies beyond

Higher-dimensional Origins

- Kaluza and Klein
- String Theory basics
- Randall-Sundrum theory
- ADD – universe on a wall theory
- Ekpyrotic universe – crashing branes
- DGP gravity and Cascading DGP
- Einstein-Cartan theory and its variants
- Aikyōn theory and octonionic cosmology
- My research into higher-d Mandelbrot Set

What does higher-d afford us?

- Resolves hierarchy/weakness of gravity
- Moves Planck scale to earlier epoch or precursor/parent universe
- Provides a spontaneous inflationary era
- Provides a mechanism for intrinsic time
- Creates an arena for 4-d on the boundary
- Surface of a 5-d sphere is 4-dimensional
- Bubbles can grow to present universe size
- Present-day cosmos is likely a 4-d bubble

What about Plato?

“Time is the image of Eternity”

- Plato is talking about what endures as seen in the duration or persistence of objects
- Spaces must also persist in time, or be woven into a persistent fabric of spacetime
- Only what resides in time actually exists
- This persistence or duration is different from measured time intervals
- Quantum particles inherit this attribute, which is seen as a half-life by observers

What of the Wavefunction?

- How do we define the wavefunction?
- Is wavefunction collapse essential to QM?
- Observer or detector's frame of reference is a localized island of condensed matter
- The appearance of collapse depends on a stable local framework matter provides
- Emergence or fixation of locality is a factor
- An expanded framework by including NCG and KvN theory [Morgan] offers options
- We can fine tune collapse parameters

How to Reconcile Time Arrows

- Anaximander's stream is made of atoms
 - i.e. quantum attributes change, otherwise same
- Spacetime is by nature non-commutative
 - Space and time are inextricable = order matters
- A higher-d viewpoint resolves paradoxes
 - Seeing our reality from the outside in could help
- Overall patterns in Math shape Physics
 - The unit n -sphere area and volume peak
 - The Mandelbrot Set is globally asymmetric
 - Core entropy of polynomials [Thurston] likewise

Surface area and volume of the unit n-sphere

Hypersurface area of n-sphere peaks at ~7

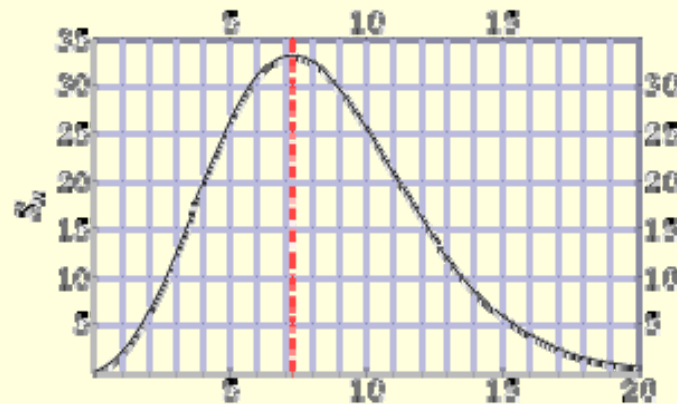


Figure from 'Hypersphere' at MathWorld

Hypervolume of n-ball (content) peaks at ~5

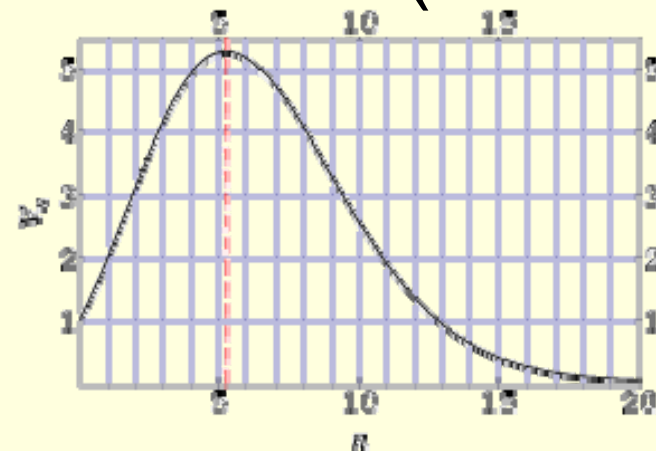


Figure from 'Ball' at MathWorld

Global Asymmetry and Entropy

The Mandelbrot Set and its bifurcation diagram

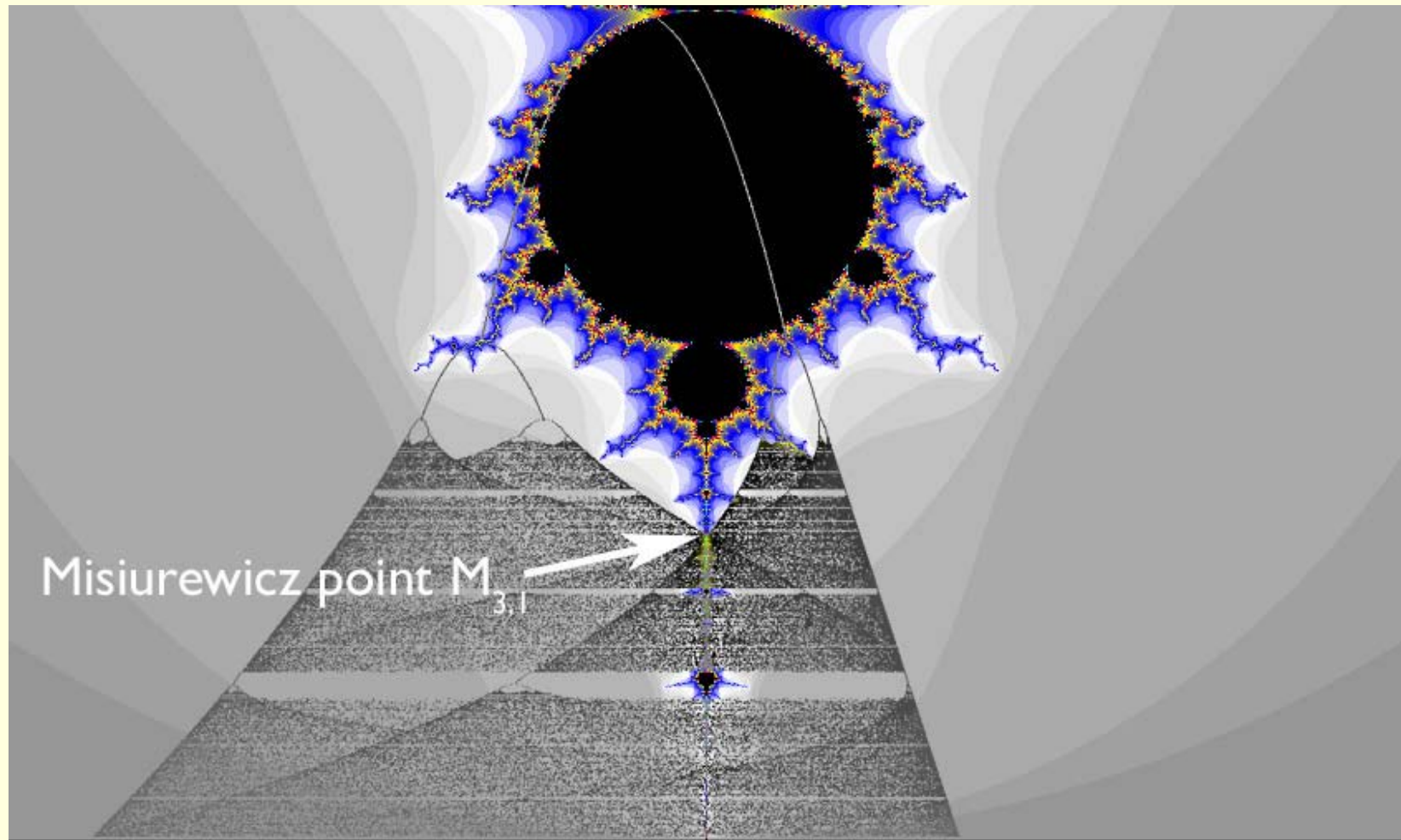


Figure created by the author

Thurston's Core Entropy

Core entropy for quadratic polynomials

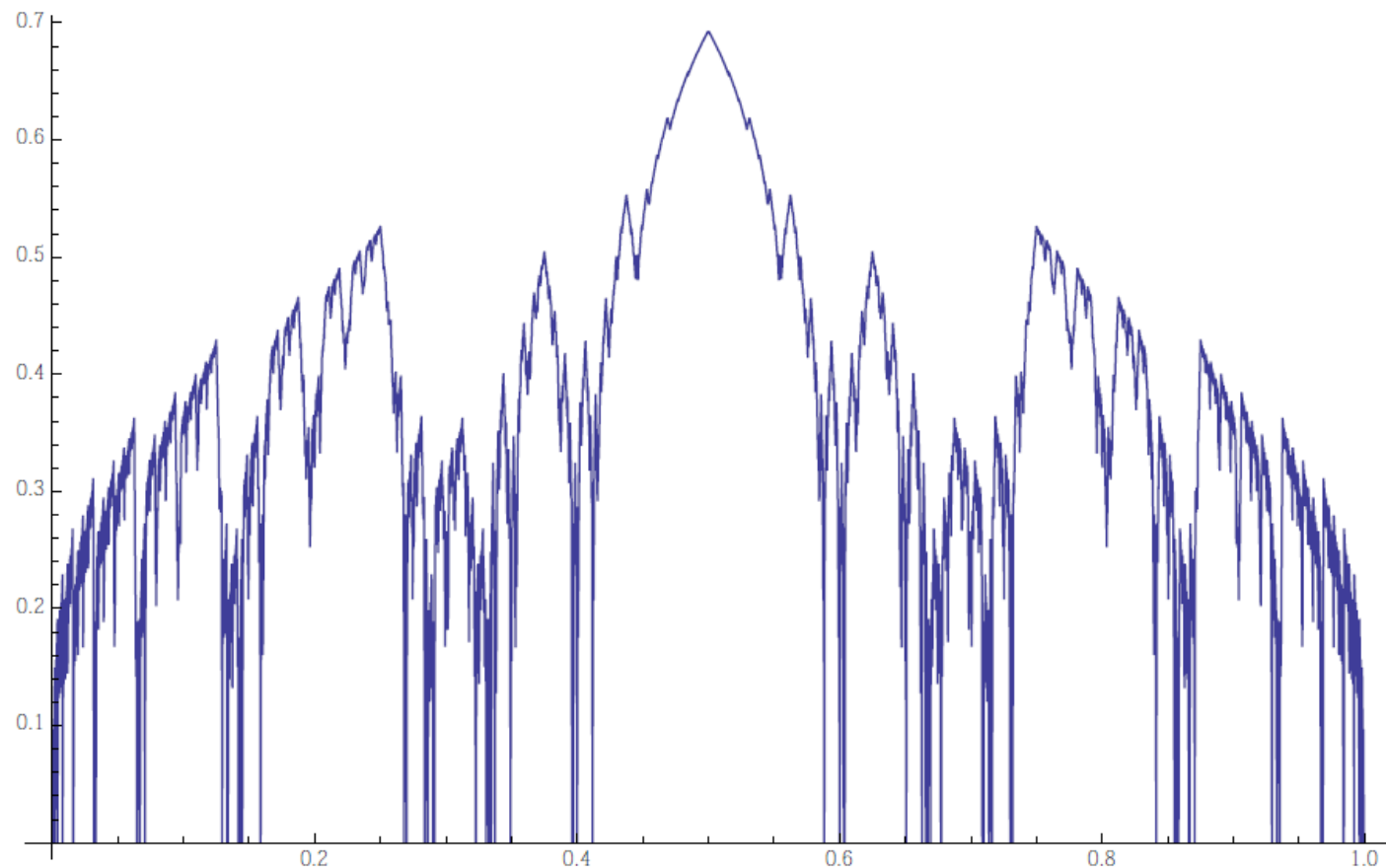


Figure by Thurston taken from talk by G. Tiozzo

We Need to be Explorers!

- We need to intrepidly go ‘beyond the reef’ around the “Island of Common Maths” to find answers and restore the heart of Math and Philosophy to the Physical Sciences



Moana promo image from Disney pictures

Thank you for your attention!

I greatly appreciate the opportunity to share my views on time with you, and I look forward to your questions, comments, and to 'timely' future developments

I have more to share and I will extend this talk and create additional materials to bring this work to a broader audience

Please feel free to contact me after MG16

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Additional Sources

- Evan Pritchard wrote “No Word for Time” talking about Algonquin culture, and his longtime friendship has provided many chances to compare notes on time
- A full list of references for this work will appear in my proceedings paper
- ‘The Intrinsic Time of Alain Connes and Evolutive Properties in higher-d Algebras’ will appear shortly in Prespacetime Journal with more related insights and details

Views of Native Philosophers

- Native or indigenous people see time very differently from Western or Eastern culture
- But the respect of natives and pagans for astronomical alignments and events makes them more scientific than many
- “No Word for Time” in Algonquin traditions
 - Clock time is ‘white man’s folly’
 - The progression of days and seasons is real
 - However; things take as long as they take
 - Turing’s law is implicitly understood

Trapping Horizon/BEC formation

- Mandelbrot Butterfly at $M_{3,1}$ shows analogy of Schwarzschild horizon and QCP of BEC

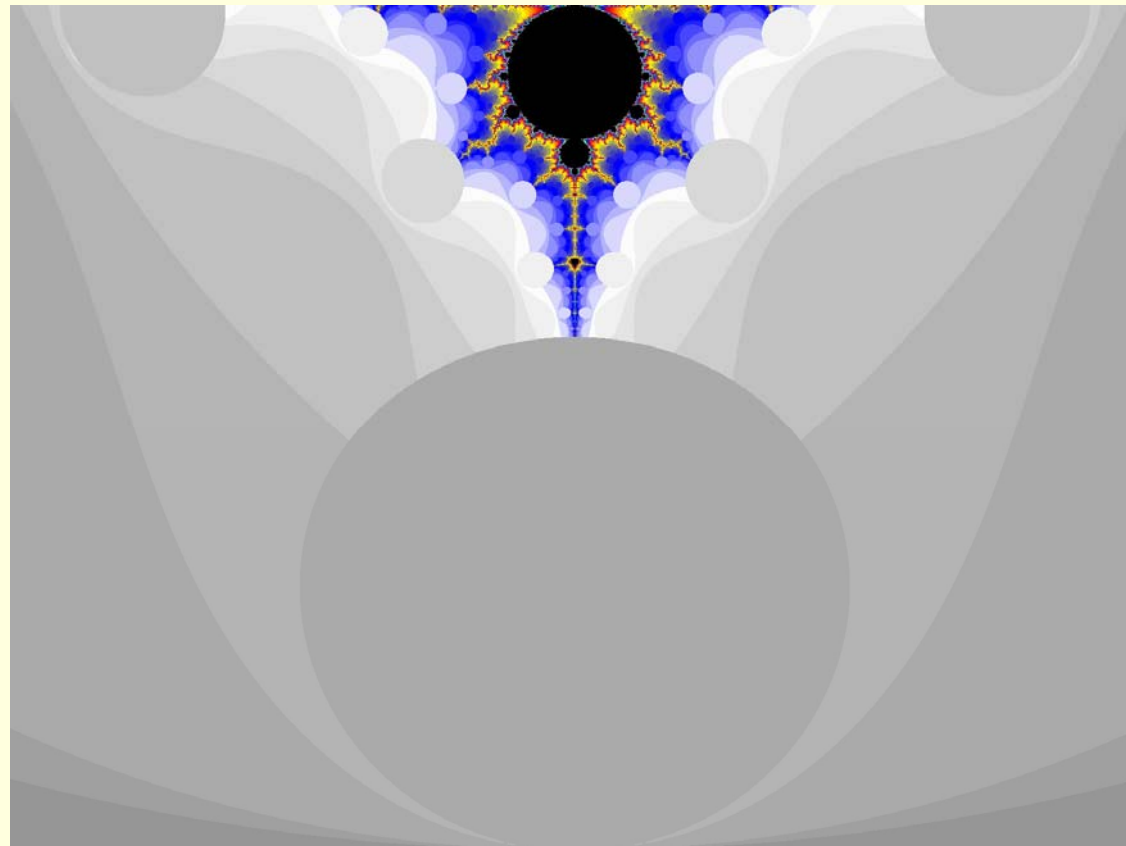


Figure created by the author

Analytic Continuation to Planck Star

- Suppressing 1st order solution shows condensation proceeds behind the horizon

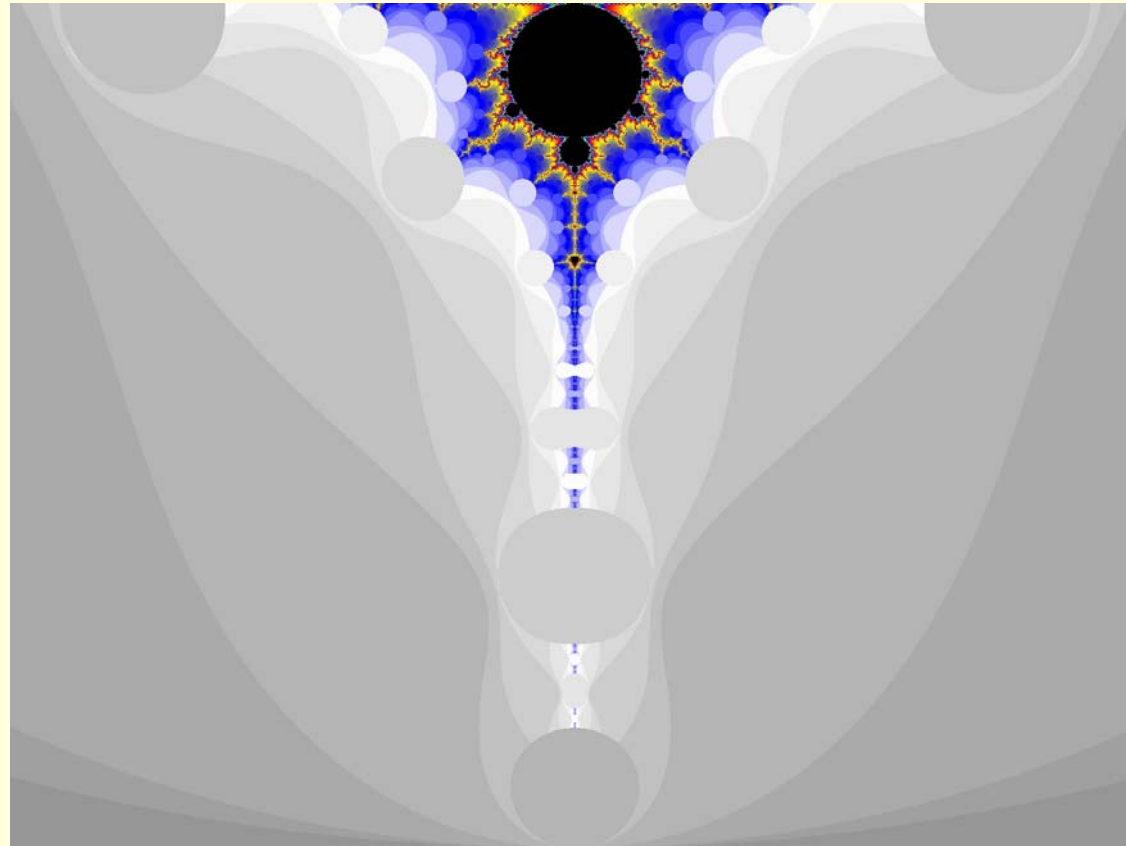


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