Explaining Time's Passage

The flow of time reexamined

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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

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
- Observation is a participation or action
- We must live with what we see or do
- There is no going back to a past condition

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 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

Views from Other Philosophies

- The doctrine of Wu-Ji in Taoist Chinese teachings echoes the view of Connes…
  - Beyond and before distinctions or polarity
  - Neither light nor dark, large nor small, …
  - Variations come first, and conditions later
- "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

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

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

where $Out(M) = Aut(M) / Int(M)$

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 flow of time is the key to that reconciliation, or a 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

$$Smooth \supseteq Top \supseteq Meas$$

- By analogy, comparing the phases of matter

$$Gas \supseteq Liquid \supseteq Solid$$

- 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
- Aikyon theory and octonionic cosmology
- My research into Mandelbrot Set cosmos

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 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
- See how 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

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

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 will have more to share and I expect to create additional materials in order to bring this work to a broader audience

- Please feel free to contact me after MG16

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My Inspirations and Sources

Alain Connes caught my imagination with 'NCG Year 2000' with the idea that spaces can evolve with time. Roberto Longo's recent work makes the basis quite clear. Carlo Rovelli's book "Reality is Not What it Seems" awakened me to how much we owe our understanding to the philosophers, and his lead article in *Found of Phys* **48**, 5 'Physics needs Philosophy, Philosophy needs Physics' is a gem. But that entire issue contains many useful insights.

Surface area and volume of the unit n-sphere

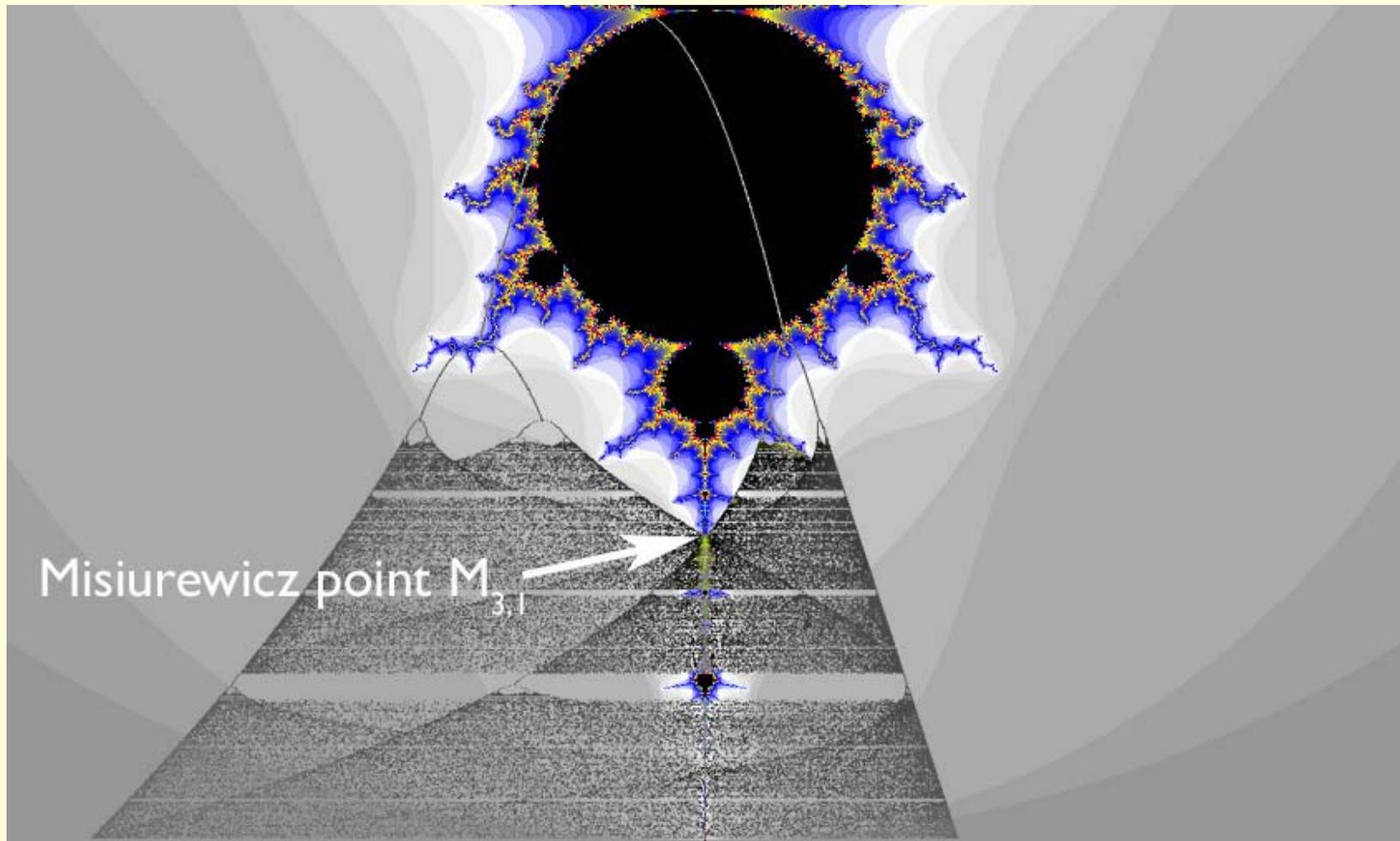Hypersurface area of n-sphere peaks at ~7
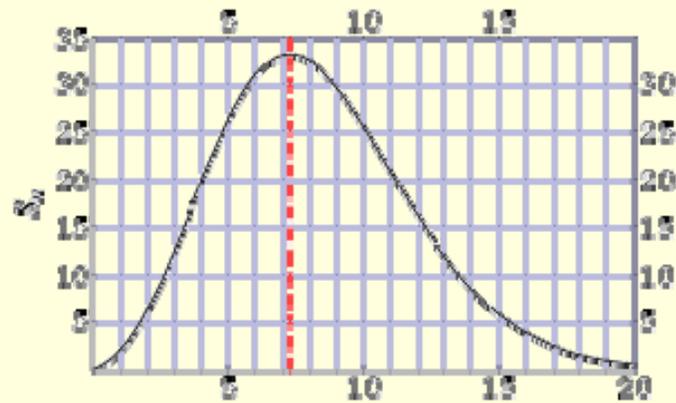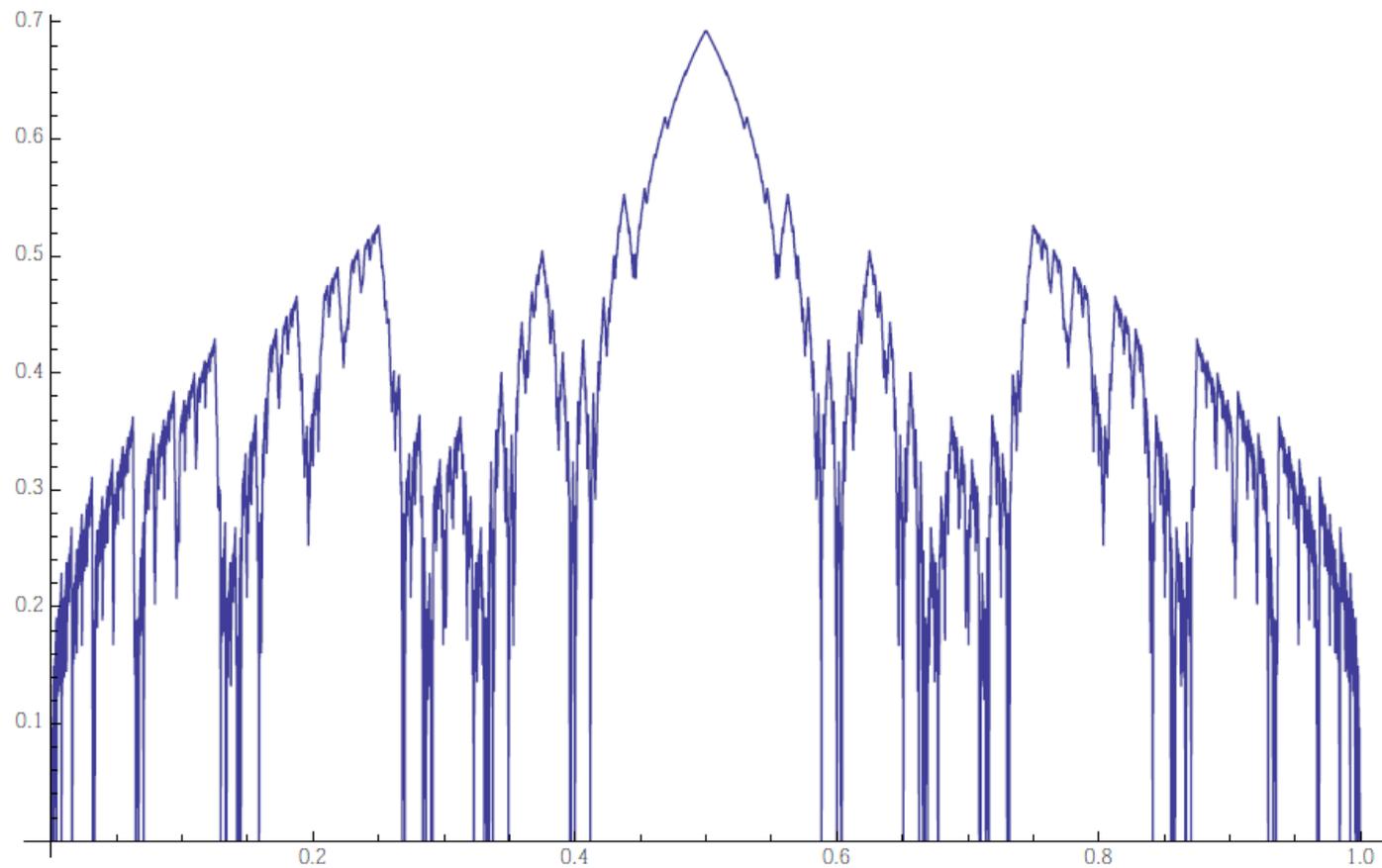

Hypervolume of n-ball (content) peaks at ~5
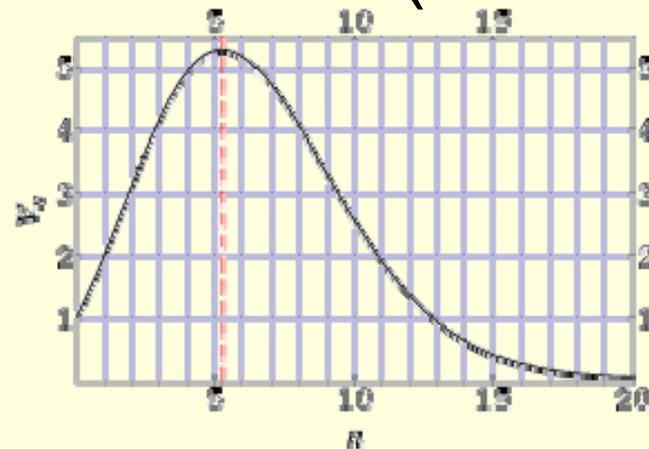
Global Asymmetry and Entropy
The Mandelbrot Set and its bifurcation diagram

Misiurewicz point $M_{3,1}$

Thurston's Core Entropy

Core entropy for quadratic polynomials

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 will appear in the proceedings paper for this event

- My paper 'The Intrinsic Time of Alain Connes and Evolutive Properties in higher-d Algebras' will appear shortly in Prespacetime Journal with more insights