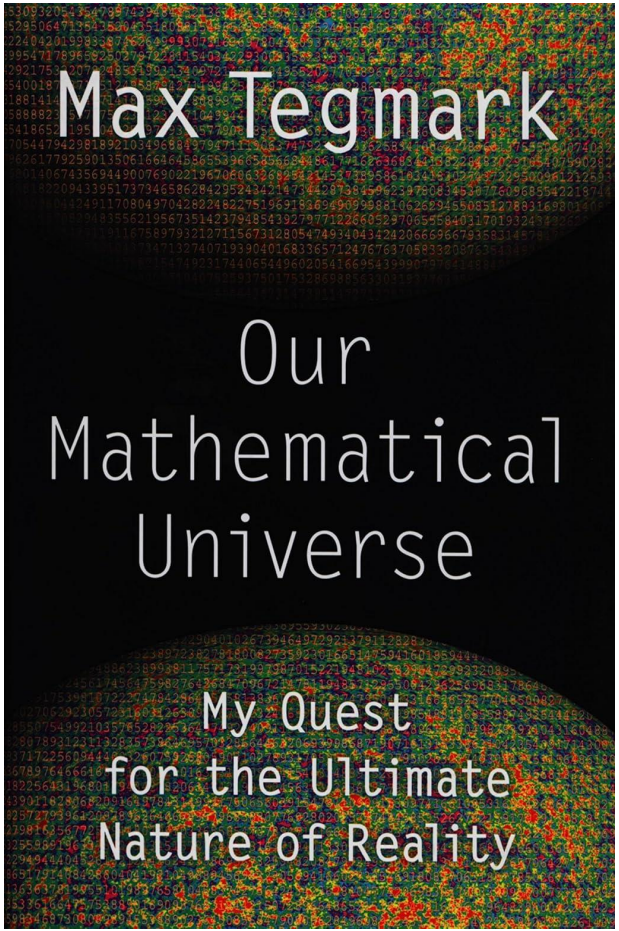
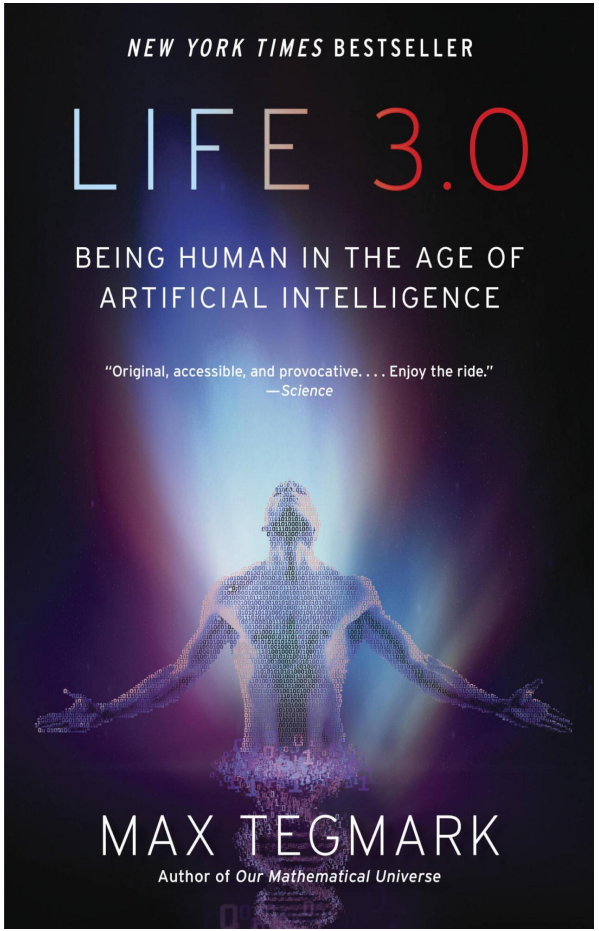
Max Tegmark and the Mathematical Multiverse

A presentation by Otto Mättas

Max Erik Tegmark

- b. 1967
- Professor at MIT
- President at the Future of Life Institute
- Known for contributions to cosmology, quantum mechanics, and artificial intelligence


Max Tegmark
Our Mathematical Universe
My Quest for the Ultimate Nature of Reality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MAX TEGMARK
Author of Our Mathematical Universe

The Multiverse Hierarchy

Level I: Spatial Extension

Definition: Infinite space with repeated initial conditions

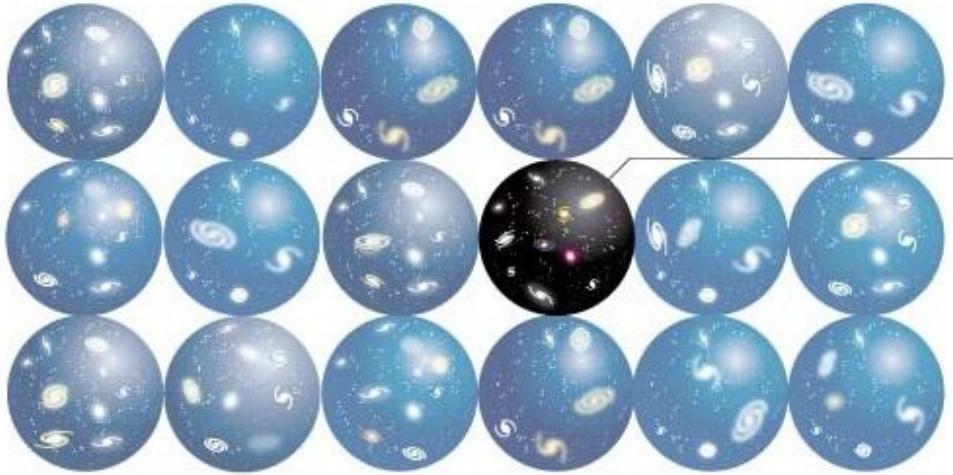
Key concept: Everything that can happen, does happen

Example: Another you making different choices ~10^10^100 meters away

If space is infinite, does this automatically follow?

The multiverse hierarchy: level 1

If the big bang started with a period of inflationary growth, there would be a multitude of universes a lot like ours – but with different arrangements of matter



Our universe
42 billion light years across – the distance light has travelled in our expanding universe

Physics:
Like ours, but with all possible initial conditions and histories replicated an infinite number of times

Support:
Plays to the idea of the principle of mediocrity – that there's nothing special about the universe we see

Relationships:
All level 1 universes bear a family resemblance to ours and to each other

Connections:
Since everything that can happen in our universe has happened in some other level 1 universe, there may be a direct connection between level 1 and level 3 quantum multiverses

Level II: Different Physical Constants

Definition: Other post-inflation bubbles with different physical laws

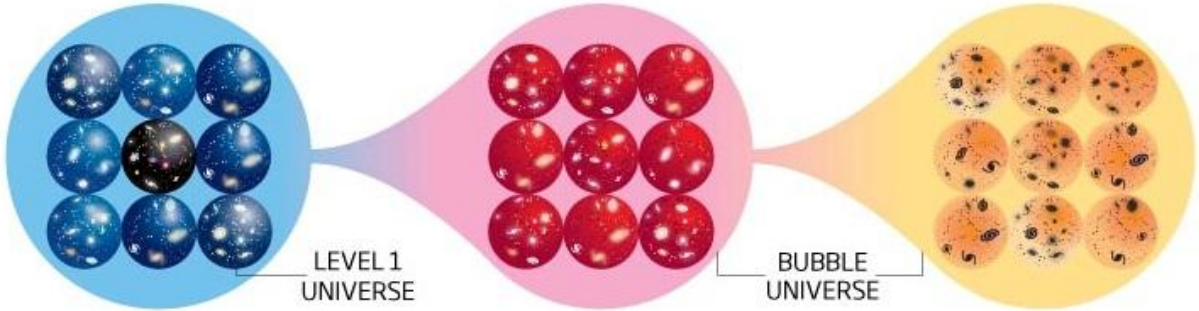
Analogy: Water states (solid/liquid/gas) vs universal constants

Example: Universes where electron/proton mass ratio differs

Are most physical constants just "cosmic addresses"?

The multiverse hierarchy: level 2

In the theory of eternal inflation, the space between universes continues to expand, and a limitless number of new "bubble" universes, with very different properties, continue to form. Each bubble universe contains an infinite number of its own level 1 universes



Physics:
Other bubble universes exhibit different laws of physics and have different dimensionality, particles, constants and forces to those seen in our universe. We might eventually discover that all these parameters flow from the same "theory of everything"

Support:
Inflation explains the uniformity and flatness of our universe and details of the cosmic microwave background. Eternal inflation implies bubble universes and provides a way of supplying string theory with the many universes it demands

Relationships:
Level 2 universes vary greatly. They represent separate bubbles or domains with different properties, and are separated from each other by inflating space

Connections:
Level 2 includes all possible level 1 universes plus an enormous variety of much stranger universes. Since everything that can happen in a particular level 2 universe has happened in other universes, level 2 may also correspond to the universes in the level 3 quantum multiverse

Level III: Quantum Many Worlds

Definition: Everett's interpretation of quantum mechanics

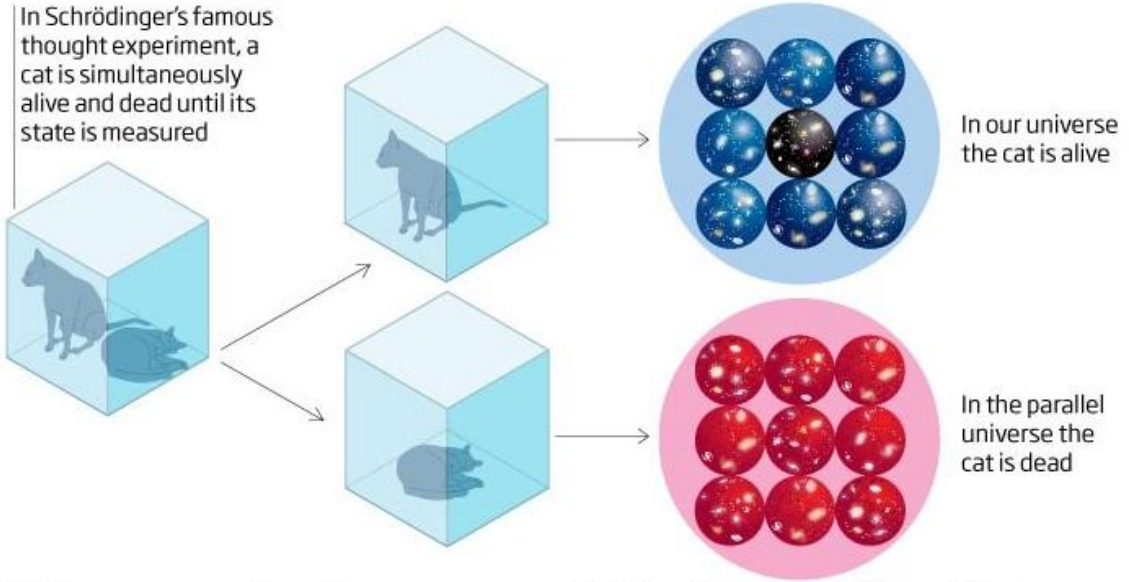
Key concept: All quantum possibilities realised

Thought experiment: The hospital cloning scenario

How does this differ from Level I?

The multiverse hierarchy: level 3

The many-worlds interpretation of quantum mechanics suggests a continually branching series of multiverses



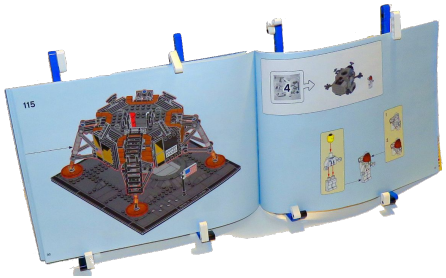
Physics:
Quantum mechanics underlies all level 1 and 2 universes, but arguably with all possible virtual or parallel worlds also realised somewhere in space

Support:
Quantum mechanics, including ideas of superposed states and collapsing wave functions, is one of the most thoroughly tested and successful theories in physics

Relationships:
Within a given universe, parallel or branching worlds follow the same physical laws. However, once histories diverge, they can no longer interact

Connections:
The parallel universes of level 3 may be realised in the multiverses of level 1 and 2

Level IV: Mathematical Structures



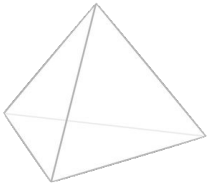
Definition: All mathematical structures exist

Key concept: Physical existence equals mathematical existence

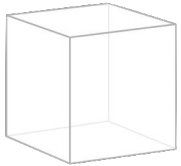
Example: Platonic solids as discovered, not invented

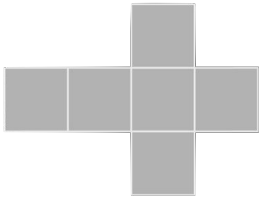
What makes this different from Jorge's Library?

Tetrahedron

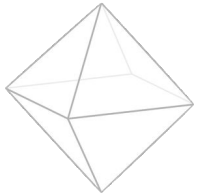


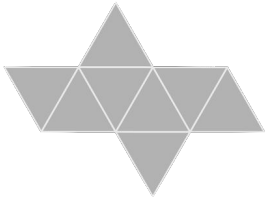
Cube





Octahedron





The multiverse hierarchy: level 4

If our universe is just a simulation, there could be infinitely many kinds of universes that differ in arbitrary ways from ours

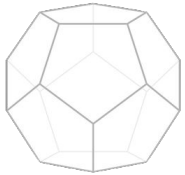
Physics:
Anything goes

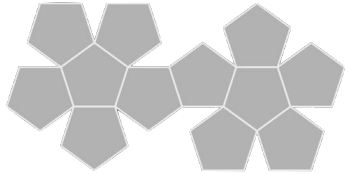
Support:
None. The idea is that long-lived technological civilisations will probably command vast computing power and may choose to run multiple "ancestor simulations" which will soon outnumber natural universes. There may be a one-to-one relationship between mathematics and reality: every conceivable mathematical system may represent a real universe

Relationships:
Arbitrary or non-existent

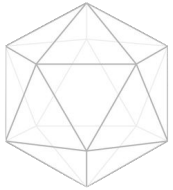
Connections:
Level 4 must contain the ultimate theory of everything. If so, there's no level 5

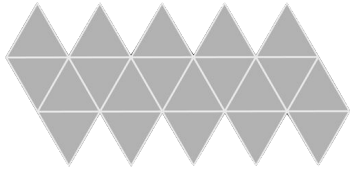
Dodecahedron





Icosahedron





The Science 360

MULTIVERSE

Level I: An extension of our universe

Level II: Universes with different physical constants

Level III: Many-worlds interpretation of quantum mechanics

Level IV: Ultimate ensemble

Science Loop

The Mathematical Universe Hypothesis

Deep Dive

Core Arguments

- Everything describable is mathematical
- No non-mathematical properties discovered
- Simplicity argument: No "special sauce" needed

Counter-arguments and Responses

- The consciousness problem
- The complexity problem
- The selection problem

Practical Implications

Practical Implications

For Physics

- Prediction: All properties must be mathematical
- Research direction: Look for mathematical patterns
- Impact on fundamental physics

For Philosophy

- Nature of reality
- Consciousness and experience
- Free will and determinism

Contemporary Relevance

Contemporary Relevance

Connection to Modern Physics

- String theory implications
- Quantum computation
- AI research

Current Research

- Tegmark's AI work at MIT
- The Intelligible Intelligence Project
- Future implications

Discussion Points

Key Questions

1. Does our universe have non-mathematical properties?
2. If there are infinite copies of you making different decisions, does free will exist?
3. If everything mathematical exists, why do we experience this particular reality?
4. How does consciousness fit into a purely mathematical universe?
5. What would falsify the Mathematical Universe Hypothesis?
6. Does this theory make testable predictions?

Thought Experiments

1. The Simulation Argument connection
2. The "Mathematical Soul" comparison
3. The complexity paradox

In Conclusion

- Mathematical structures have an abstract existence
- This existence doesn't require any physical substrate
- Simple structures might be more fundamental
- Our observed reality might be one of the simpler mathematical structures
- This could explain why physics follows elegant mathematical patterns rather than chaos

- Our external physical reality is a mathematical structure.
- Mathematical existence is freedom from contradiction. *Hilbert*
- If you're simulated, live an interesting life.