Fairy Dust in Physics: How Non-Physical Views of Information Impede Theory Progress

Terry Bollinger
February 15, 2025

First: A Trillion-Dollar Impact Brag for DC QC Meetup

From my last Nov 2, 2024 Washington DC Quantum Computing Meetup group talk [1]:

> *1:28:14 TB: "If a large chunk of the backtrack [is] creating codes that then separate [holographic data storage] dimensions, we could short-circuit that and say, 'You don't have to generate your own code. I'll give you a Walsh code — here, take it!' and it would say, 'Oh, yeah… thank you! You just saved me about a gazillion watts of processing time or energy cost!'"*

Two months later on Dec 27, DeepSeek issued a report on how predefining LLM database dimensionality was key to the performance improvements that devastated their competition's stock values:

> *"During pre-training, we train DeepSeek-V3 on 14.8T high-quality and diverse tokens. The pre-training process is remarkably stable. Throughout the entire training process, we did not encounter any irrecoverable loss spikes or have to roll back."*

More opportunities: (1) View *all* bits, even in real numbers, as holographic; (2) Use optical holography.

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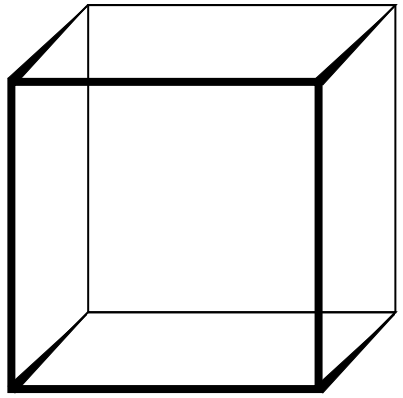
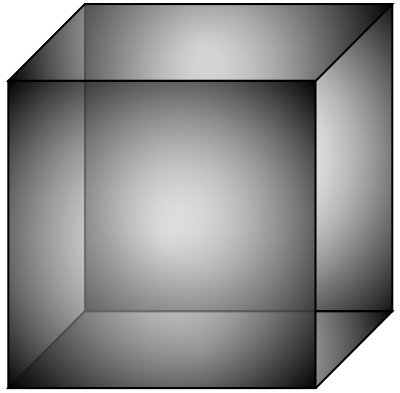
[1] T. Bollinger, *The First Nobel Prize for Insidious Software Degradation* [Generative AI as a Hologram] (YouTube video), Washington DC Quantum Computing Meetup **2024**, 1102 [Nov. 2] (2024). https://youtu.be/qq6_cJqVX5E?t=1h28m14s

[2] A. Liu et al., DeepSeek-V3 Technical Report, arXiv preprint arXiv:2412.19437, [Dec. 27] (2024). https://arxiv.org/pdf/2412.19437. Page 4, paragraph 4.

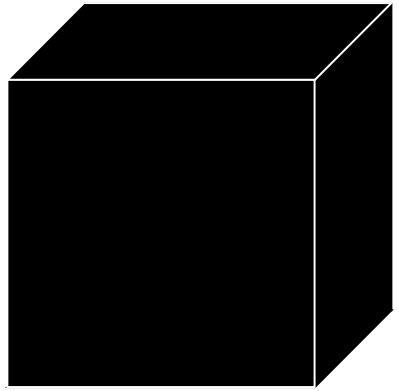
How many *bits* are in a cubic cm of empty space?



(1) None?



(2) Perhaps a few?

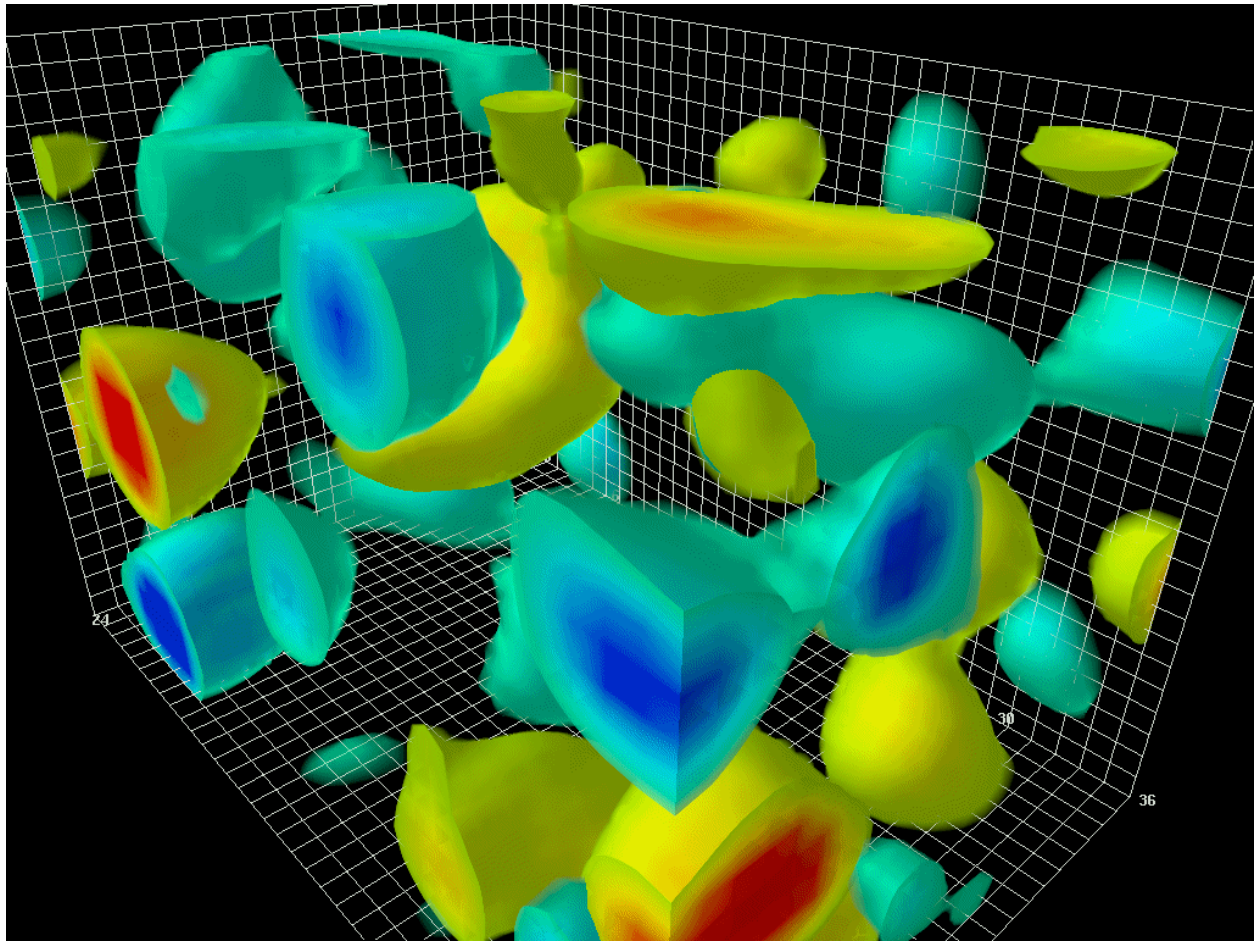


(3) Almost infinitely many?

A few questions:

- **What do you interpret a "bit" to be?**
- **If (2) or (3), what creates the bits?**
- **If (2) or (3), is there also energy?**
- **If (2) or (3), can you store/recall data?**
- **Without store/recall, are they "bits"?**

"Almost infinitely many" ➔ Quantum field theory



Derek Leinweber CC BY 4.0: Visualizations of Quantum Chromodynamics
In 2004, Nobel Laureate Frank Wilczek used this animation in his Prize Lecture.
https://upload.wikimedia.org/wikipedia/commons/2/2a/Quantum_Fluctuations.gif

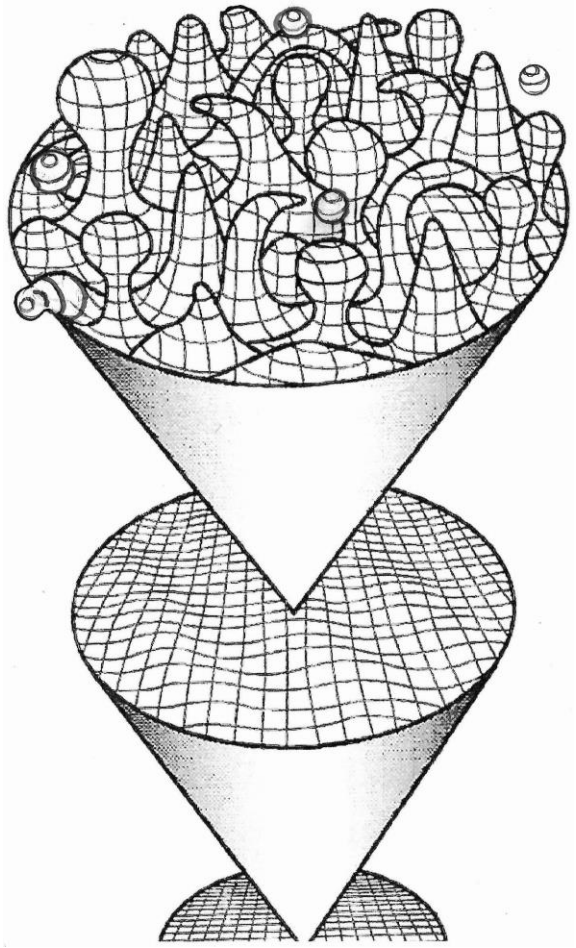
DM = Derek Muller, Veritasium (YouTube)
DL = Derek Leinweber, University of Adelaide, Australia
https://youtu.be/J3xLuZNKhlY?t=1m2s, Apr 30, 2013

DL: "What you're looking at here is the energy density of the gluon field fluctuations. Where the little red spots come out, the energy density is very high, and it fades down through the colors so, at the lowest energy, the field fluctuations are not rendering in this animation, so we can actually see into it."

DM: And what we see is a bubbling soup of quantum field fluctuations that come and go incredibly quickly. The frame rate of this simulation is one million billion billion frames per second. Now that is truly high speed! The dimensions of this box are absolutely tiny: They are a millionth of a billionth of a meter, roughly enough space to stick two protons. But there are no protons here. **This is a simulation of the vacuum 'on its own,' what we normally think of as 'empty space.'**

*DL: "Empty space is actually full of this quark-and-gluon field fluctuations. And, on average, it is possible to annihilate a quark from **empty space** because it **is not empty!**"*

"Almost infinitely many [more!]" ➔ Quantum gravity



NOTE: The bubbles in this figure are ~***100 billion billion*** **(10^{20}) times smaller (!)** than the proton-scale animated fluctuations of Leinweber's QCD figure.

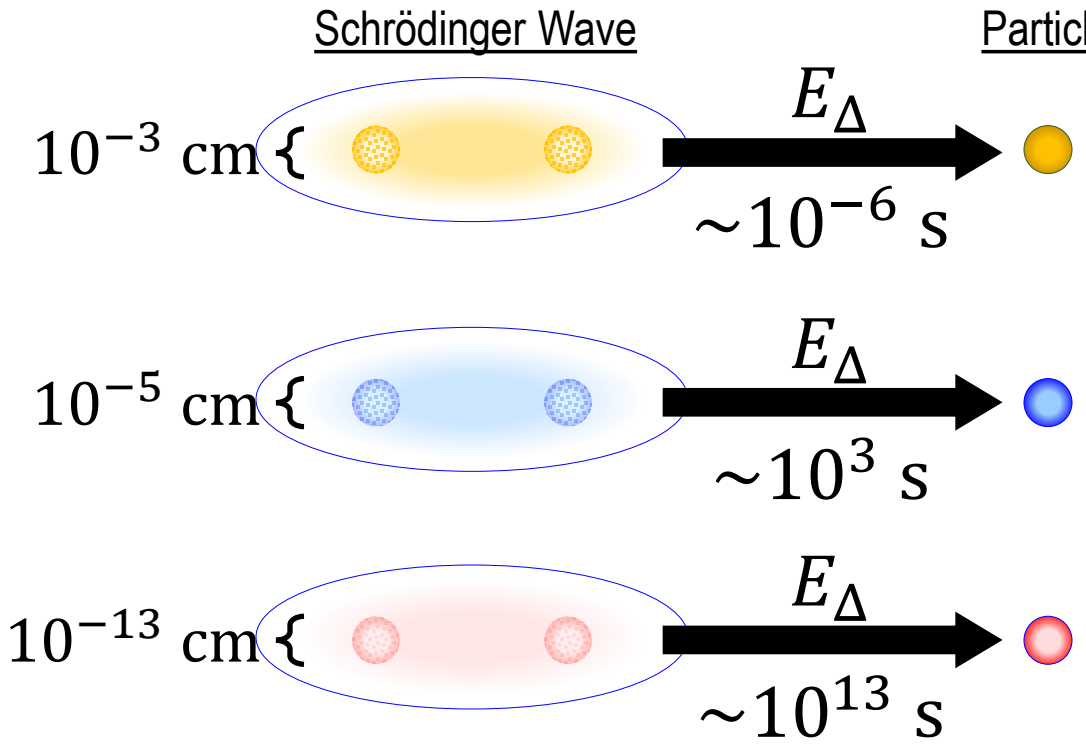
"[The Planck length] is … important [for] quantum gravity because it may be approximately the size of the smallest black holes."
— *Planck length*, Simple English Wikipedia

Jarrokam (Wikimedia), CC BY-SA 4.0, March 6, 2016. Planck scale reality. https://commons.wikimedia.org/w/index.php?curid=47370081

G. 't Hooft, *Dimensional Reduction in Quantum Gravity*, arXiv preprint gr-qc/9310026 [Oct. 19] (1993). https://arxiv.org/abs/gr-qc/9310026, p. 6

"... given any [black hole horizon] closed surface, we can represent all that happens inside [the black hole] by degrees of freedom on this surface itself. This, one may argue, suggests that quantum gravity should be described entirely by a topological quantum field theory, in which all physical degrees of freedom can be projected onto the boundary. ***One Boolean variable per Planckian surface element should suffice.*** *The fact that the total volume inside is irrelevant may be seen as a blessing since it implies that we do not have to worry about the metric inside."*

"Perhaps a few?" → Penrose Collapse Interpretation

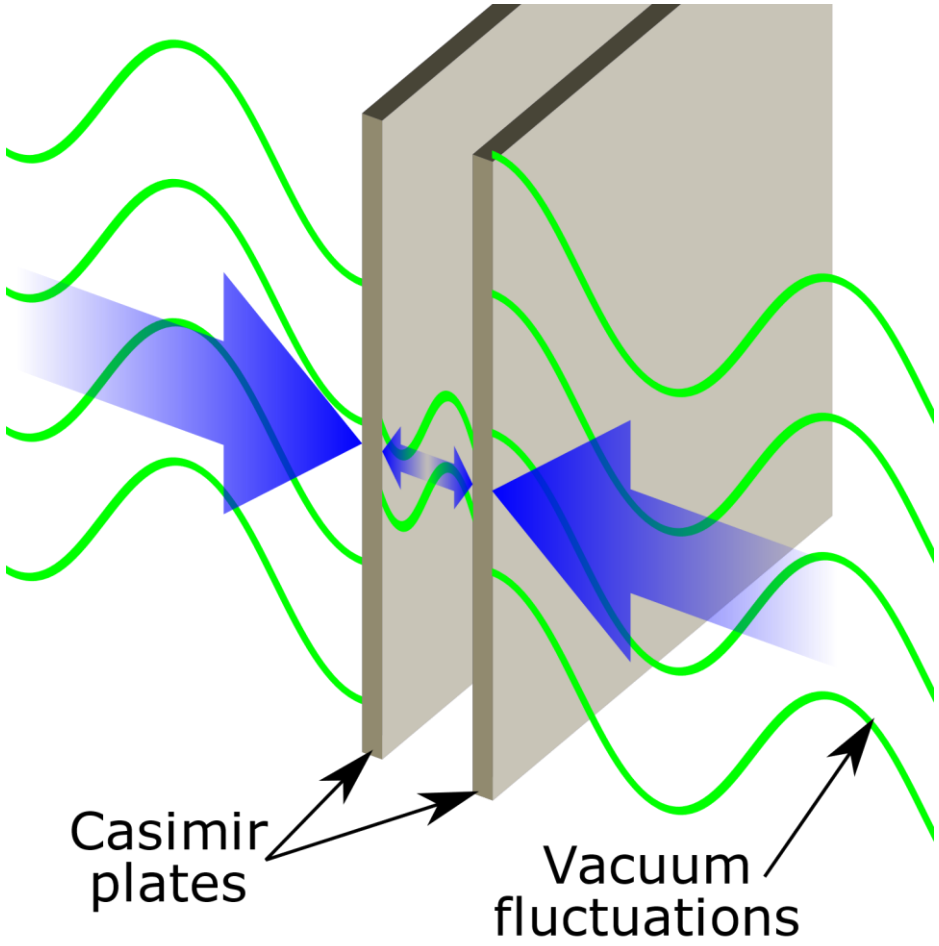


In the Penrose gravitational collapse interpretation, scale-dependent gravitational energy interactions play the role of (relatively rare) "observer bits."

R. Penrose, *On Gravity's Role in Quantum State Reduction*, General Relativity and Gravitation **28** (5), 581–600 (1996). http://image.sciencenet.cn/olddata/kexue.com.cn/upload/blog/file/2010/8/20108101917057588O.pdf

"… the gravitational interaction energy, should be the relevant measure of the required 'energy uncertainty' E_Δ." … "For a single proton [in two superposed locations], we may expect … decay [in] the order of a few million years. For a water speck 10^{-5} cm in radius … about an hour or so; for a speck 10^{-3} cm in radius, something like a millionth of a second. These results indeed seem reasonable, and if confirmed would supply a very plausible solution to the quantum measurement problem…"

What about energy in space? ➔ The Casimir Effect



Emok, CC BY-SA 3.0, via Wikimedia Commons
https://commons.wikimedia.org/wiki/File:Casimir_plates.svg

H. B. G. Casimir, *On the Attraction between Two Perfectly Conducting Plates*, Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen **51**, 793–795 (1948).
https://dwc.knaw.nl/DL/publications/PU00018547.pdf

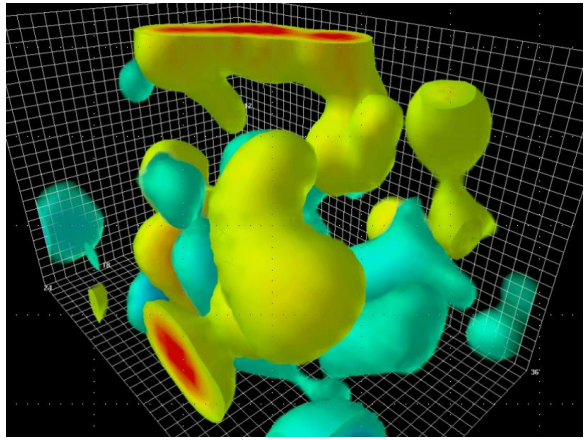
"We are thus led to the following conclusions. There exists an attractive force between two metal plates which is independent of the material of the plates as long as the distance is so large that for wavelengths comparable with that distance the penetration depth is small compared with the distance. This force may be interpreted as a zero-point pressure of electromagnetic waves."

"Although the effect is small, an experimental confirmation seems not unfeasible and might be of a certain interest."

Forty-nine years later, S. K. Lamoreaux proved that the attractive effect Casimir predicted is experimentally observable:

S. K. Lamoreaux, *Demonstration of the Casimir Force in the 0.6 to 6 μm Range*, Physical Review Letters **78**, 5–8 (1997).
http://web.mit.edu/~kardar/www/research/seminars/Casimir/PRL-Lamoreaux.pdf]

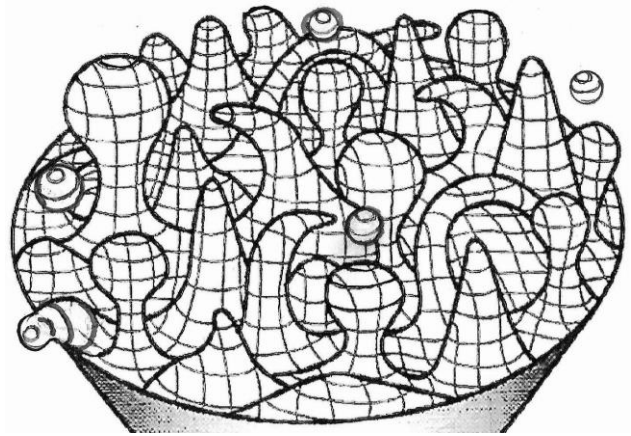
A Closer Look: Quantum Field Theory



Derek Leinweber: *"**What you're looking at here is the energy density of the gluon field fluctuations**. **…** on average, it is possible to annihilate a quark from empty space because it is not empty. … The empty vacuum actually costs an enormous amount of energy to create, and if you were able to create it, you'd discover that that is actually unstable — that any sort of perturbation would push that empty vacuum into something where **the vacuum is actually full of quantum field fluctuations**."*

- If you count *fields* as real, how "empty" is the space inside a proton?
- Question: If you could uniformly fill a room with flux fields as intense as the ones inside a proton, what would happen if you stepped in?
- Answer: Instantaneous obliteration down to your sub-particle level, followed obliteration of earth and possibly the entire solar system.
- Is it accurate to label regions containing such fields "empty" space?
- Nitpick: "*gluon* field fluctuations" versus "*quantum* field fluctuations."

A Closer Look: Quantum gravity

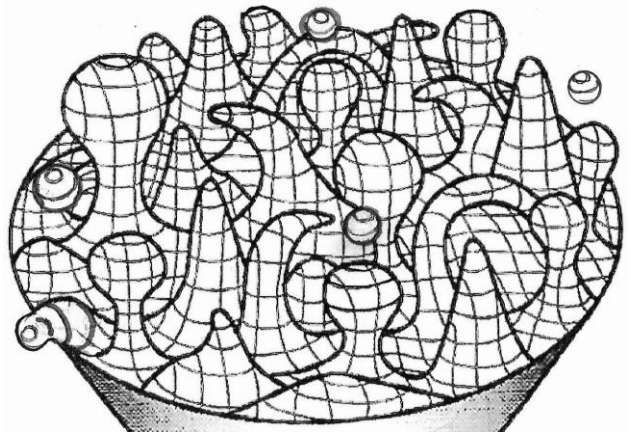


't Hooft: *"**Using cellular automata** … implies more constraints. … Unfortunately, any such lattice scheme **seems to be in conflict with local Lorentz invariance** … The most direct and obvious physical cut-off [is] **the formation of microscopic black holes**. … **One Boolean variable per Planckian [microscopic black hole] surface element should suffice.***

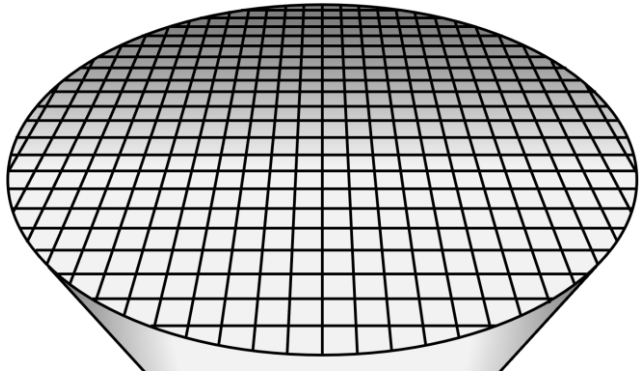
- "Using cellular automata"… *presumes* what is supposedly being proven, which is a binary surface on black holes. (The power of emerging 80s/90s computer technologies fascinated physicists at that time and influenced their thinking.)
- "Conflict with local Lorentz invariance" is a sneaky way of saying, "We no longer fully accept Einstein's special relativity. Lattices are so much easier!"
- Chip-design jaw-dropper: How did data-obliterating black holes become *flip-flops*?

2020 Experimental Disproof of Planck Scale Foam

Wheeler's 1955 "Planck foam" speculation:



HAWC 2020 gamma-ray tested reality:



J. A. Wheeler, *Geons*, Physical Review **97** (2), 511 (1955). https://blackholes.tecnico.ulisboa.pt/gritting/pdf/gravity_and_general_relativity/Wheeler_Geons.pdf

S. Carlip, *Spacetime foam: a review*, Reports on Progress in Physics **86** (6), 066001 (2023). https://iopscience.iop.org/article/10.1088/1361-6633/acceb4/ampdf

Carlip: *"In the mid-1950s, Wheeler … argued that quantum fluctuations … at the Planck scale [lead] to wild and rapidly varying fluctuations in spacetime geometry and topology, which he called 'spacetime foam.'"*

Wheeler: "*To the transatlantic passenger flying above it, the ocean appears smooth… [but] in a lifeboat he sees the foam forming and breaking."*

A. Albert et al., *Constraints on Lorentz invariance violation from HAWC observations of gamma rays above 100 TeV*, Physical Review Letters **124** (13), 131101 (2020). https://arxiv.org/abs/1911.08070

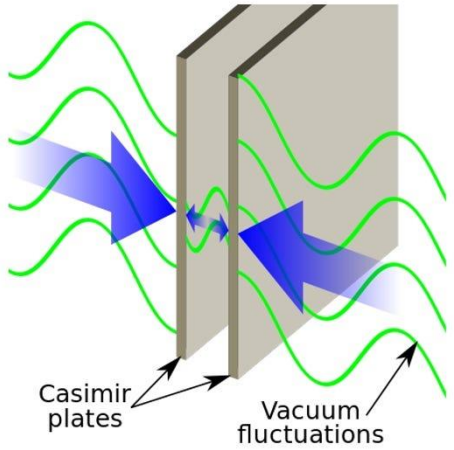
"… a hard photon decay cutoff due to LIV [Lorentz invariance violation] would be at the same energy for any source … HAWC [evidence of 100 TeV photon emissions from at least four astrophysical sources] thus can exclude [the possibility of new, non-Lorentz-invariant physics emerging at any energy level less than] the LIV energy scale …, $E_{LIV}^{(1)}$, [which we have now set] to greater than 10^{31} eV. [This new upper bound for continuation of standard Lorentzian physics is] over 1800 times the Planck energy scale [of] $E_{Pl} \approx 1.22 \times 10^{28}$ eV."

A Deeper Problem: Lattice Physics are Single-Frame

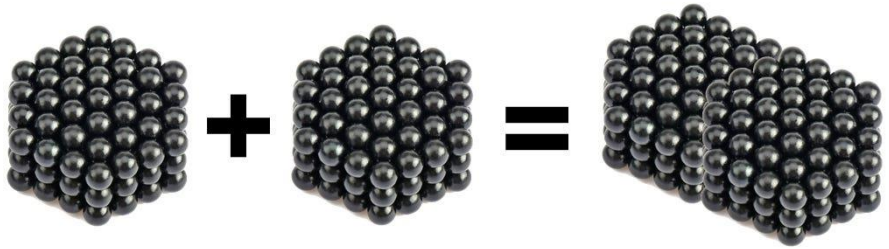
- The vacuum of Einstein's Special Relativity looks *exactly the same* regardless of who examines it, or how they are moving.
- Lattices *define a space* (and thus a single inertial frame) by the inherent spacing and relationships of their nodes.
- Physicists know this, but find the lattice model so attractive for calculation purposes that they use it anyway, e.g., for QFT.
- This lack of Einsteinian relativity in lattices is why most physics paper assume some sort of "cut-off" (e.g., $E_{LIV}^{(1)}$) beyond which Einsteinian special relativity fails and must be replaced.

A Closer Look at Energy: The Casimir Effect

This is what everyone shows:



This is what's really going on:



Terry Bollinger, CC BY-SA 4.0, Medium.com, May 10, 2024. Figure 1 of "The Famous Casimir-Effect Figure is a Hoax"

H. B. G. Casimir in **1948**: *"In order to obtain a finite result it is necessary to multiply the integrands by a function $f(k/k_m)$ which … tends to zero … rapidly for $(k/k_m) \rightarrow \infty$… The physical meaning is obvious:* ***For very short waves (X-rays, e.g.) our plate is hardly an obstacle at all and therefore the zero point energy of these waves will not be influenced by the position of this plate.****"*

… "We are thus led to the … conclusion. … [that] this force [is] a zero-point pressure of electromagnetic waves." [!!!! See next page on "transparency."]

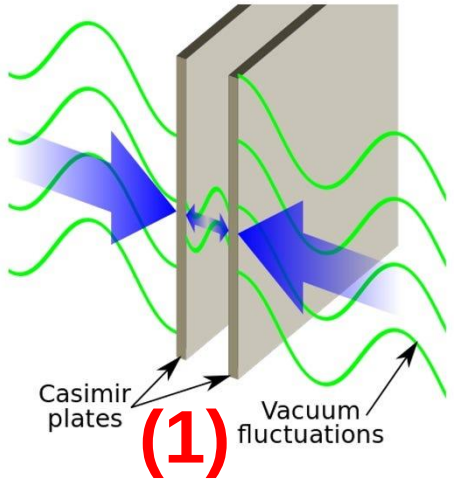
H. B. G. Casimir in **1998**: *"… by clever experiments … the existence of electromagnetic zero-point energy …has been established beyond doubt.*

"But one can also take a more modest point of view. **Inside a metal there are forces of cohesion**, and if you take two metal plates and press them together, these forces of cohesion begin to act. On the other hand, **you can start from one piece [of metal] and split it. You first have to break chemical bonds, and [then] overcome [classical] van der Waals forces… If you separate the two pieces even further, there remains a curious little tail: The Casimir force. [It] is the last — but also most elegant — trace of [internal] cohesion energy.**"

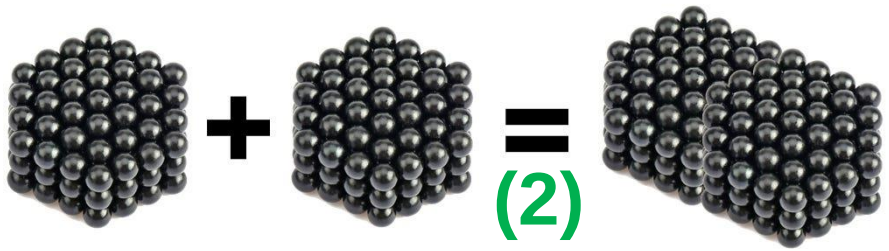
H. B. G. Casimir, *Some Remarks on the History of the So-Called Casimir Effect*, in The Casimir Effect 50 Years Later. World Scientific, Sep. 1998. pp. 3–9. https://books.google.com/books?id=PI84DwAAQBAJ&pg=PA3

Casimir's Cosmic Incineration Problem

This is what everyone shows:



This is what's really going on:



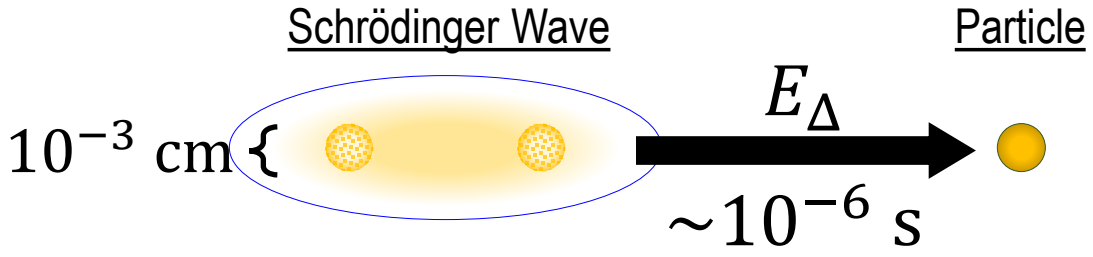
Terry Bollinger, CC BY-SA 4.0, Medium.com, May 10, 2024. Figure 1 of "The Famous Casimir-Effect Figure is a Hoax"

Casimir 1948: "… **(1)** ***For very short waves (X-rays, e.g.) our plate is hardly an obstacle at all.***

Casimir 1998: "… **(2)** ***the existence of electromagnetic zero-point energy … has been established beyond doubt… [but] the Casimir force… is [also] the last … trace of [internal] cohesion energy.***"

- **Assertions (1) and (2) *cannot co-exist in the same universe.***
- **Matter is *never* "transparent" to indefinitely high (e.g., gamma) EM. If (1) is true, these waves incinerate and infinitely compress all matter. Thus, these higher-energy waves *cannot exist.***
- **Conclusion: The *maximum energy available* for quantum field theory (QFT) is *the integral of all past cohesion-separation energies.* (!)**

A Closer Look: Penrose Collapse Interpretation



R. Penrose: *"… the gravitational interaction energy, should be the relevant measure of the required 'energy uncertainty' E_Δ."*

- Probably the most solidly grounded of the "space contains bits: arguments.
- Penrose argues that his "gravitational interaction energy," which is extremely weak for objects as tiny in mass as protons, quickly become powerful for larger objects in which this gravitational interaction becomes more measurable.
- In effect, this argument attaches "bits" to the *curvature* of spacetime, giving fewer bits for flatter space.
- Biggest problem: He sets up the gravitational interaction energy as special. Why not, for example, make *any* accelerating energy bump into a wave collapse?

Chaos vs. Persistence: What Counts as a Bit?

- The Penrose concept of space containing bits due to very slight curvatures captures an important point: Persistence.
- Fluctuating fields and foamy spacetime are fully chaotic and *do not* store information in a persistent fashion.
- For quantum chromodynamics, the *persistent* information is strikingly small and simple: three quarks of two types.
- The Penrose concept has persistence because it relies not just on space, but on *matter* — fermionic matter — to shape space.
- Hypothesis: Persistent information *requires* fermionic matter.

Stationary Bits Need Matter and Are Hard to Build

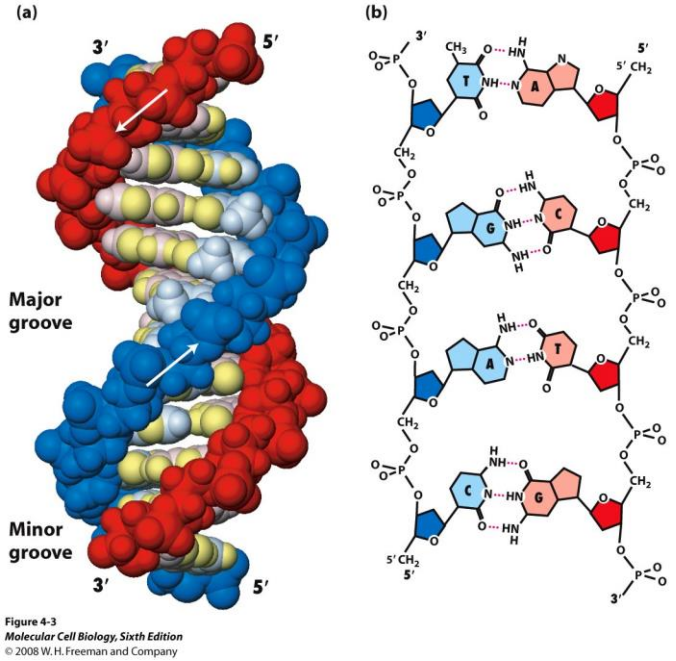
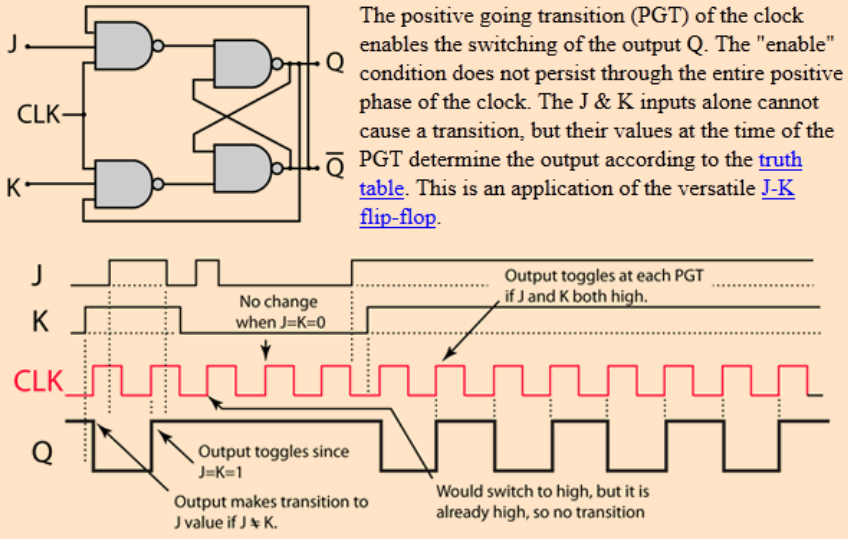
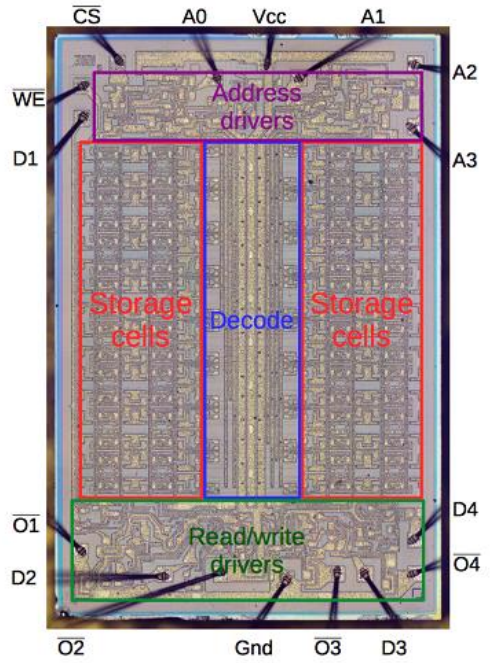
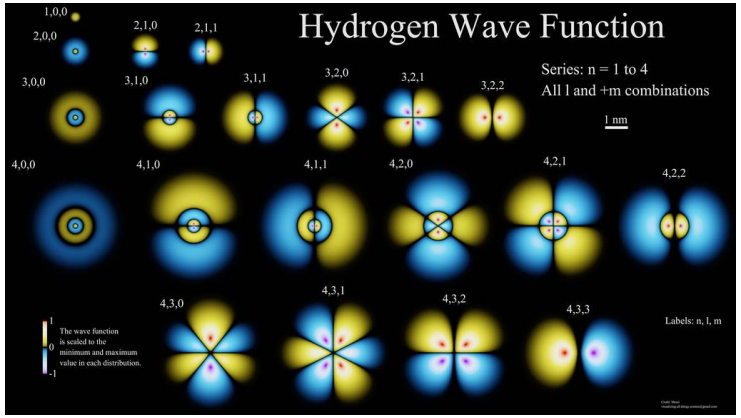


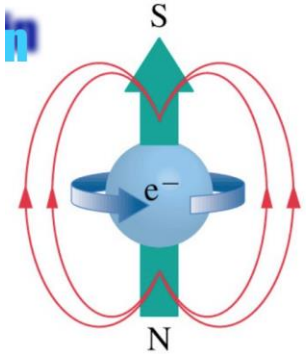
Figure 4-3
Molecular Cell Biology, Sixth Edition
© 2008 W. H. Freeman and Company

Switching Example: J-K Flip-Flop

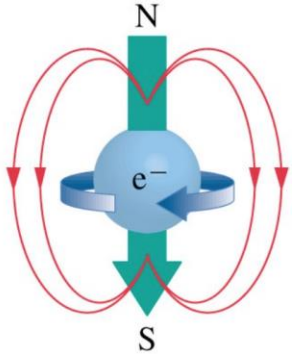






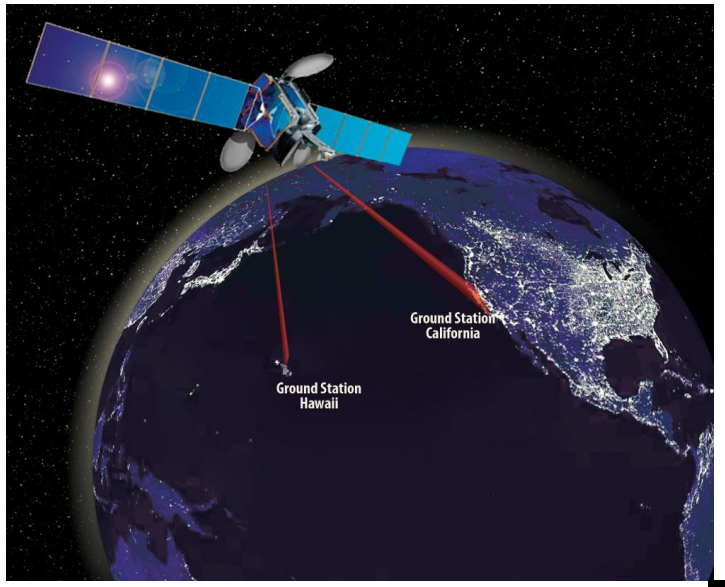


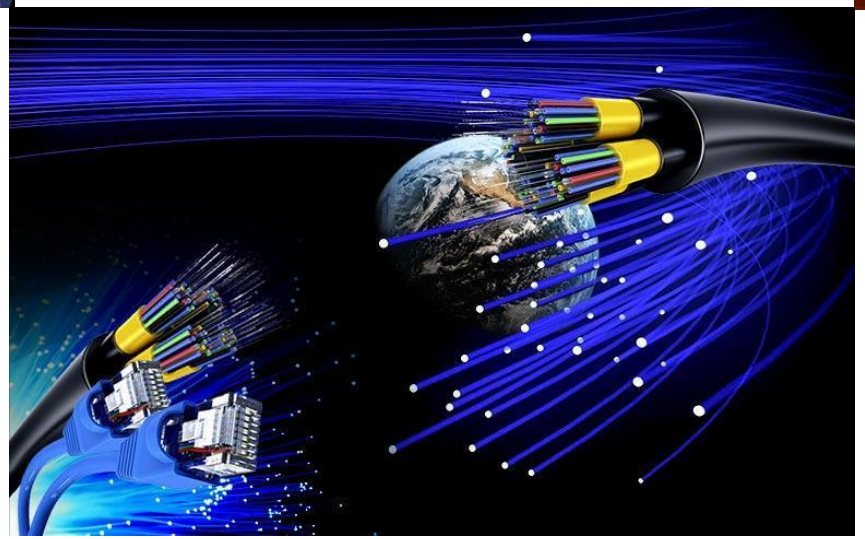
$m_s = +\frac{1}{2}$



$m_s = -\frac{1}{2}$

Moving Bits Need Material Transmitters/Receivers

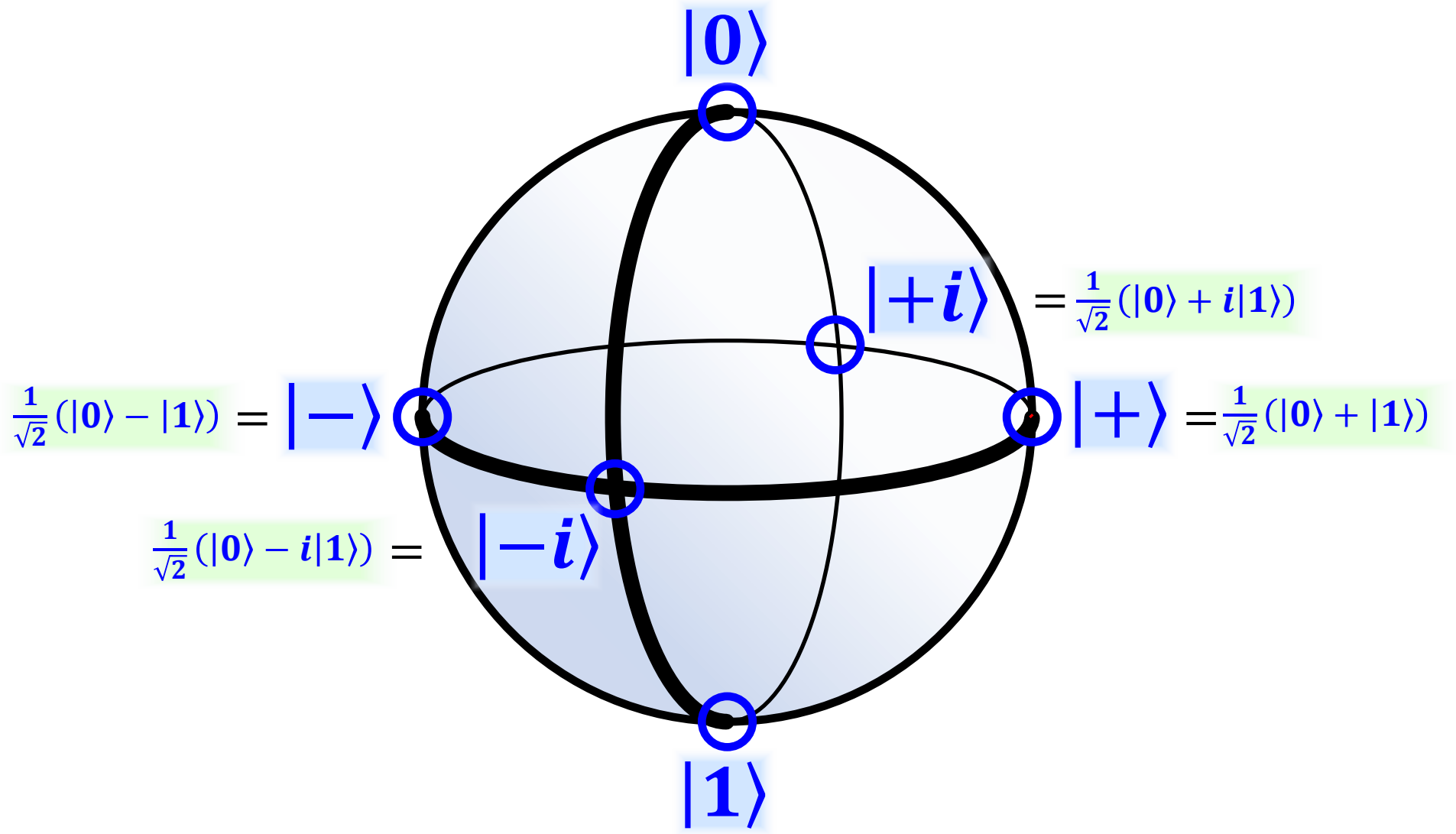




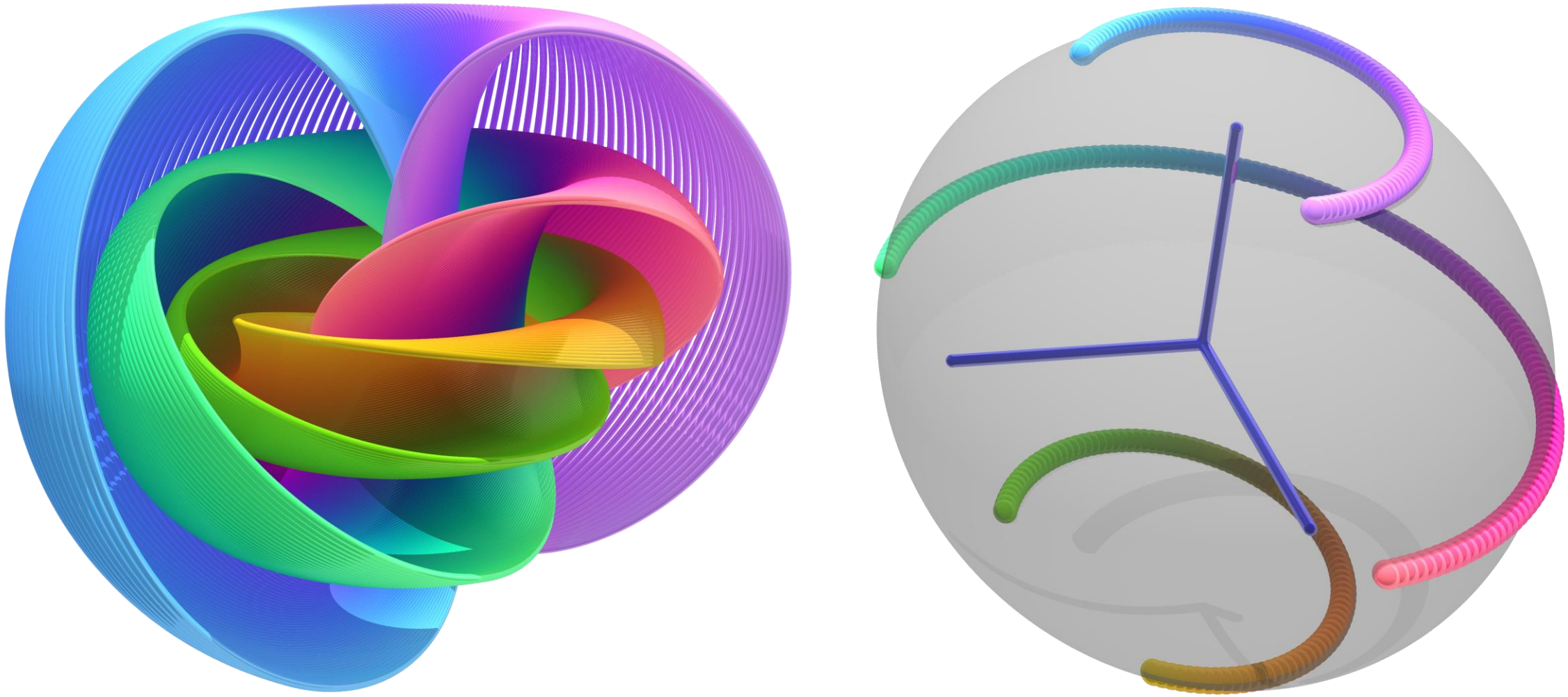
How Do Bits Work in Mathematics?

- All mathematical equations are written using static bits.
- Much of math is devoted to transforming such bits reliably.
- All *applications* of equations require computed interpretations.
- In the case of physics, those interpretations must have testable experimental consequences.
- Problem:
  - Need for non-data-storing **chaos bits** *explodes* at small physics scales (e.g., color force fluctuations [real], quantum foam [false], Casimir [false]).
  - Are such physics chaos bits real, or are they a feature of mathematics?

Time for a Closer Look: Bloch Sphere Mathematics

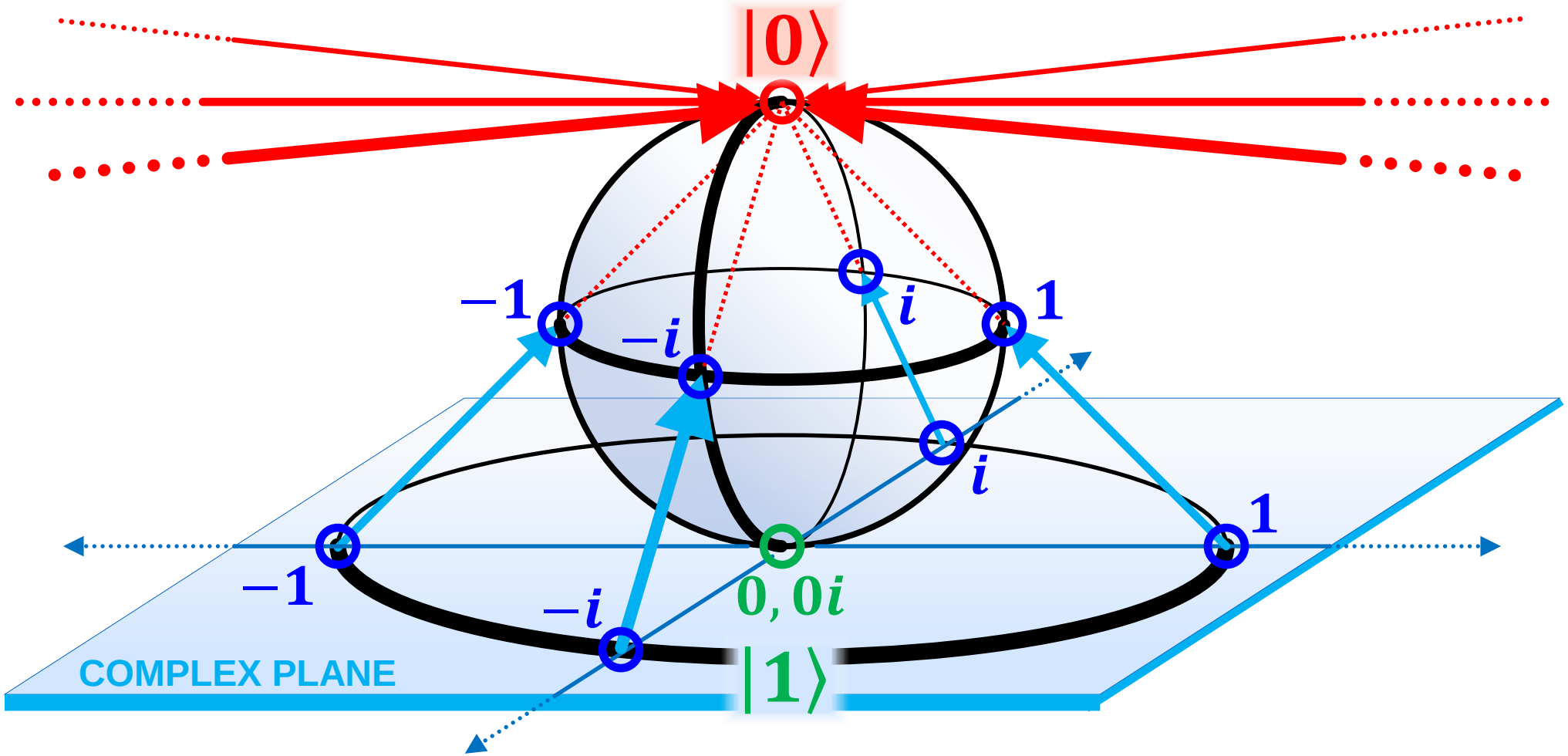


Hopf fibration: Mapping 3-Sphere States to the Bloch Sphere



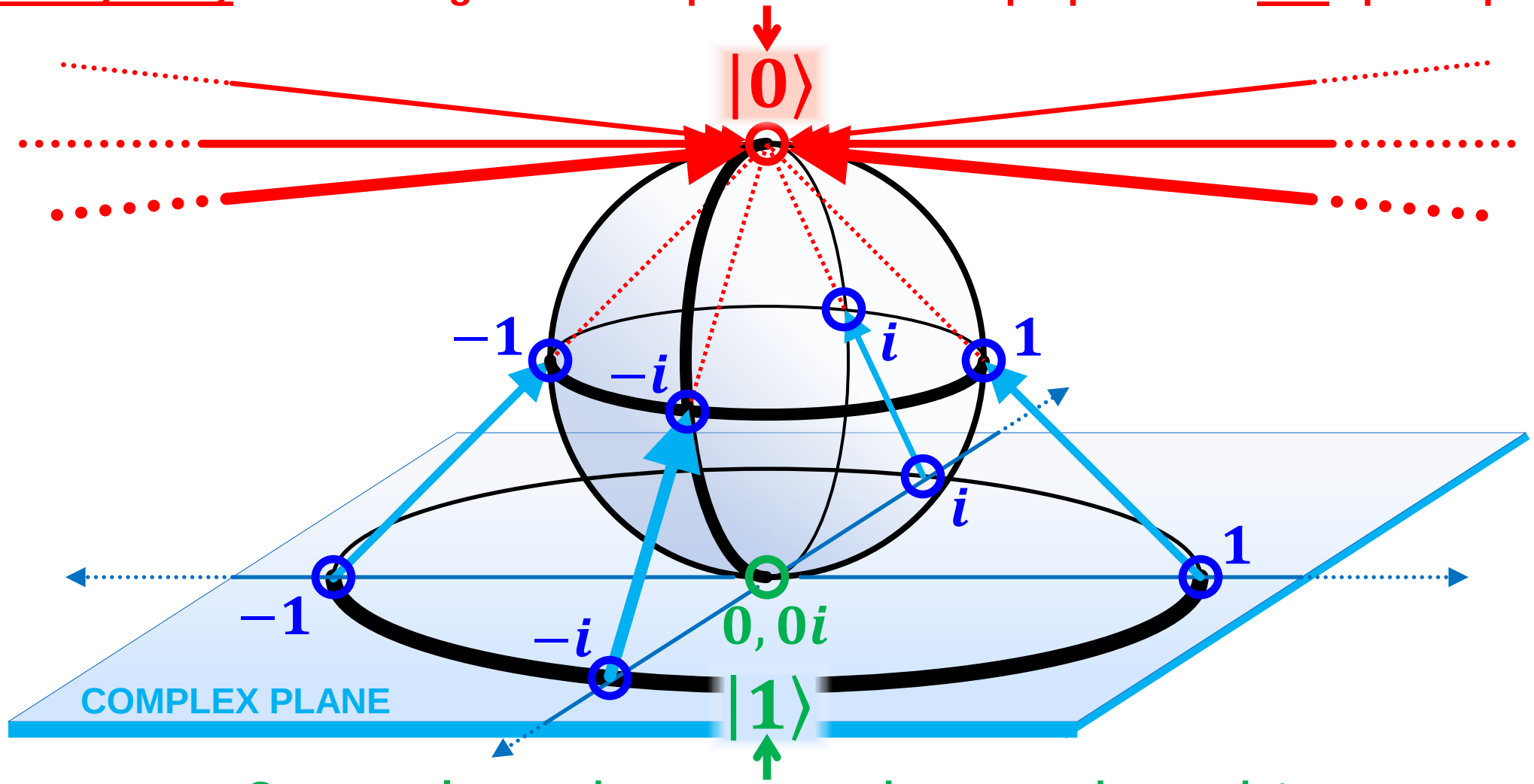
Niles Johnson, CC BY 4.0, https://commons.wikimedia.org/w/index.php?curid=22485543

An Easier View: Projecting the Complex Plane Onto a Sphere



Deeper: Why is the Bloch Sphere So Asymmetric?

Infinitely many infinite-magnitude complex numbers superposed on one sphere point



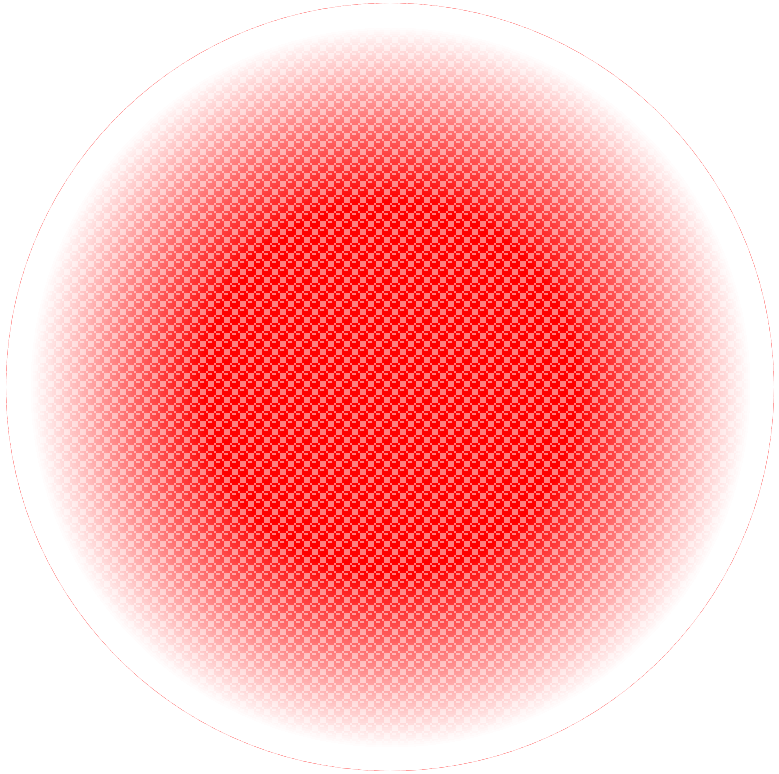
One complex number superposed on one sphere point

Gaussian Integer $\mathbb{Z}[i]$ Density Near $|1\rangle$ and $|0\rangle$

$|1\rangle$

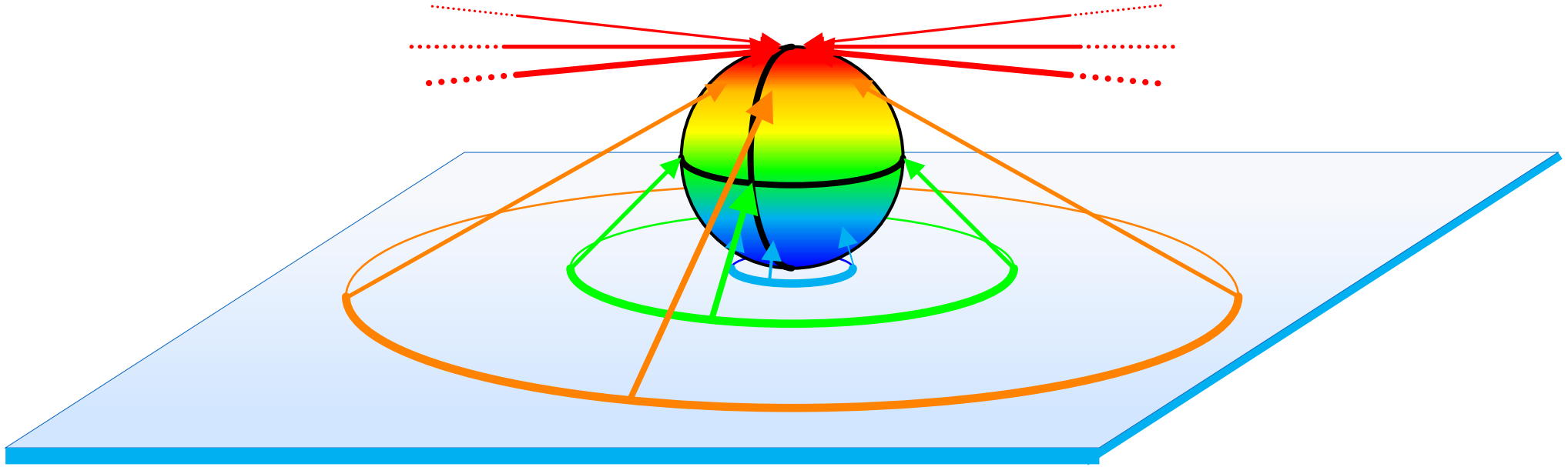
$\mathbb{Z}[i]$ Density:
1 / steradian

$|0\rangle$



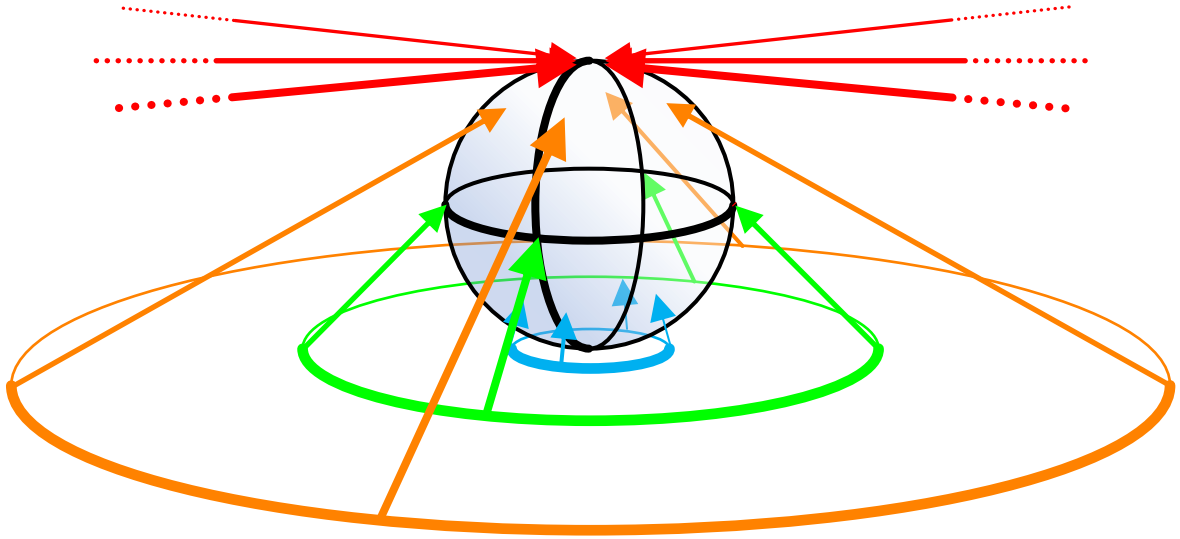
$\mathbb{Z}[i]$ Density:
∞ / steradian

Intuition #1: Compression of the Complex Plane



- Observation: Compression feels “wrong” at an intuitive level:
  - Thinking of the complex plane as a *material* (fermionic) object tells us that it should stay stiff and retain its geometric (spacetime) relations.
  - Reluctance to accept infinite compression near the top of the sphere is deeply wired into our understanding of how the world works.

Intuition #2: Projection of Rays



- Observation: Ray projection “feels” like the right approach:
  - The name gives away the source of the intuition: Classical light.
  - It is easy to picture beams of light projecting states onto the sphere.
  - Question: Is this “boson” intuition truly better than the fermionic one?

Are the Givens of Math Just Classical Physics?

- Any concept of geometric stiffness and angles requires familiarity with fermionic condensed matter physics.
- This idea is so critical to survival that it is wired into our brains.
- Real fermionic matter has *finite* (atomic or particle) bit density.
- From quantum physics, we now know classical (geometric) optics is an illusion that assumes point-like, bullet-like photons.
- Light projection also assumes *infinite many data receptors* at the $|0\rangle$ top of the Bloch sphere.
- Light projection also assumes *infinite light speed* for $|0\rangle$ rays.

A Different Mathematical Path

- Hypothesis #1: The only persistent bits (p-bits) in the universe are those directly associated with matter and energy.
- Hypothesis #2: Physics processes generate non-persistent chaos bits (c-bits) primarily in response to energetic probing.
- Hypothesis #3: The majority of chaos bits describe in papers are not real, but are created on paper by applying impossible classical 1700 math ideas such as infinite free bits, infinite light speed, perfect points, and “free” dimensional orthogonality to domains in which number persistent bits is tiny.
- New goal: Develop the mathematics of *sparse-bit physics*

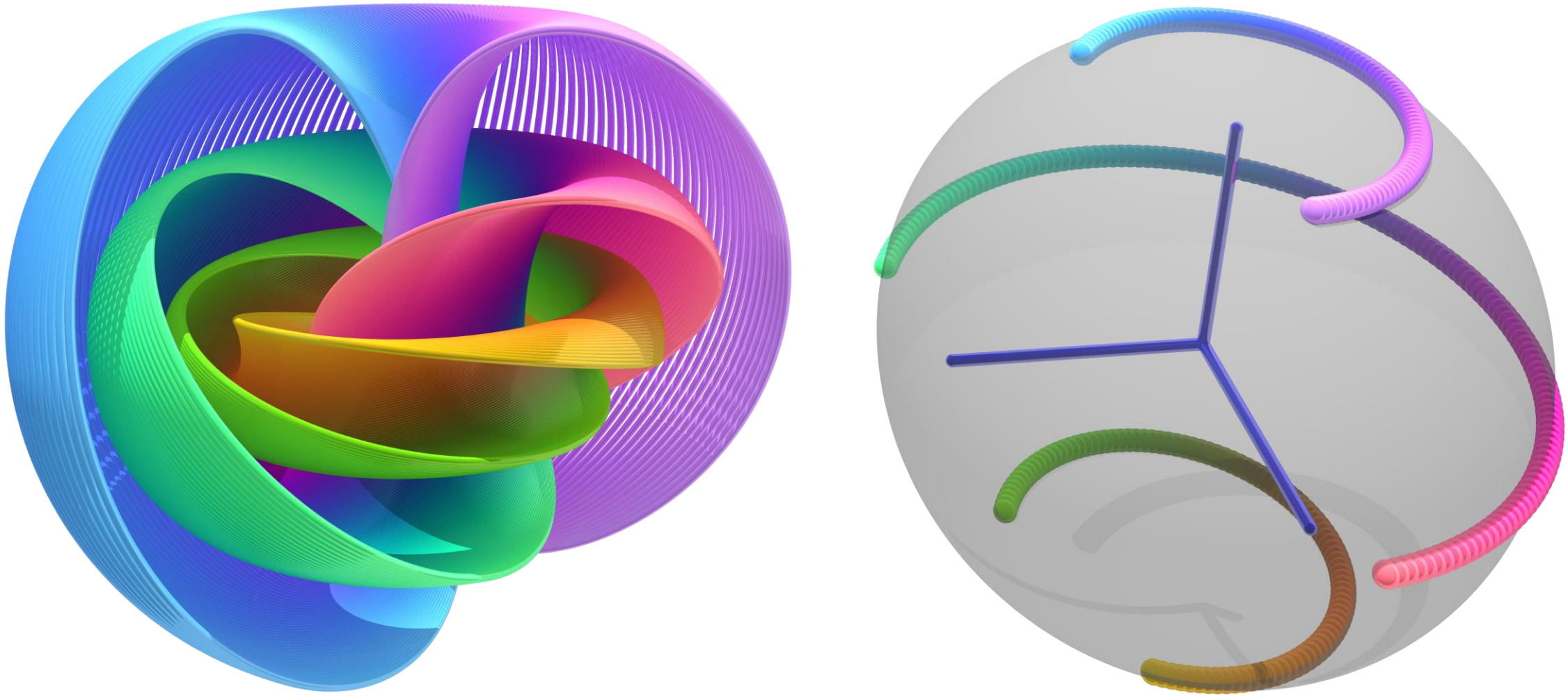
Three Sparse-Bit Examples

Quantizing the Bloch sphere using quaternions

Fermions as tesseract bridge vectors

Collective interpretations of hadron forces

Hopf Fibrations Are Too Complex for Qubits



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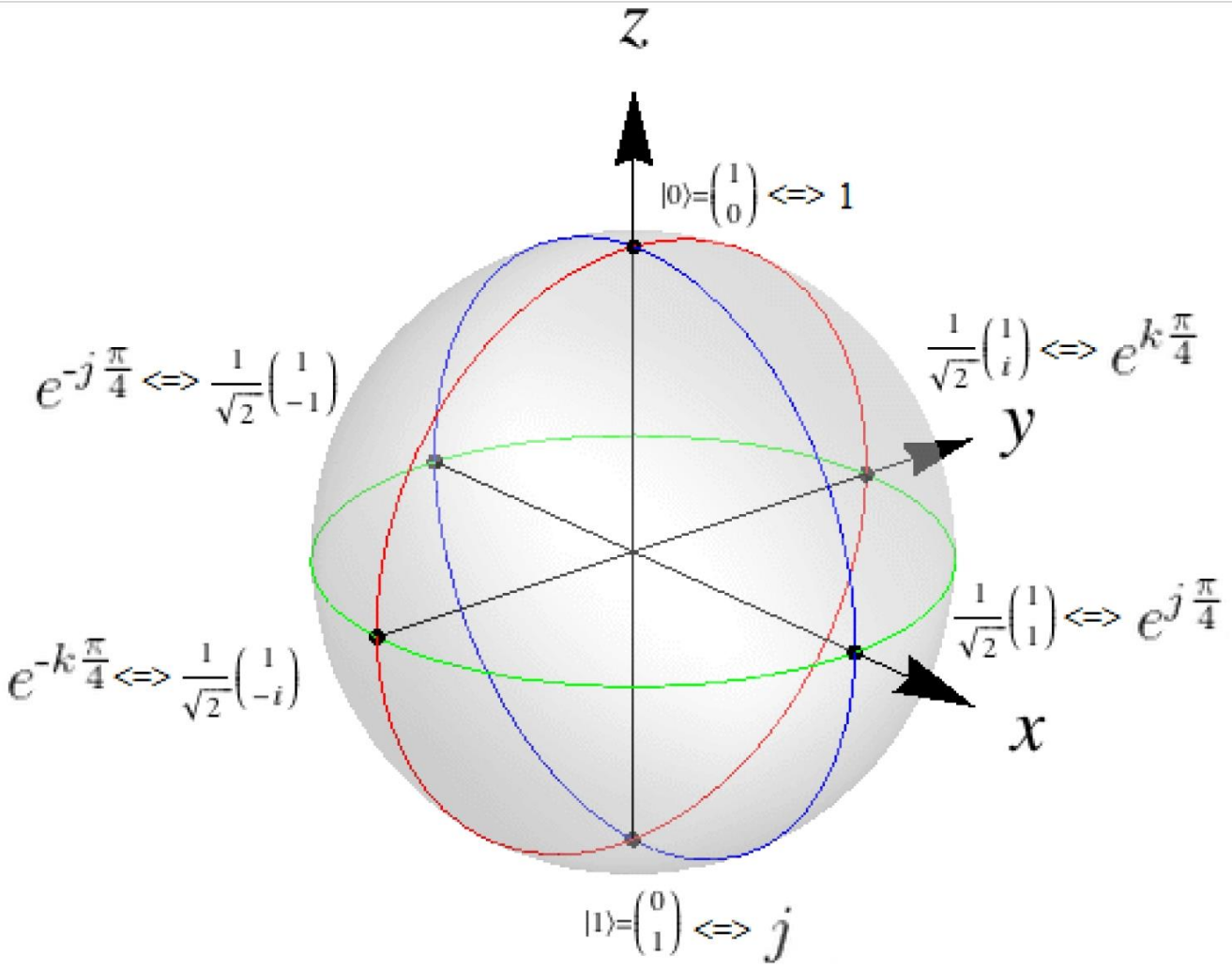
Quaternions Also Capture Bloch Sphere Math

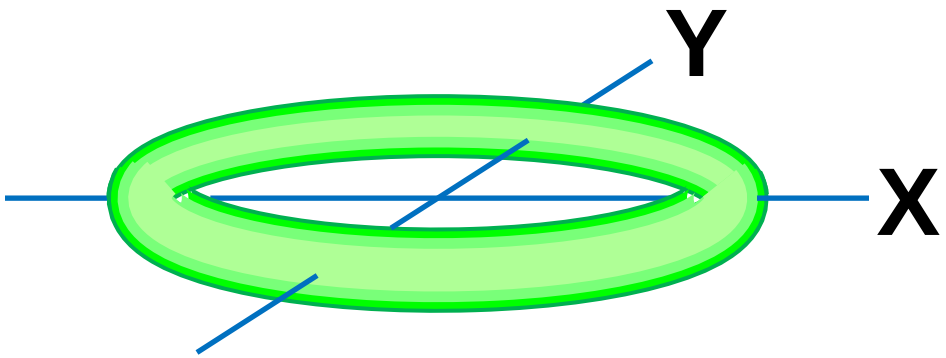


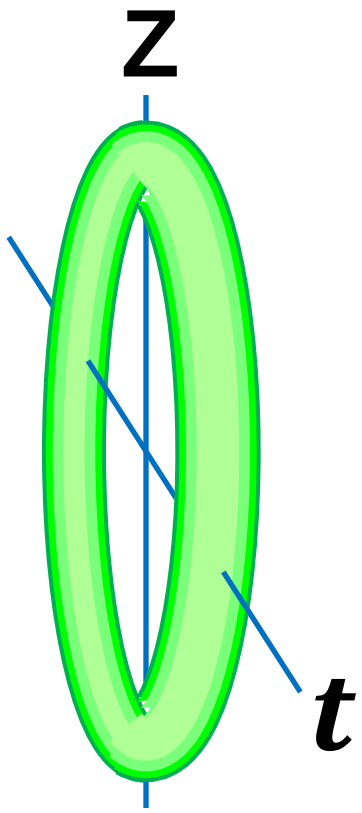
K. B. Wharton and D. Koch, *Unit Quaternions and the Bloch Sphere*, Journal of Physics A: Mathematical and Theoretical **48** (23), 235302 (2015). https://arxiv.org/abs/1411.4999, page 5, figure 1.

← *Six spinors with their quaternion equivalents mapped onto the Bloch sphere.*

Minimizing Quaternion Components

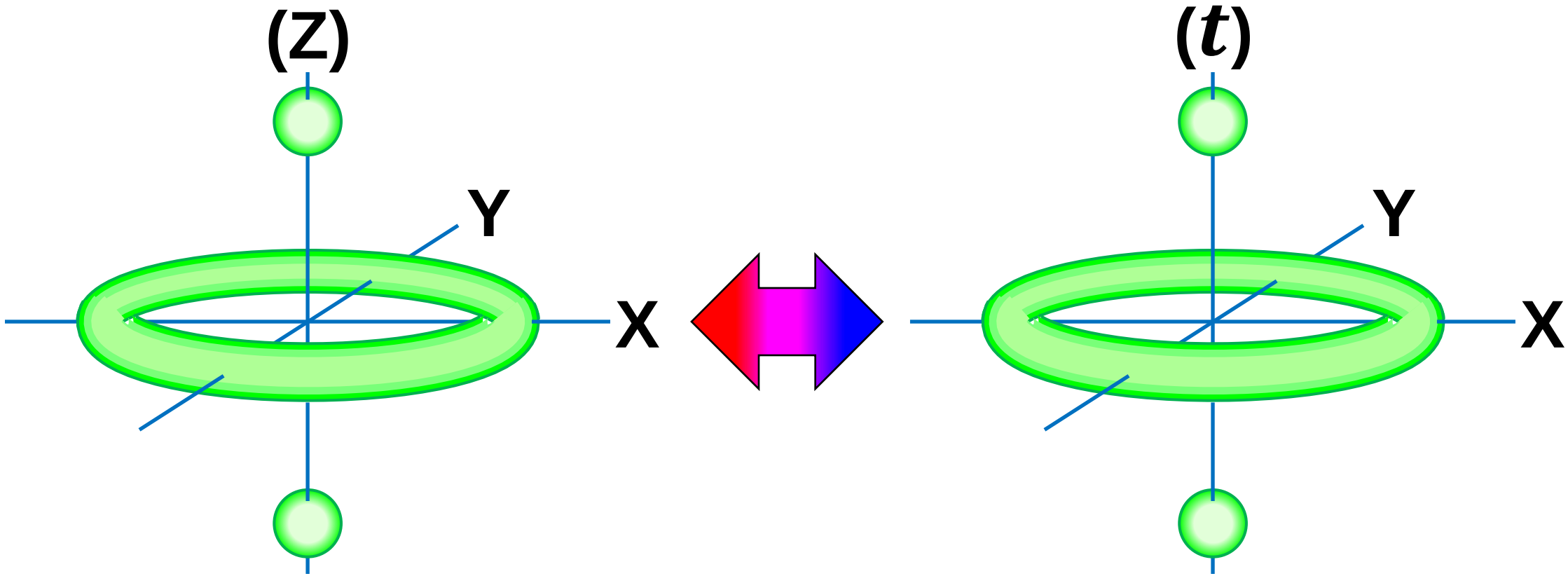
- When interpreted as *rotations*, quaternions break down into two rotating rings, each of which is *fully perpendicular* to the other.
- These two rings capture quaternion behavior in simpler terms.



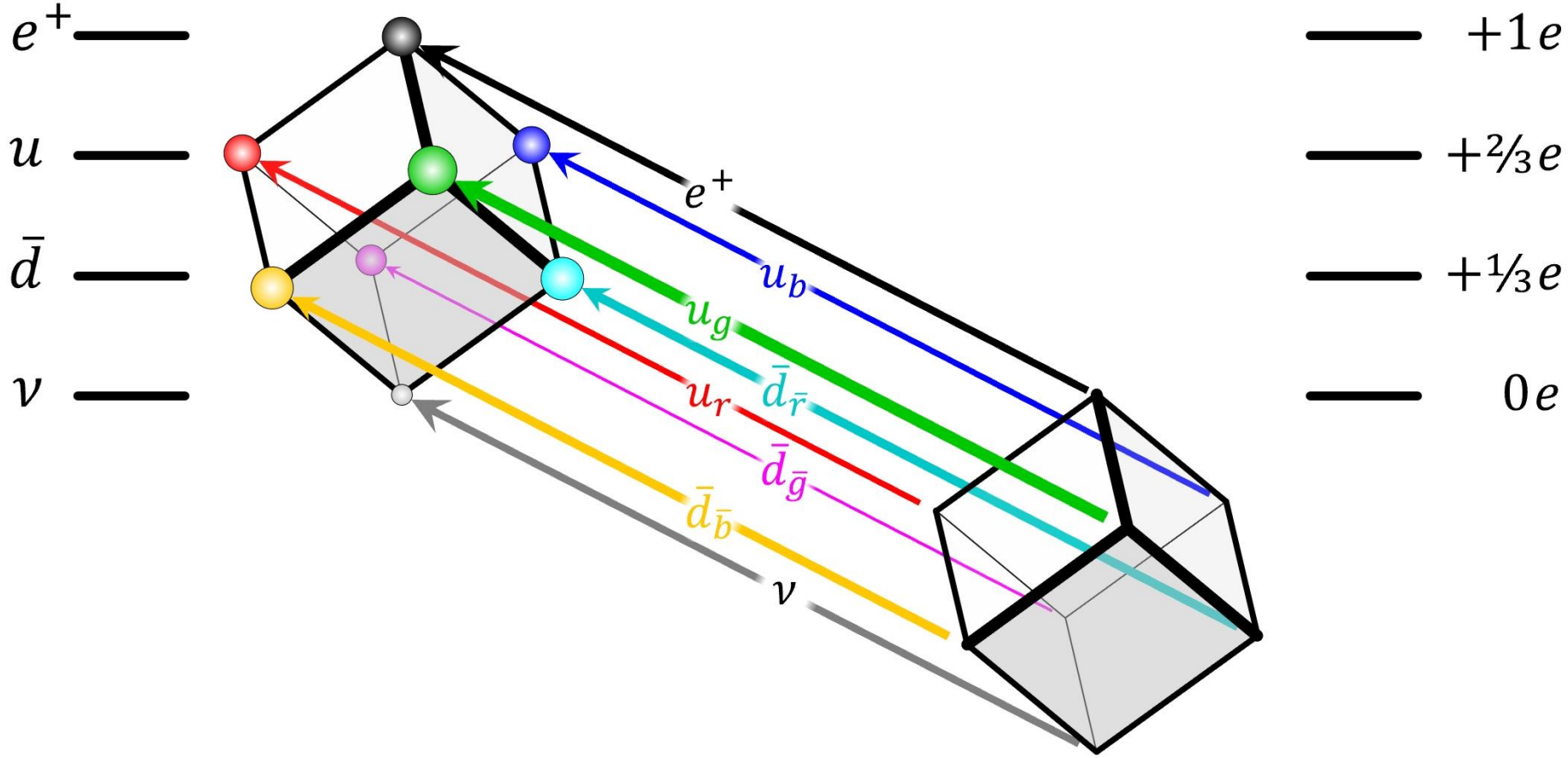


Use Intersection Slicing Instead of Fiber Mapping

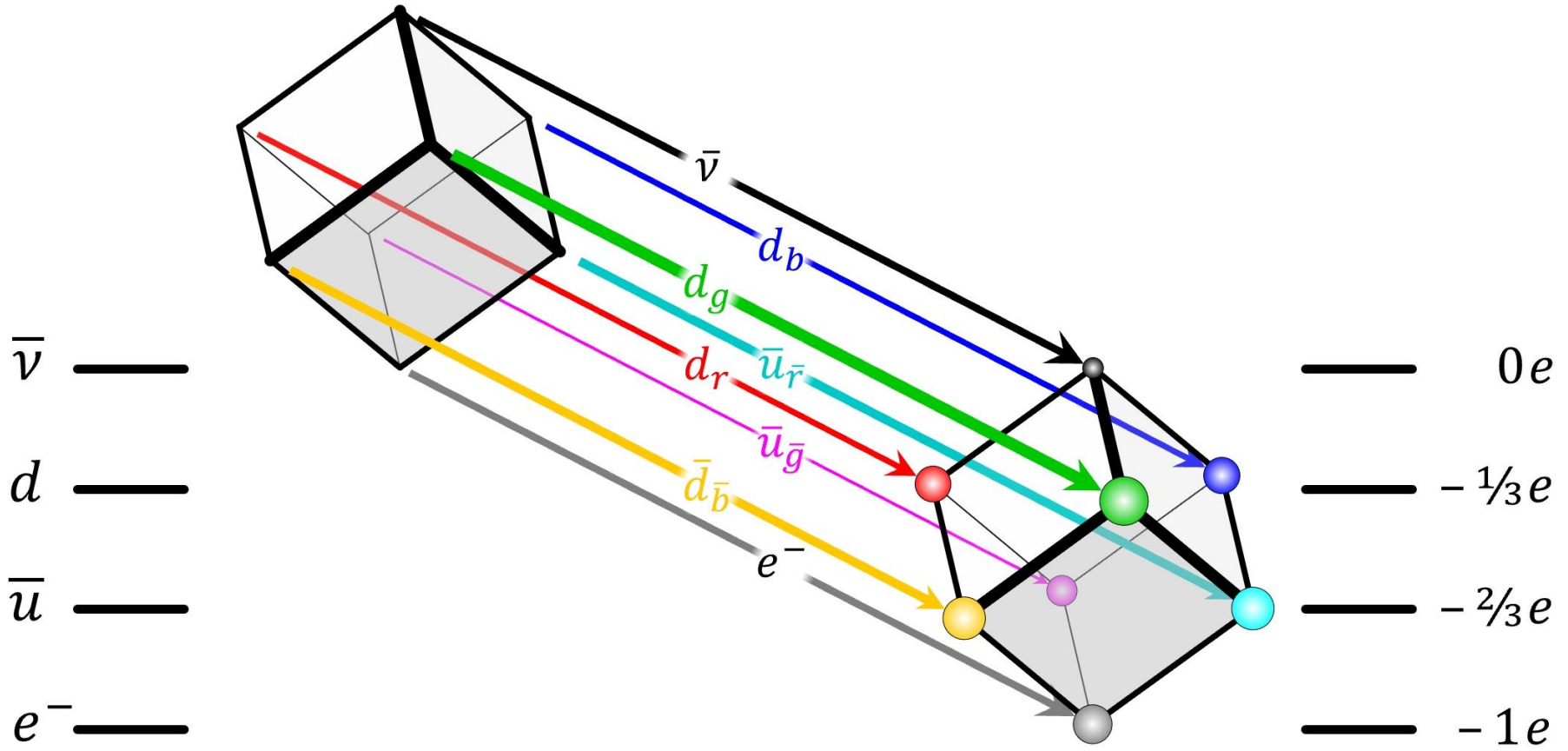
- Rotations in XY become *angular momentum*.
- Rotations in Zt become *quantum phase* (energy).



First Generation "Up" Fermions as T_3 Weak-Isospin Tesseract Bridge Vectors

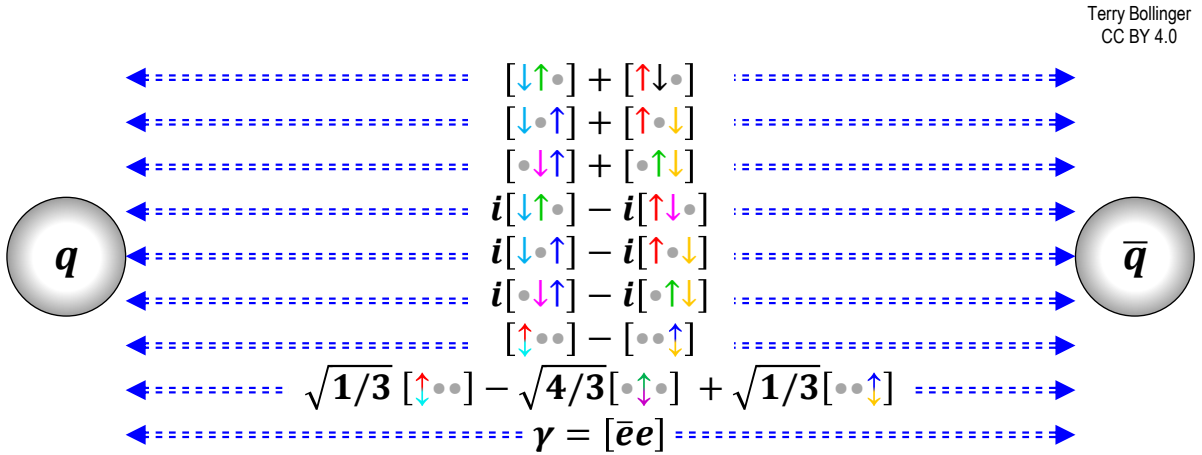


First Generation "Down" Fermions as T_3 Weak-Isospin Tesseract Bridge Vectors



The 9, 3, and 1 Views of Internal Pion Forces

The Nine Standard Model Force Particles in Pions



The Three Tohu Force Particles in Pions

The Single Imposition Force Particle in Pions

Summary

- Physics is simpler than it seems, but also a lot stranger because space and time become properties of matter.
- Much of the complexity in current theory is c-bit noise created by using 1700s continuum math idealizations of classical physics in domains where only create non-physical noise.
- The goal of physics should be to create elegant, extremely sparse models in which persistent bits are rare and precious.
- Understanding space and time better are critical.
- March 15: The missing parameter that makes space fractal.