



# Revisiting the Casimir Effect

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*Presented at:* **Washington Quantum Computing Meetup (on OrionX YouTube)**

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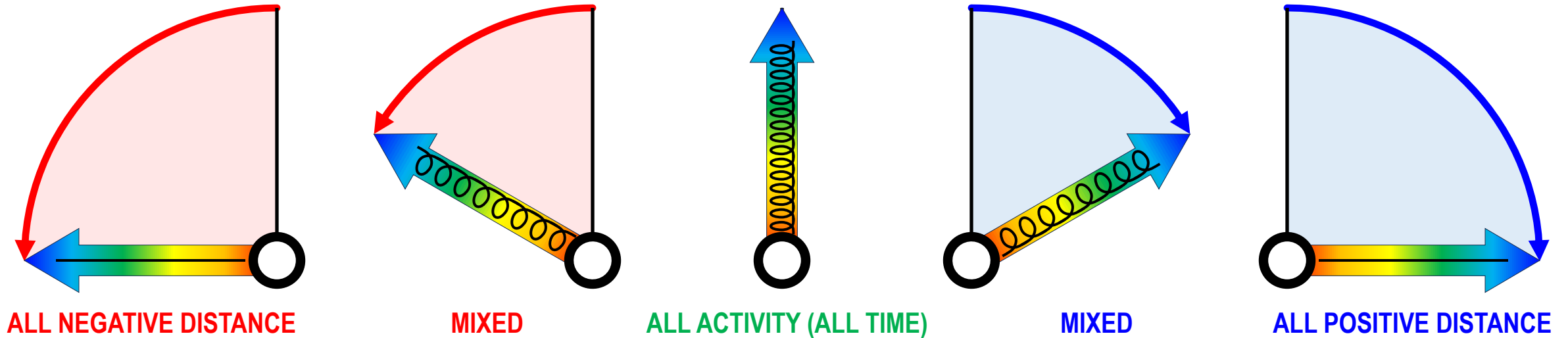


# Part I. The Deeper Casimir Problem: The State-Machine Universe (SMU)

# Beneath Space and Time Lies A **State Machine**

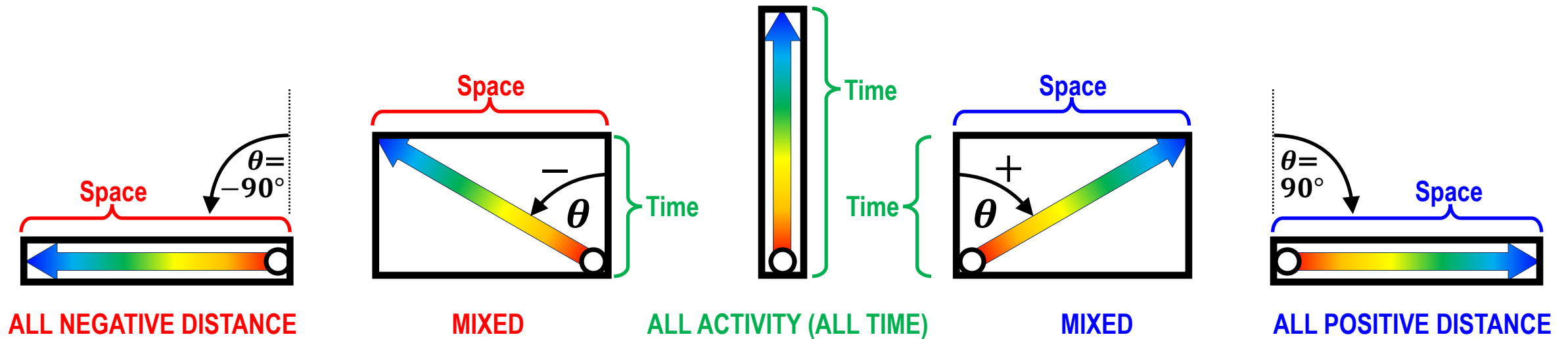
- All *testable* definitions of space and time require **matter and energy**
- All *testable* definitions of space and time require an **energy history**
- Result: Inertial frame spacetime definitions become *local only*
- Question: **If spacetime maths are *not* universal, what maths *are*?**
- Answer: **State machines**
  - **Every** inertial frame instance becomes a *subset* state machine
  - Space and time become *behavior patterns* encoded onto those subsets
- The universe remains **large-scale deterministic**. However, ...
- All concepts of “**space**” and “**time**” as *entities* (fabrics) disappear

# Dynamics: 1 DAU (Distance-Activity Unit) per Cycle



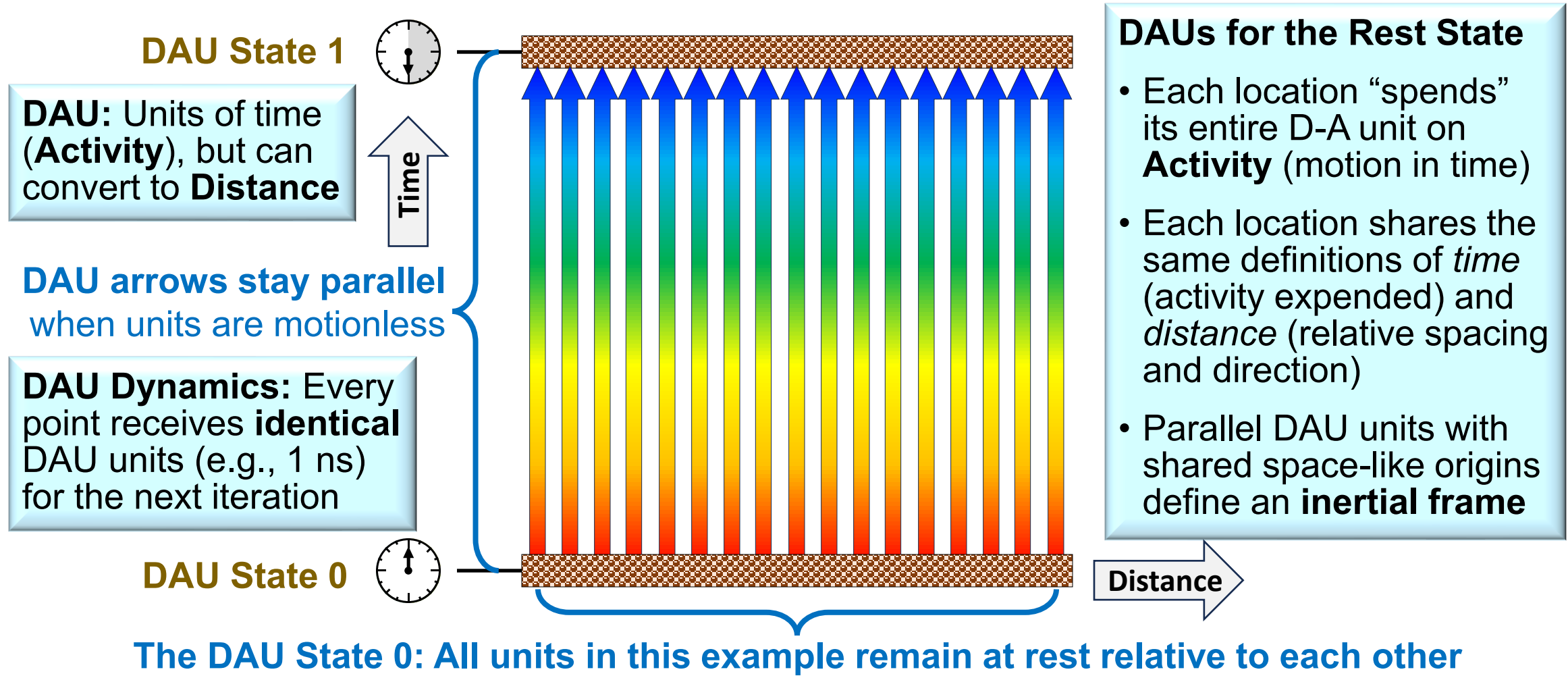
- One DAU per cycle **transforms its attached matter unit** to a new state
  - **Vertical DAU** = 100% Activity transformation (passage of time)
  - **Horizontal DAU** = 100% Distance transformation (relocation in space)
- **Matter units** are vastly multiscale, from **particles** to **cosmic “walls”**
- “Speed” movie analogy: **Activity = loops**, **Distance = straight driving**
  - Motion **cannot stop**, so the only options are loops (**time**) or travel (**distance**)

# Adouane-Bollinger Diagonal (ABD) Spacetime

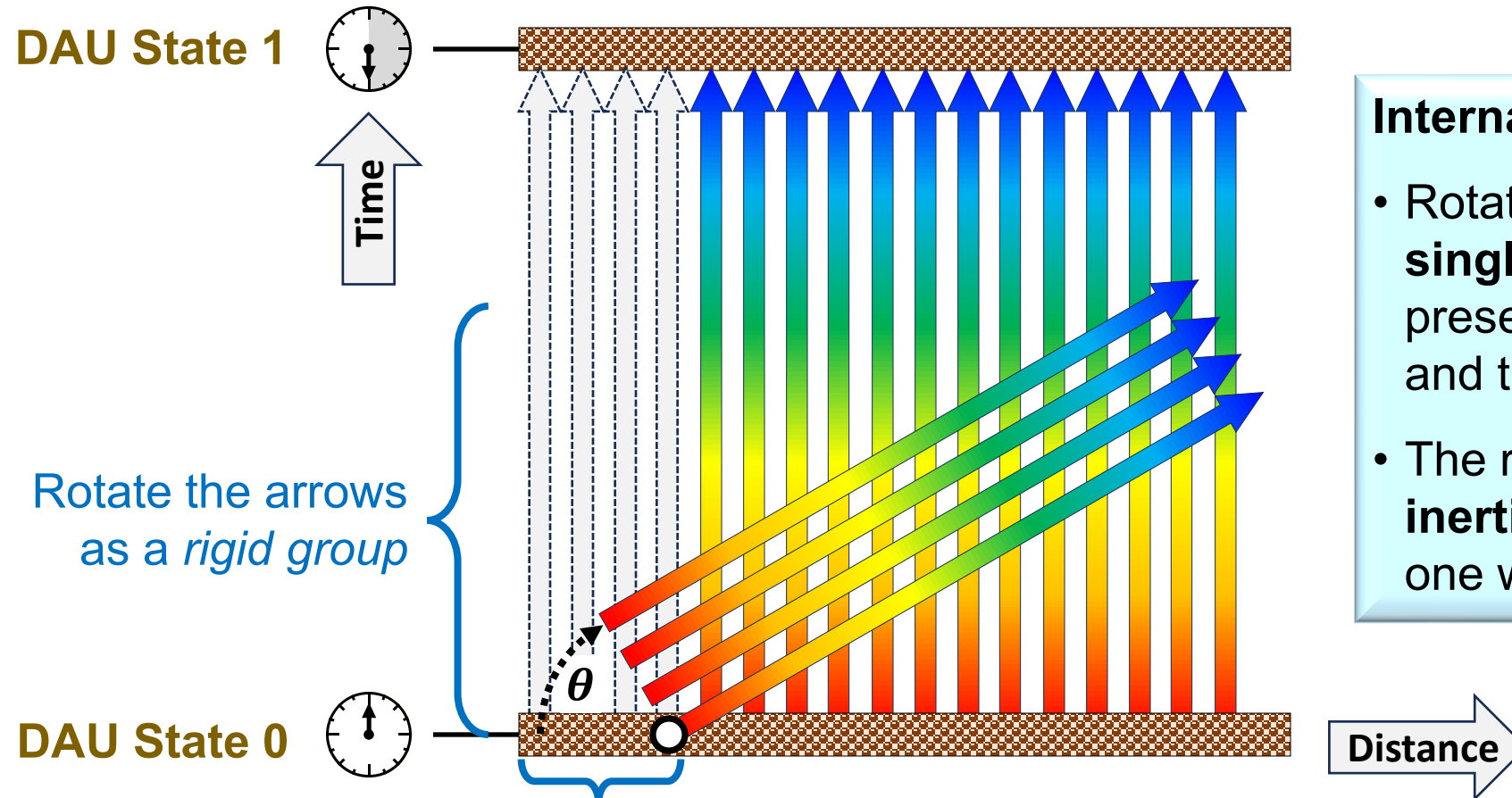


- An impressive simplification by the [EttanEhsan YouTube](#) channel:
  - Every choice of a DAU unit angle ( $\theta$  in the figures) forms a box
  - The DAU unit stays the same length and forms the diagonal of the box
  - The box fully defines the *interchangeability of space and time*
  - Its **height** defines the **time elapsed** for that unit during this cycle (cosine  $\theta$ )
  - Its **width** defines the **space traveled** during this cycle (sine  $\theta$ )

# At-Rest (Largest Possible) Spacetime Operator Set



# Tilting DAU Arrows Converts Some Time to Distance



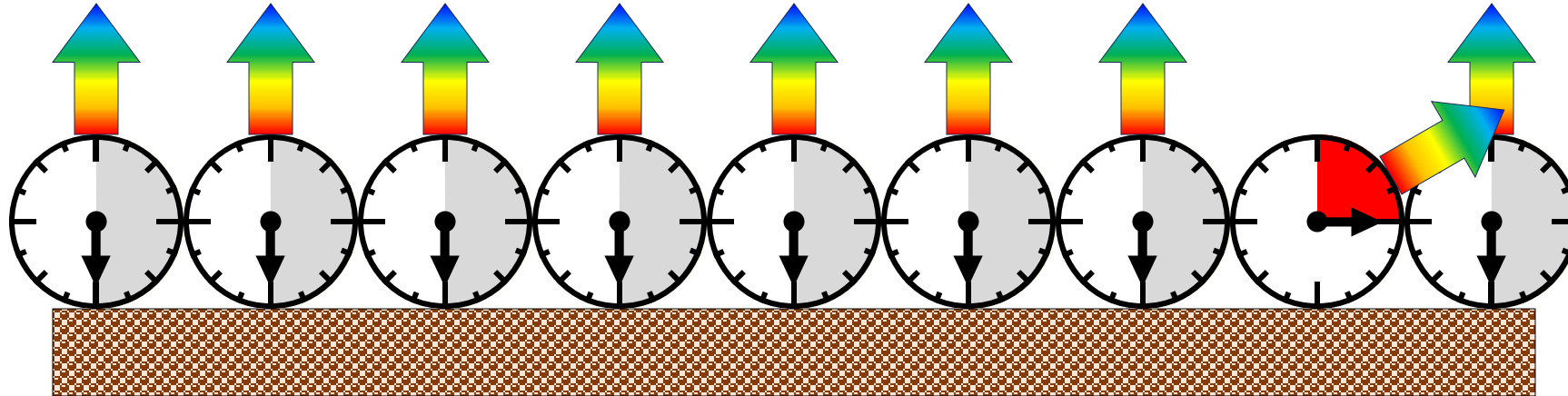
## Internal results:

- Rotating arrows as a **single rigid group** preserves their space and time relations
- The result is a **valid inertial frame**, but one with a *limited size*

**Items with grouped DAU arrows must be prepared in advance:**

They must be moved closer together, and their rear clocks must be set forward in time

# The Universe as a State Machine

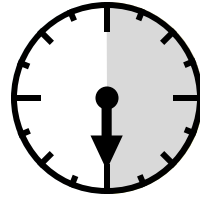


## The DAU model *is not* a “spacetime” model

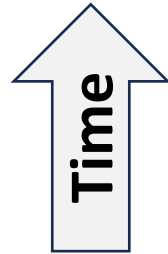
- The DAU model is a *state machine* model
- The fermionic universe is the state machine, and is the *only* reality that exists. Physics drives its state transitions.
- Time and space exist only as *transformation operators*

# Physics As a Parallel-Execution State Machine

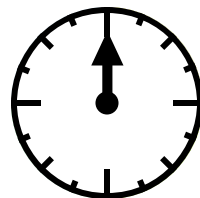
State 1



← Largest frame



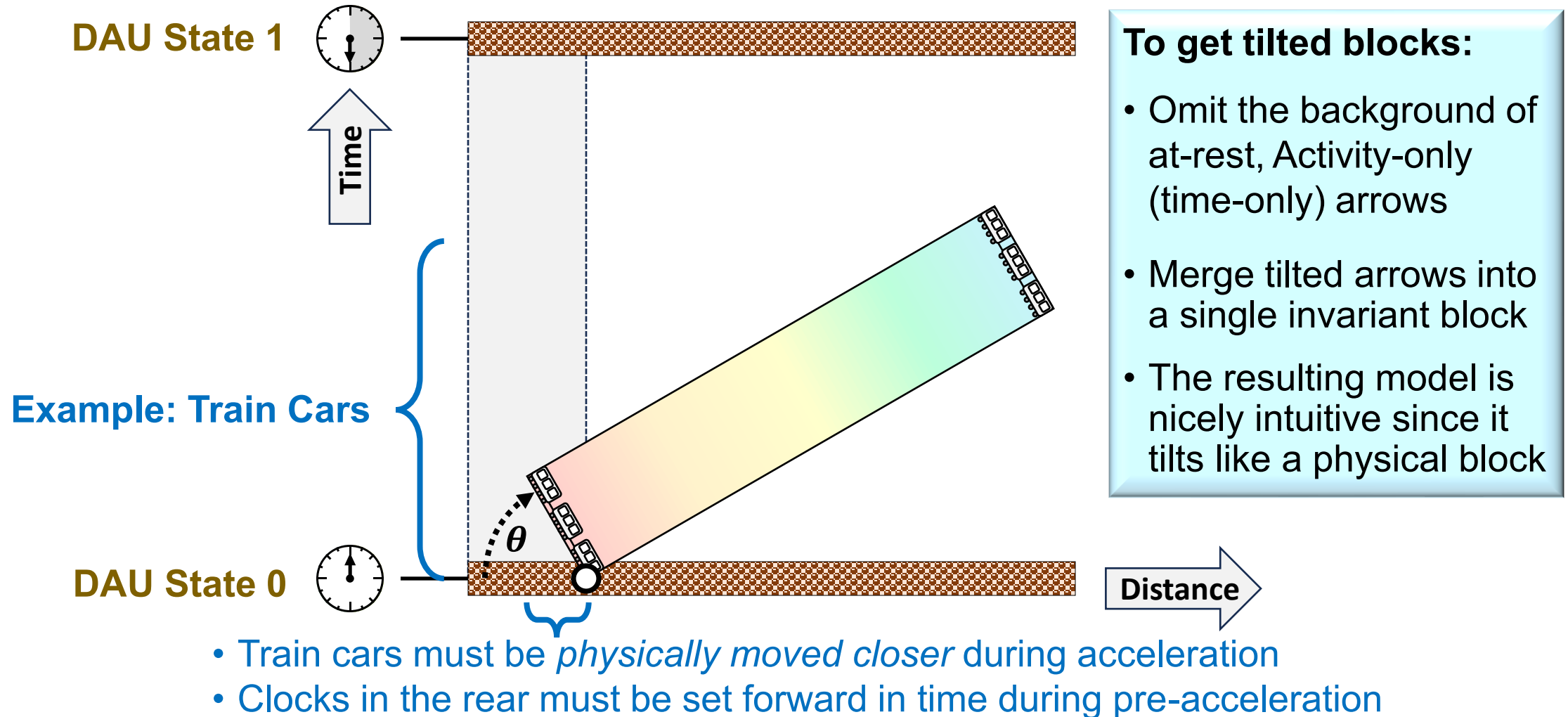
State 0



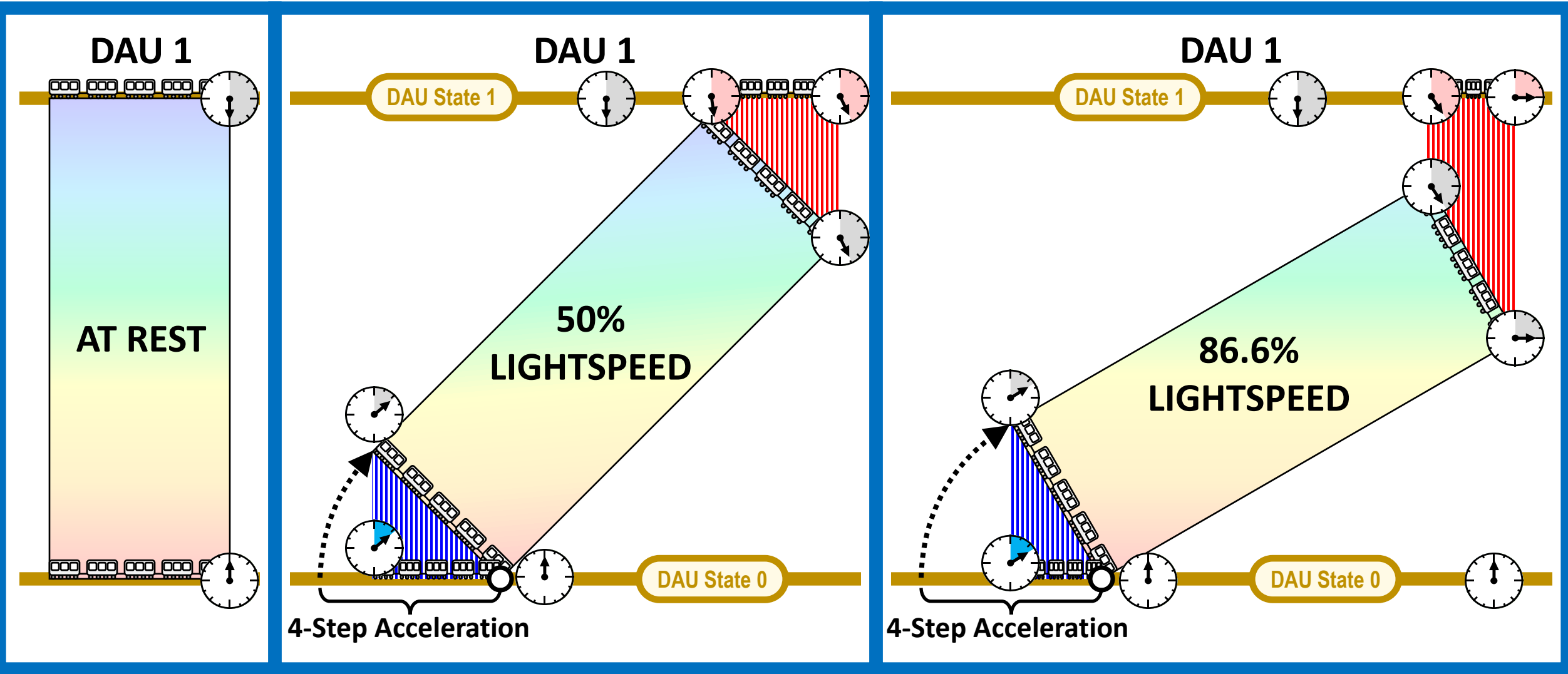
← Largest frame



# A Simpler Visual: The *Tilted Block* Formalism

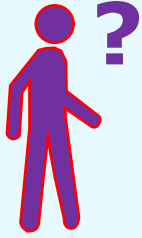


# Three Examples of Tilted-Block Relativity (TBR)



# Acceleration Requires Four Irreversible Transformations

**(1)**  
SELECT



Select GPS satellites for boosting to a new shared inertial frame

**(2)**  
SQUEEZE



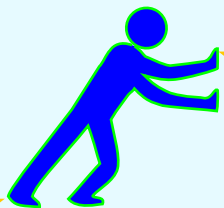
Squeeze (physically shorten) the distances between the satellites

**(3)**  
SYNC

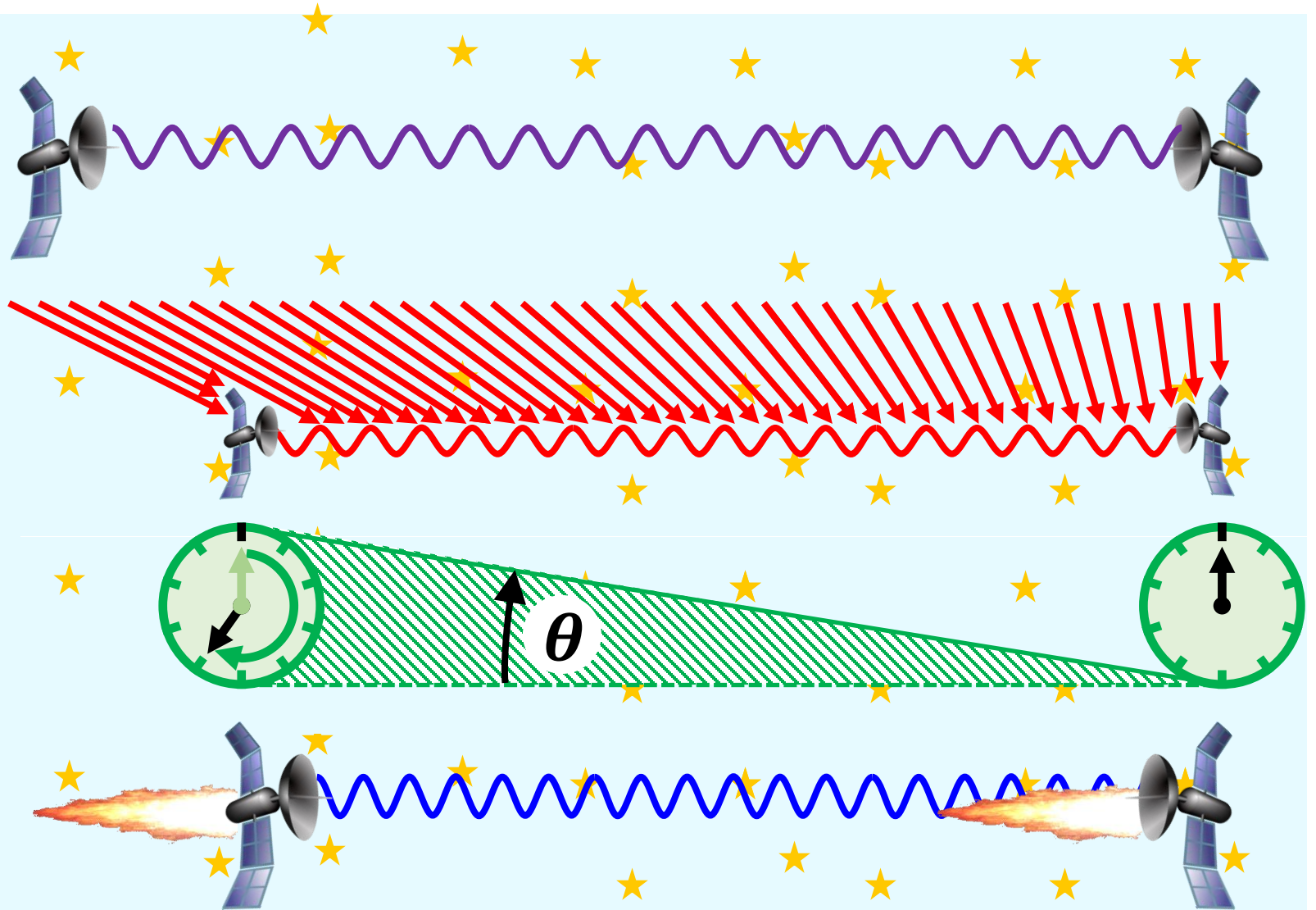


Sync their clocks by falsely "aging" (resetting) rearward clocks

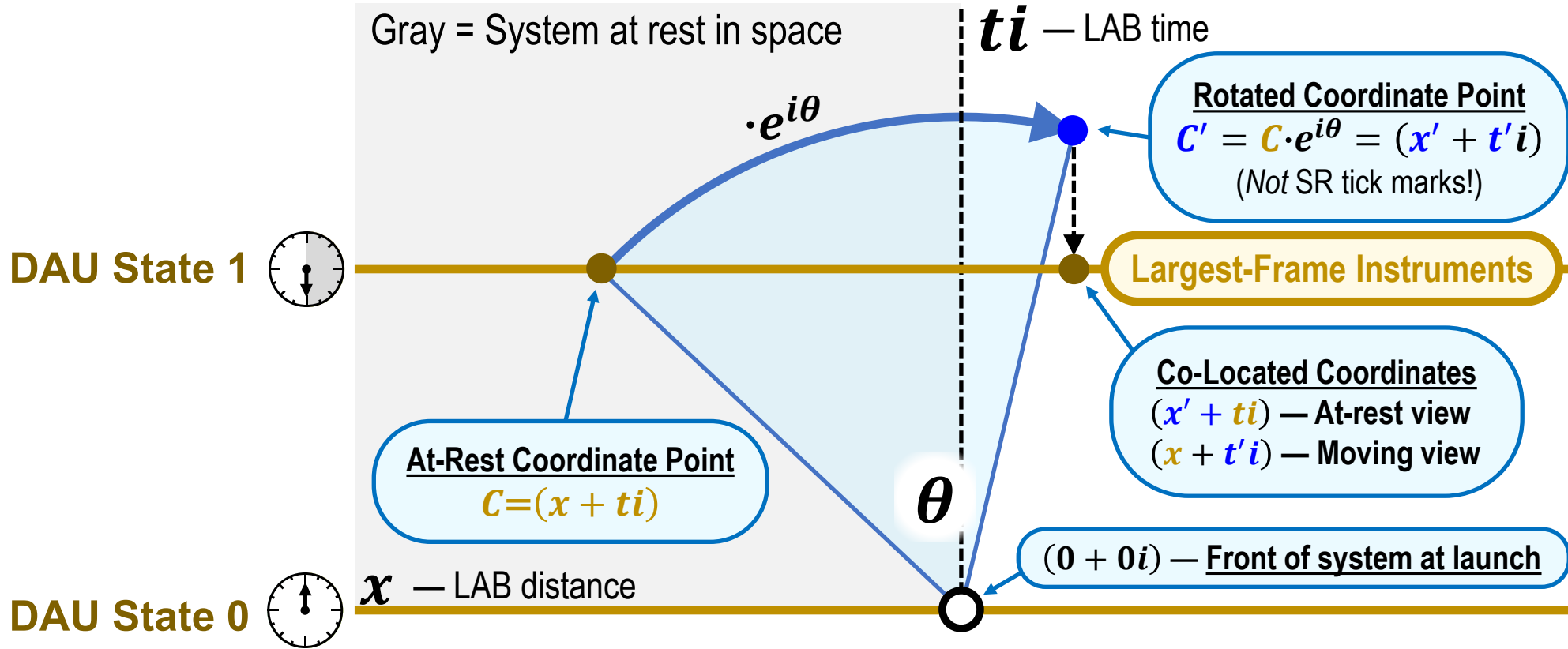
**(4)**  
SEND



Send the satellites by pushing each one separately



# Pre-Spacetime Math: Complex Plane Relativity (CPR)



$$C' = C \cdot e^{i\theta} = (x' + t'i) \text{ where } x' = \text{Re } C \cdot e^{i\theta} \text{ and } t' = \text{Im } C \cdot e^{i\theta}$$

$$C_R = C_{Rest} = (x' + ti), \quad C_M = C_{Moving} = (x + t'i) = M(C_M)$$

# Is SMU a “Simulated Universe” Model?

## ➤ Nope.

- Despite its use of the computer-compatible state machine model, *SMU does not postulate a separate substrate executing the model*
- Instead, SMU asserts that physics exists because what we call *matter and energy are organized as a state-machine structure*
- The SMU dependence on matter for state storage means:
  - “Now” as defined by the SMU is the *only* reality (*no block universes*)
  - There is *barely enough storage for one universe* (*no multi-worlds*)
  - All quantum phenomena involve loss of spacetime detail (*fuzzy spacetime*)
  - *Quantum Field Theory needs a full rewrite* (but with the *same* predictions)

# Does SMU Mean Space is More Fundamental than Time?

- No, but SMU requires a very different interpretation of “distance”
- Without “space,” separation of local states (units) cannot occur
- Just as time emerges from “looping” of an irresistible direction of change, distance emerges from state-isolating forms of looping
- The same effects that give rise to well-separated radio frequencies give rise to well-separated states that we think of as “distances”
- The role of *momentum space* (reciprocal space) is critical:
  - Location space and momentum space form a *broken symmetry*
  - The severe compaction of momentum space enables vast “space” distance
  - This is one of the most intriguing future topics for the SMU model



# Part II. Minkowski Space Is a Math Error

# What Happened to Minkowski Space?

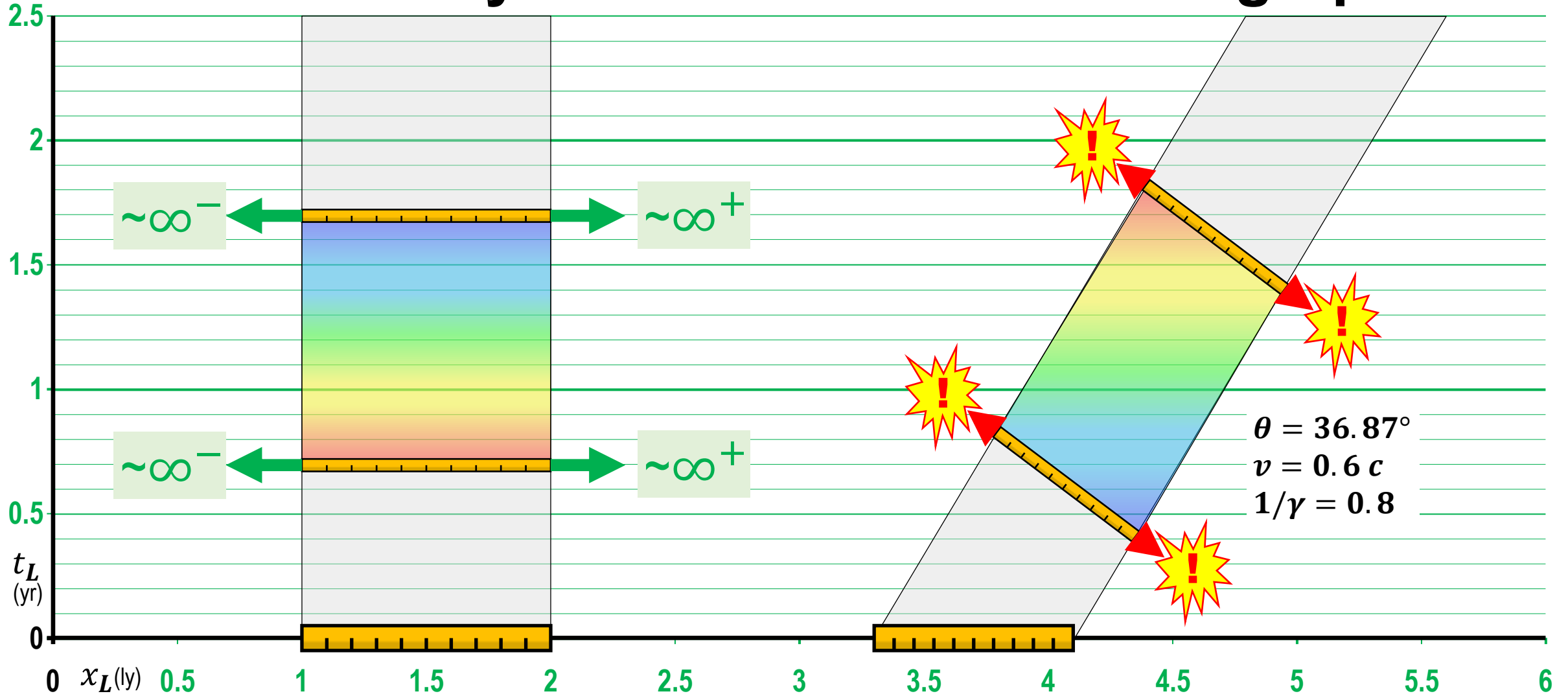
- All of the Poincaré/Lorentz transforms *still apply*
  - Creating a new inertial frame creates a new definition of space and time
  - That definition is as *valid internally* as any other spacetime definition
  - However, *the new definitions apply only within the created inertial frame*
  - Non-trivial scoping (acceleration tracking) eliminates *all* time “paradoxes”
  - *Multiple spacetimes apply* to every subset of the largest available frame
- The negative time signature of Minkowski space is a math error
  - Leonard Susskind described beautifully why the minus exists:  
L. Susskind, *The Proper Time Invariant*, in *Special Relativity Lecture 1*, Stanford (YouTube), Apr. 26, 2012. <https://youtu.be/toGH5BdgRZ4?t=1h31m21s>
  - The error (Einstein): Assuming frames can always share the same origin

# Einstein's Subtle Shared-Origins Error

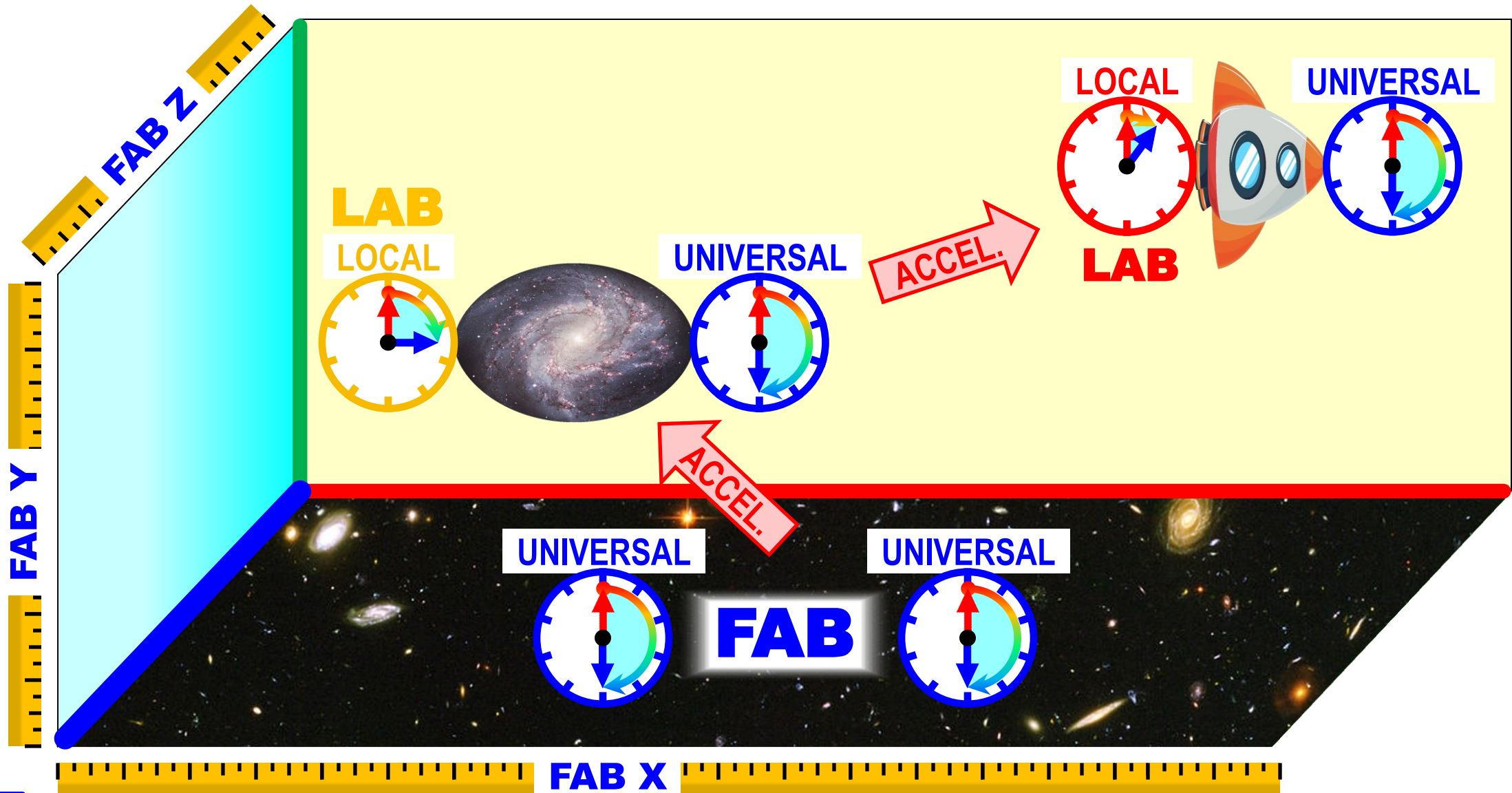
- To derive his inertial frame coordinate transformation equations, Einstein assumed in 1907 [1] that one can:
  - “... choose as the starting point of time in both systems the moment at which the coordinate starting points  $[(t, x, y, z)=(0,0,0,0)$  and  $(t', x', y', z')=(0,0,0,0)]$  coincide;”
- This violate the tilted-block principle that time resets must place the zero point at the *front* of the tilted block to prevent time paradoxes

[1] A. Einstein, *Coordinate-Time Transformation* [Sec. 3, pp. 418–420, in ‘*About the Principle of Relativity and the Conclusions Drawn from It*,’ pp. 411–462], *Jahrbuch der Radioaktivität und Elektronik* **4** (4), 418–420 (1907). See Section 3, page 418. <https://sarxiv.org/ref.1907-04-04.0418.engl.pdf>

# There Is Always a Euclidean Embedding Space

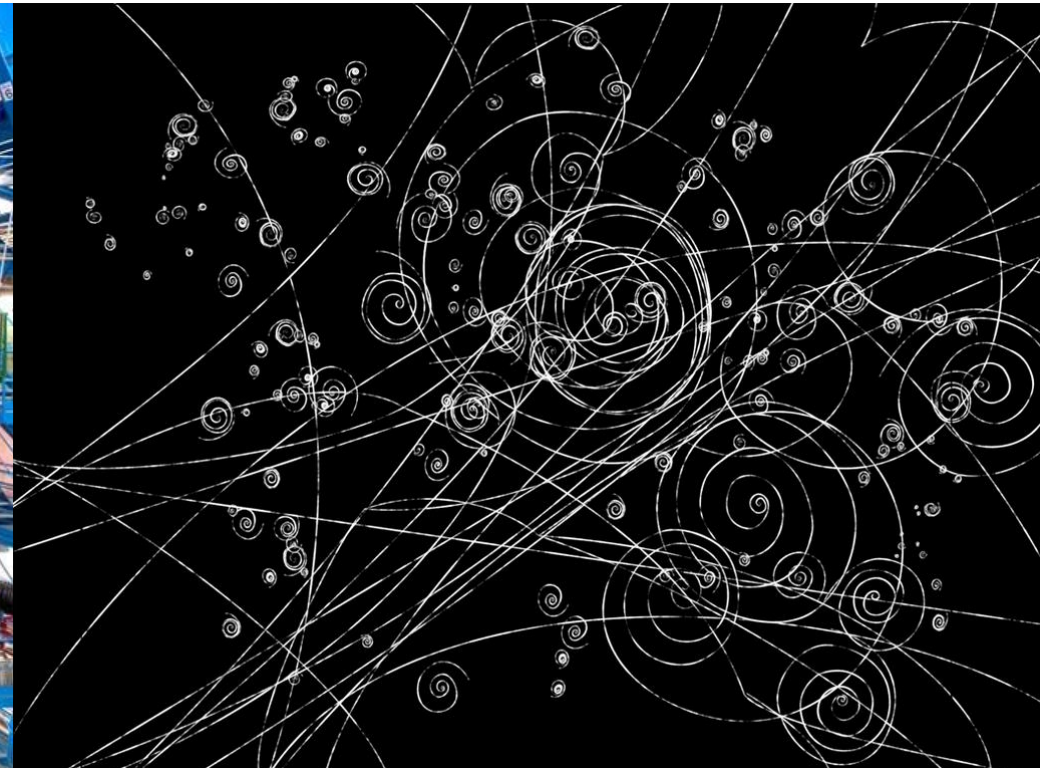
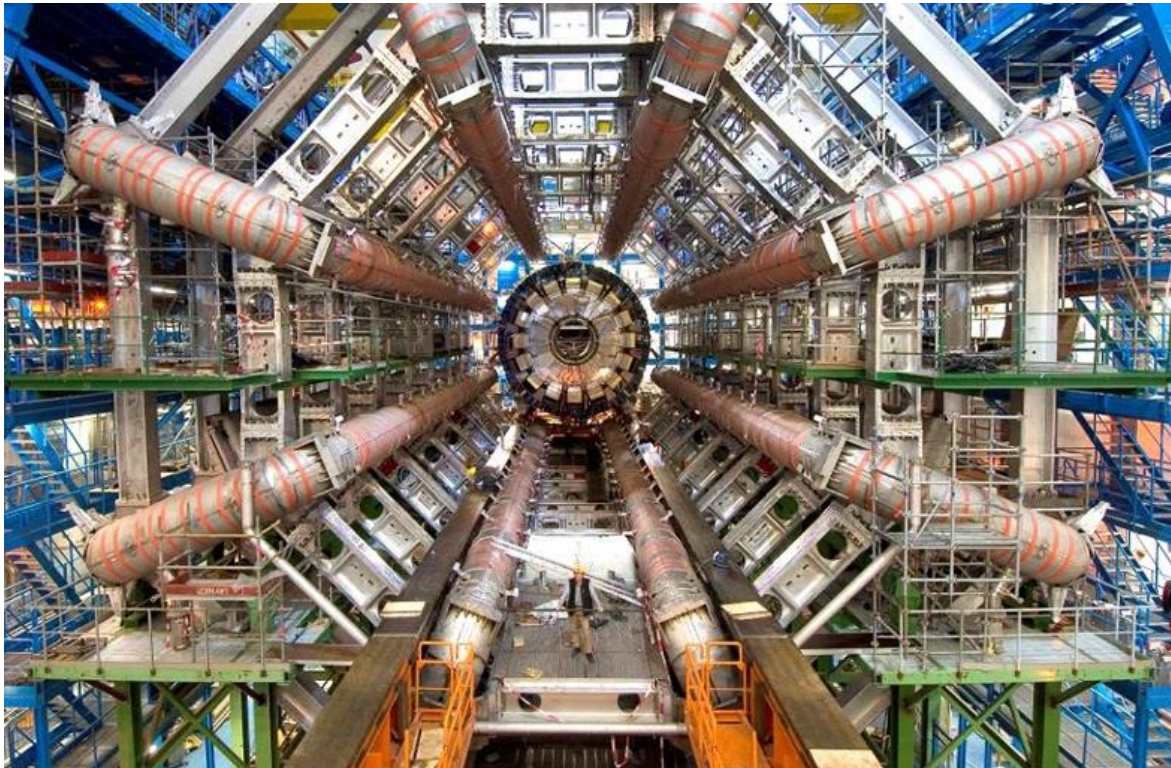


# First / Latest Ancestral Bubble (FAB / LAB) Coordinates



# Real-World Examples of LAB Euclidean Invariants

- Question: Are Last Ancestral Bubble (LAB) viable experimentally?
- Answer: Of course they are. CERN uses them to record its data.



# Minkowski and Differential Geometry

- Another problem: In a state machine formulation, Minkowski's "substance" hypothesis disappears entirely:

*"To never let a yawning emptiness, let us imagine that everywhere and at any time, something perceivable exists. In order not to say matter or electricity, I will use the word 'substance' for that thing."*

— H. Minkowski, Space and Time. 80<sup>th</sup> Assembly of German Natural Scientists and Physicians, [Sep. 21] (1908). <http://www.minkowskiinstitute.org/mip/books/minkowski.html>

- Minkowski used this assumption to argue that special relativity is a purely **geometric concept based on his lengthy "world lines."**
- Important implication: **Differential geometry is *not* the foundation of the universe.** Like spacetime, differential geometry only *emerges*.

# Einstein v1 on Minkowski's "World Lines" Relativity

Einstein was *not* happy and *not* afraid to say so.

*"When, later on, Minkowski built up the special theory of relativity into his 'world-geometry,' Einstein said on one occasion: 'Since the mathematicians have invaded the theory of relativity, I do not understand it myself any more.'"*

— A. Sommerfeld, *To Albert Einstein's Seventieth Birthday*, in 'Albert Einstein: Philosopher, Scientist,' P. A. Schilpp, Ed., in 'The Library of Living Philosophers,' Volume VII, Open Court, 1949, pp. 97–106. Page 102.

*Valentine Bergmann on what Einstein told him about the tensor model: "Superfluous learnedness"*

— A. Pais, *Subtle is the Lord: The science and the life of Albert Einstein*, Oxford University Press, 1982. Page 152.

Minkowski: *"With a hardy piece of chalk I can draw four world axes on the blackboard."*

— H. Minkowski, *Space and Time*. 80<sup>th</sup> Assembly of German Natural Scientists and Physicians, Sep 21, 1908.



Einstein, in a lecture about special relativity shortly after Minkowski's talk: *"This has been done elegantly by Minkowski; but chalk is cheaper than grey matter, and we will do it as it comes."* [Ouch!]

— George Pólya attended the lecture and reported the comment. Béla Bollobás reported Pólya comment in his *Littlewood's Miscellany*, Cambridge University Press, 1986. Page 152 (yes, same page number as the Pais quote).

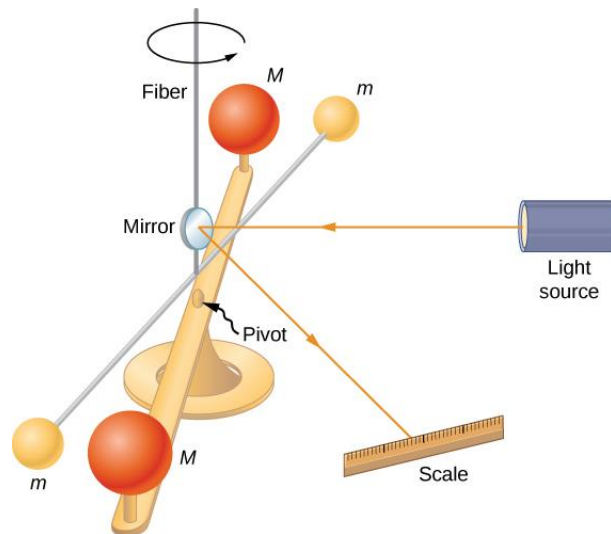


# Part III.

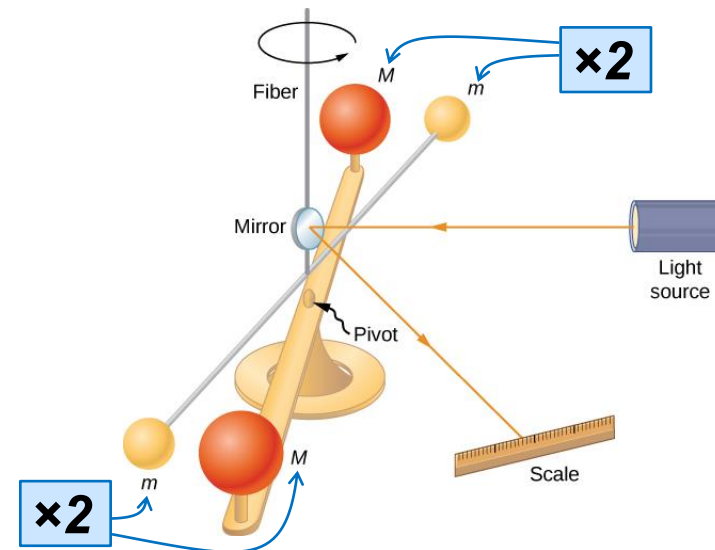
# New: Gravity as a Lorentz transform

# New: Gravity Transforms *Within* the State Machine

- SMU *requires* relativistic mass to be real and attached to matter
- The gravitational masses of instruments in a spaceship coasting at  $0.866 c$  are thus **doubled** relative to their pre-acceleration masses
- How, then, is Einstein's full inertial-frame symmetry preserved?



**Rest Masses  $M$  and  $m$  at Launch**



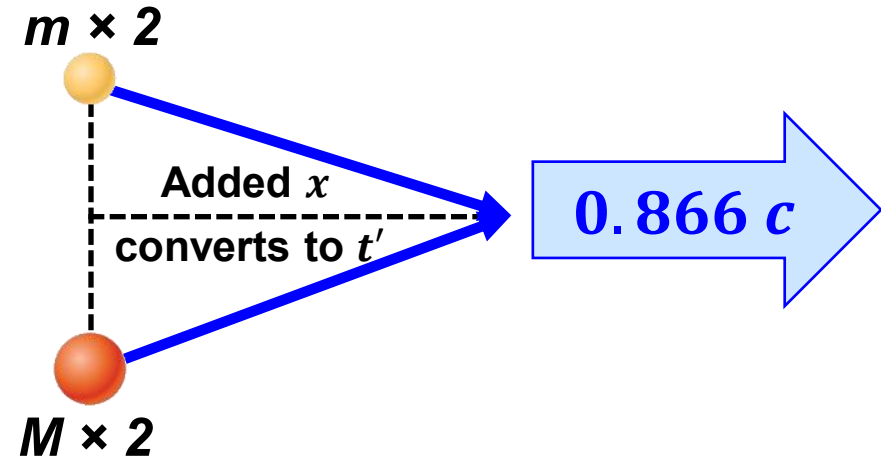
**Masses  $M$  and  $m$  *double* in the  $0.866 c$  system**

# Distance-to-Time Conversion Rescues Gravity

- Increases in their masses cause moving balls to collide faster
- However, their shared velocity adds length to the interactions
- Conversion of length to time delays the collision in the moving view
- Implication: Gravity transforms *within* Euclidean special relativity



**$M$  and  $m$  collide in a time defined by their masses**



**$M$  and  $m$  collide faster, but the moving unit sees the added distance as additional time-to-collision**



# Part IV. Reference Library of Casimir Papers

# A Few Casimir Effect Papers (1 of 5)

- [1] H. Nikolić, *Emergent Diffeomorphism Invariance in Toy Models*, Fortschritte Der Physik 2300026 (2023). <https://arxiv.org/abs/2301.04448>
- [2] A. Albert et al. (HAWC Collaboration), *Constraints on Lorentz invariance violation from HAWC observations of gamma rays above 100 TeV*, Physical Review Letters **124**, 131101 (2020). <https://arxiv.org/abs/1911.08070>
- [3] H. Nikolić, *The Origin of Casimir Effect: Vacuum Energy or van Der Waals Force? [Slides]*, Modern Aspects of Quantum Physics (2018). <http://thphys.irb.hr/wiki/main/images/2/2c/Casimir.pdf>
- [4] H. Nikolić, *Is Zero-Point Energy Physical? A Toy Model for Casimir-like Effect*, Annals of Physics **383**, 181 (2017). <https://arxiv.org/abs/1702.03291>
- [5] H. Nikolić, *Proof That Casimir Force Does Not Originate from Vacuum Energy*, Physics Letters B **761**, 197 (2016). <https://www.sciencedirect.com/science/article/pii/S0370269316304567>
- [6] C. D. Markle, *On the Orientation Dependence of the Casimir Force [PhD Thesis]*, Washington University Open Scholarship, Dec 30, 2013. <https://openscholarship.wustl.edu/etd/1191/>

# A Few Casimir Effect Papers (2 of 5)

- [7] C. D. Markle and R. Cowsik, *General Approach to Casimir Force Problems Based on Local Reflection Amplitudes and Huygens' Principle*, *Physical Review A* **85**, 052516 (2012).  
<https://arxiv.org/abs/1203.5326>
- [8] B. C. Denardo, *Water Wave Analog of the Casimir Effect [Video]*, NPSPHYSICS (YouTube), June 29, 2012. <https://youtu.be/H-GnwnEnLCA>
- [9] B. C. Denardo, J. J. Puda, and A. Larraza, *A Water Wave Analog of the Casimir Effect*, *American Journal of Physics* **77**, 1095 (2009).  
[https://wucj.lab.westlake.edu.cn/Others/Casimir\\_effect.pdf](https://wucj.lab.westlake.edu.cn/Others/Casimir_effect.pdf)
- [10] Emok, *Casimir Forces on Parallel Plates [Figure]*, Wikipedia (2008).  
[https://en.wikipedia.org/wiki/Casimir\\_effect#/media/File:Casimir\\_plates.svg](https://en.wikipedia.org/wiki/Casimir_effect#/media/File:Casimir_plates.svg)
- [11] R. L. Jaffe, *The Casimir Effect and the Quantum Vacuum*, *Physical Review D* **72**, (2005).  
<https://arxiv.org/abs/hep-th/0503158>
- [12] S. K. Lamoreaux, *The Casimir Force: Background, Experiments, and Applications*, *Reports on Progress in Physics* **68**, 201 (2004).  
<https://courses.physics.ucsd.edu/2014/Fall/physics215a/project/Casimir-Review.pdf>

# A Few Casimir Effect Papers (3 of 5)

- [13] S. K. Lamoreaux, *Demonstration of the Casimir Force in the 0.6 to 6 Mm Range*, Phys. Rev. Letters **78**, 5 (1997). <http://web.mit.edu/~kardar/www/research/seminars/Casimir/PRL-Lamoreaux.pdf>
- [14] J.-L. Thiffeault, M. Purcell, and R. Correll, *What a Rindler Observer Sees in a Minkowski Vacuum*, PHY 387M, Relativity Theory Course, the University of Texas at Austin (1993). <https://people.math.wisc.edu/~jeanluc/talks/rindler.pdf>
- [15] J. Schwinger, L. L. DeRaad Jr, and K. A. Milton, *Casimir Effect in Dielectrics*, Annals of Physics **115**, 1 (1978). <https://www.sciencedirect.com/science/article/abs/pii/0003491678901720>
- [16] T. H. Boyer, *Quantum Electromagnetic Zero-Point Energy of a Conducting Spherical Shell and the Casimir Model for a Charged Particle*, Physical Review **174**, 1764 (1968). <http://web.mit.edu/~kardar/www/research/seminars/Casimir/PR-Boyer68.pdf>
- [17] E. J. W. Verwey and J. Th. G. Overbeek, *Theory of the Stability of Lyophobic Colloids*, Journal of Colloid Science **10**, 224 (1955). [https://dspace.library.uu.nl/bitstream/handle/1874/16118/verwey\\_55\\_theory.pdf](https://dspace.library.uu.nl/bitstream/handle/1874/16118/verwey_55_theory.pdf)

# A Few Casimir Effect Papers (4 of 5)

- [18] J. Th. G. Overbeek and M. J. Sparnaay, *Experiments on Long-Range Attractive Forces between Macroscopic Objects*, *Journal of Colloid Science* **7**, 343 (1952).  
[https://dspace.library.uu.nl/bitstream/handle/1874/18537/overbeek\\_52\\_experiments.pdf](https://dspace.library.uu.nl/bitstream/handle/1874/18537/overbeek_52_experiments.pdf)
- [19] E. J. W. Verwey, *Theory of the Electric Double Layer of Stabilized Emulsion*, *Proc. Konink. Nederland. Akad. Wetenschap* **53**, 375 (1950).  
<https://dwc.knaw.nl/DL/publications/PU00018788.pdf>
- [20] H. B. G. Casimir, *On the Attraction between Two Perfectly Conducting Plates*, in *Proc. Kon. Ned. Akad. Wet.*, Vol. 51 (1948), p. 793.  
<https://dwc.knaw.nl/DL/publications/PU00018547.pdf>
- [21] H. B. G. Casimir and D. Polder, *The Influence of Retardation on the London-van Der Waals Forces*, *Physical Review* **73**, 360 (1948).  
<https://www.mit.edu/~kardar/research/seminars/Casimir/PR-CasimirPolder48.pdf>
- [22] E. J. W. Verwey and J. Th. G. Overbeek, *Theory of the Stability of Lyophobic Colloids: The Interaction of Sol Particles Having an Electric Double Layer* (Elsevier Publishing Company Inc., 1948). <https://www.damtp.cam.ac.uk/user/gold/pdfs/teaching/VerweyOverbeek.pdf>

# A Few Casimir Effect Papers (5 of 5)

- [23] E. J. W. Verwey, *Theory of the Stability of Lyophobic Colloids [Paper]*, The Journal of Physical Chemistry **51**, 631 (1947). <https://pubs.acs.org/doi/epdf/10.1021/j150453a001>
- [24] H. C. Hamaker, *The London-van Der Waals Attraction between Spherical Particles*, Physica **4**, 1058 (1937). <https://www.damtp.cam.ac.uk/user/gold/pdfs/teaching/hamaker.pdf>

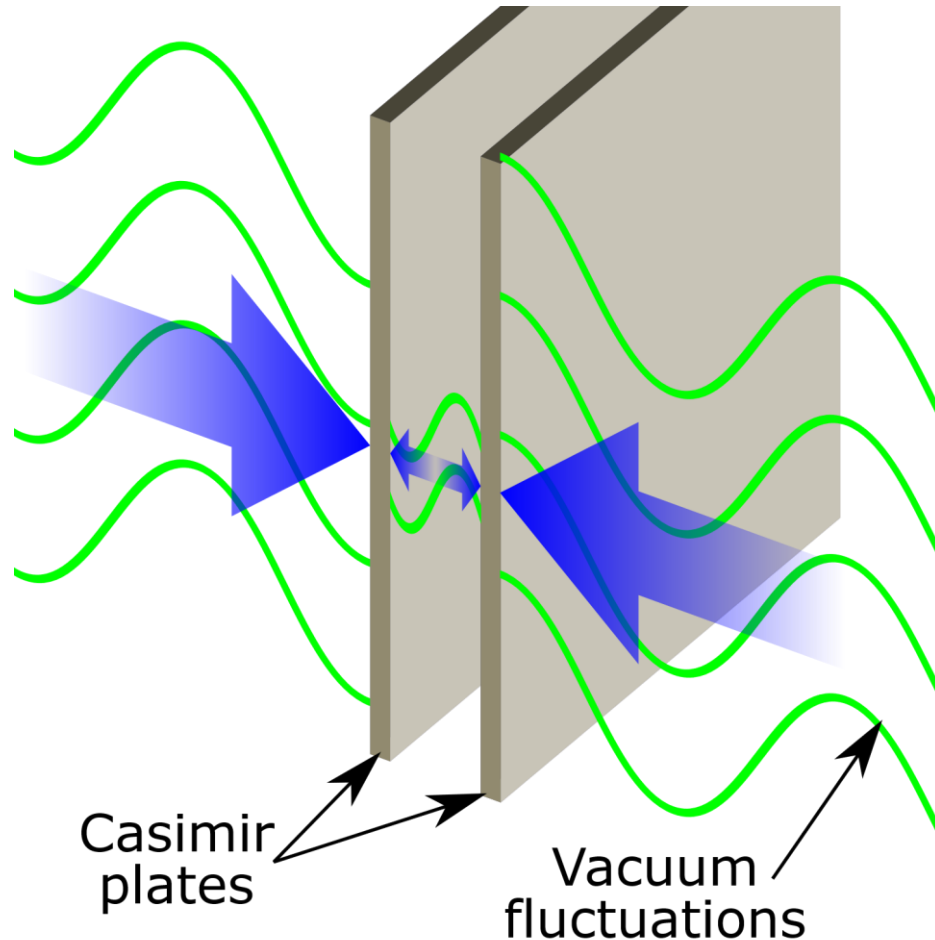
## **Previous Bollinger YouTube presentations addressing the Casimir Effect:**

- [26] T. Bollinger, A Critical Look at Infinitesimals in Physics. Apabistia Notes 2025, 09131200 [Sep. 13] (2025).  
Slides: <https://sarxiv.org/apa.2025-09-13.1200.pdf>  
Video: <https://youtu.be/4YPvucRP9kw>  
This citation: <https://sarxiv.org/apa.2025-09-13.1200.01.pdf>
- [27] T. Bollinger, *Fairy Dust in Physics: How Non-Physical Views of Information Impede Theory Progress*. Apabistia Notes **2025**, 0215130002 [Feb. 15] (2025).  
Slides: <https://sarxiv.org/apa.2025-02-15.1300.01.pdf>  
Video: [https://youtu.be/JjCiI3\\_7pdg](https://youtu.be/JjCiI3_7pdg)  
Edited transcript: <https://sarxiv.org/apa.2025-02-15.1300.02.pdf>  
This citation: <https://sarxiv.org/apa.2025-02-15.1300.03.pdf>



# Part V. A Critical Look at the Casimir Effect

# Standard Casimir: Empty QED Space Has Nearly Infinite Energy



Emok, CC BY-SA 3.0, via Wikimedia Commons  
[https://commons.wikimedia.org/wiki/File:Casimir\\_plates.svg](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:

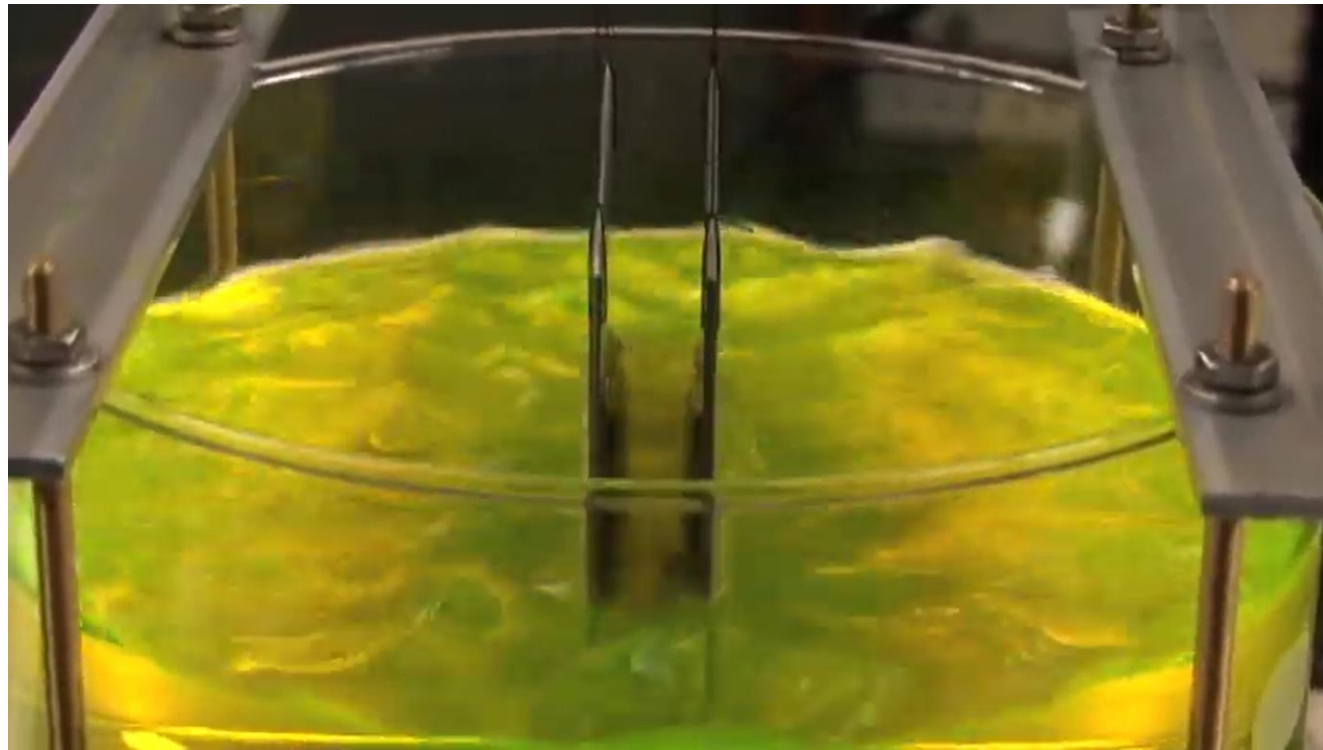
S. K. Lamoreaux, *Demonstration of the Casimir Force in the 0.6 to 6  $\mu\text{m}$  Range*, Physical Review Letters **78**, 5–8 (**1997**).

<http://web.mit.edu/~kardar/www/research/seminars/Casimir/PRL-Lamoreaux.pdf>

# All Real Casimir Models Require Violent Waves

2:30 *“This is tricky because we are pushing the shaker and the amplifier nearly to their limits.”*

— B. C. Denardo, *Water Wave Analog of the Casimir Effect*. NPSPHYSICS (YouTube), [Jun. 29] (2012). <https://youtu.be/H-GnwnEnLCA>



# Absurdity #1: Casimir Effect Creates Black Holes

- What folks tend to forget about Casimir plates is that **the force comes entirely from *outside* the plates, *not* from the gap**
- The gap is nothing more than a region where **a tiny sliver of all possible “free space” oscillations cannot exist**
- This absence then makes *a sliver* of the outside wave forces visible
- There is a huge problem with this argument:
  - The ultimate “thin gap” is the ***solid metal within each plate (zero gap)***
  - Applying the gap rule consistently means the gamma-and-beyond **quantum fluctuations should crush each plate until it becomes a black hole**
  - The gap model works *only* if you “exempt” all but a minute sliver of waves

# Absurdity #2: Casimir Effect Incinerates All Matter

- Casimir's explanation for exempting most forms of radiation:

*“For very short waves (X-rays, e.g.) our plate is hardly an obstacle at all.”*

— 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>

- There exists **no physics pathway** by which Casimir's assertion of “**transparency**” is plausible
- Far from being transparent to them, **metal plates should absorb or reflect X-rays and higher energies**
- The only correct outcome of this thought problem scenario is **cosmic incineration of all matter** (if black holes do not form first)

# A Belated Clarification (Confession?): Casimir 1998

Near the end of his life in 2000, Casimir said this:

*“But one can also take a more modest point of view.*

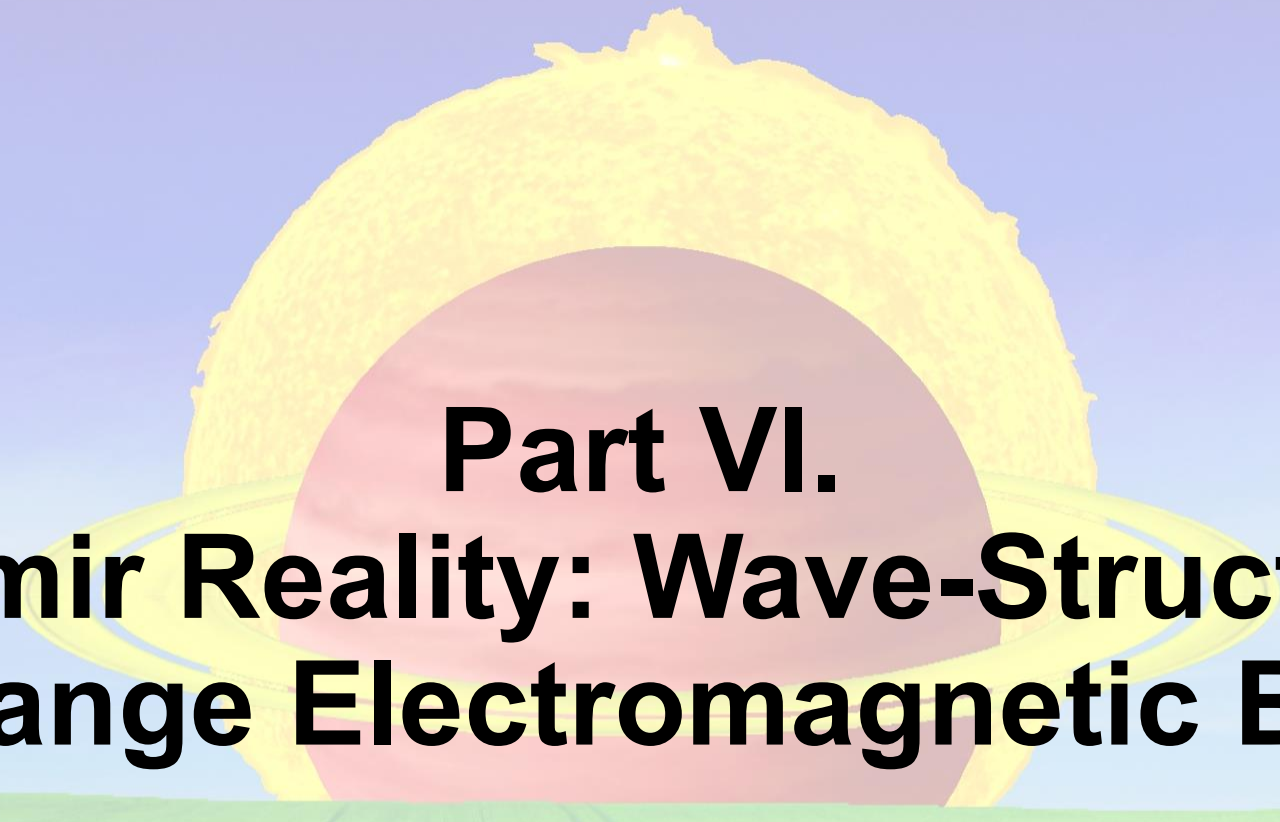
*Inside a metal, there are forces of cohesion. And if you take two metal plates and press them together, these forces of cohesion begin to act. On the other hand, you can start from one piece and split it. Then you have first to break chemical bonds and next to overcome van der Waals forces of classical type. And if you separate the two pieces even further, there remains a curious little tail.*

*The Casimir force is the last but also the most elegant trace of cohesion energy.”*

— H. B. G. Casimir, *Some Remarks on the History of the So Called Casimir Effect*, pp. 3–9 in M. Bordag, Ed., Leipzig, *The Casimir Effect 50 Years Later: The Proceedings of the Fourth Workshop on Quantum Field Theory Under the Influence of External Conditions*, Germany: World Scientific, [Sep. 14-18] (1998). See end of page 7: <https://books.google.com/books?id=PI84DwAAQBAJ&pg=PA7>

# Relevance of SMU to the Casimir Effect

- The State Machine Universe (SMU) **excludes every major aspect of Niels Bohr's interpretation of the Casimir effect**
- The very *concept* of a **spacetime fabric disappears (operators only)**
- **All versions of "infinite" energy at very short distances disappear**
- **All particles in the Standard Model become *emergences*, funded solely by how much energy is locally available**
  - **Particle emergences reveal *rules* guiding specialized state transformations**
  - **Particles represent specific "recipes" for funding and creating novel, extremely **localized variations of higher-complexity spacetime****
  - **Protons, for example, are extremely stable local spacetime states with only the *potential* to generate quarks, gluons, pions, and other phenomena**

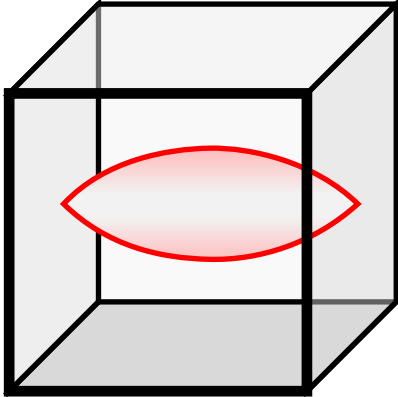


# Part VI.

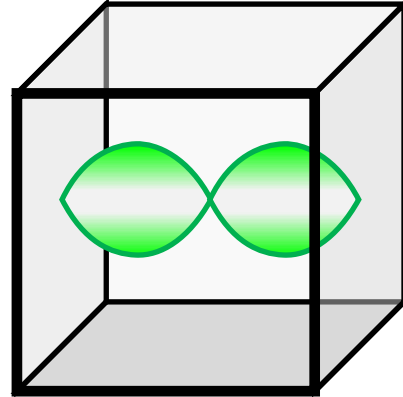
# Casimir Reality: Wave-Structured Long-Range Electromagnetic Bonding

# Wave-Like Electrons and Long-Range Bonding

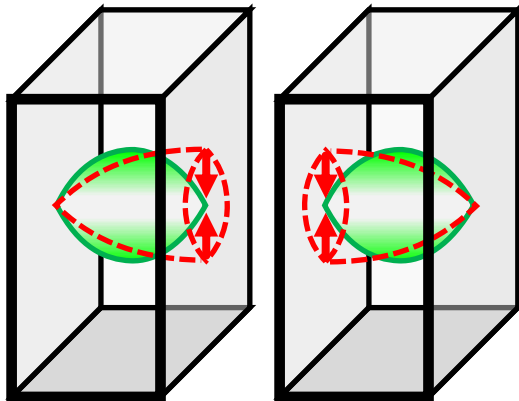
*Conduction electrons are waves, not particles*



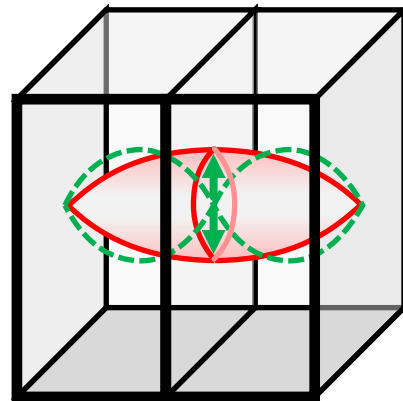
*You must add energy to add more loops*



*Pulling two plates apart locks in this added energy*



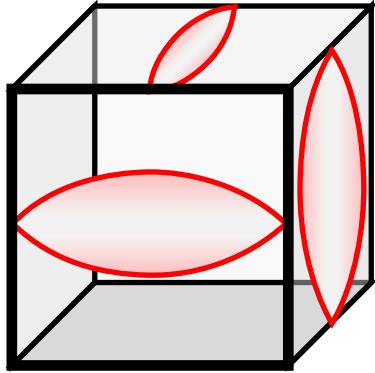
*Casimir Effect: Stored energy gently pull plates back together*



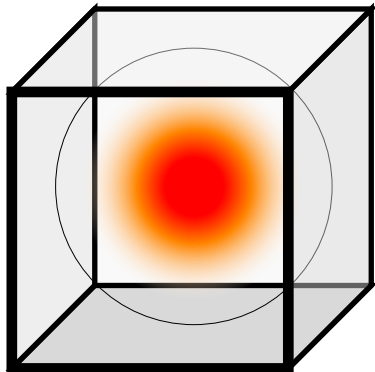
- The “interesting” properties of metals stem mostly from electrons behaving like waves
  - Conduction
  - Reflection
  - Ductile strength
- Breaking a piece of metal also breaks some of these bonds
- Casimire (1998) noted that it is this bond breaking that creates the effect named for him (!)

# How Do Electron Waves Create Long-Range Bonds?

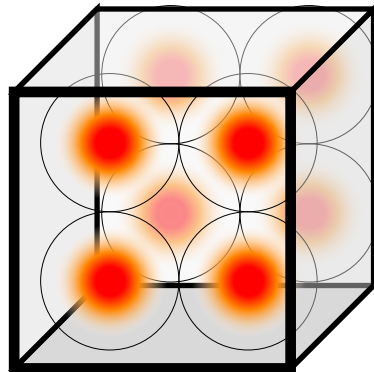
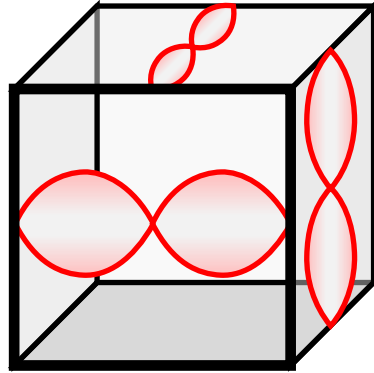
*Electrons form waves in all three directions*



*Result: Weak, multi-scale concentrations of charge*



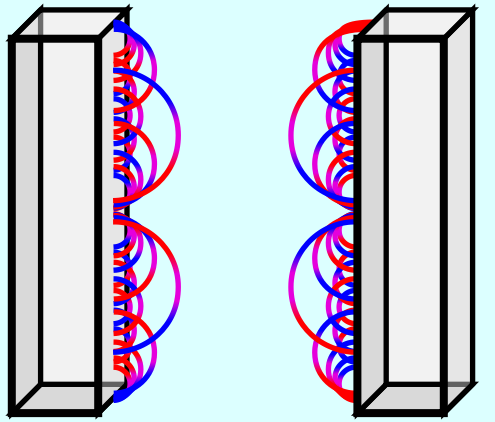
*More energetic electron waves also go all three ways*



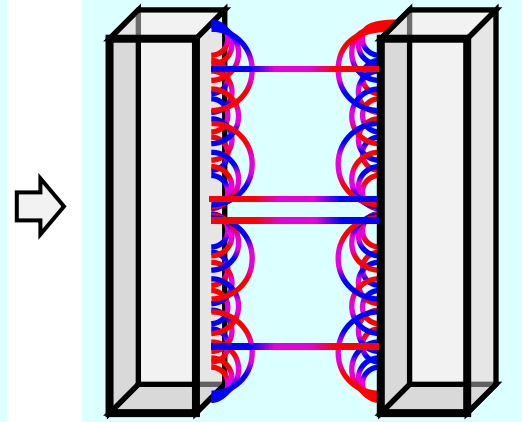
- The lowest-energy electrons create human-scale “lumps” (polarons) in charge distributions
- While tiny, even one non-even electron has substantial charge
  - These distributions mimic the situation that gives van der Waals
  - The scale is vastly larger, however
- Most of the attraction arises from the lowest-energy electrons
- Most electrons add very little

# Frequency Dependence of the Casimir Effect

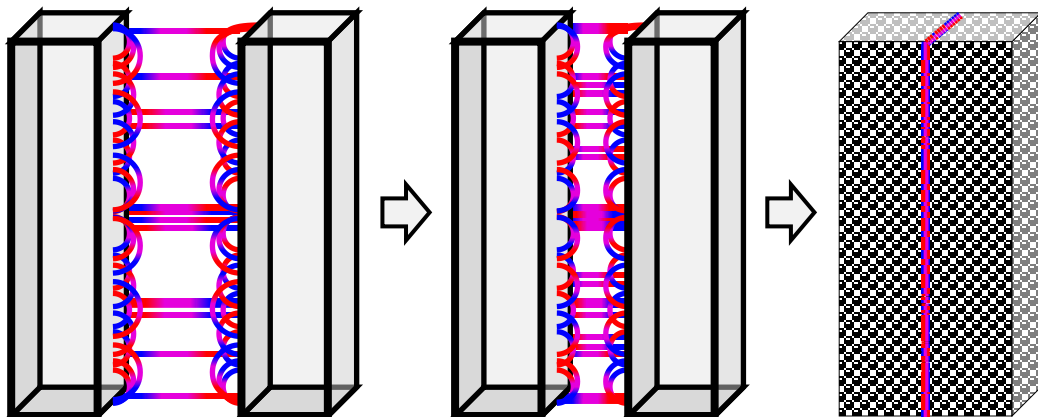
(a) Too far for the Casimir Effect!



(b) Largest polarons link first



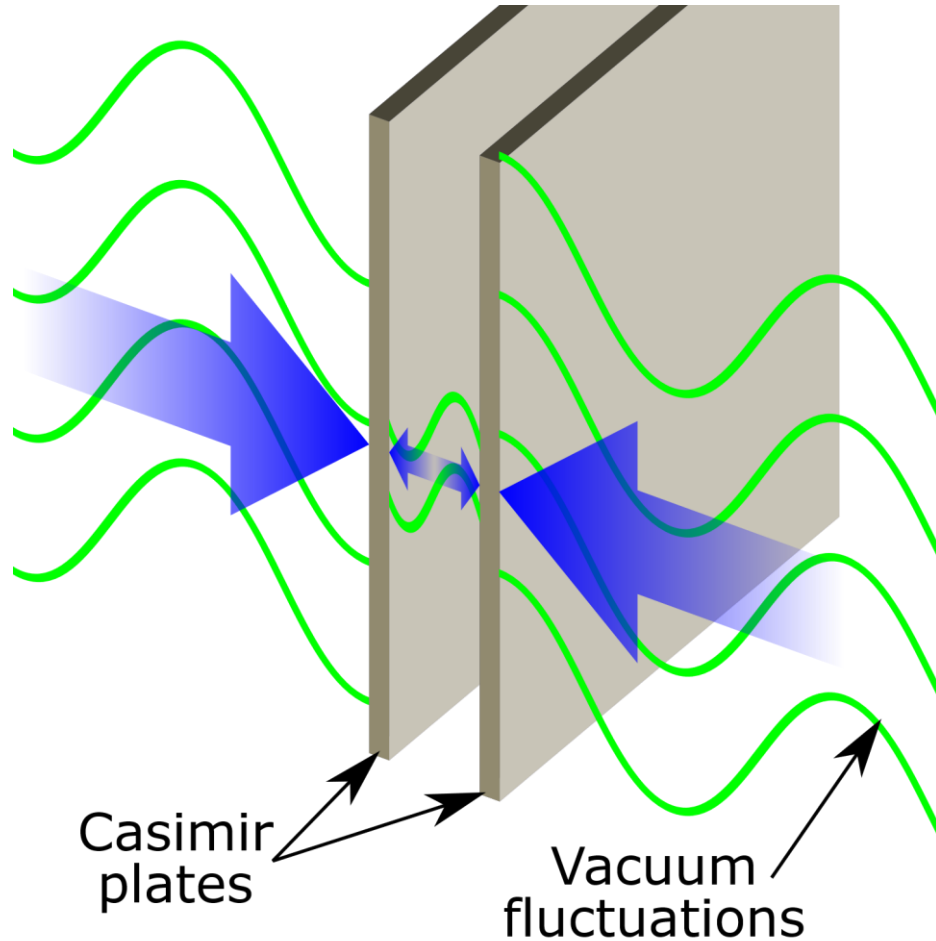
(c) Reducing gap links smaller-scale polarons and increases pull. Pull stops increasing at the atomic scale (van der Waals limit).



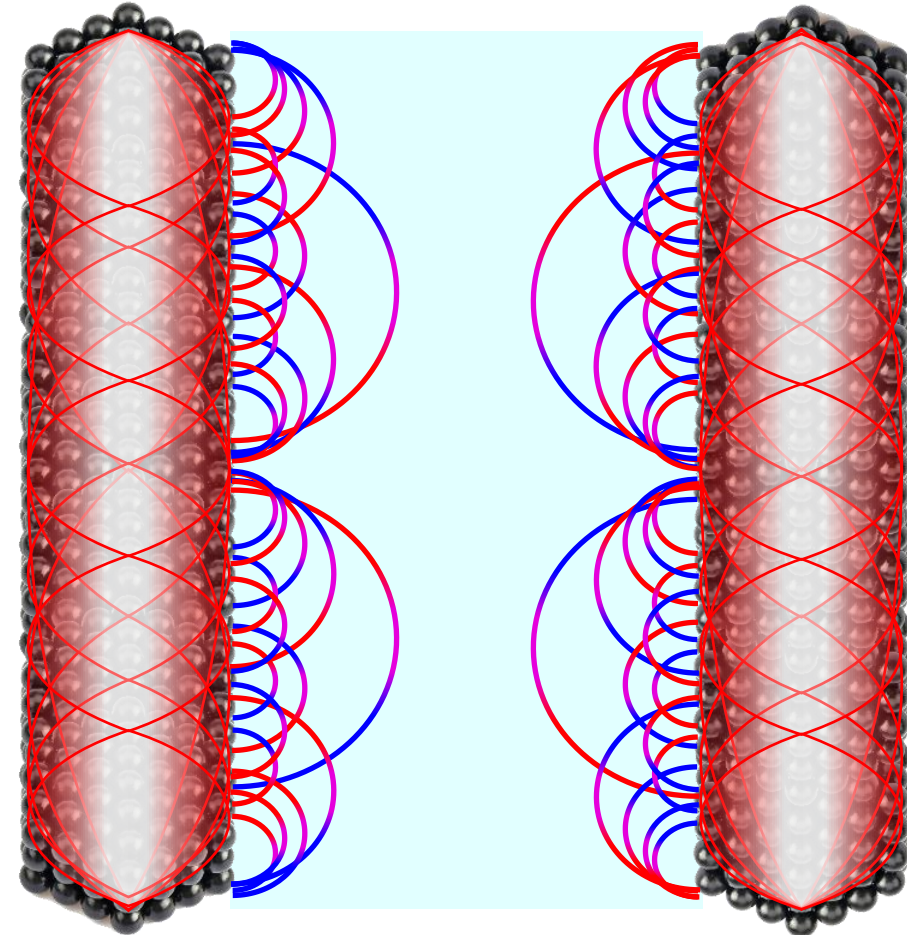
- The Casimir attraction depends directly on resonant electron wave polaron charge distributions
- Consequently:
  - The lowest frequencies contribute most to the attraction effect
  - The highest frequencies add little
  - There is always an atomic cut-off
- These effects are detectable at laboratory scales
- Larger gaps help suppress van der Waals contributions

# Molecular Casimir: Empty Space Uses Residual EM Bonding

*Pressure comes from infinite external EM pressure vs. depleted gap EM modes*



*What Casimir never quite said out loud: The structured pull arises from internal wave-like polaron attractions*



# Summary

- Minkowski space is a math error that must be deprecated
- Treating reality as a state machine simplifies special relativity and allows a fully Euclidean treatment of space and time. (Note: There is a high potential for quaternions to “click” better with this model.)
- The role of information needs serious upgrading, e.g., to explain quantum mechanics more as a low-resolution phenomenon
- Something is seriously, seriously incorrect in the foundations of quantum field theory (but *not* most of the results)
- Bohr’s interpretation of Casimir’s long-distance bonding resulted in astonishing levels of mathematical misdirection

