

Urs Schreiber

New York University Abu Dhabi
Center for Quantum & Topological
Systems

The \$1 Million Puzzle: Hadrons and Quantum Computers

Why Modern Physics Needs a New Global Mathematics

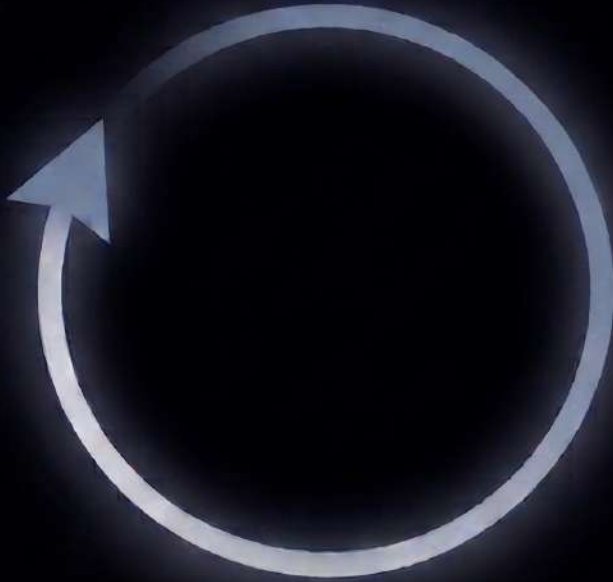




PARTICLE
PHYSICS



QUARKS IN A NUCLEUS

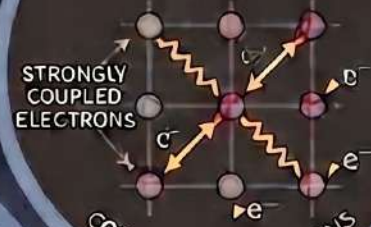


PARTICLE PHYSICS



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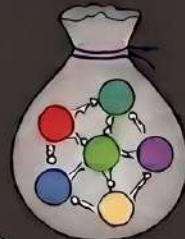
SOLID STATE PHYSICS



CORRELATED ELECTRONS

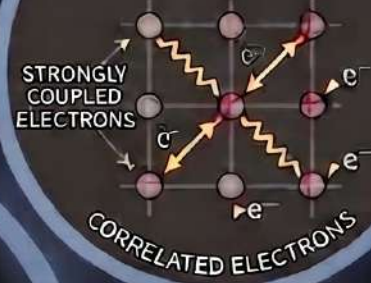


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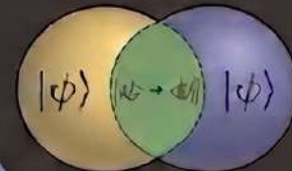


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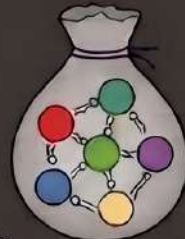
QUANTUM COMPUTING



SUPERPOSITION STATES

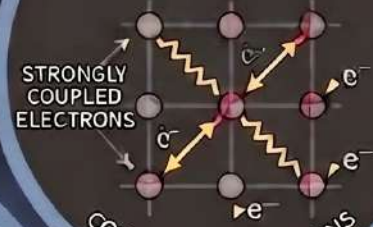


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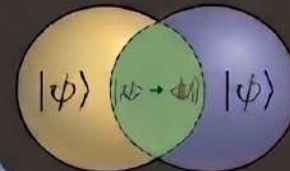
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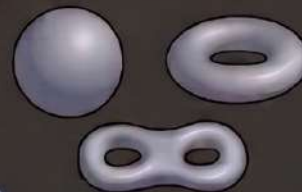
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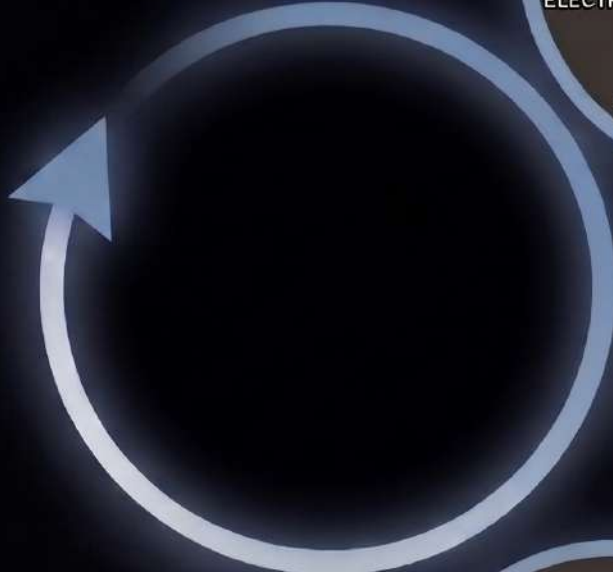


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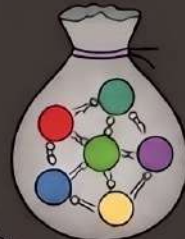
TOPOLOGY



GENUS AND CONNECTIVITY

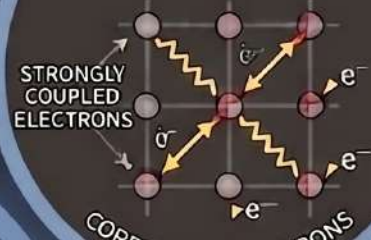


PARTICLE PHYSICS

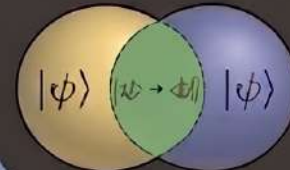


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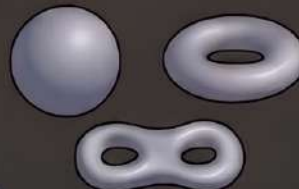
SUPERPOSITION STATES

HOMOTOPY THEORY



KNOT THEORY

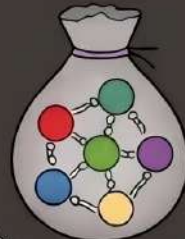
TOPOLOGY



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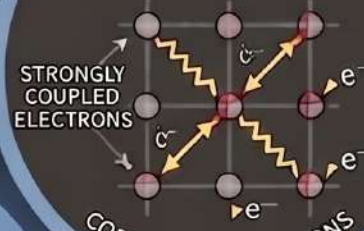


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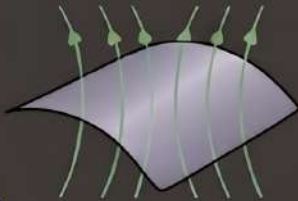


QUARKS IN A NUCLEUS

SOLID STATE PHYSICS



GEOMETRIC HOMOTOPY



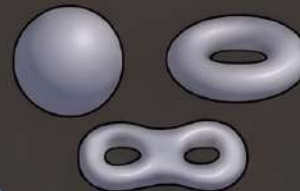
FLUX THROUGH SURFACES

HOMOTOPY THEORY



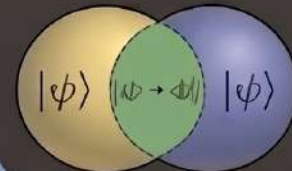
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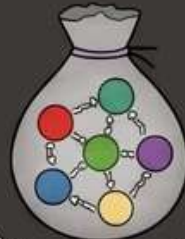
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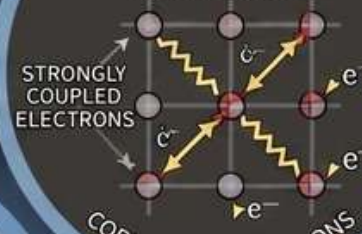


PARTICLE PHYSICS



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STRONGLY COUPLED ELECTRONS

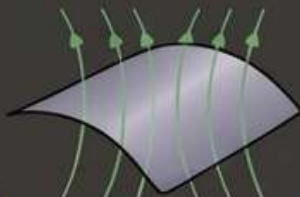
CORRELATED ELECTRONS

HOMOTOPY TYPE THEORY

$$x_1 = x_2 : \text{Type}$$

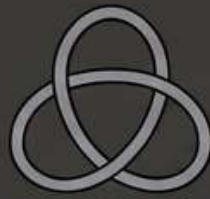
IDENTITY TYPES

GEOMETRIC HOMOTOPY



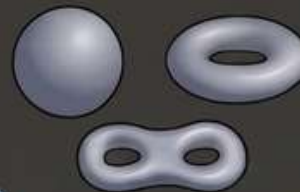
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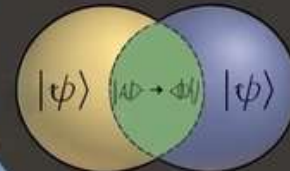
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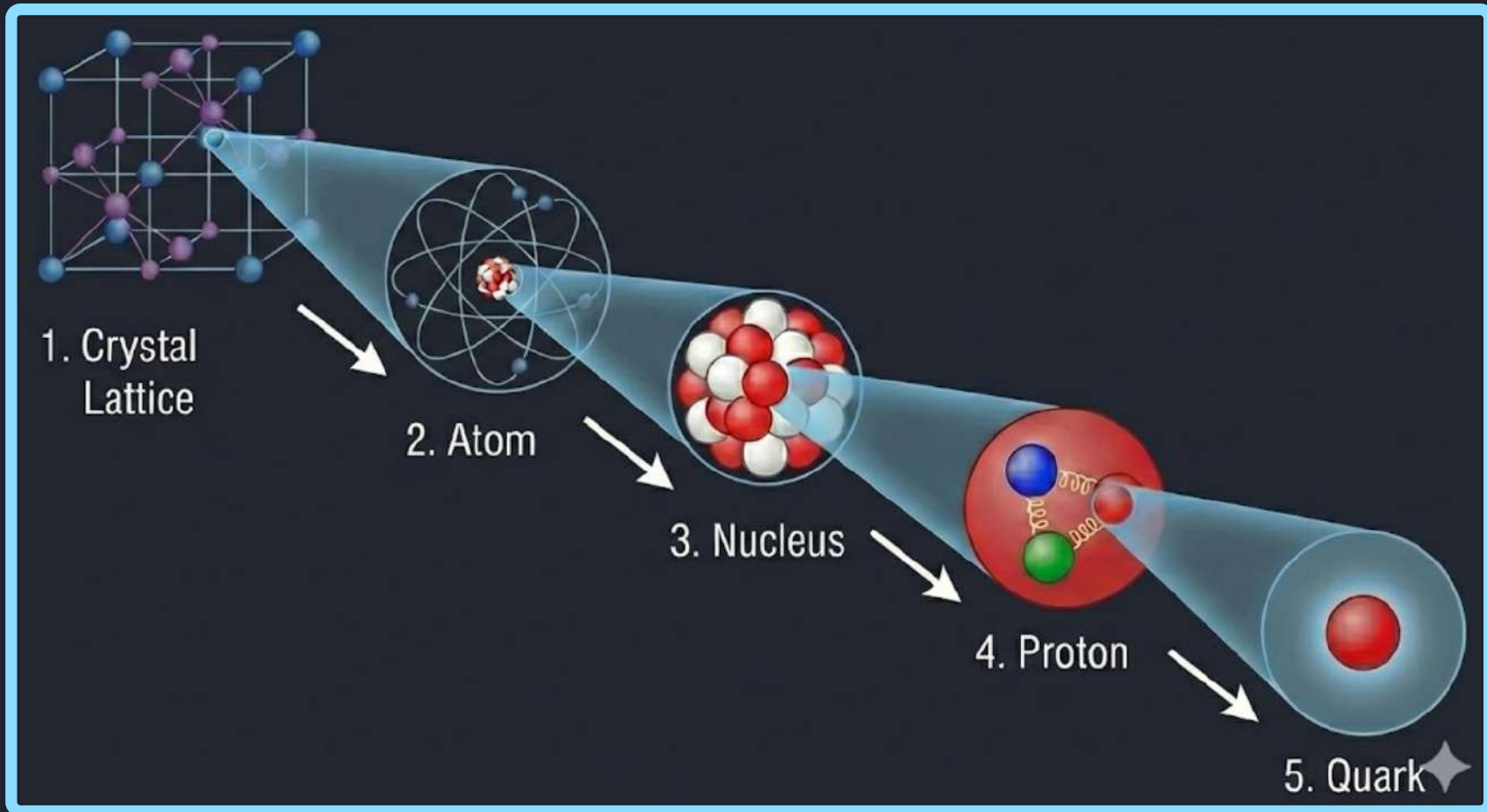


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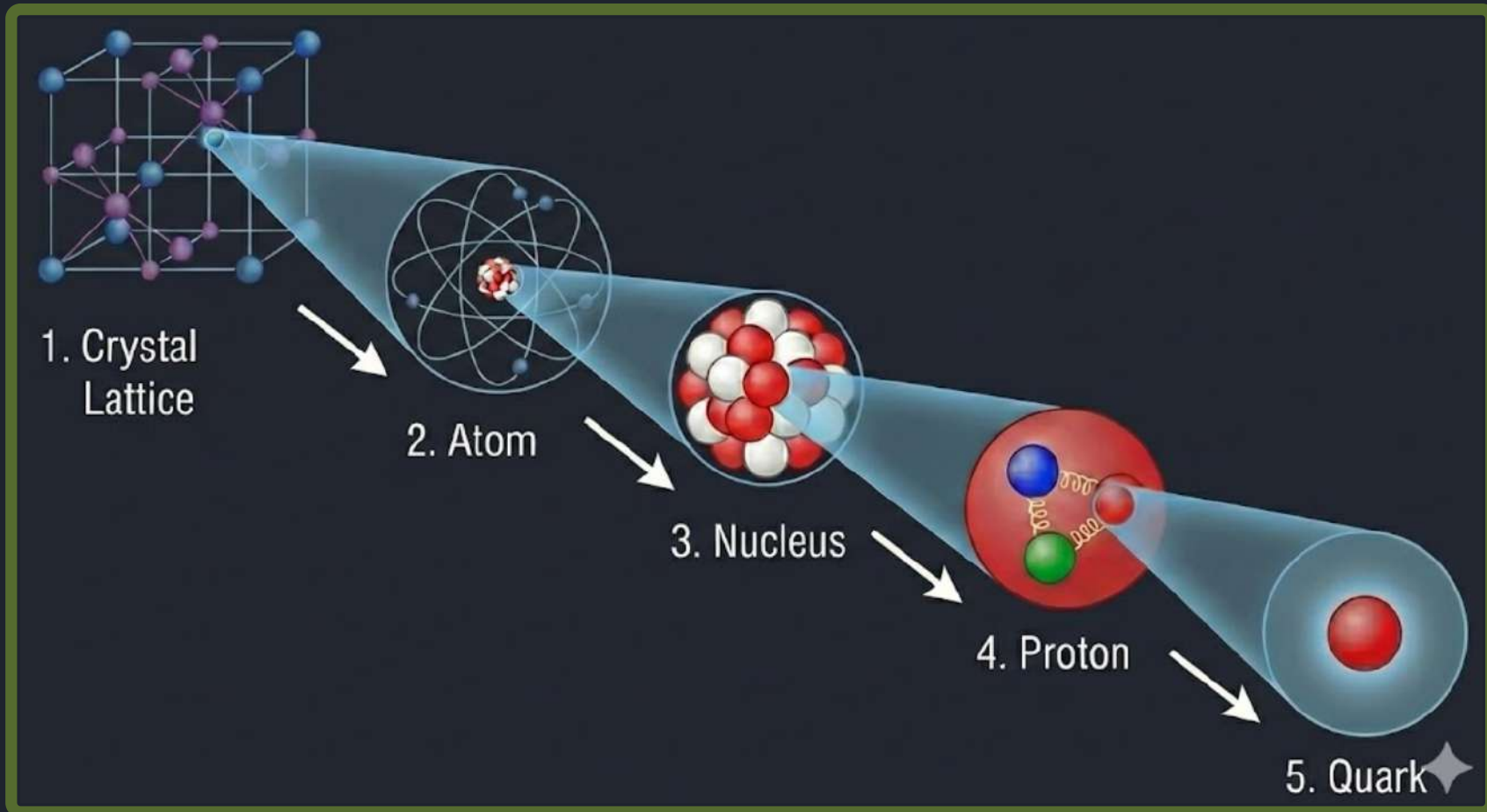


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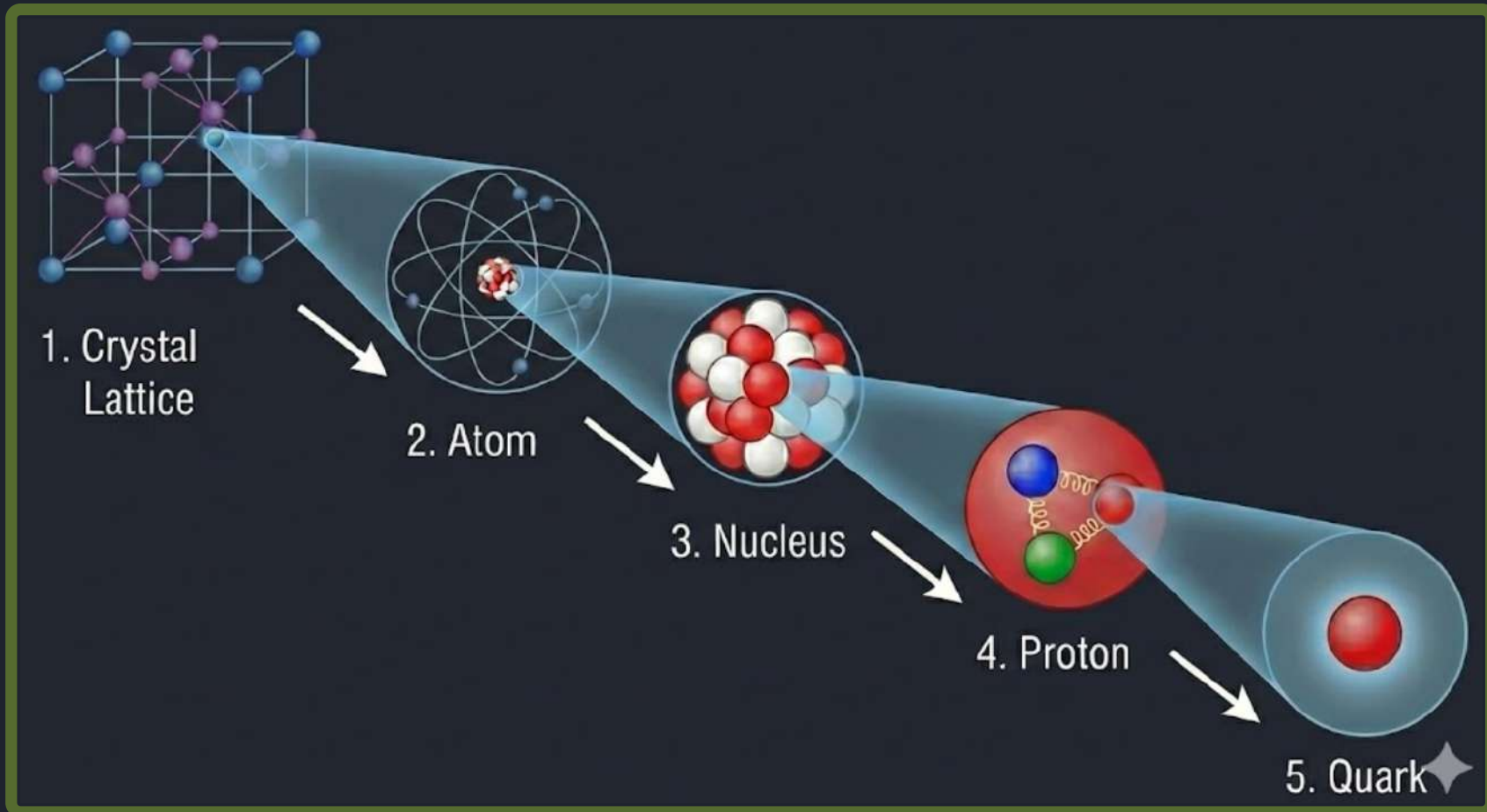


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Columbia Department of Mathematics

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Siegel 2025

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As 2025 ends, the Standard Model still
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Wired 2016

A screenshot of a Wired article header. The top navigation bar features the Wired logo on the left, a hamburger menu icon, and a user profile icon with the text 'SUBSCRIBE' on the right. Below the navigation bar, the author's name 'BRENDAN COLE' is displayed in a white box, followed by the category 'SCIENCE' and the date 'AUG 5, 2016 8:02 AM'. The main headline is 'Sorry, Folks. The LHC Didn't Find a New Particle After All' in a large, bold, black font. Below the headline is a sub-headline: 'Physicists keeping on trying to prove the Standard Model wrong, and they keep failing.' with a small black diamond icon to its right.

W I R E D   SUBSCRIBE

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Science 2022

A screenshot of a Science article from 2022. The page has a dark background with white text. At the top left, the categories 'NEWS | PHYSICS' are visible. The main headline is 'Ten years after the Higgs, physicists face the nightmare of finding nothing else' in large, bold white font. Below the headline is a sub-headline: 'Unless Europe's Large Hadron Collider coughs up a surprise, the field of particle physics may wheeze to its end'. At the bottom left, the date and time '13 JUN 2022 • 1:30 PM ET' and the author 'BY ADRIAN CHO' are listed. A small white star icon is in the bottom right corner.

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W I R E D

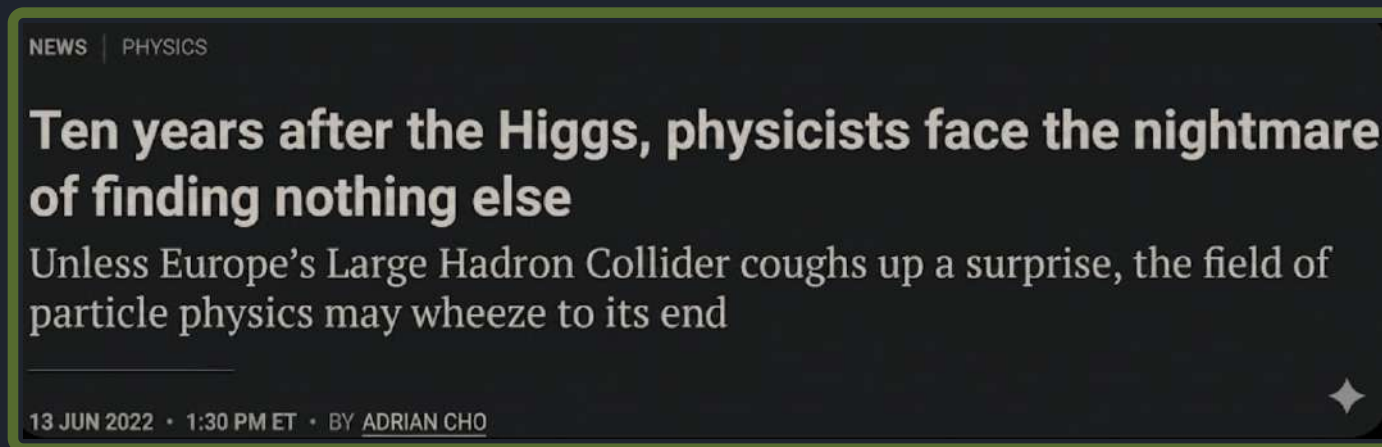
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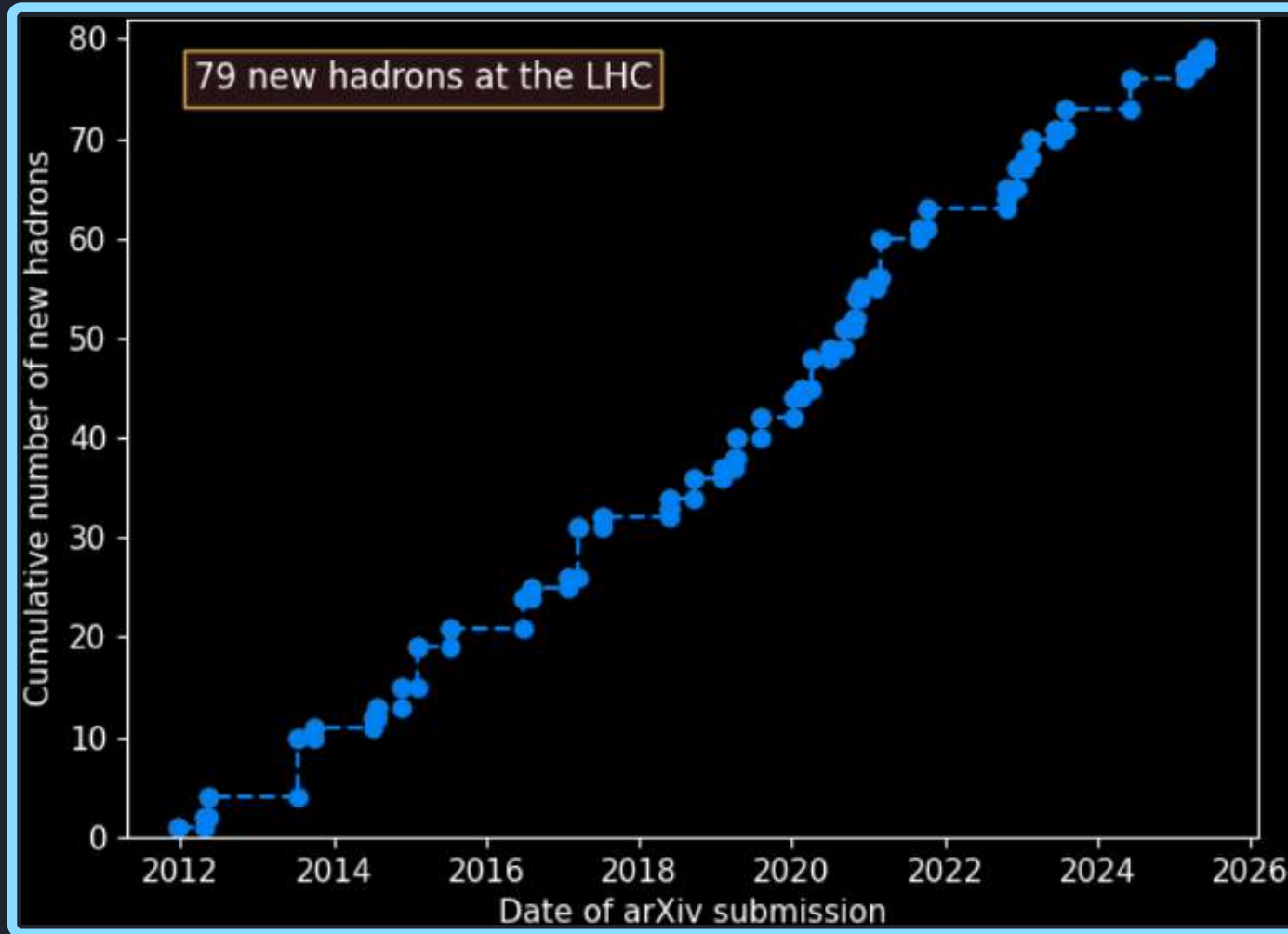
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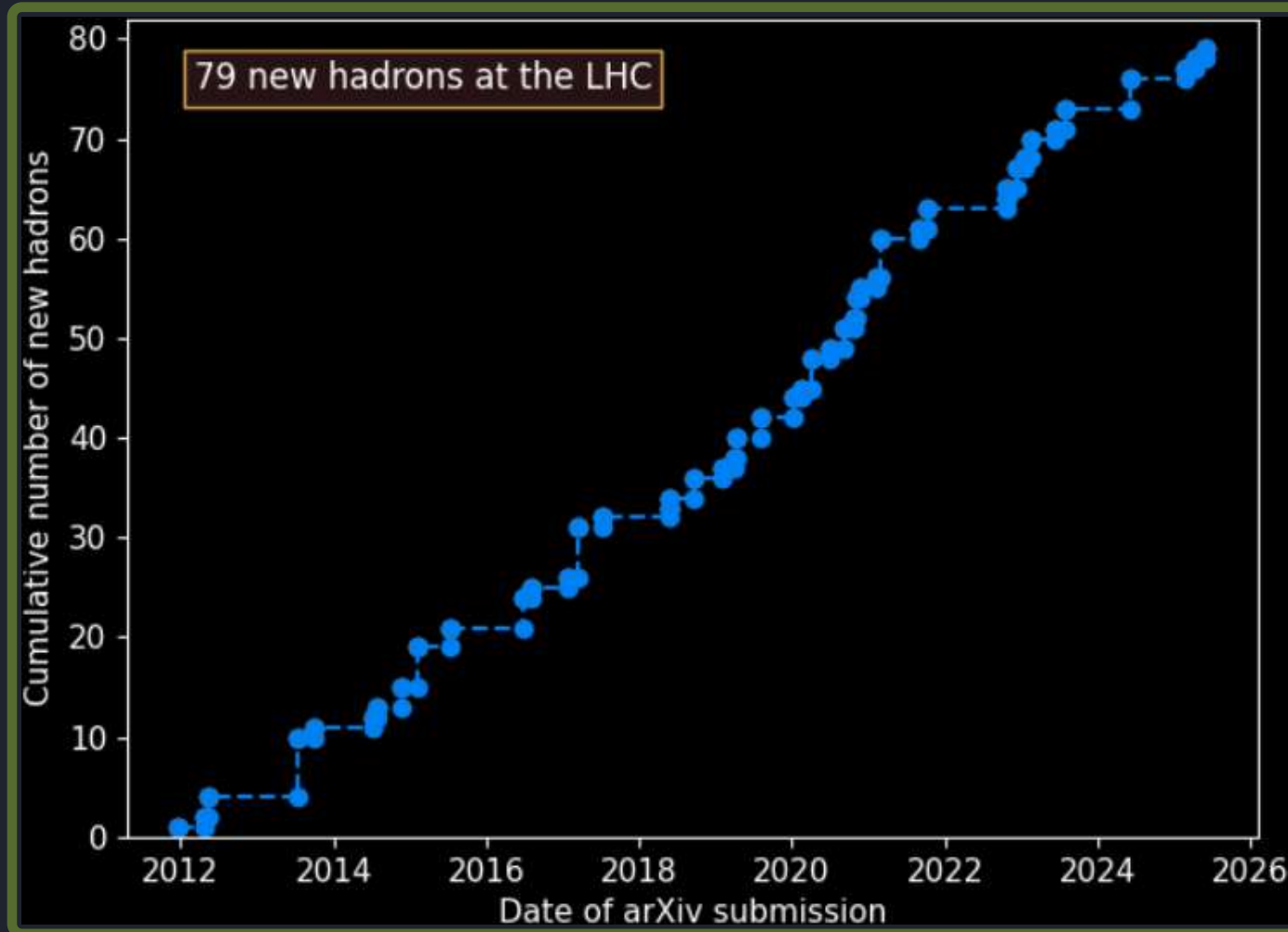
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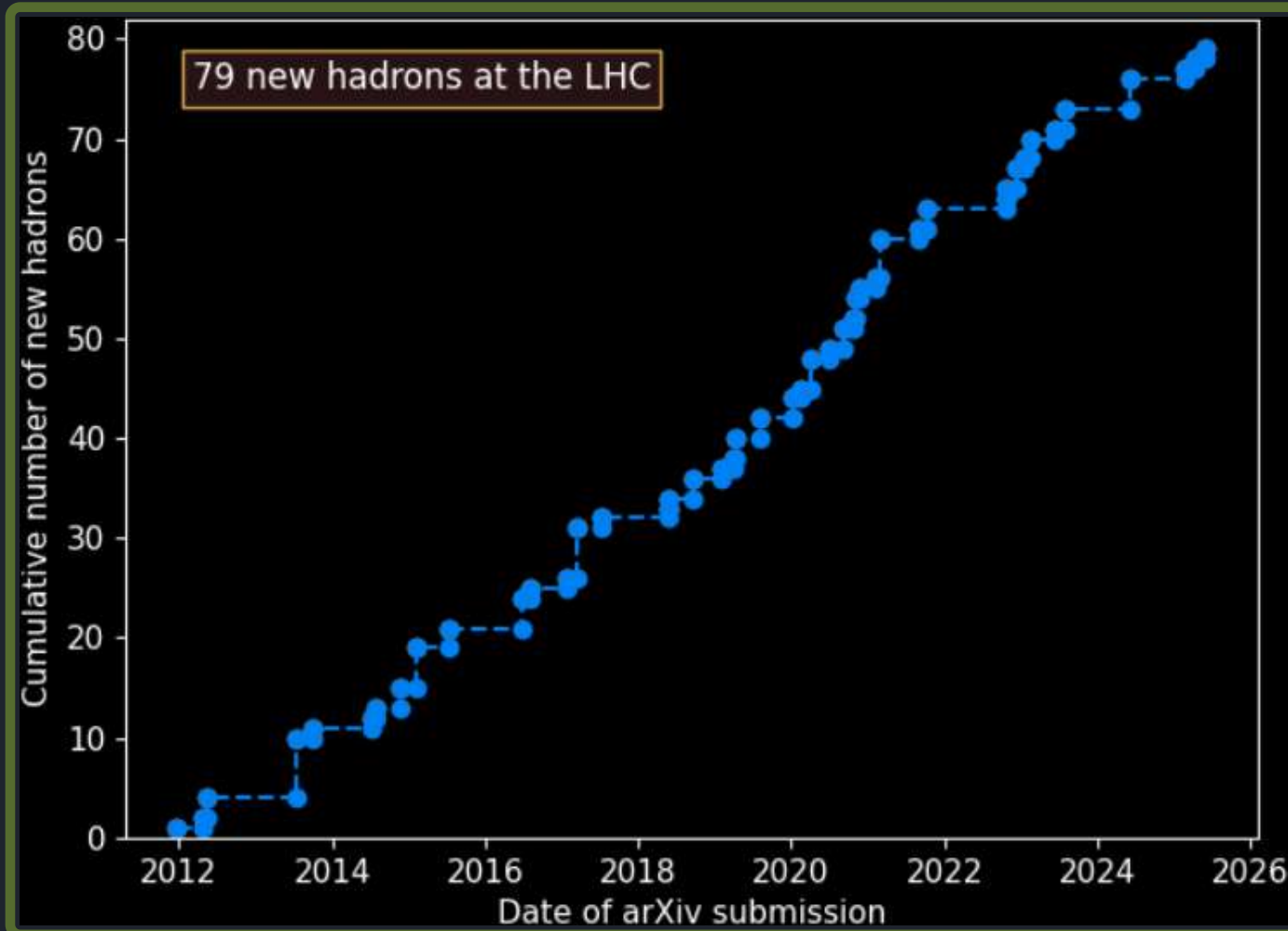
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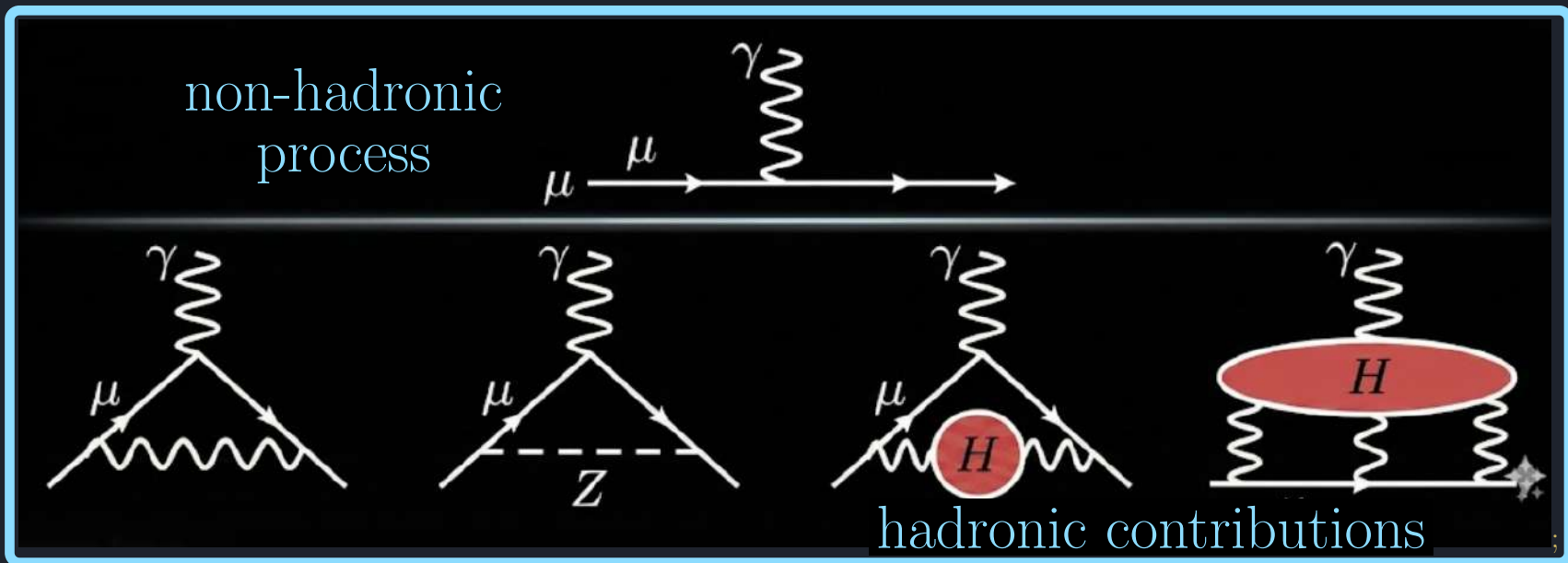
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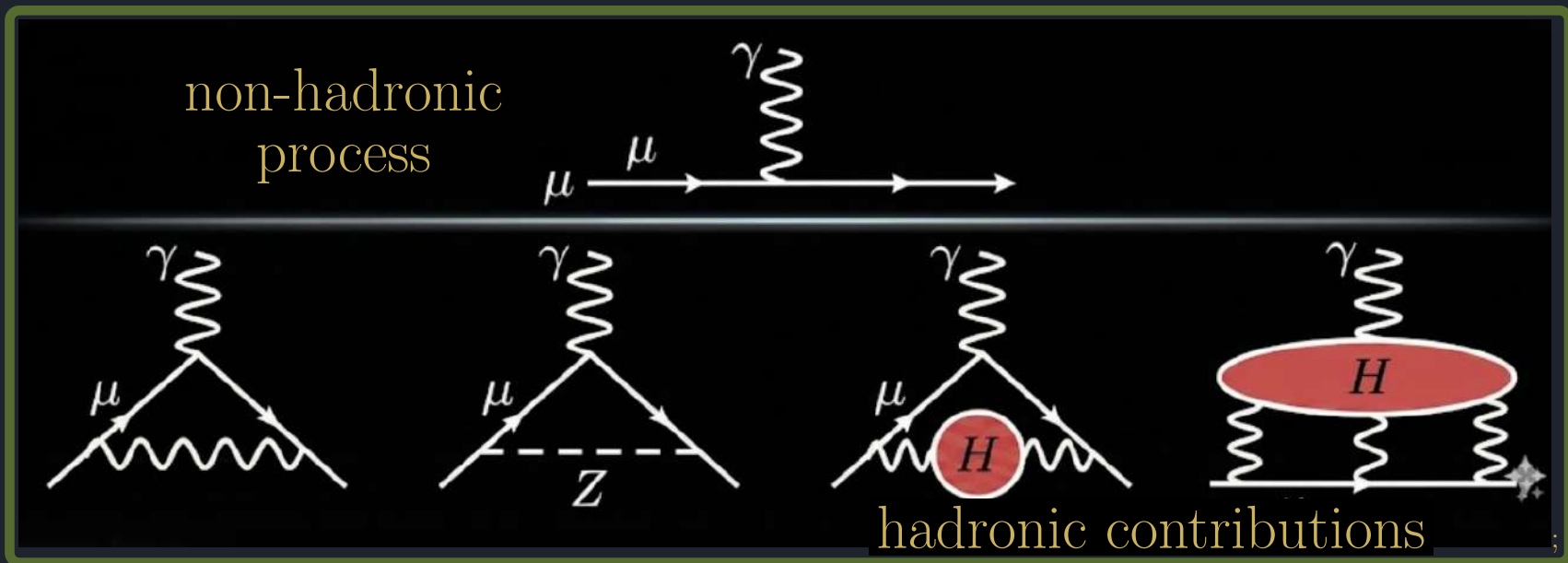
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Reboud 2025

The screenshot shows a workshop page with the following elements:

- Title:** Taming hadronic uncertainties in and beyond the Standard Model
- Dates:** Oct 22–24, 2025
- Location:** IJCLab, Europe/Paris timezone
- Search:** A search bar with the placeholder text "Enter your search term".
- Navigation:** A sidebar menu with "Overview" and "Timetable" options.
- Main Content:** A paragraph starting with "Hadronic form factors remain one of the primary sources of uncertainty in flavour observables. This workshop aims to bring together the lattice, phenomenological and experimental communities to discuss the latest improvements in the calculation, description and use of these form factors."

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CernCourier 2026

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Athron et al. 2023

Hadronic uncertainties versus new physics for the W boson mass and μ on $g - 2$ anomalies

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Nature Communications **14**, Article number: 659 (2023) | [Cite this article](#)

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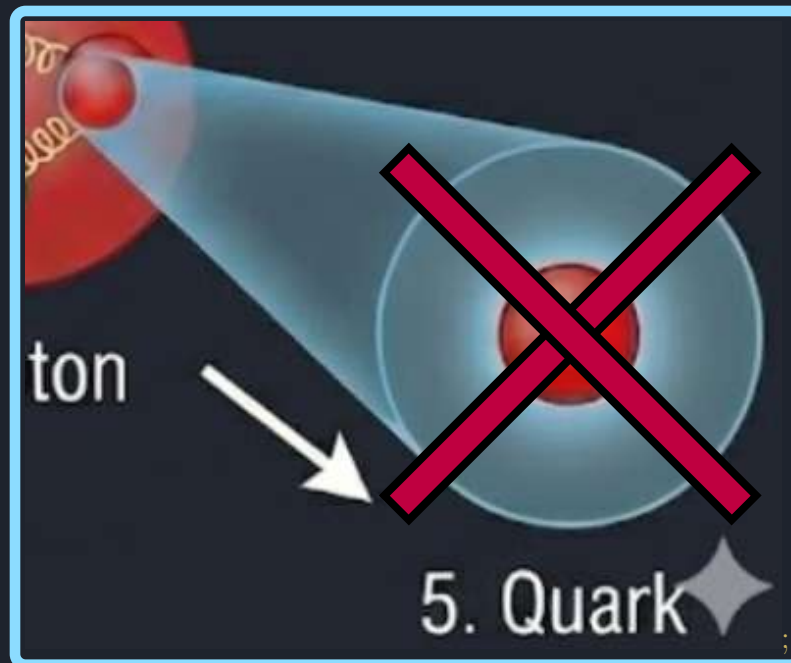
What gives?

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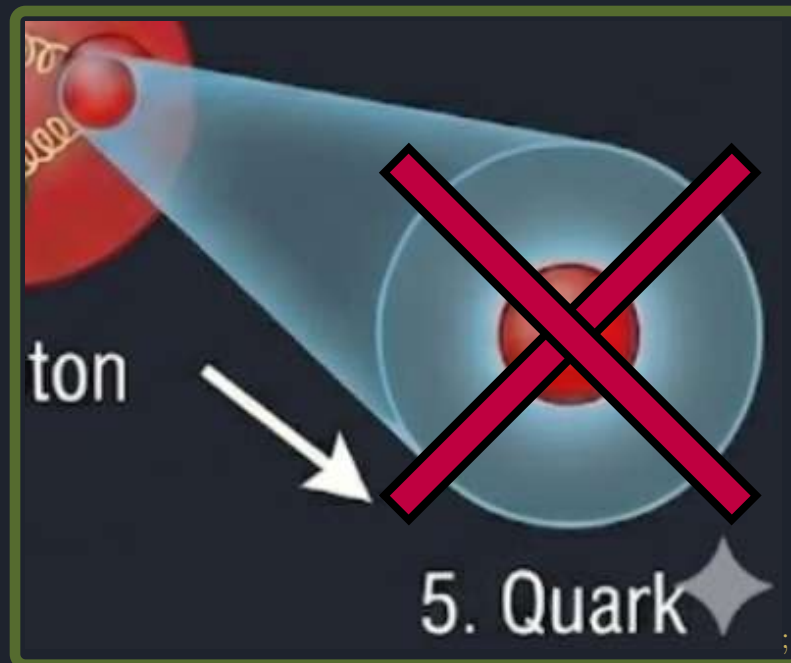
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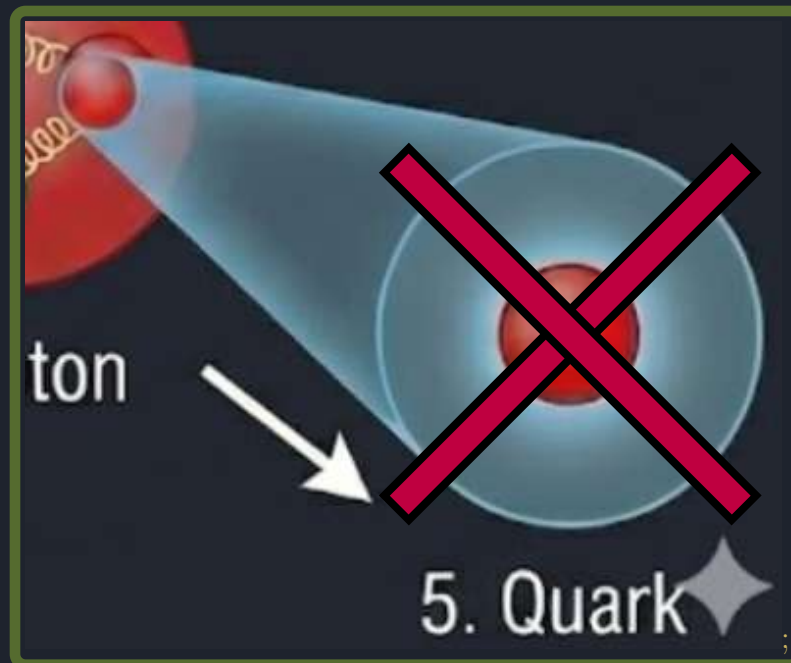
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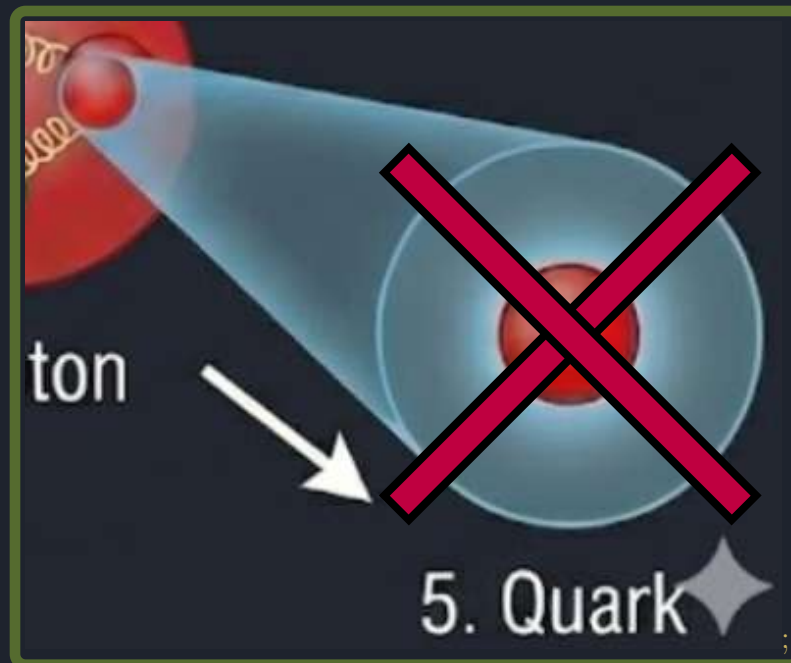
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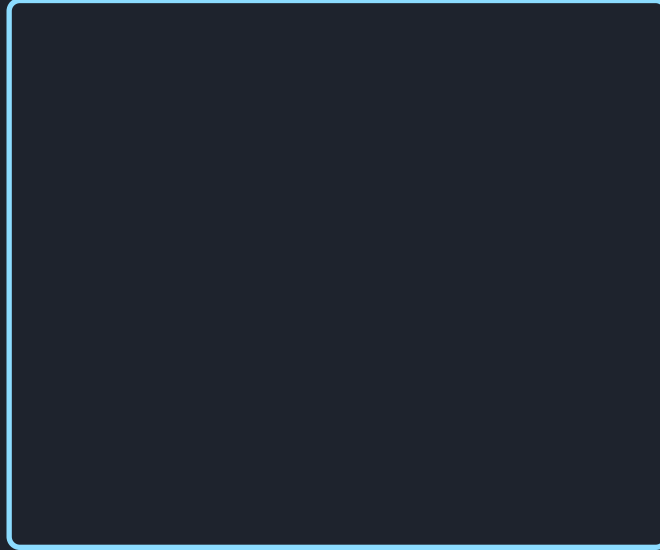
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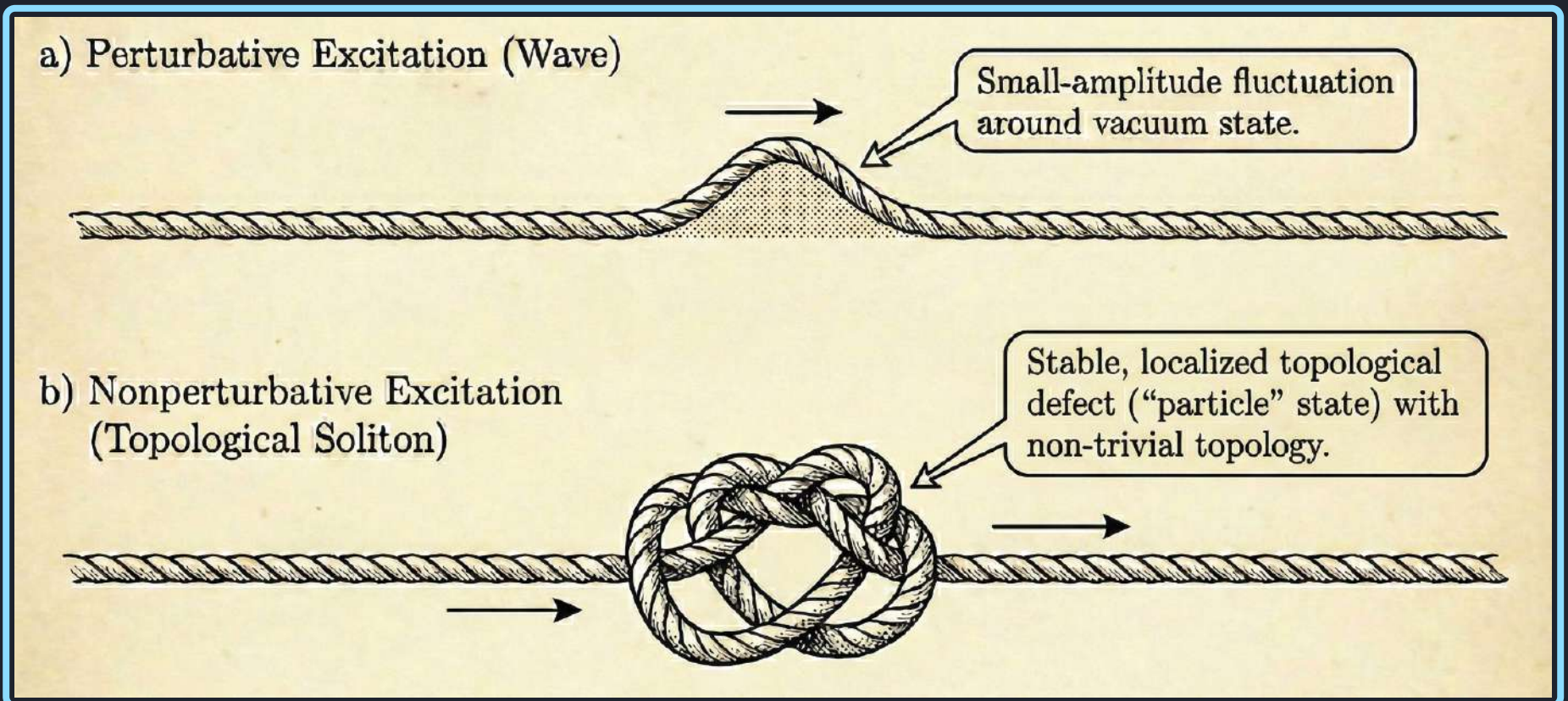
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Elephant in the room:

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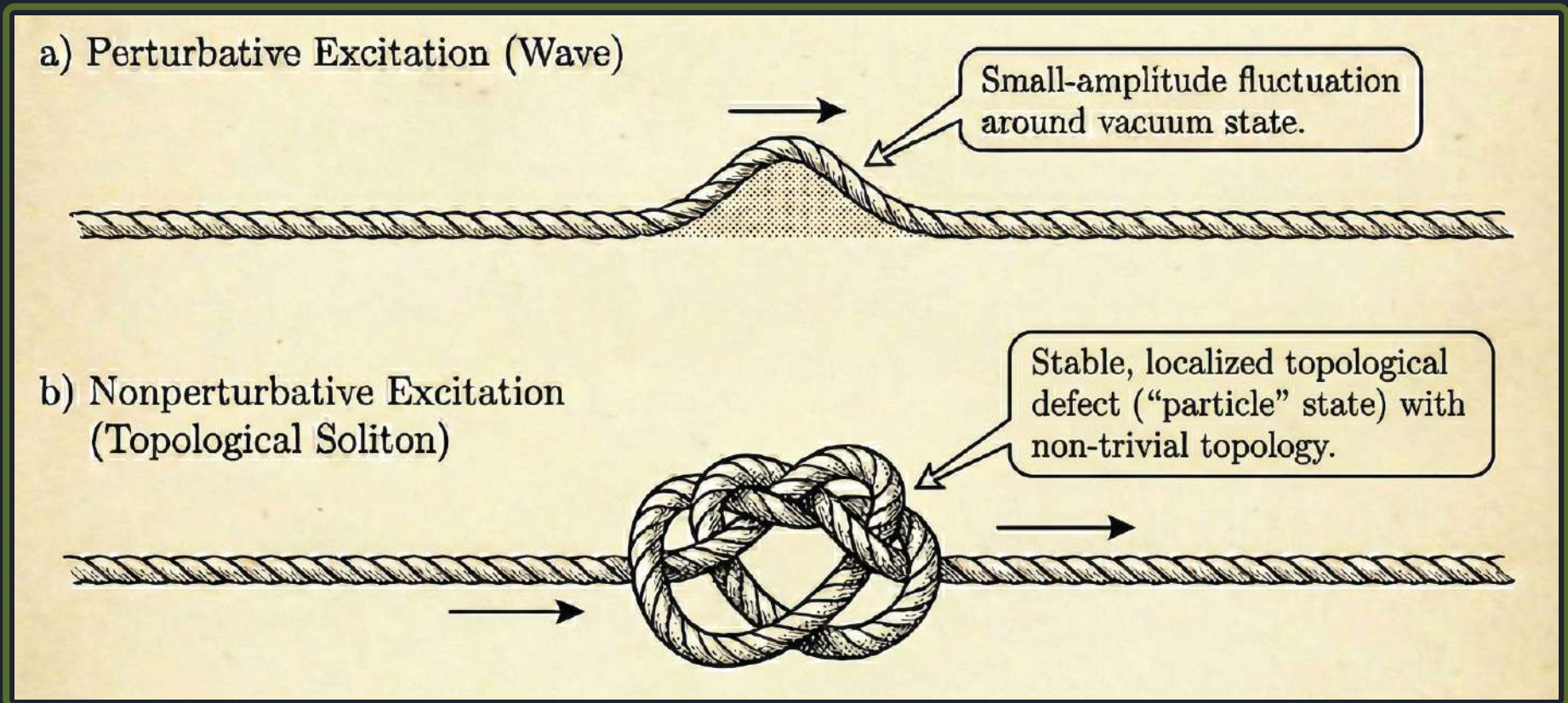
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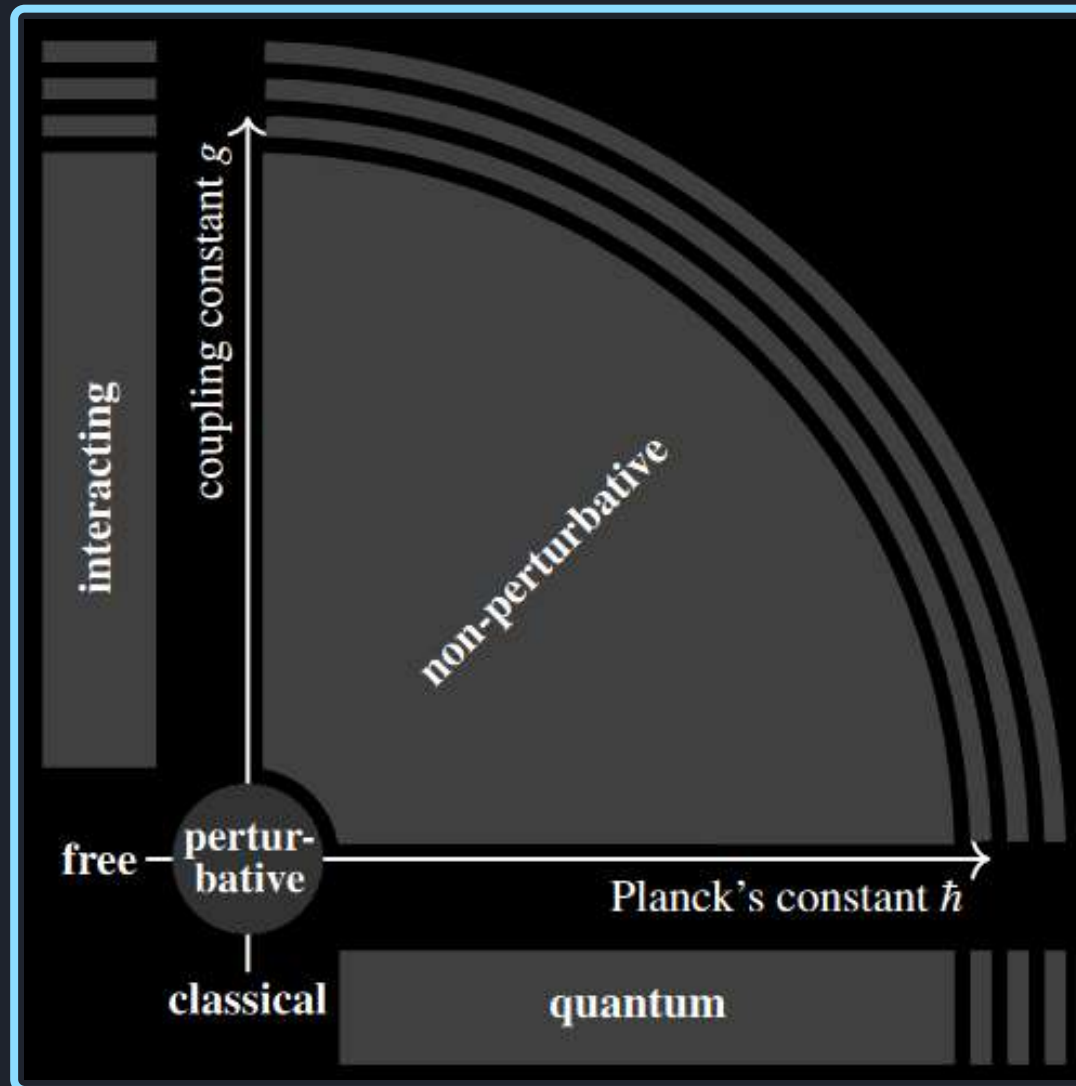
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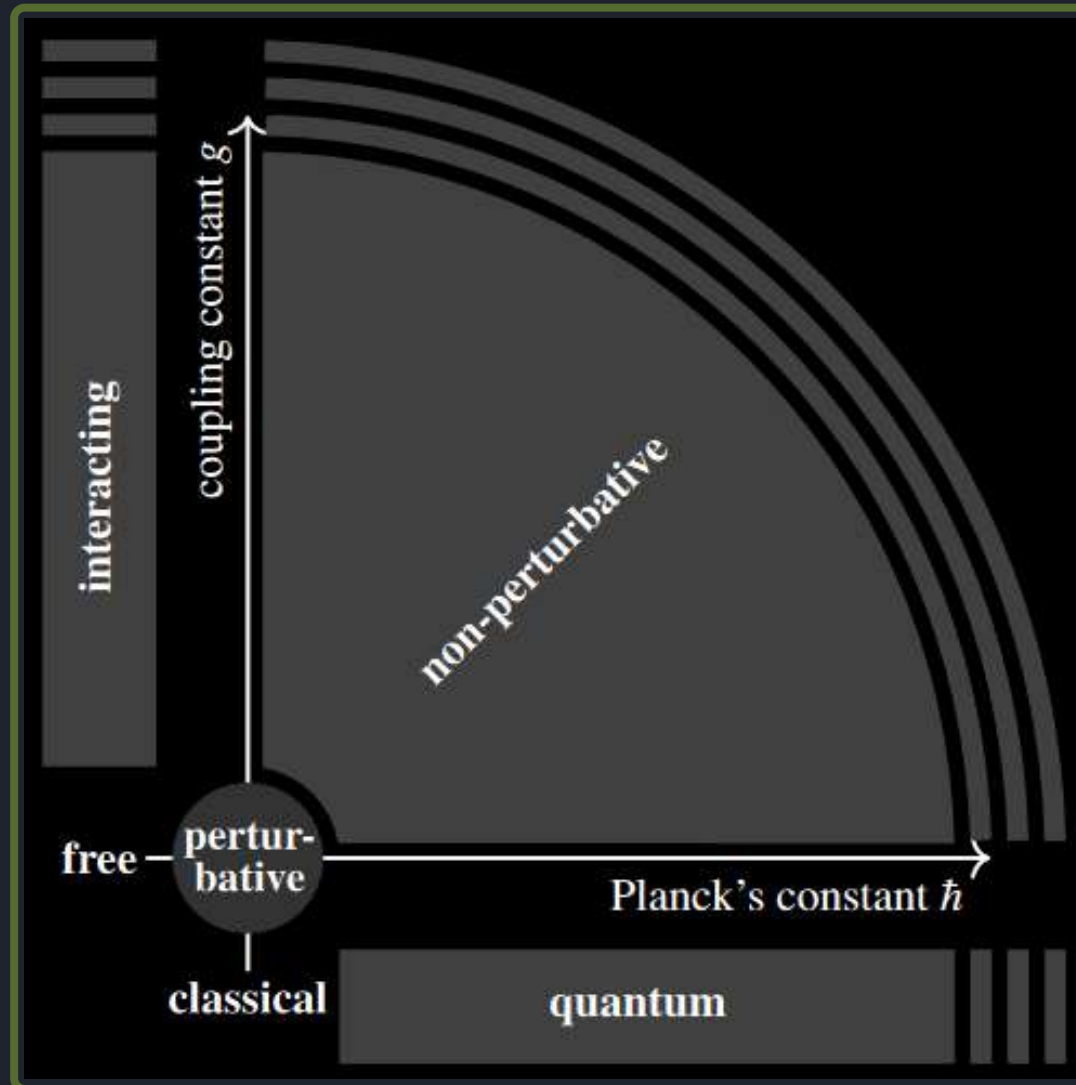
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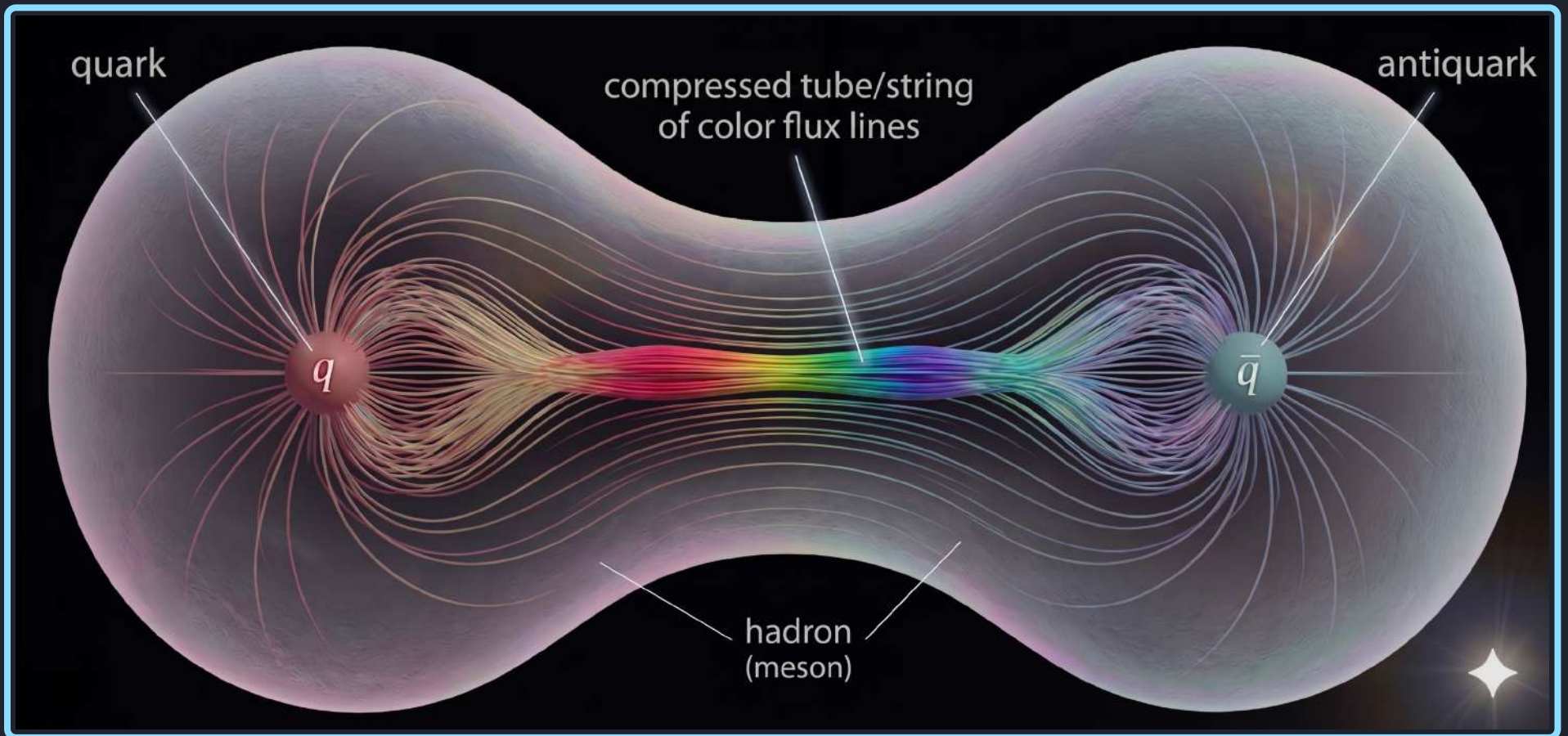
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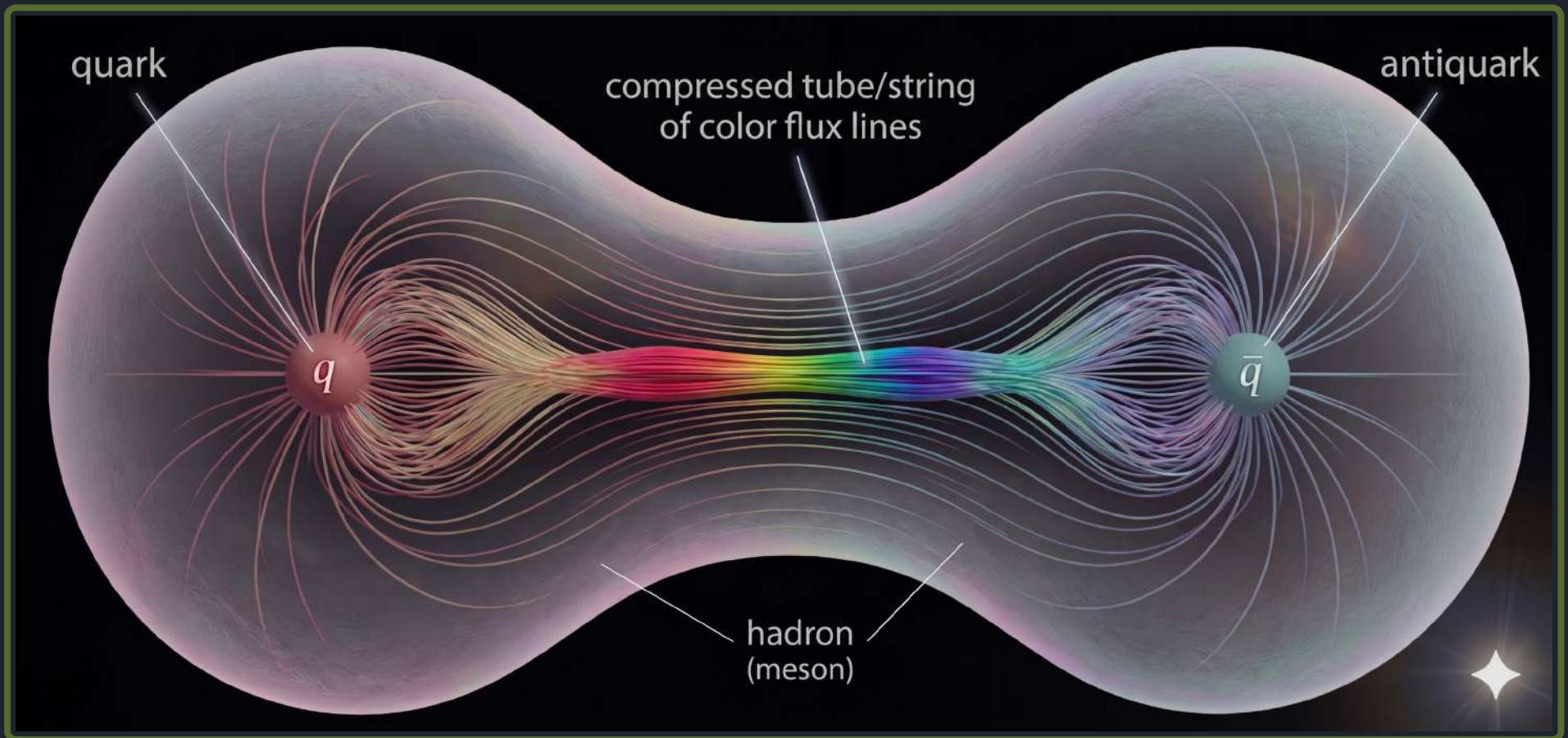
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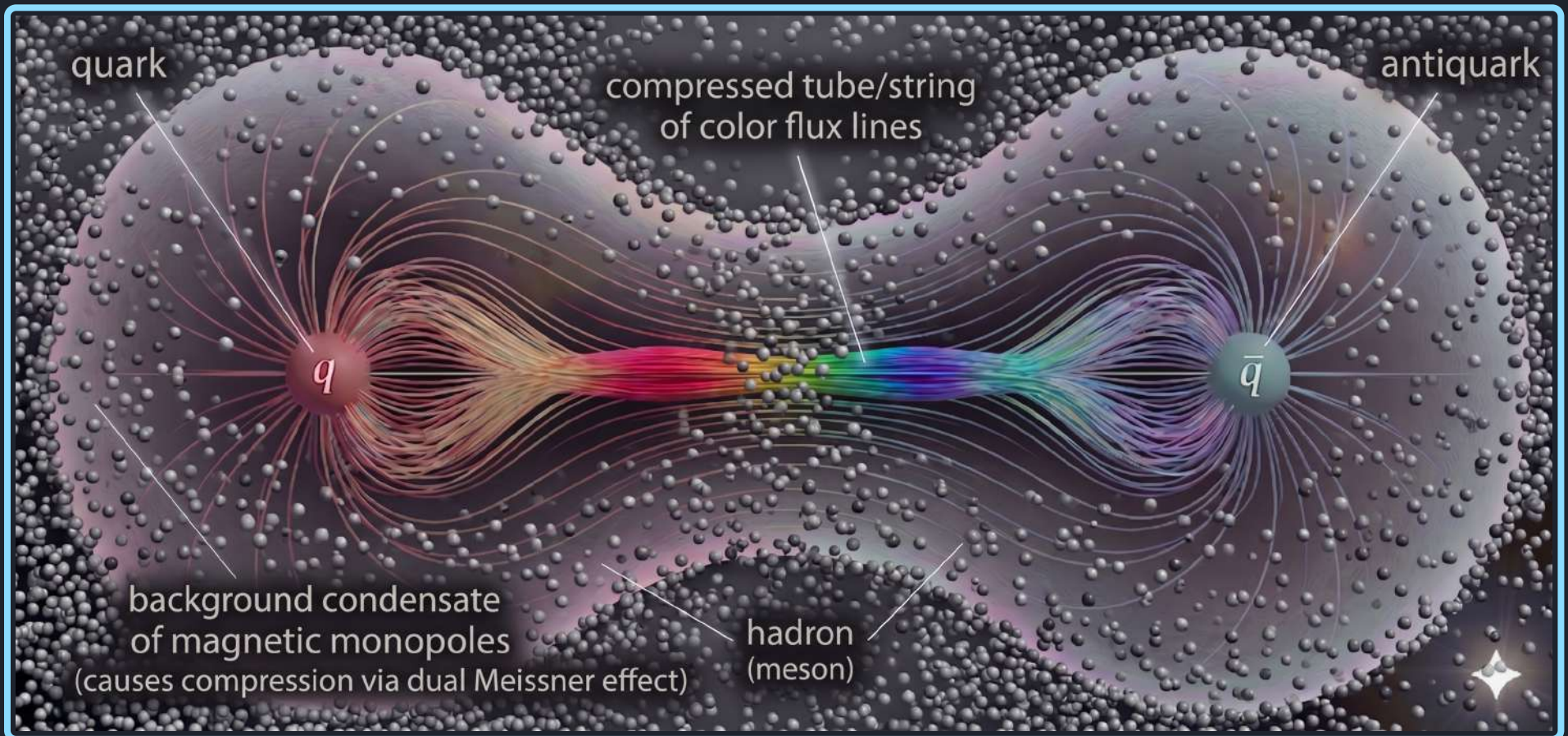
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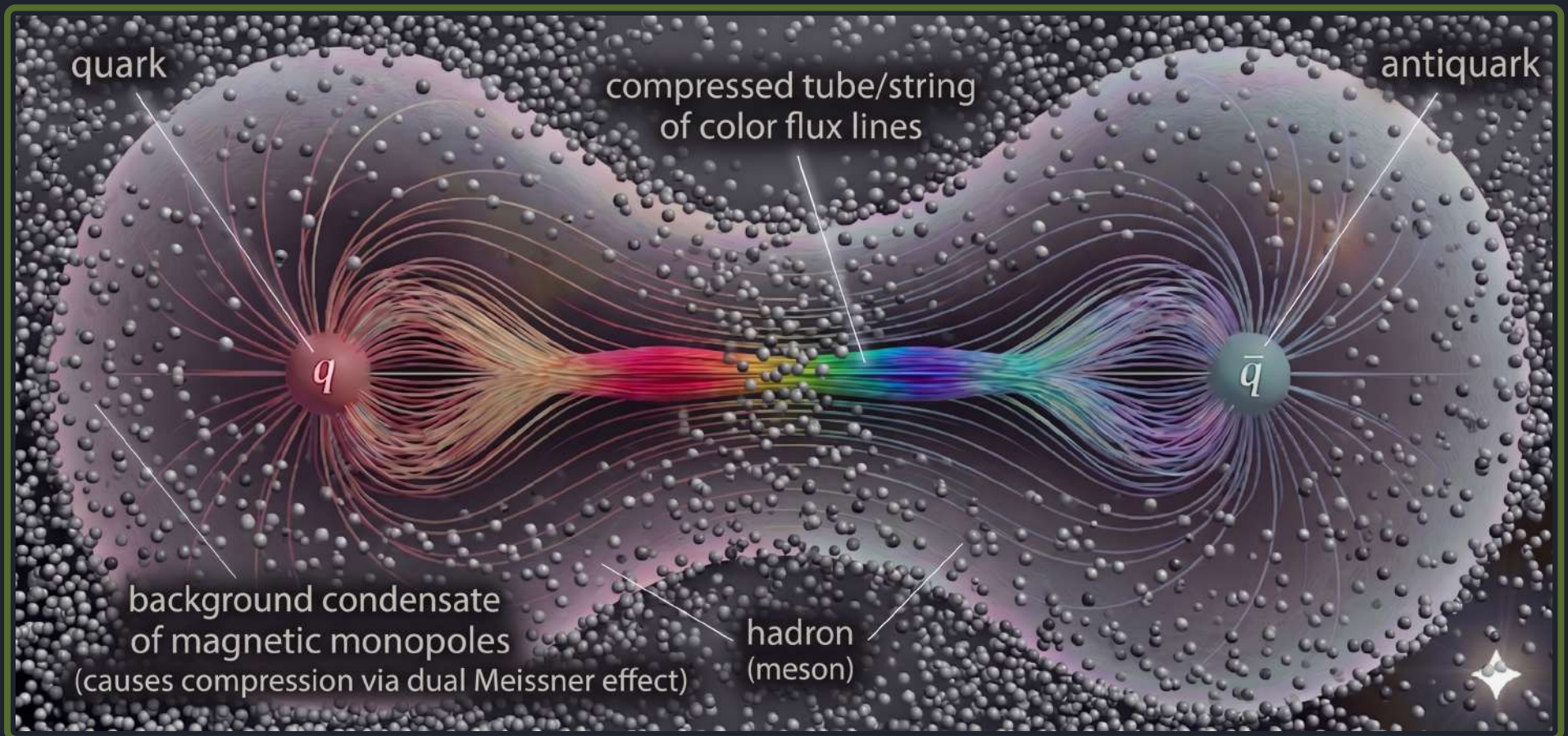
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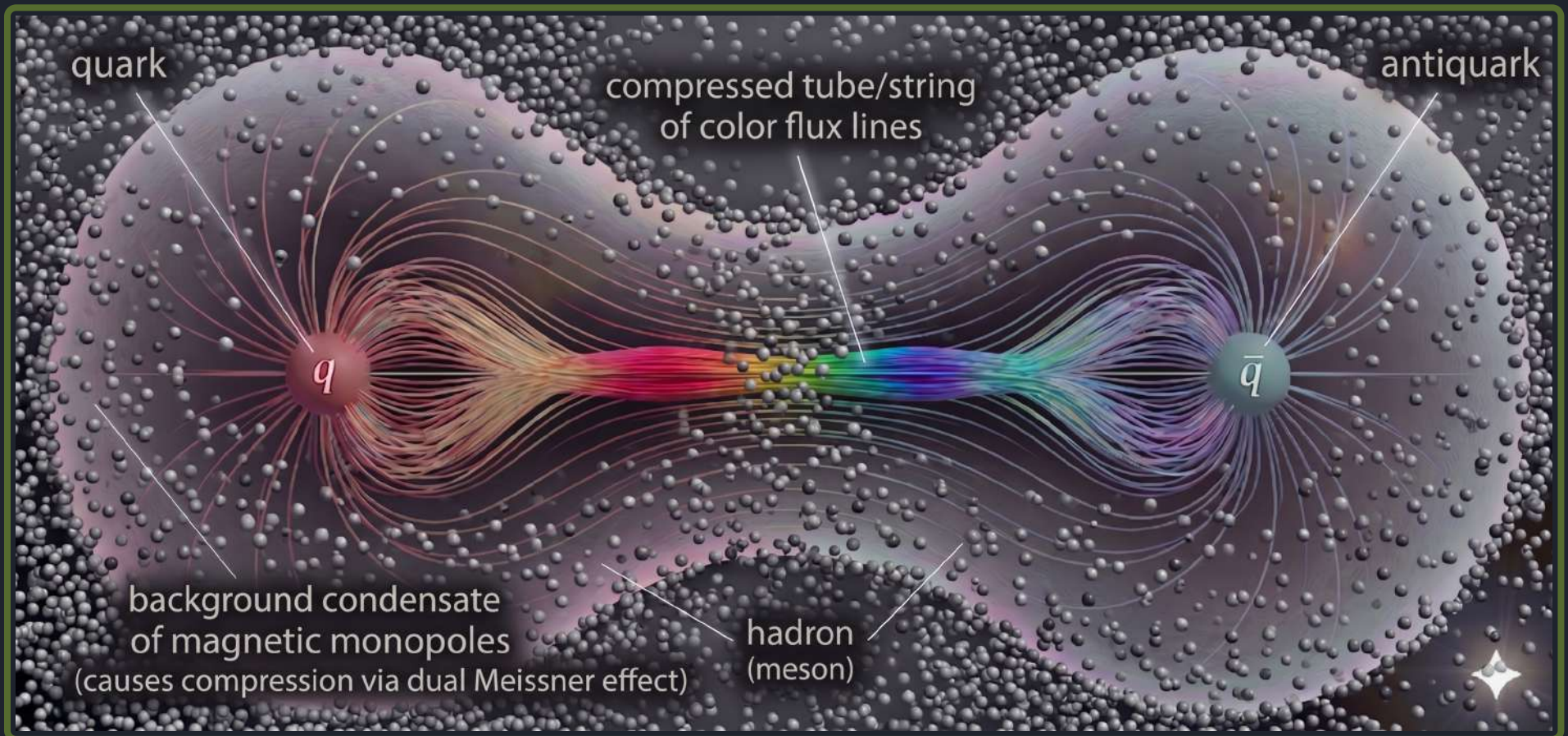
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So the question is: How to make this mathematically precise?
We come back to this later. Now first on a related problem...

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where many particles condense to solids or fluids

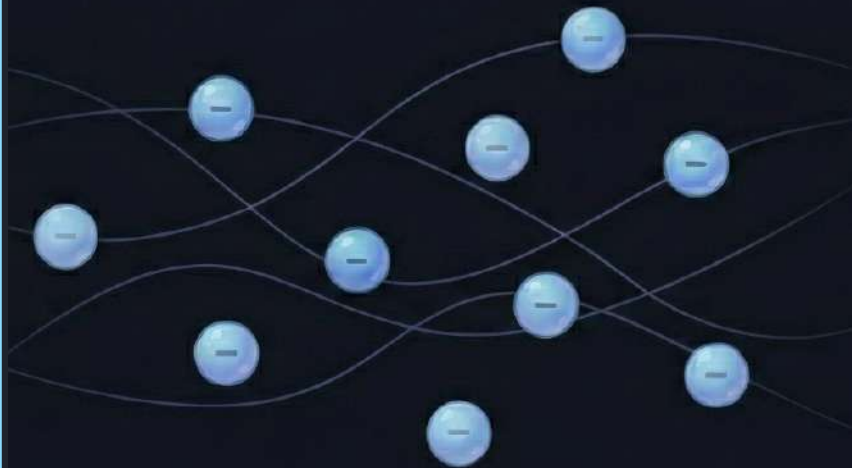
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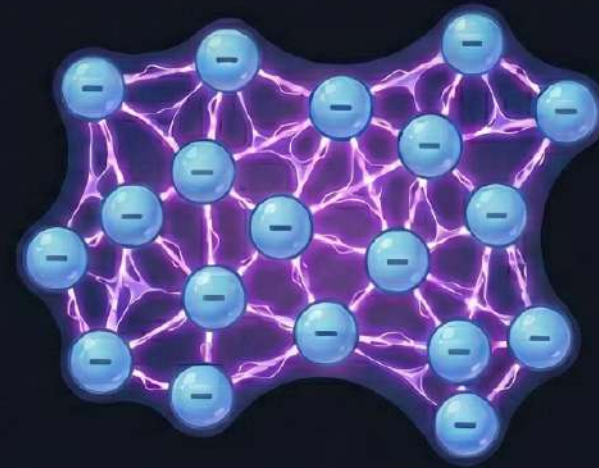
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(Independent)



Like individuals in a sparse crowd,
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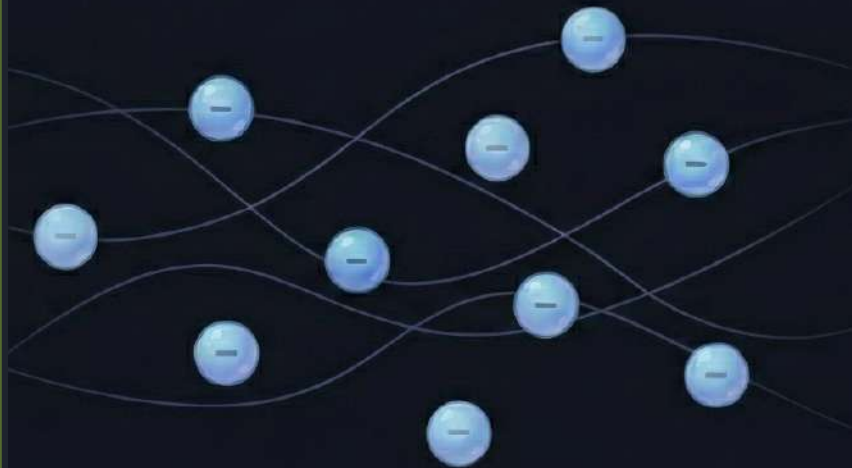


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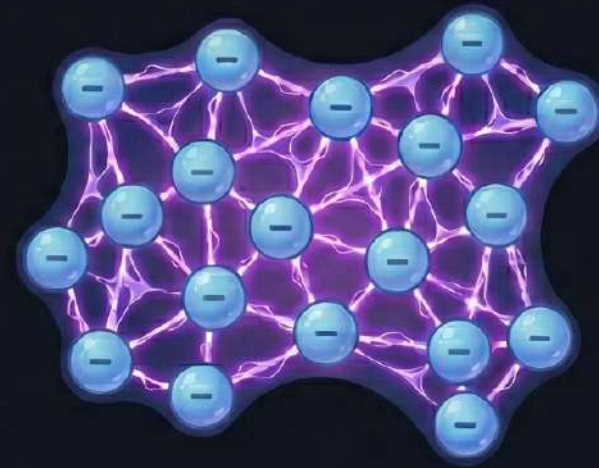
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Feature: Strong correlations

physicsworld.com

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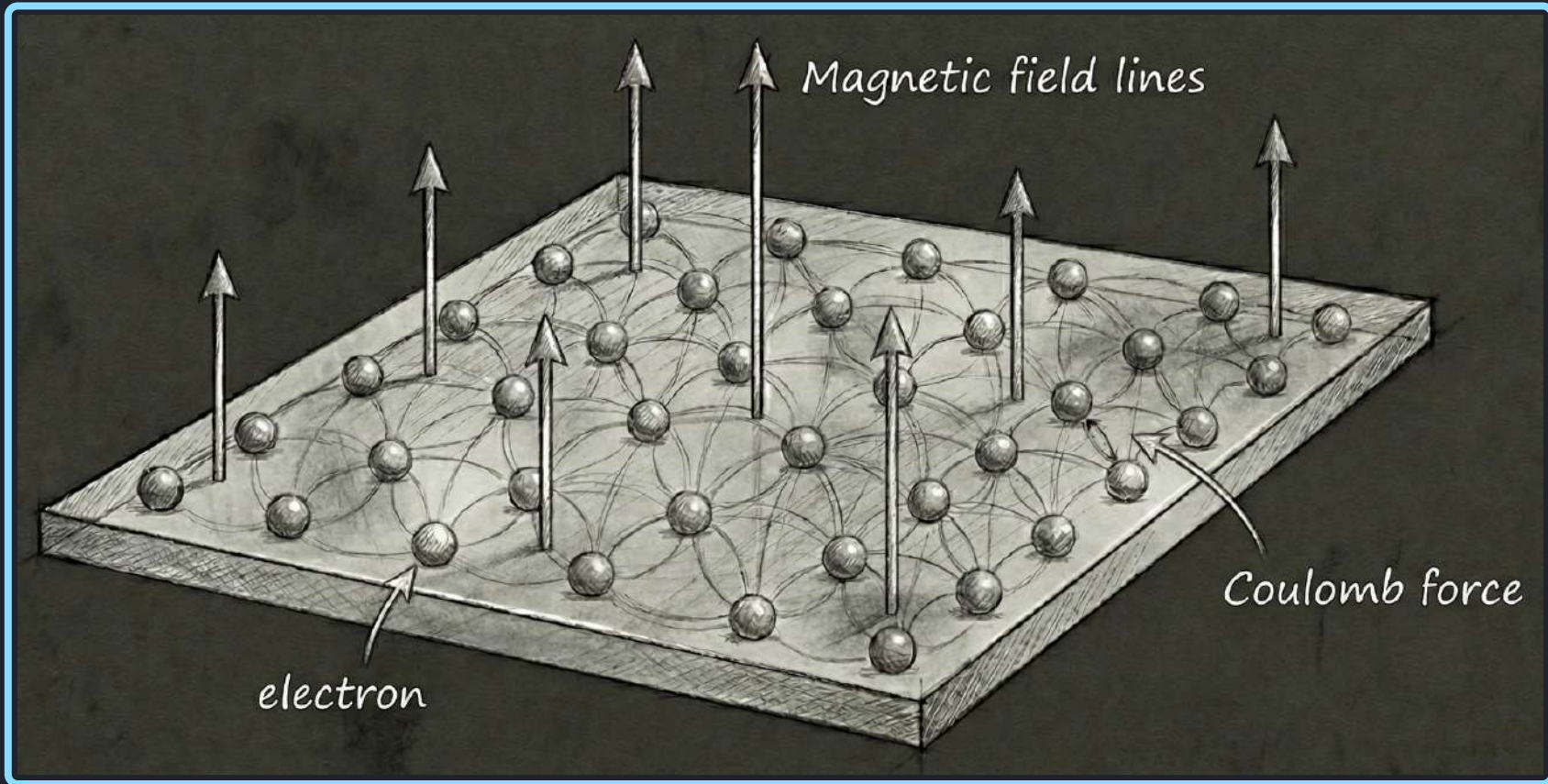
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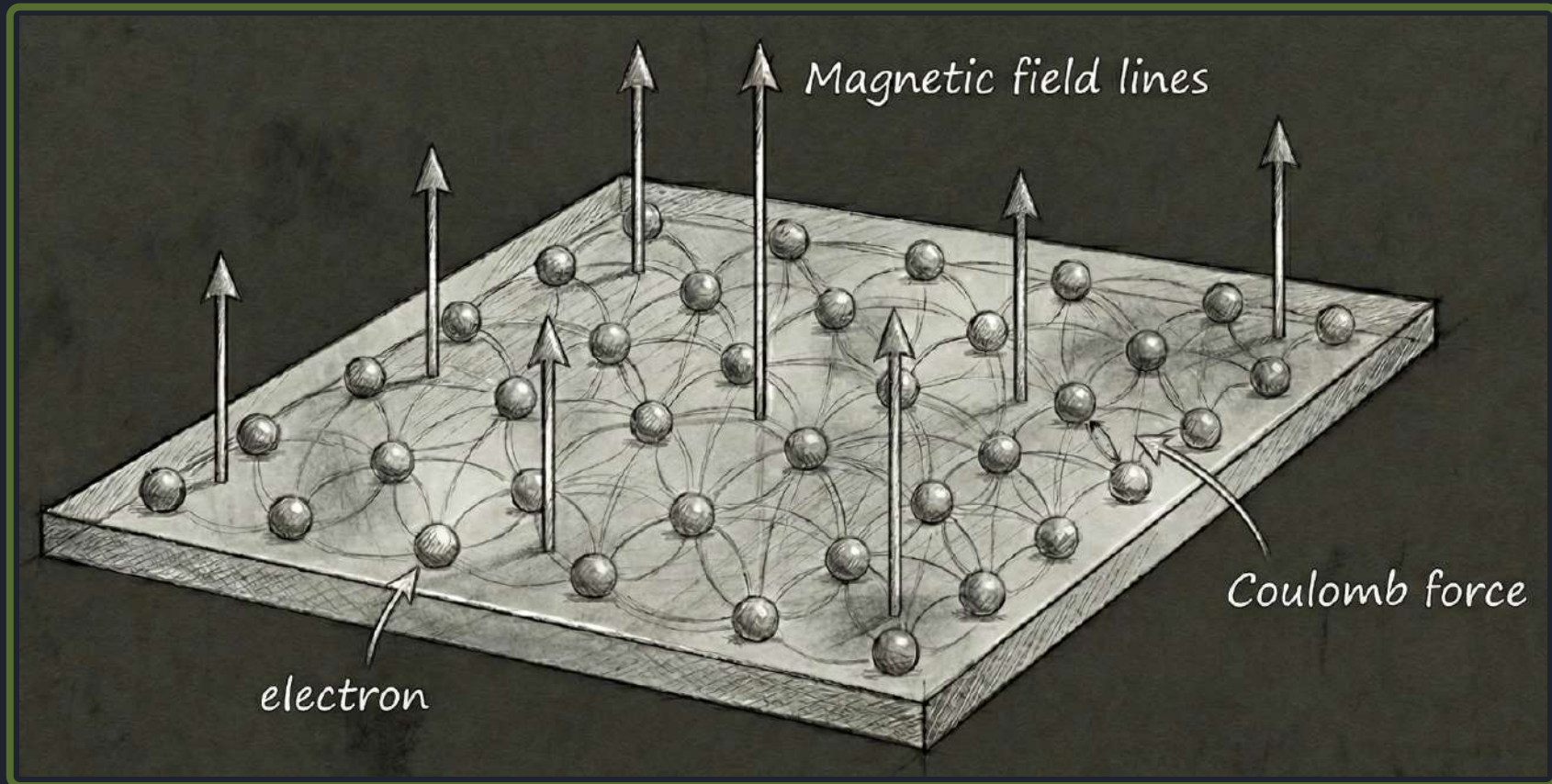
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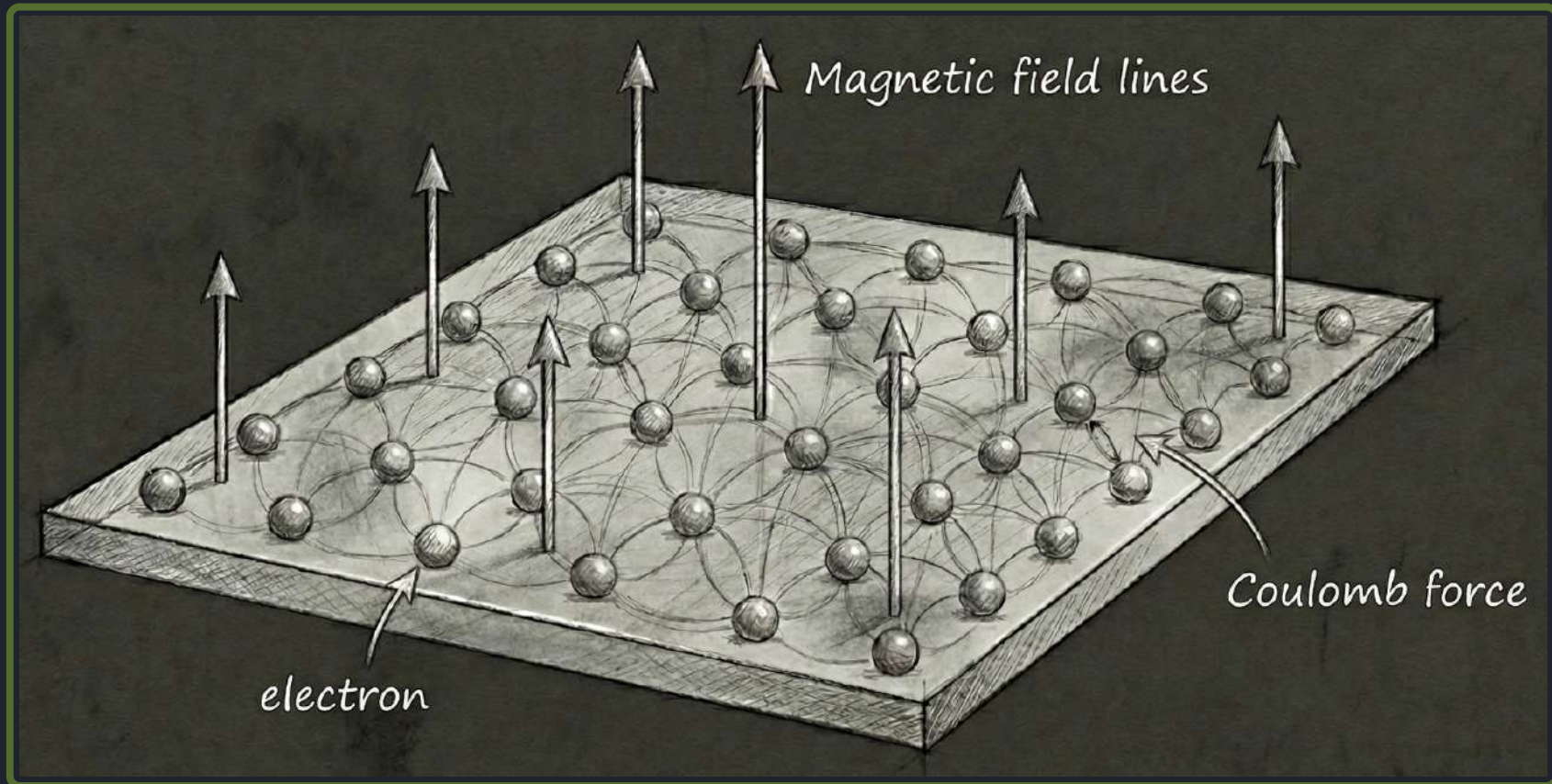
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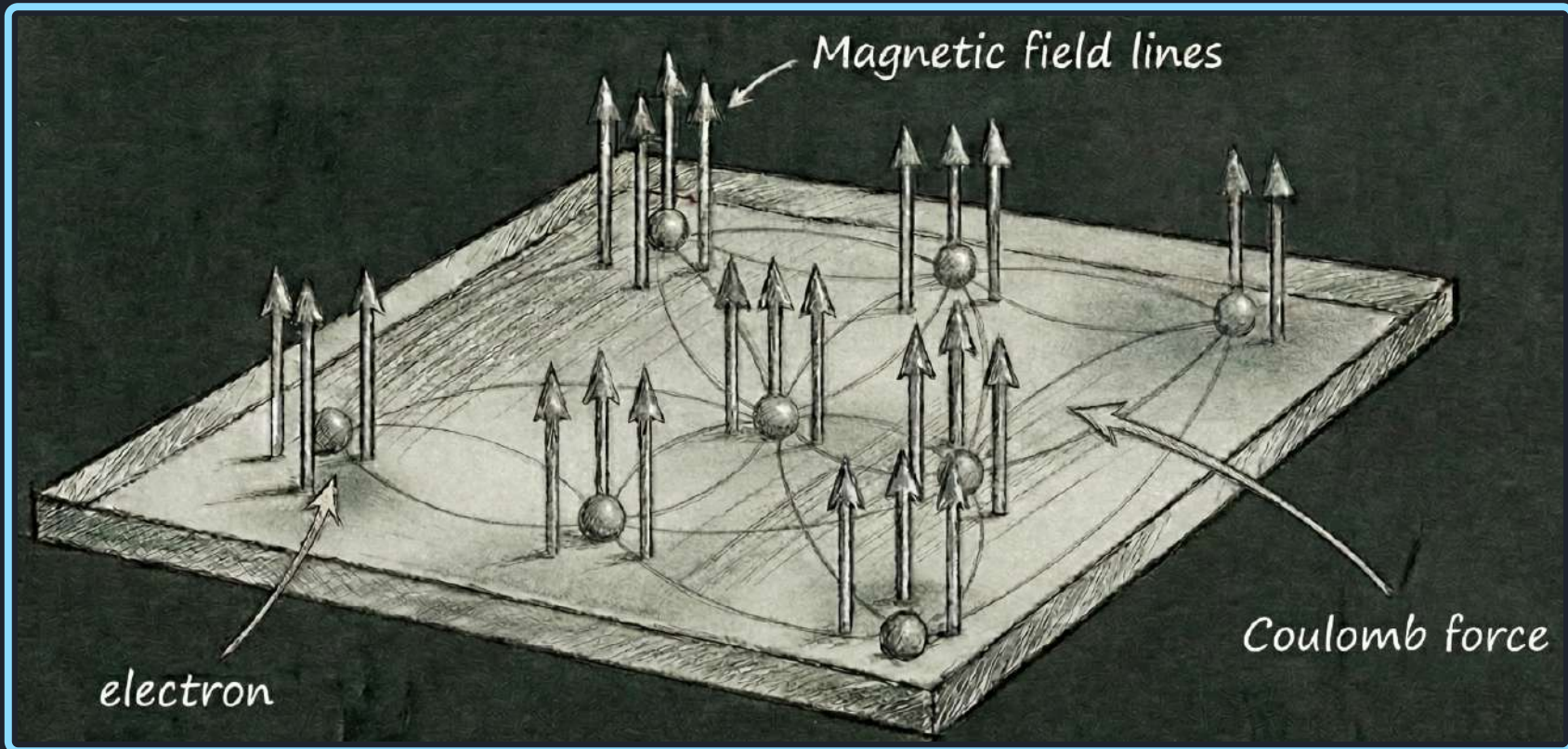
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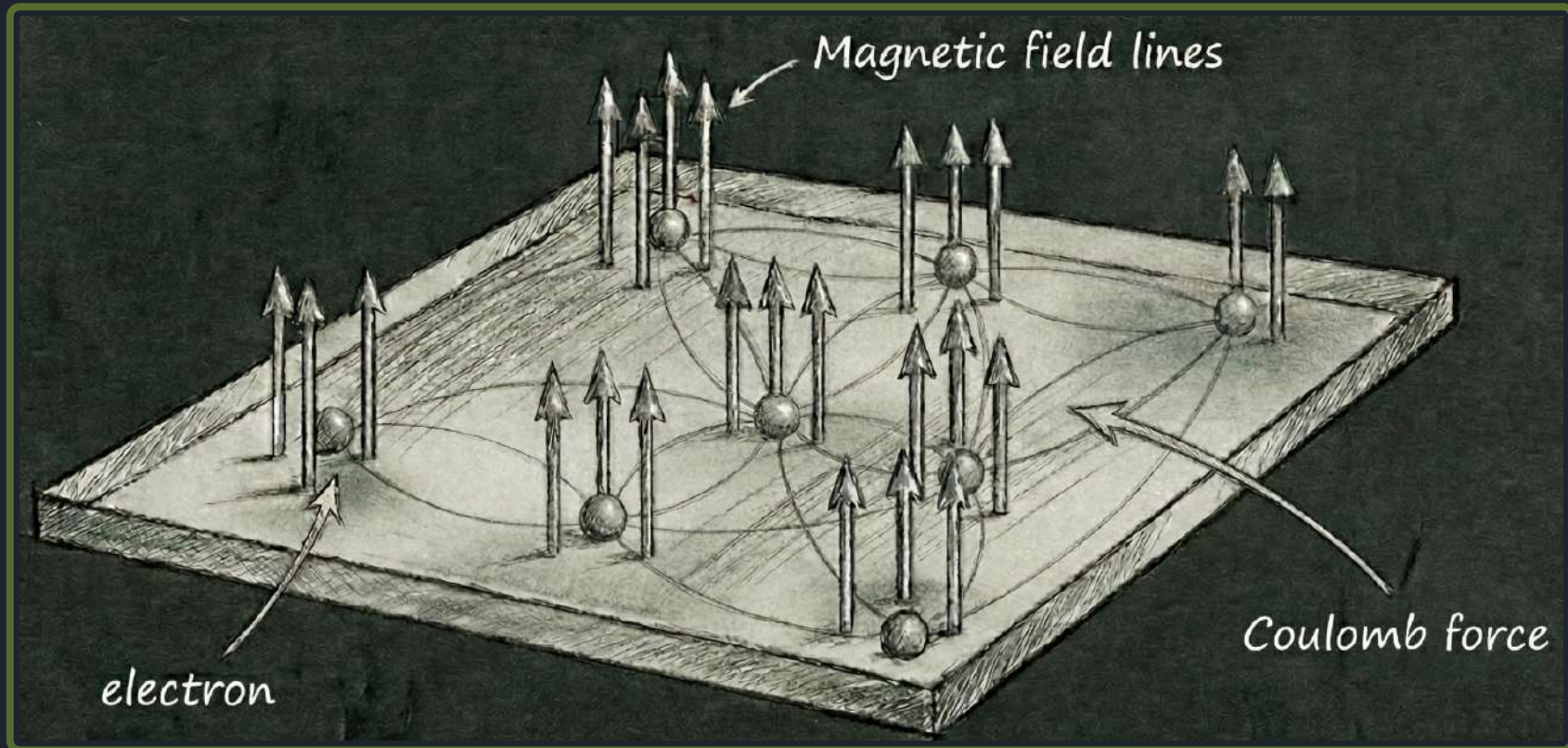
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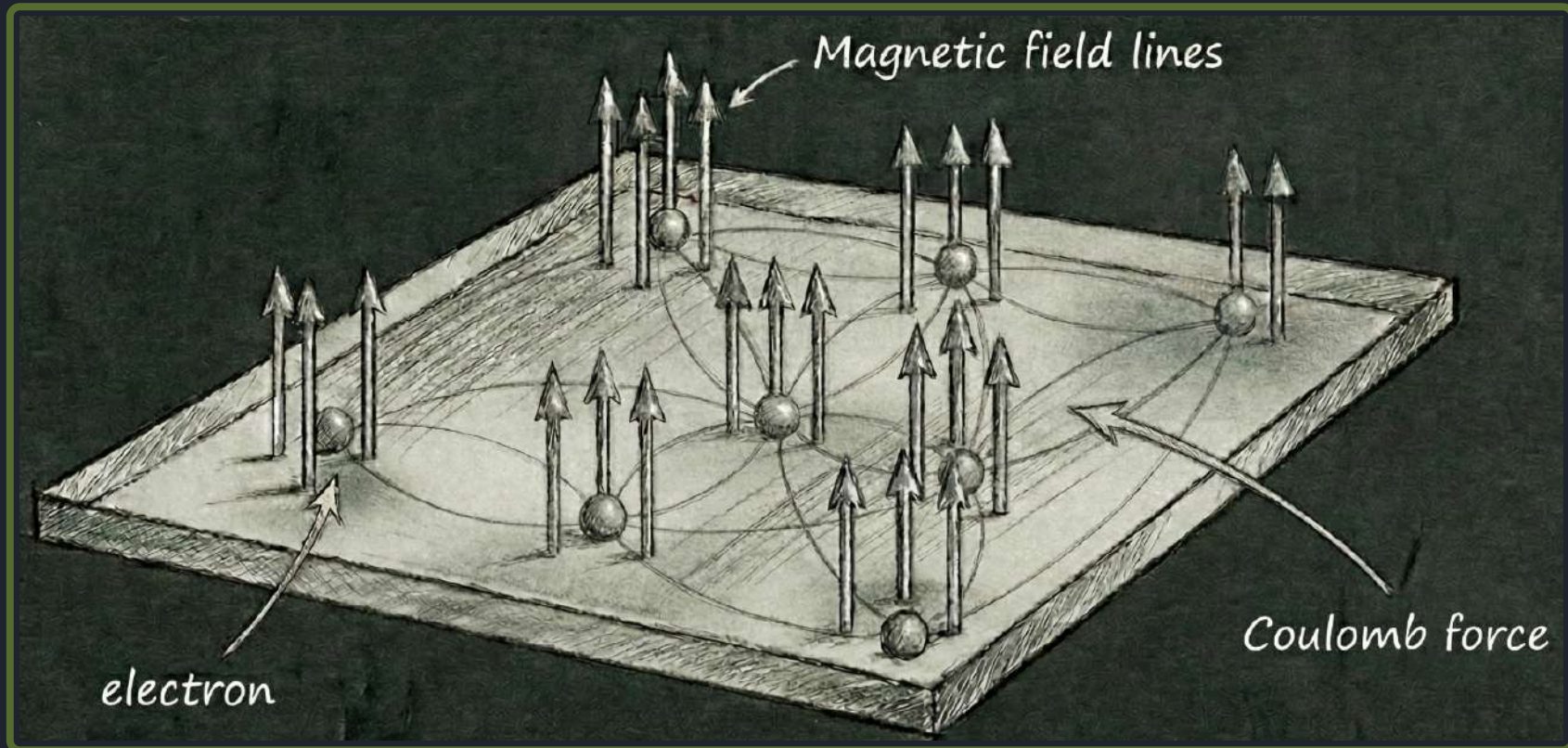


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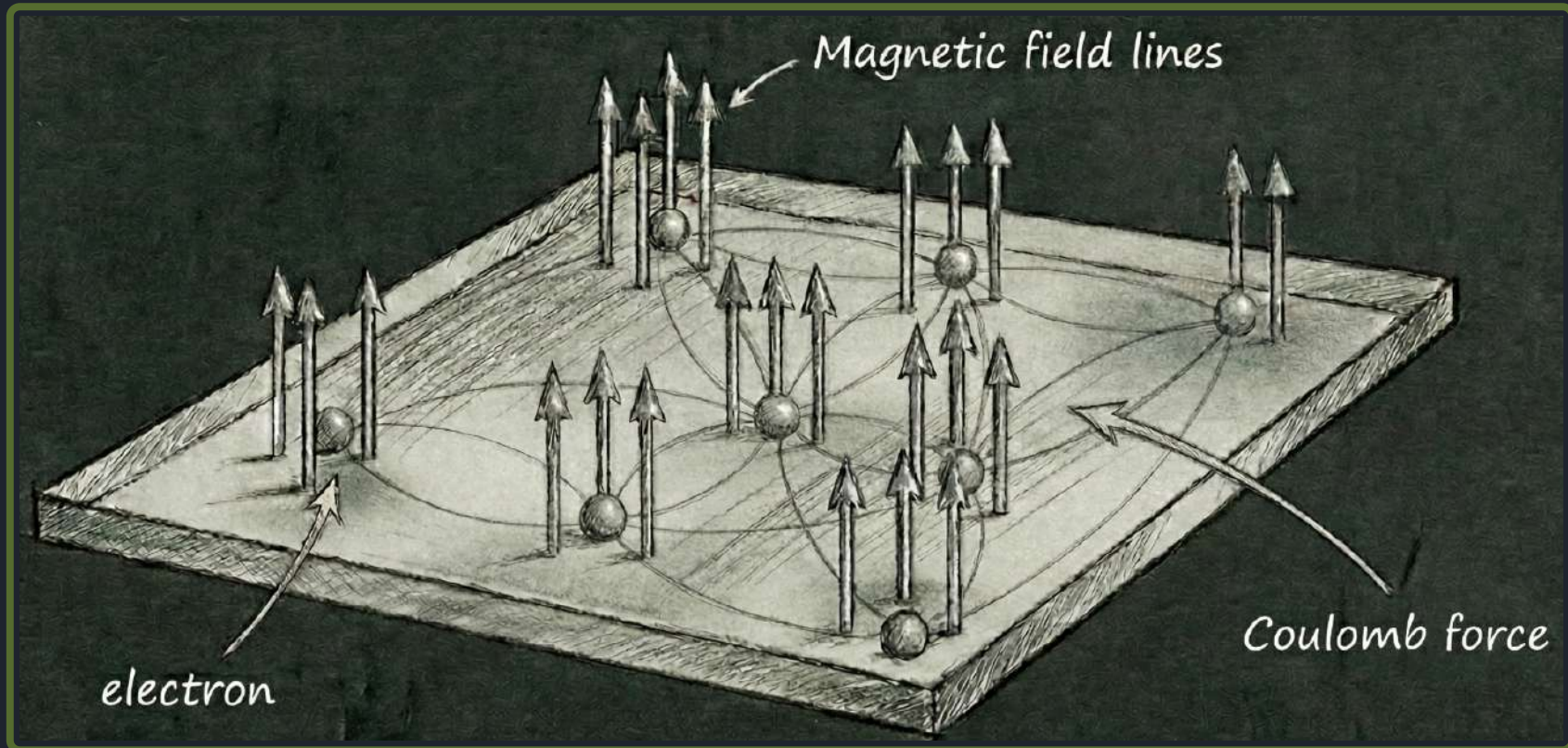
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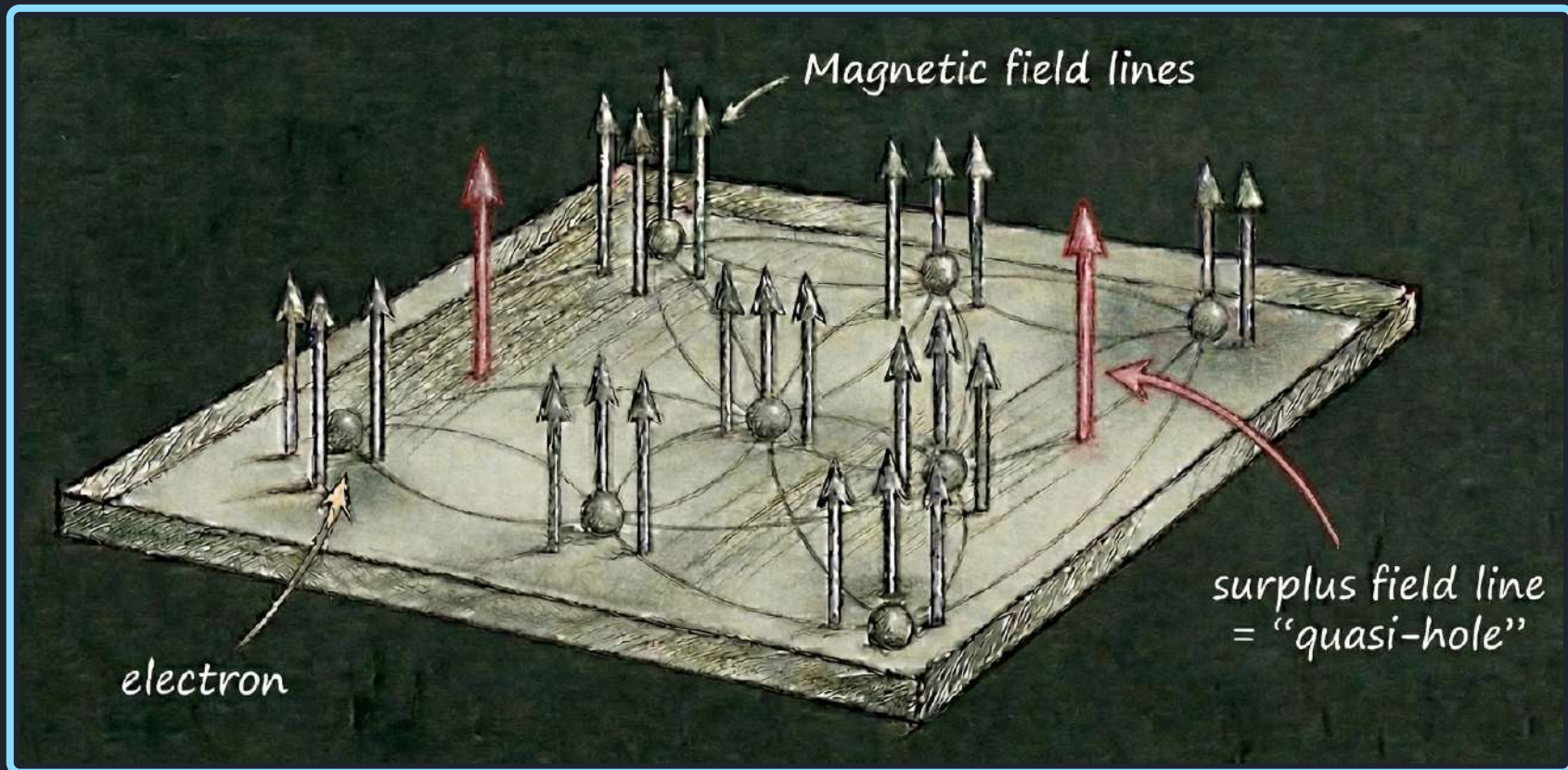


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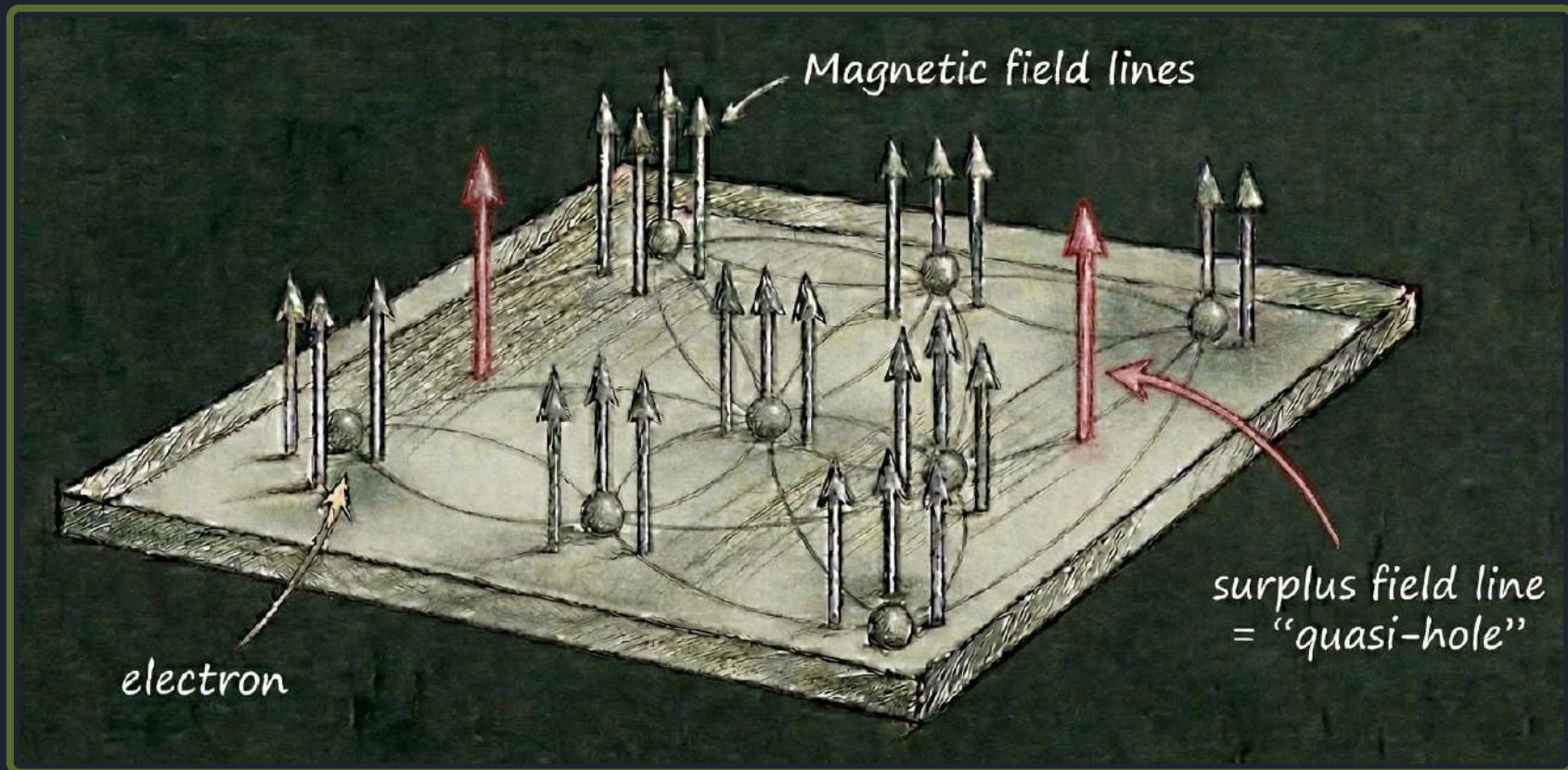
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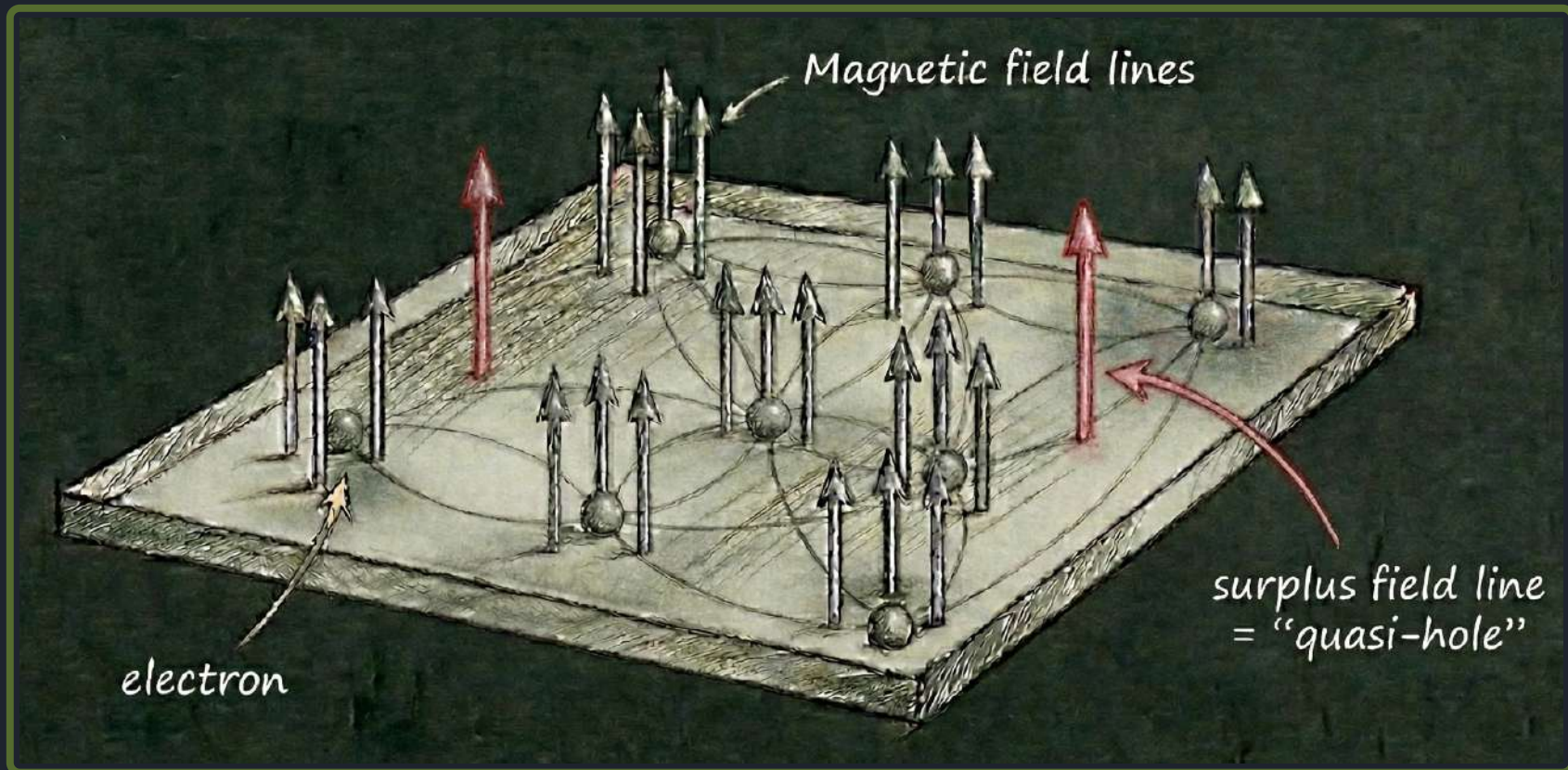


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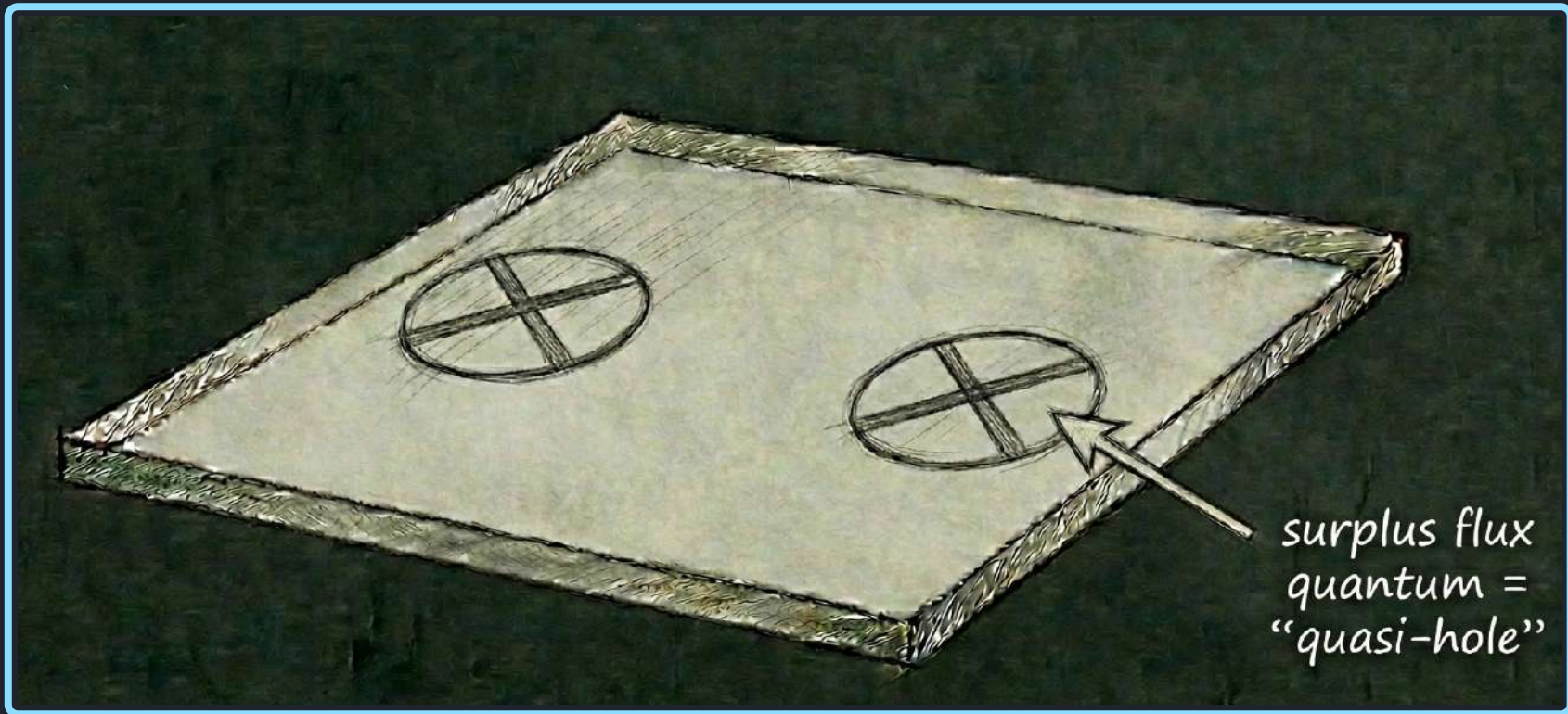


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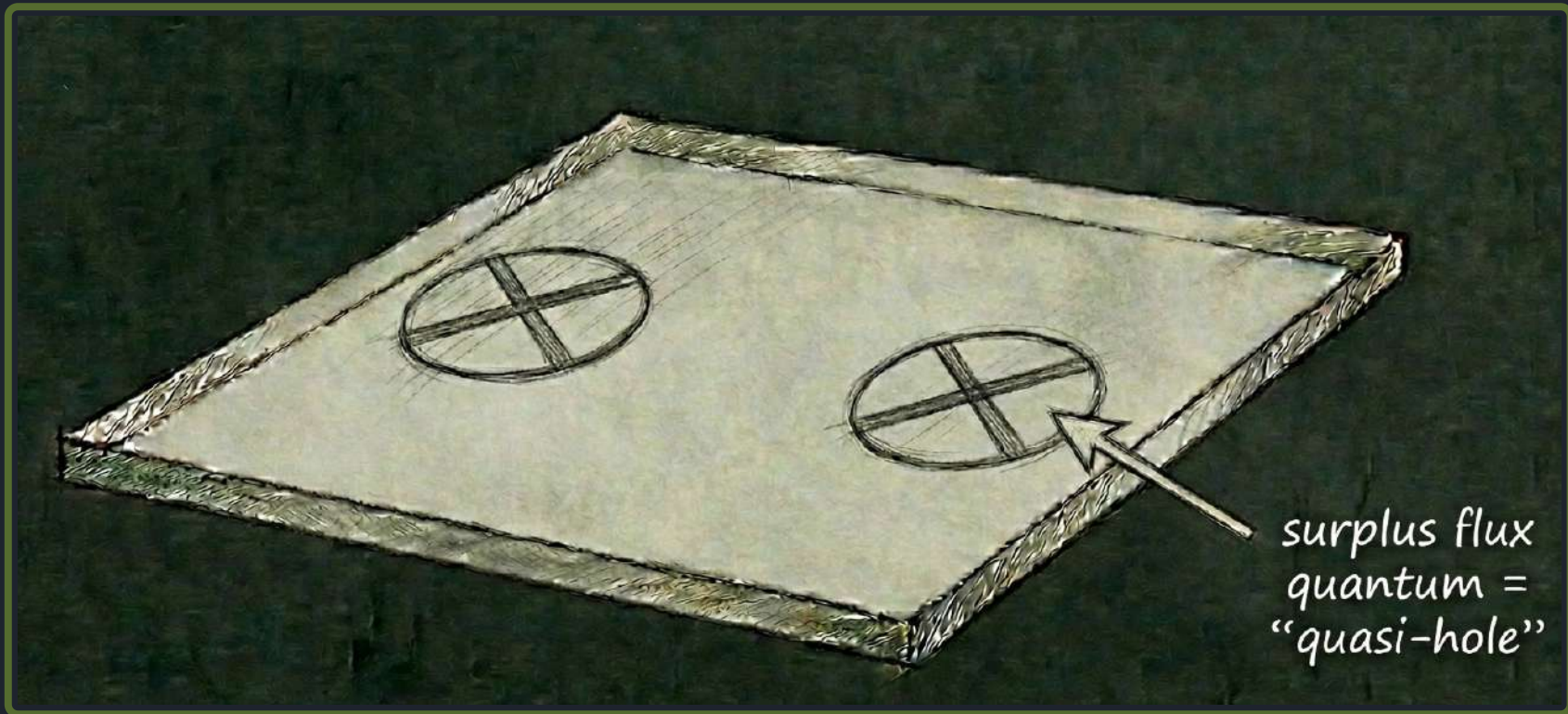
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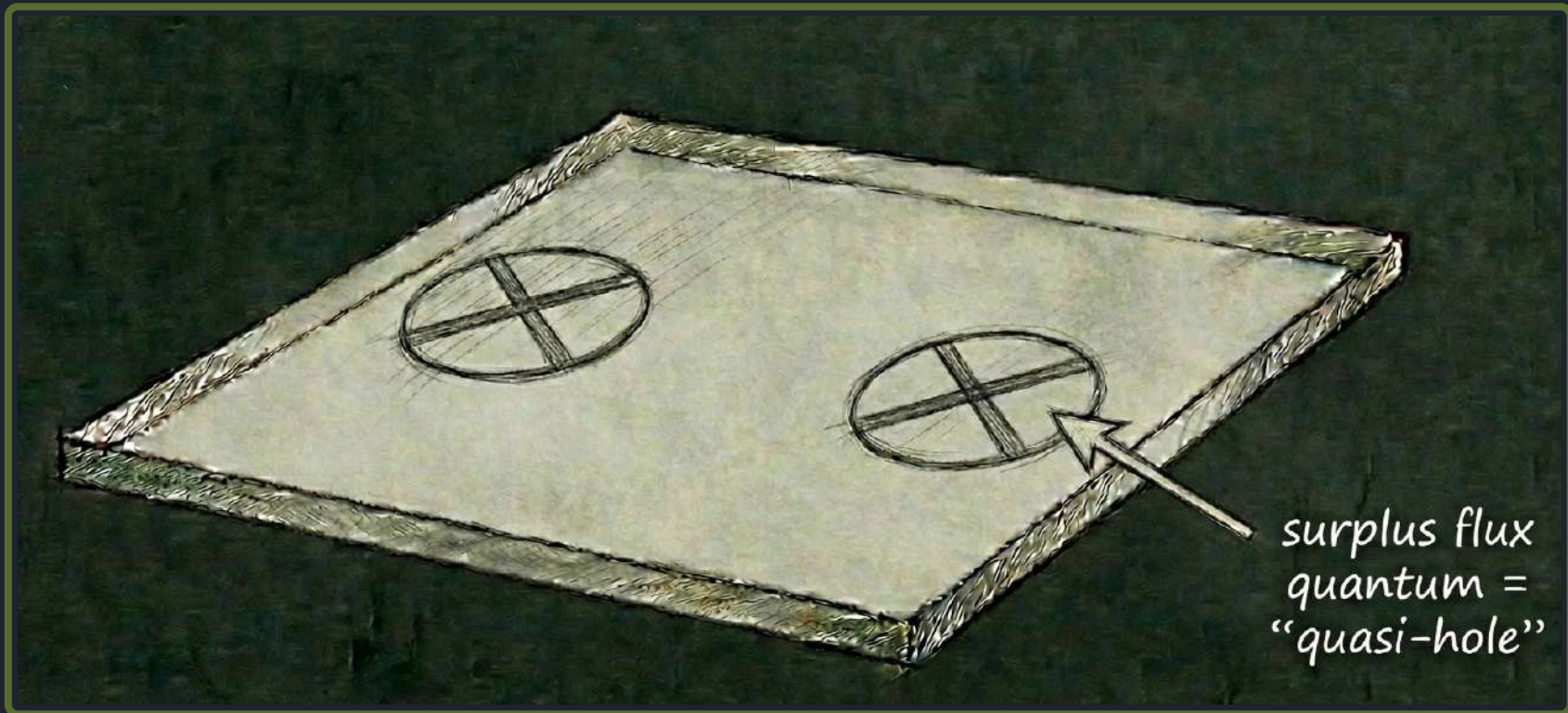


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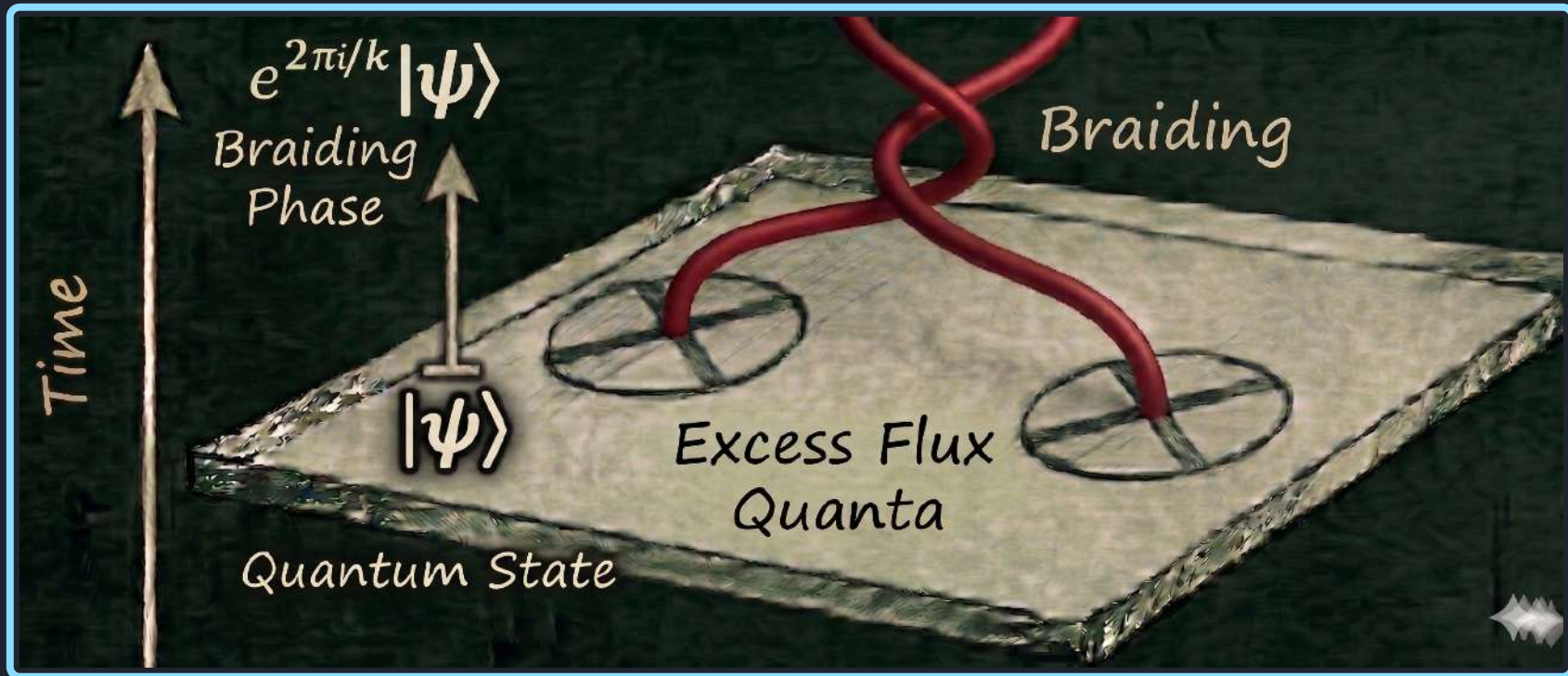


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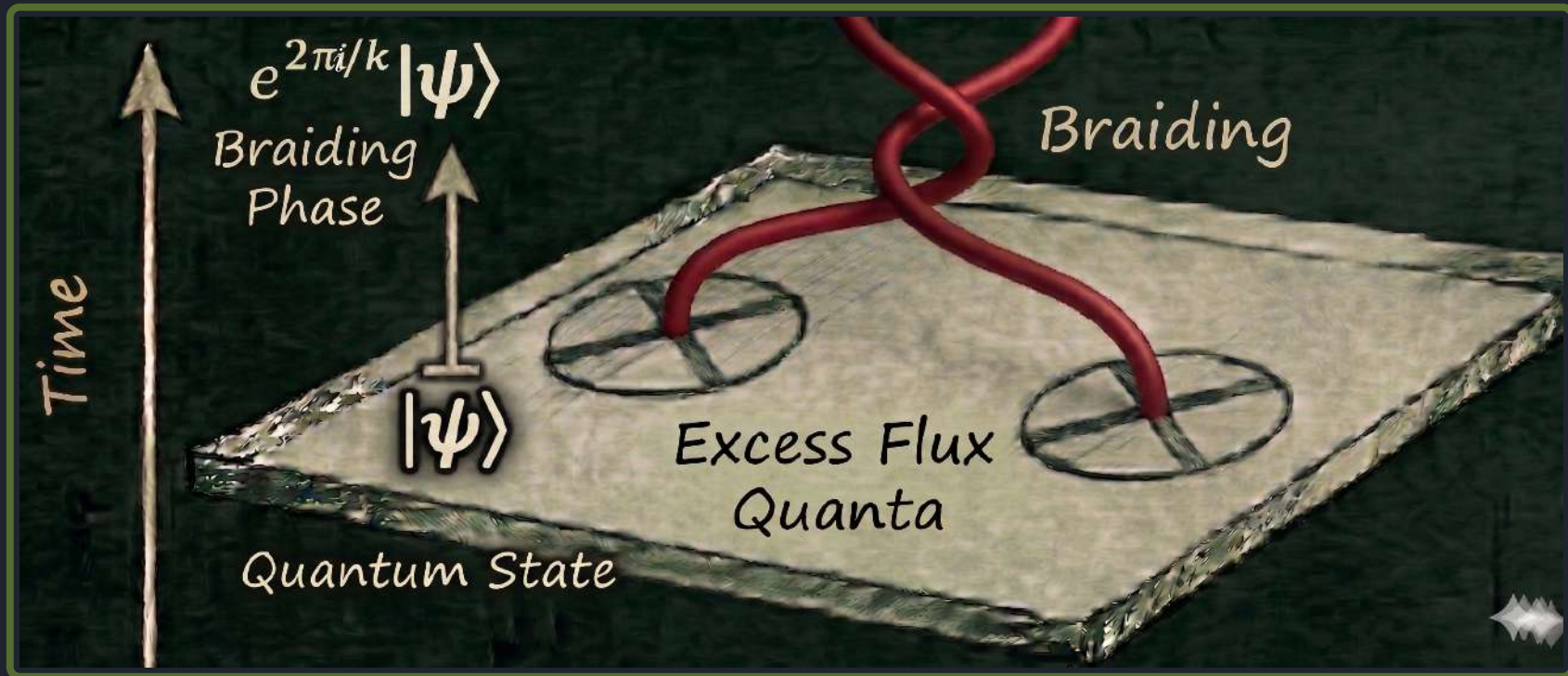
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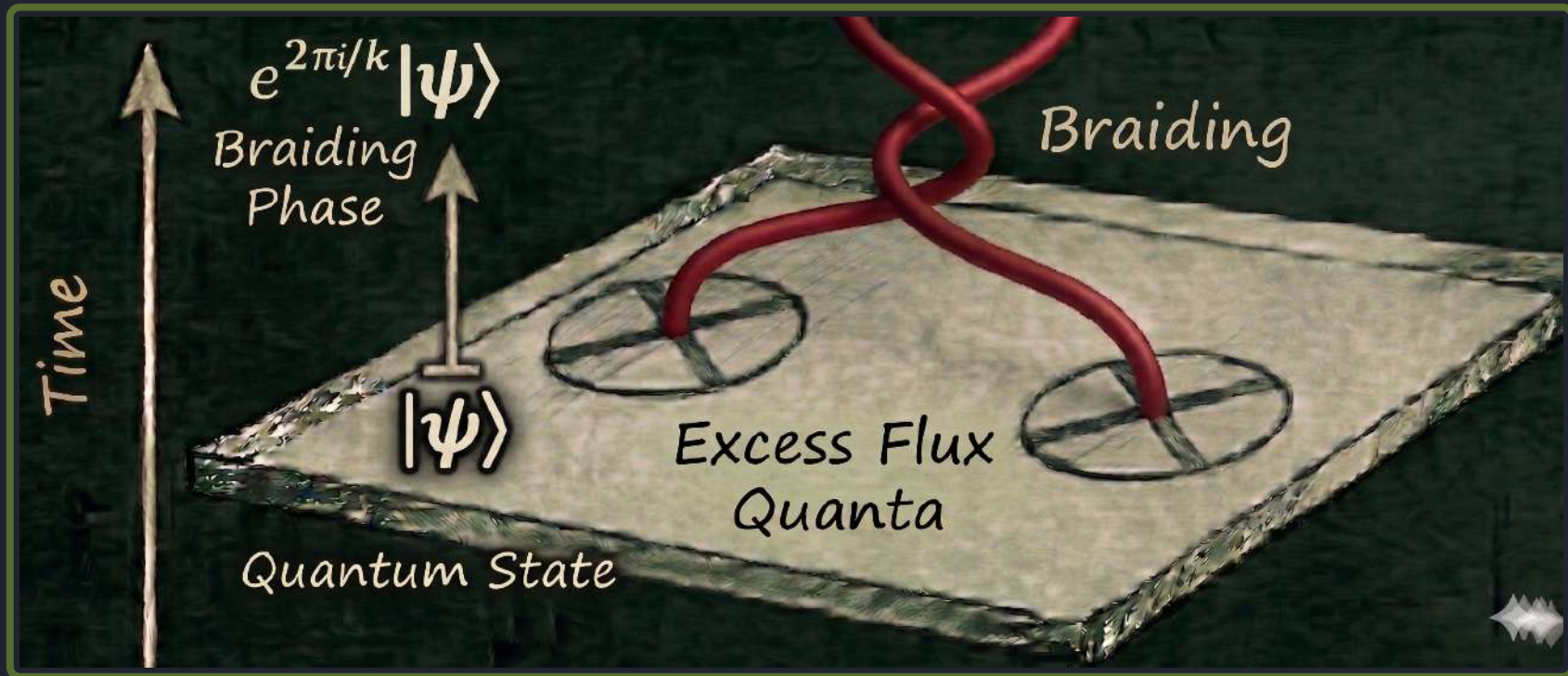


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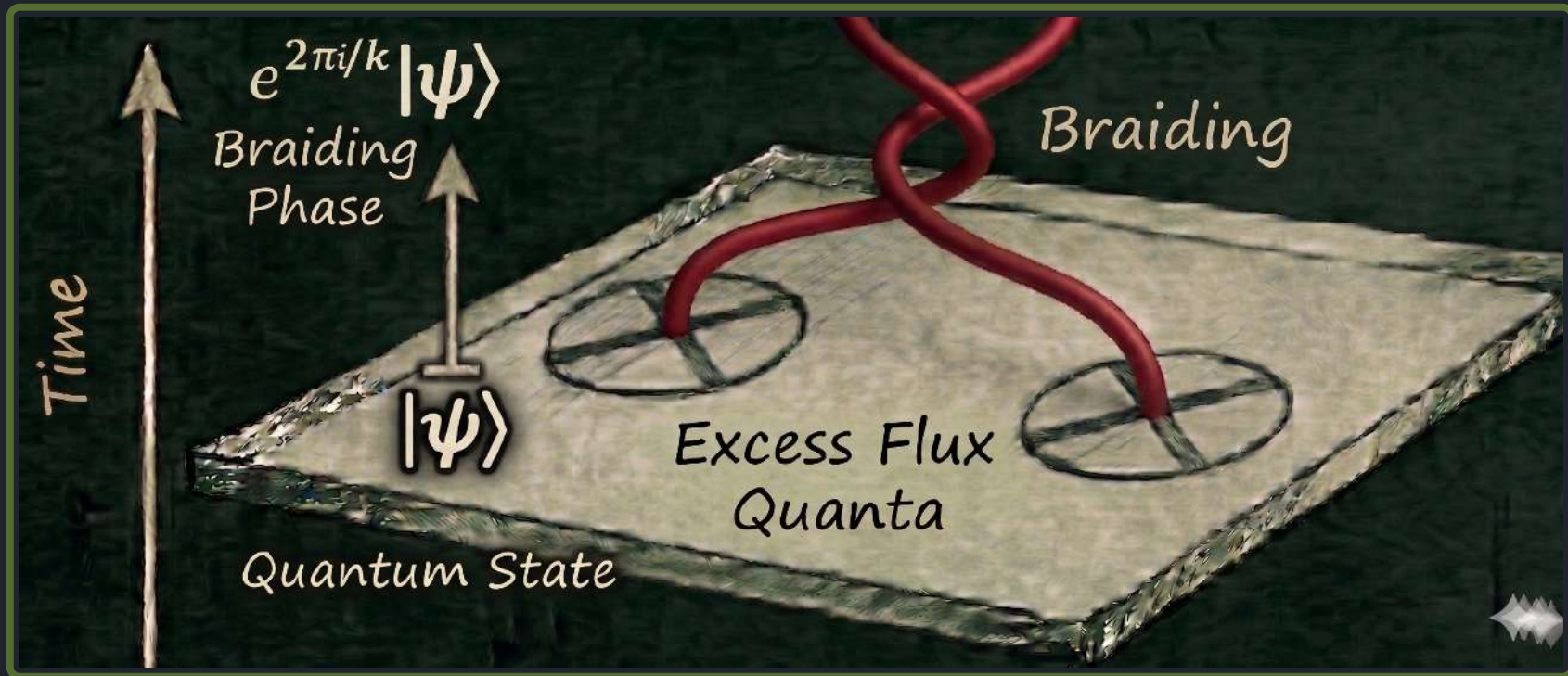
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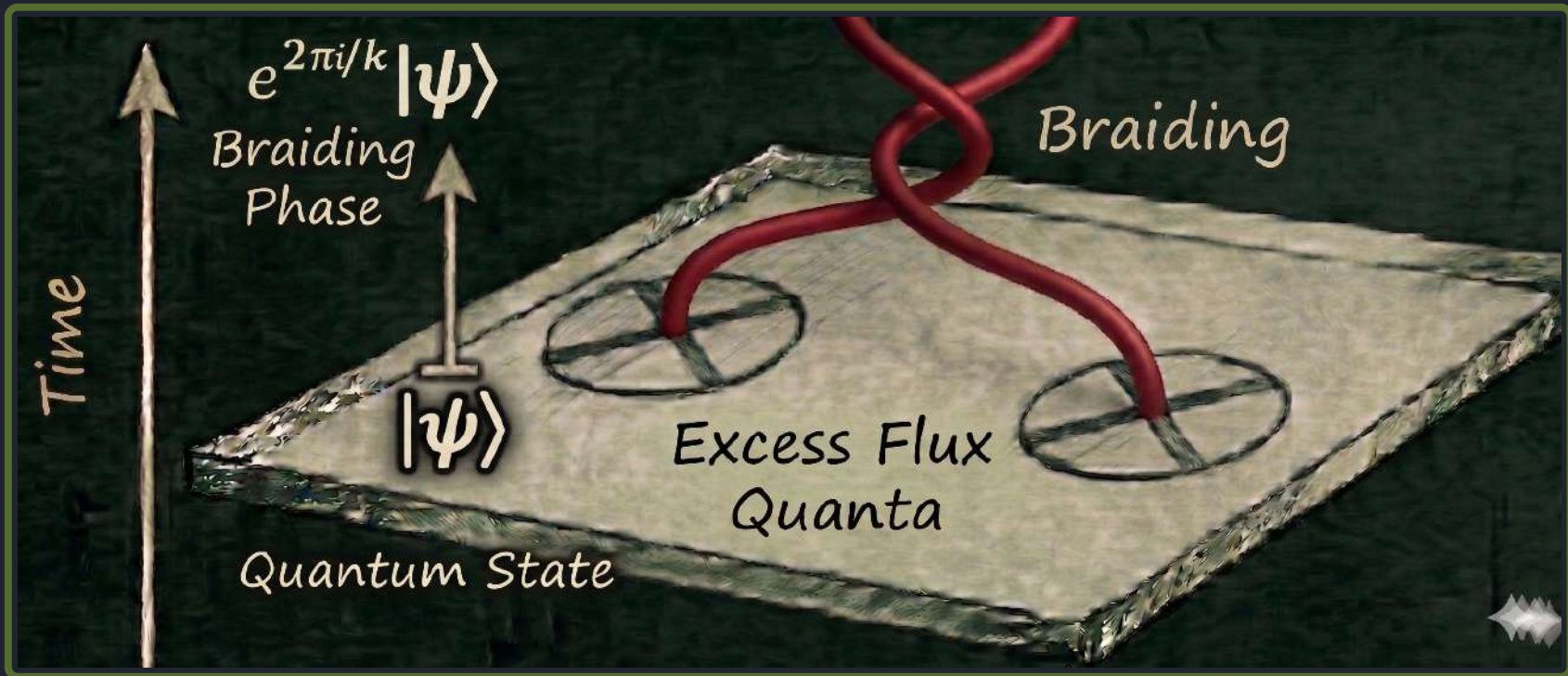
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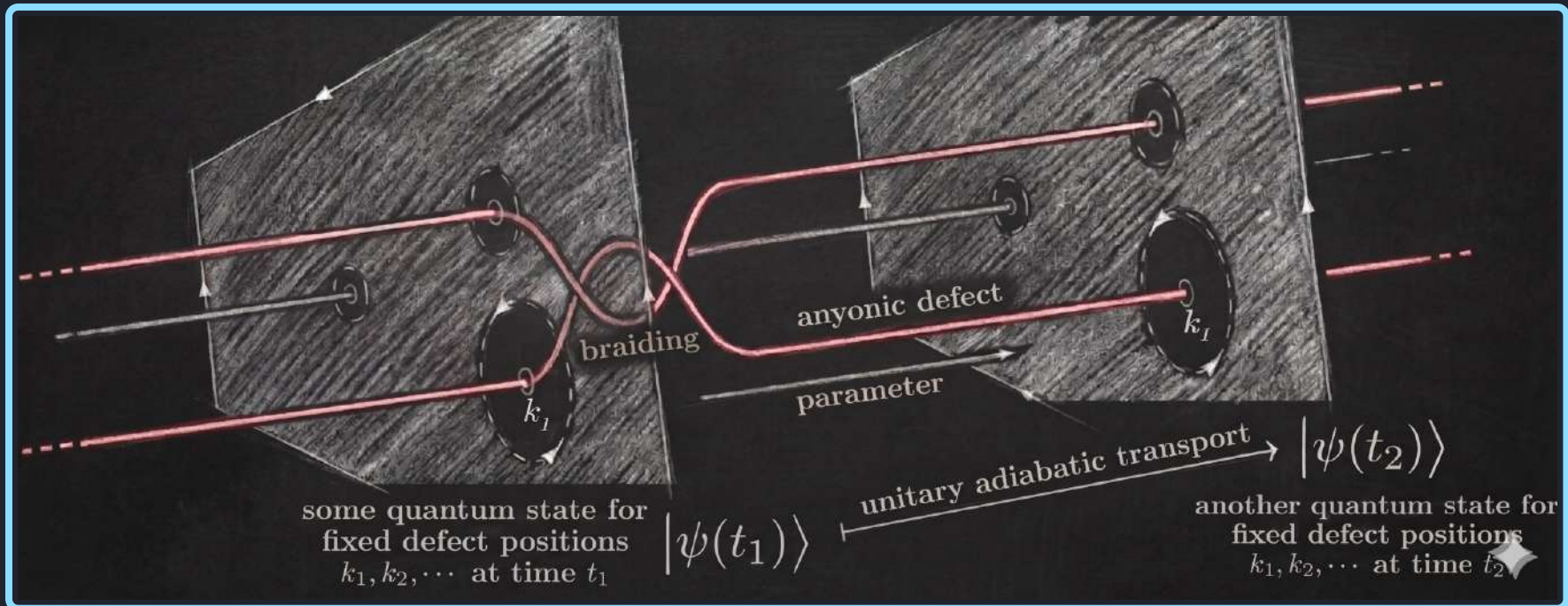


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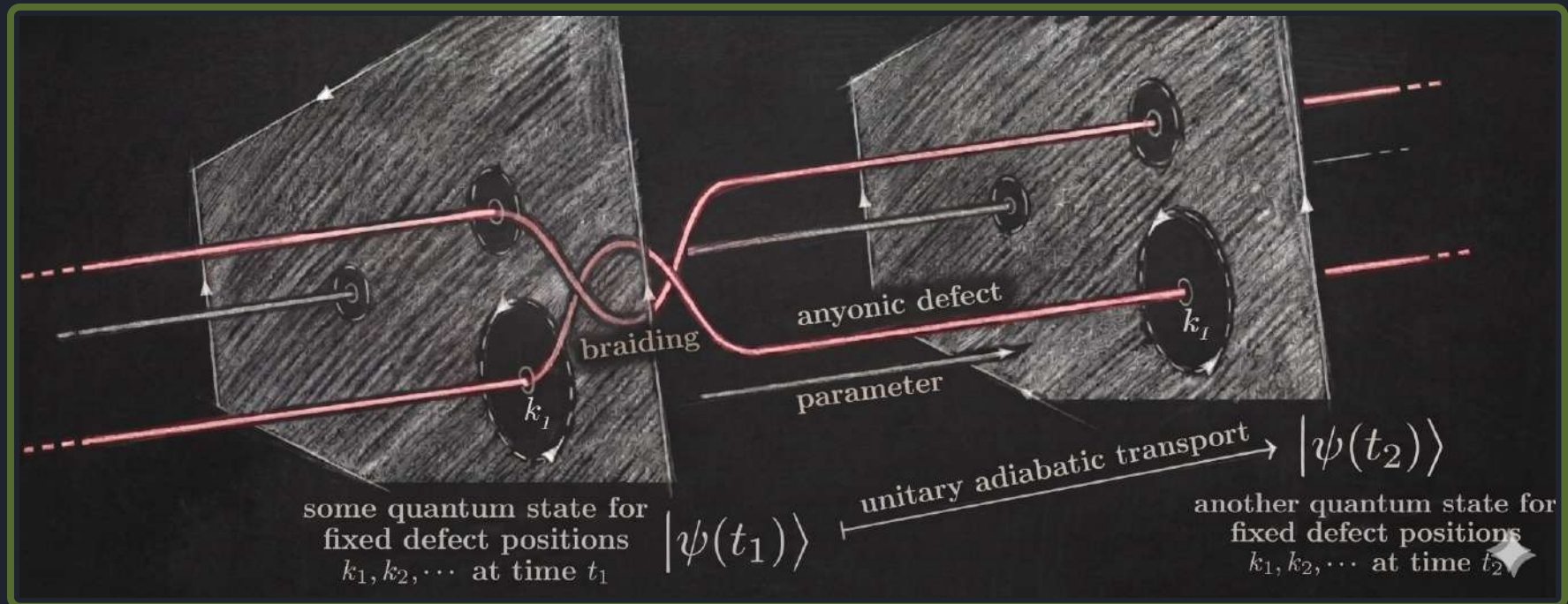
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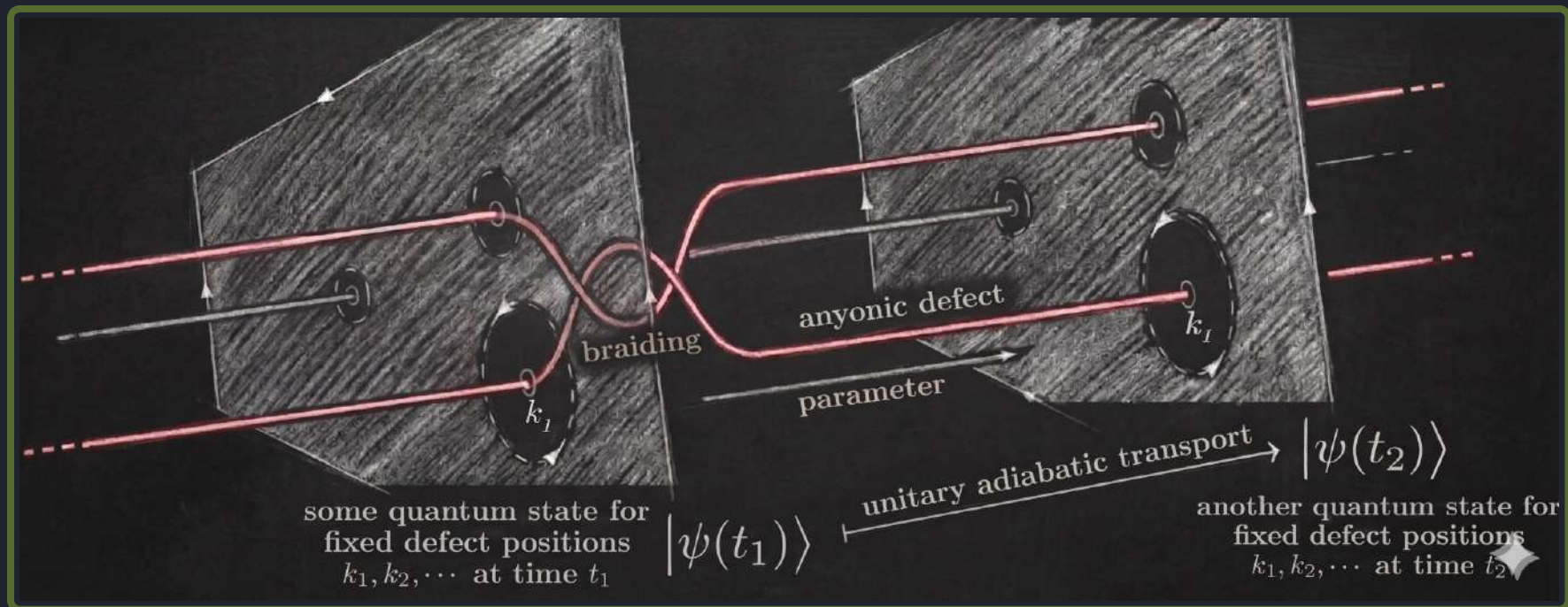


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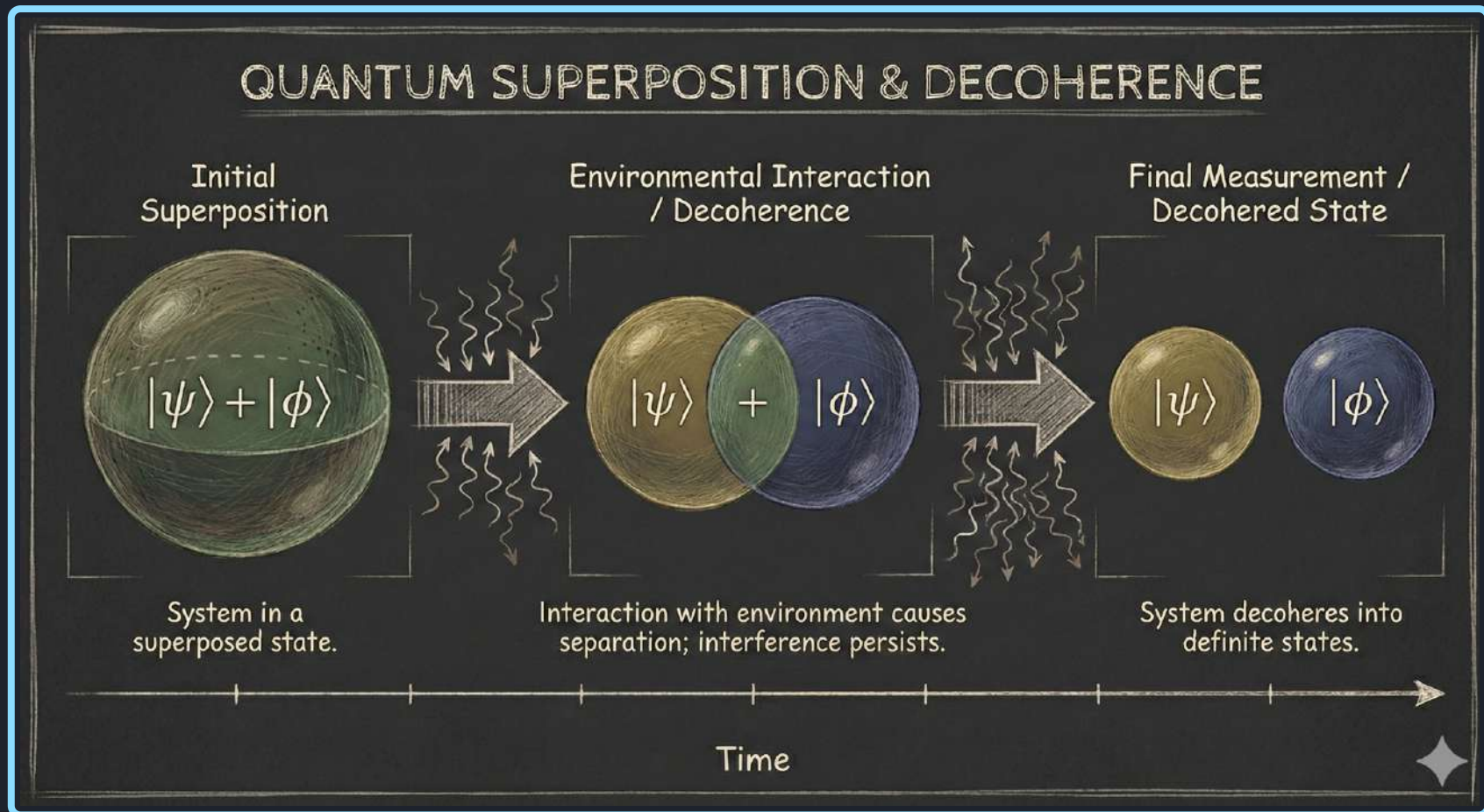
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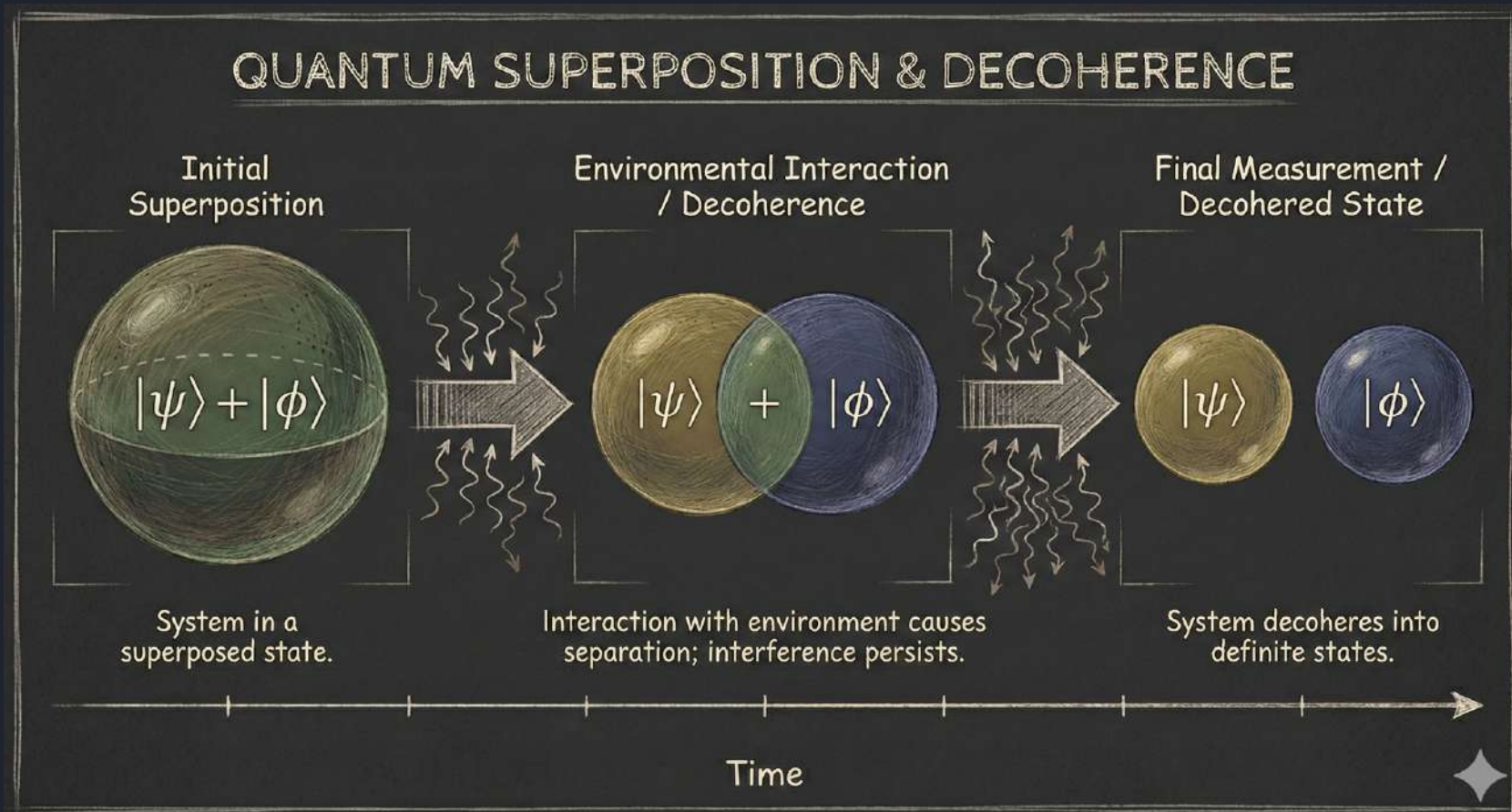
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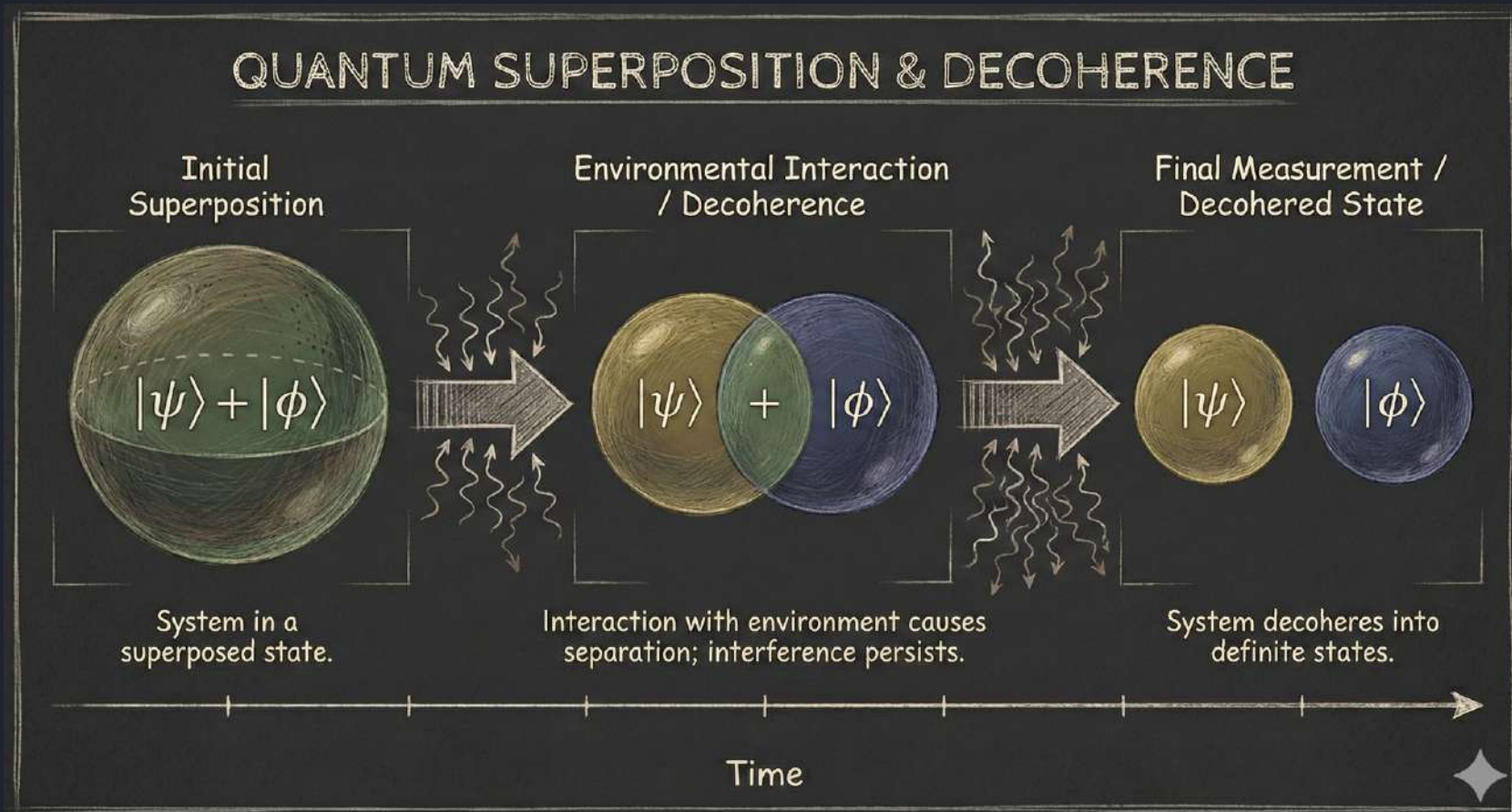


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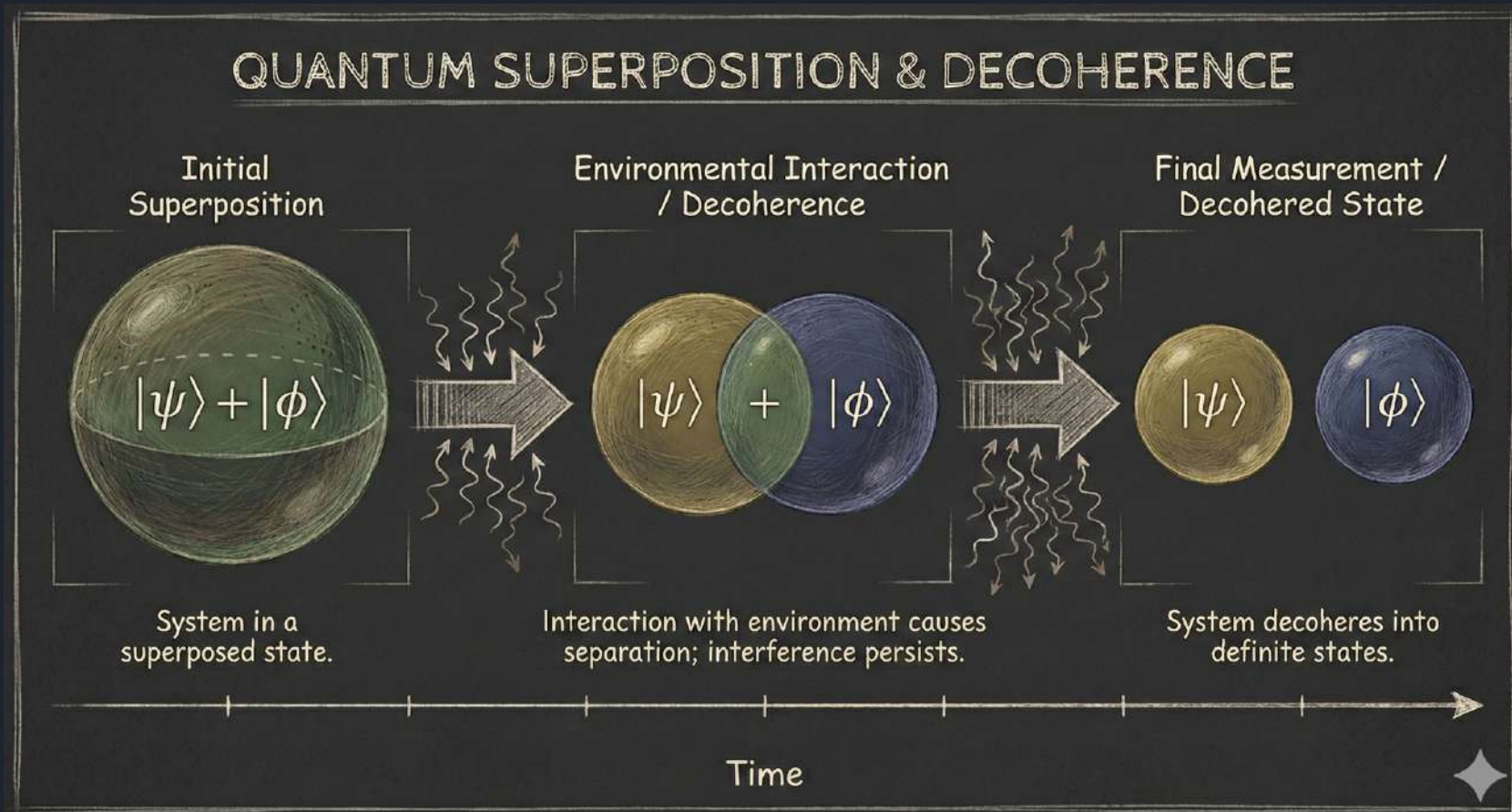
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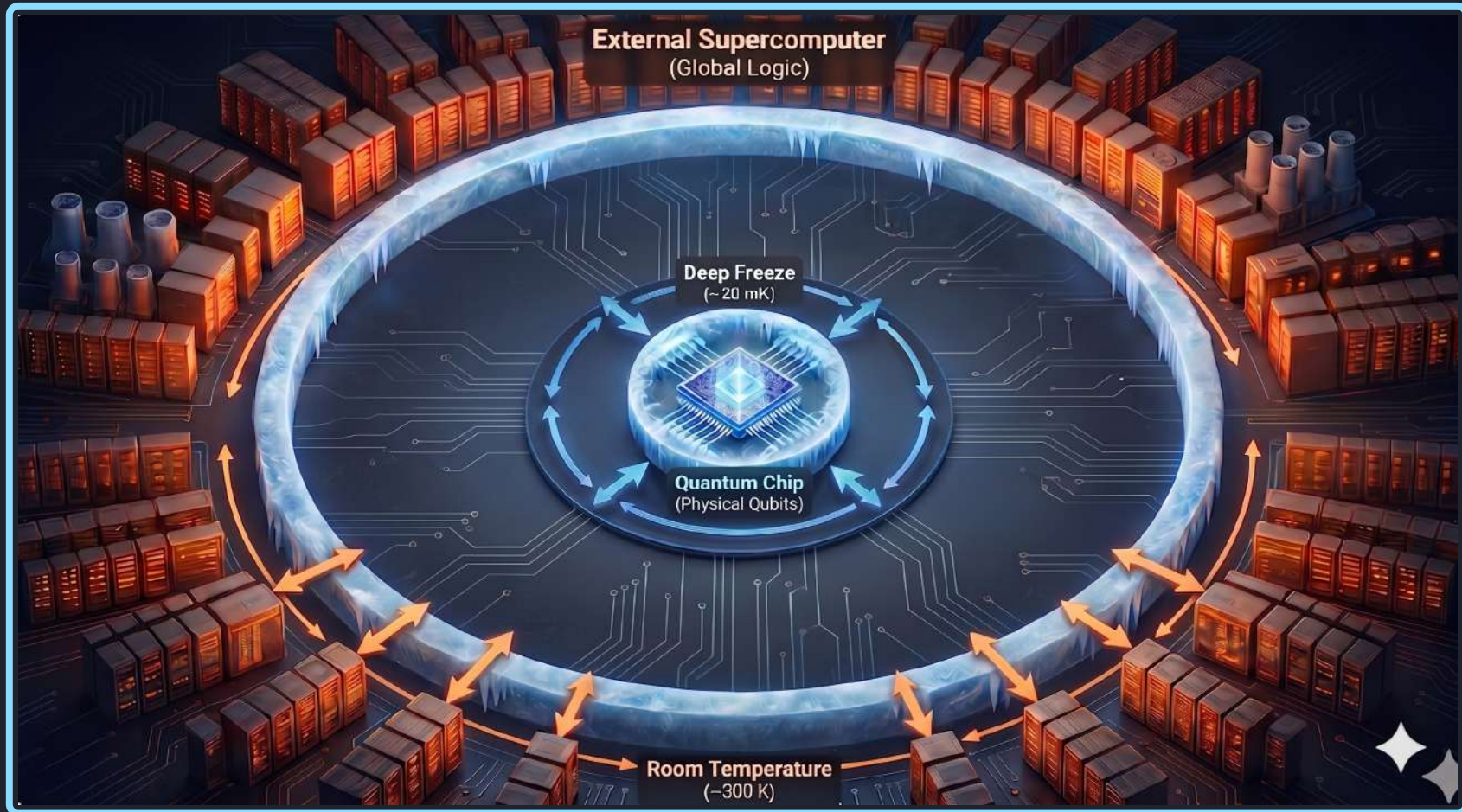
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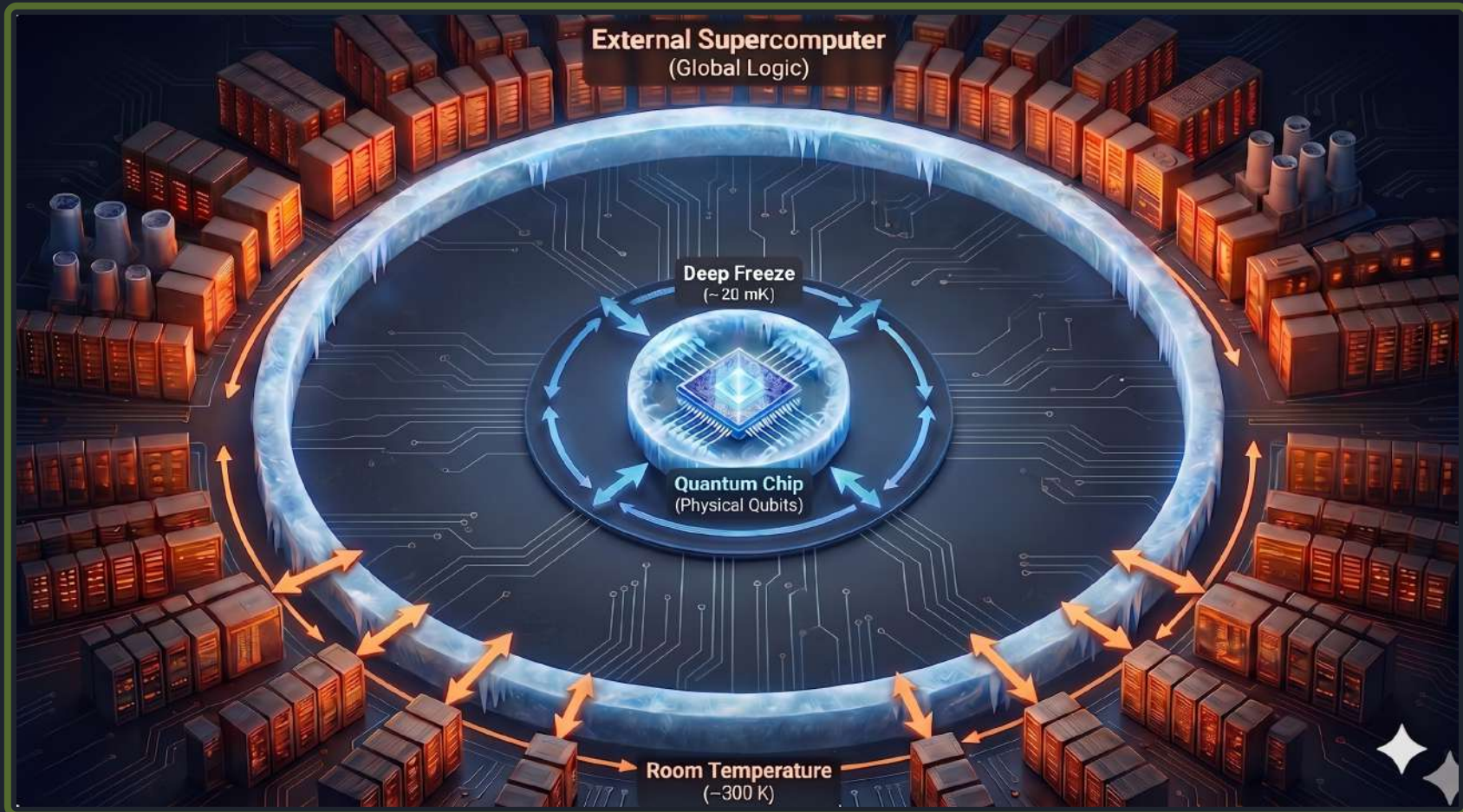
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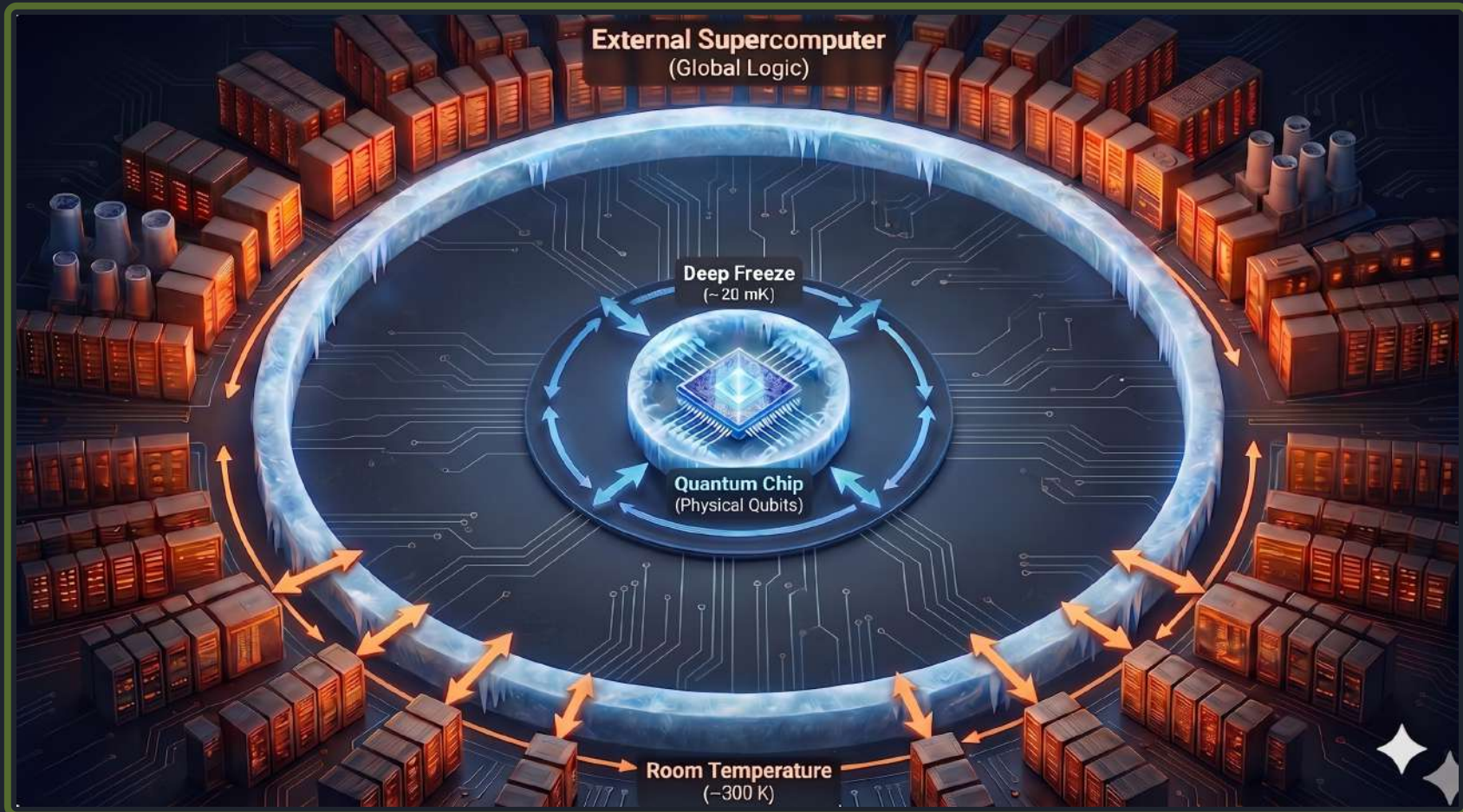
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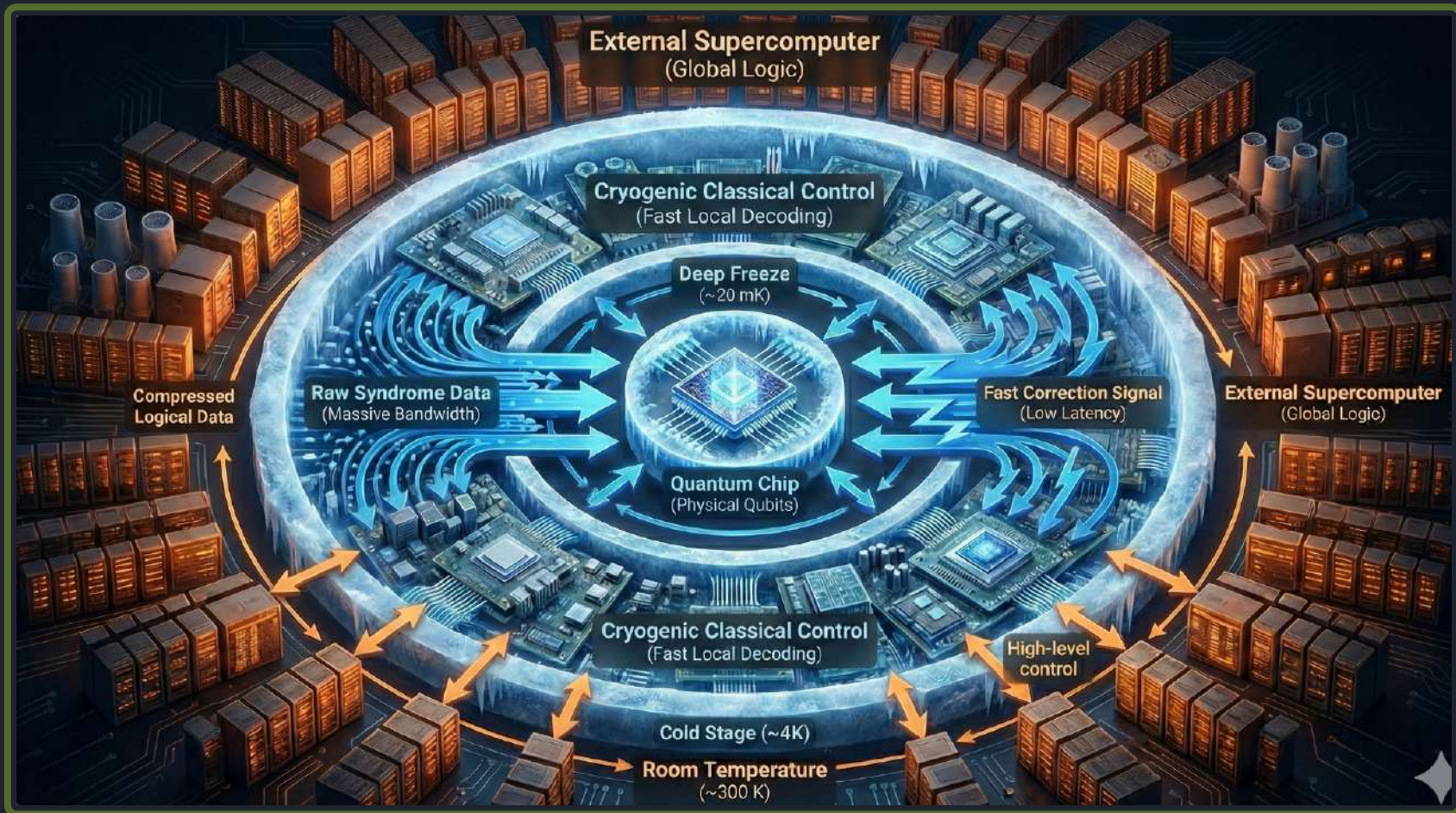
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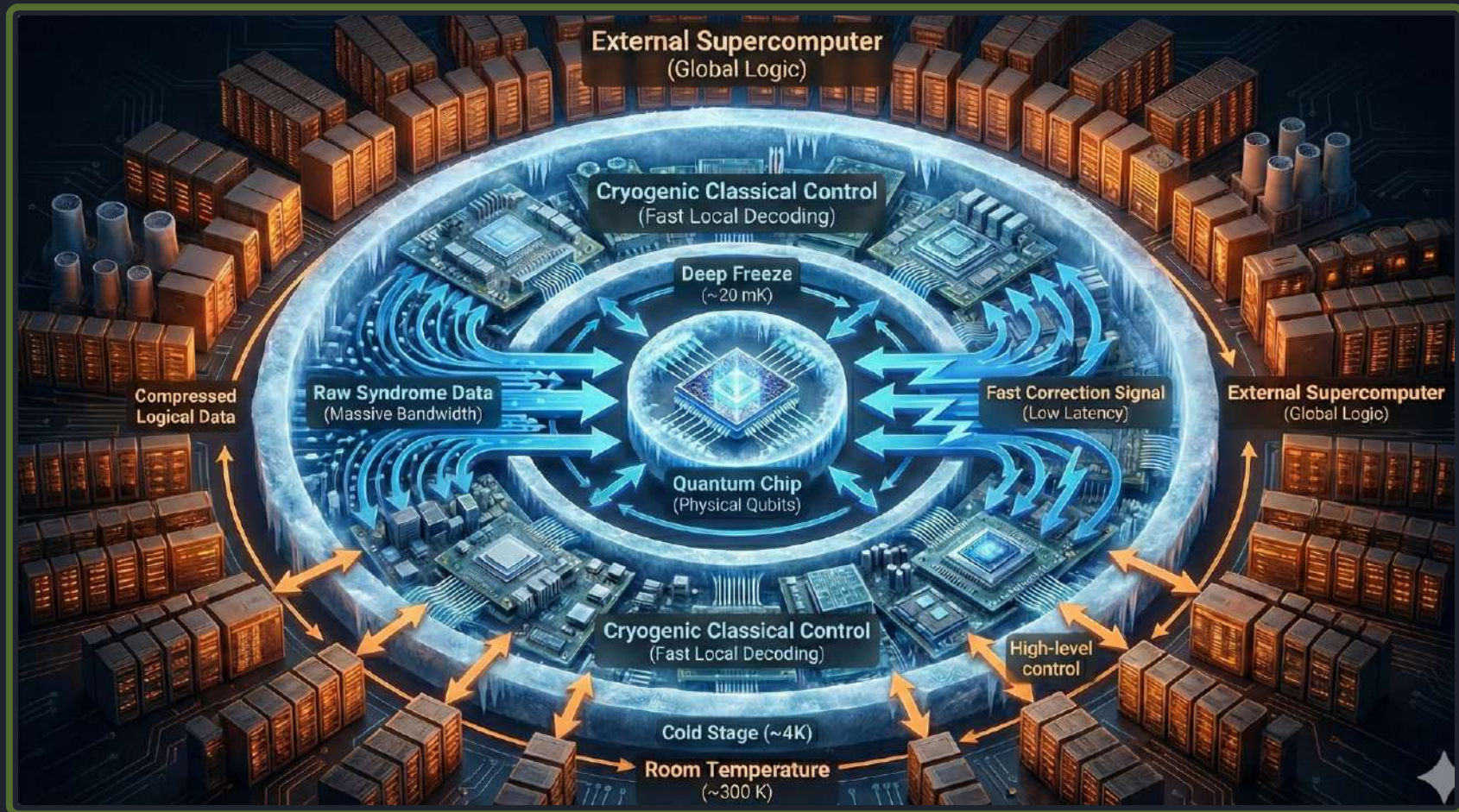
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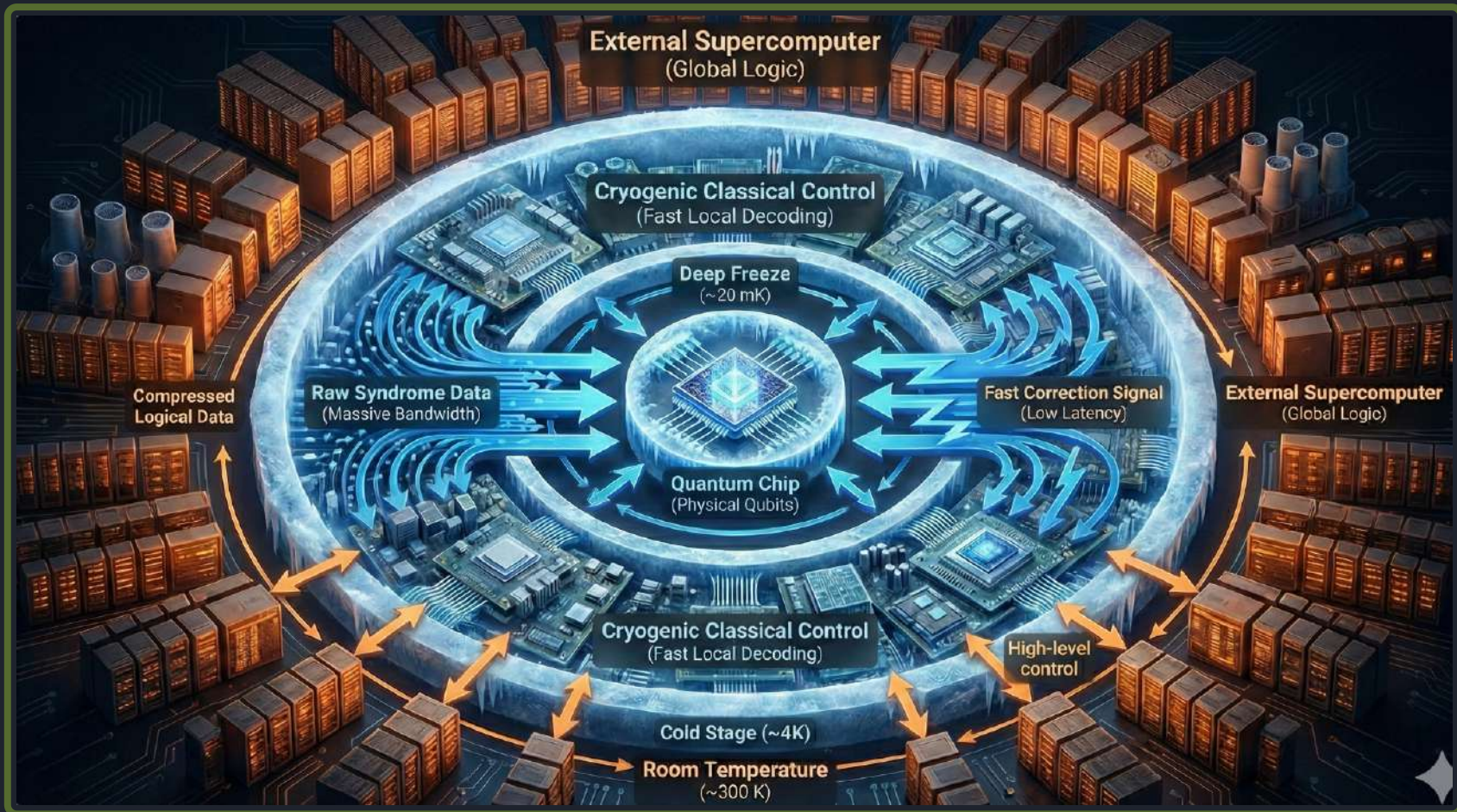
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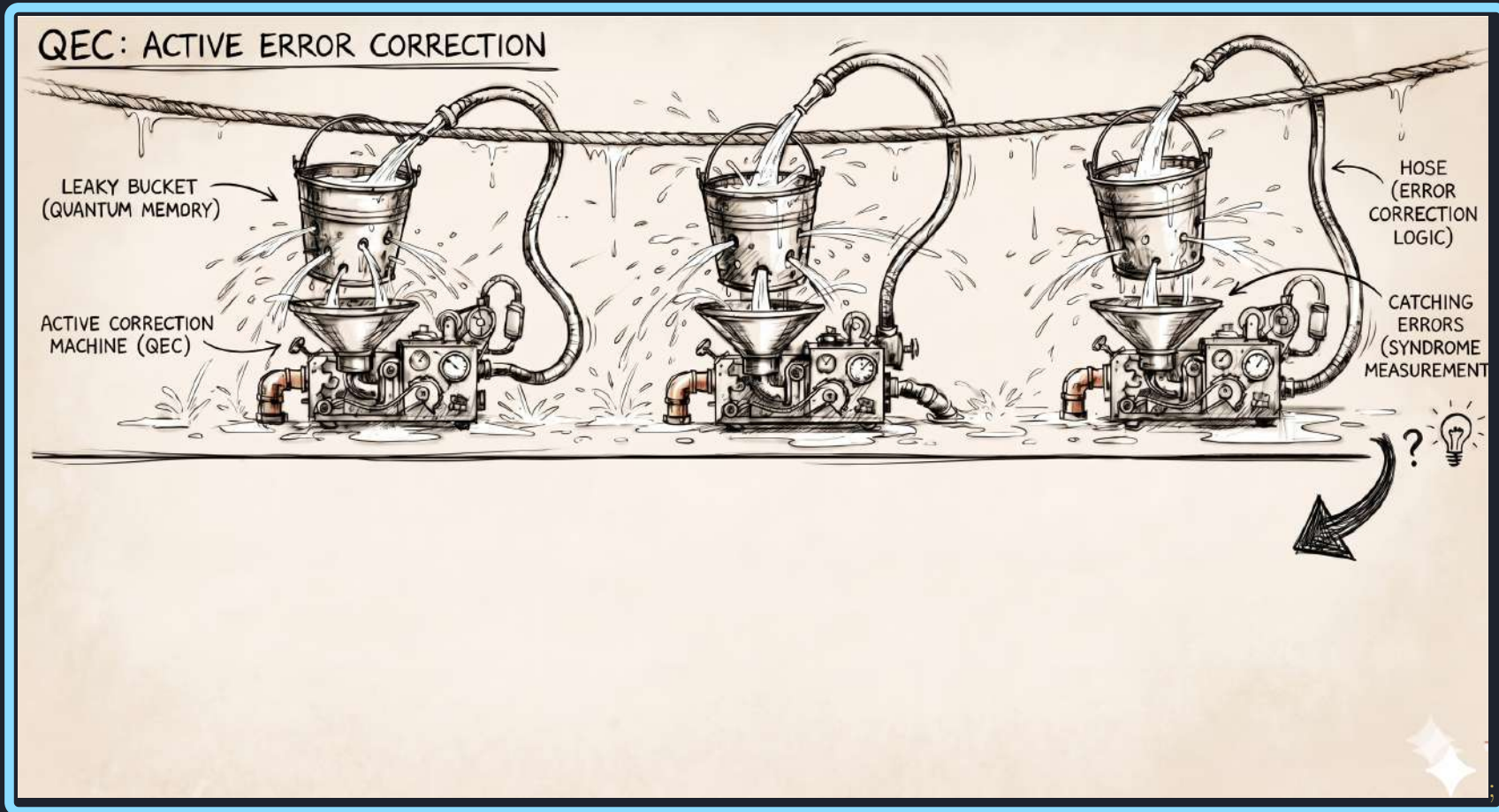
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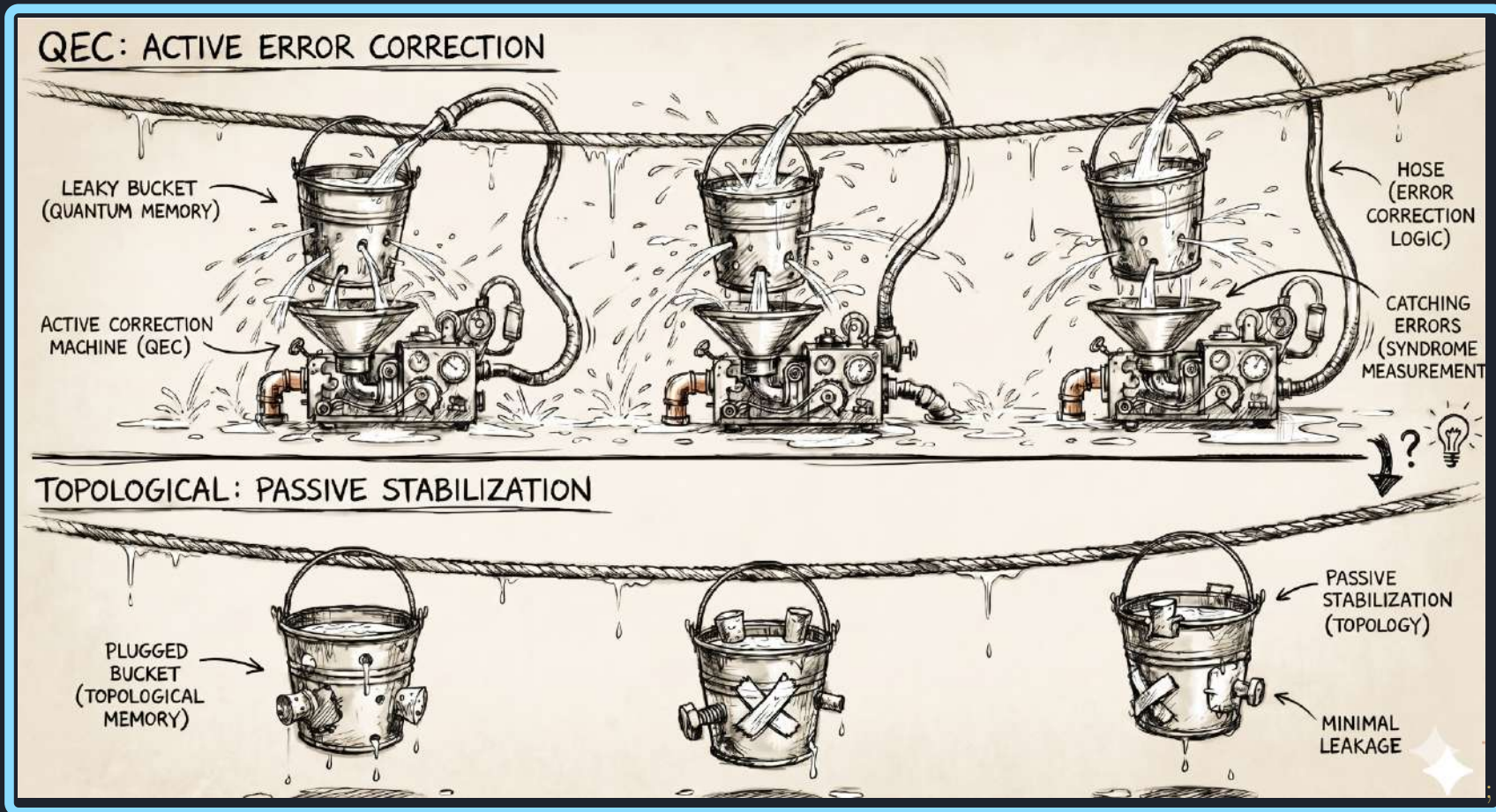


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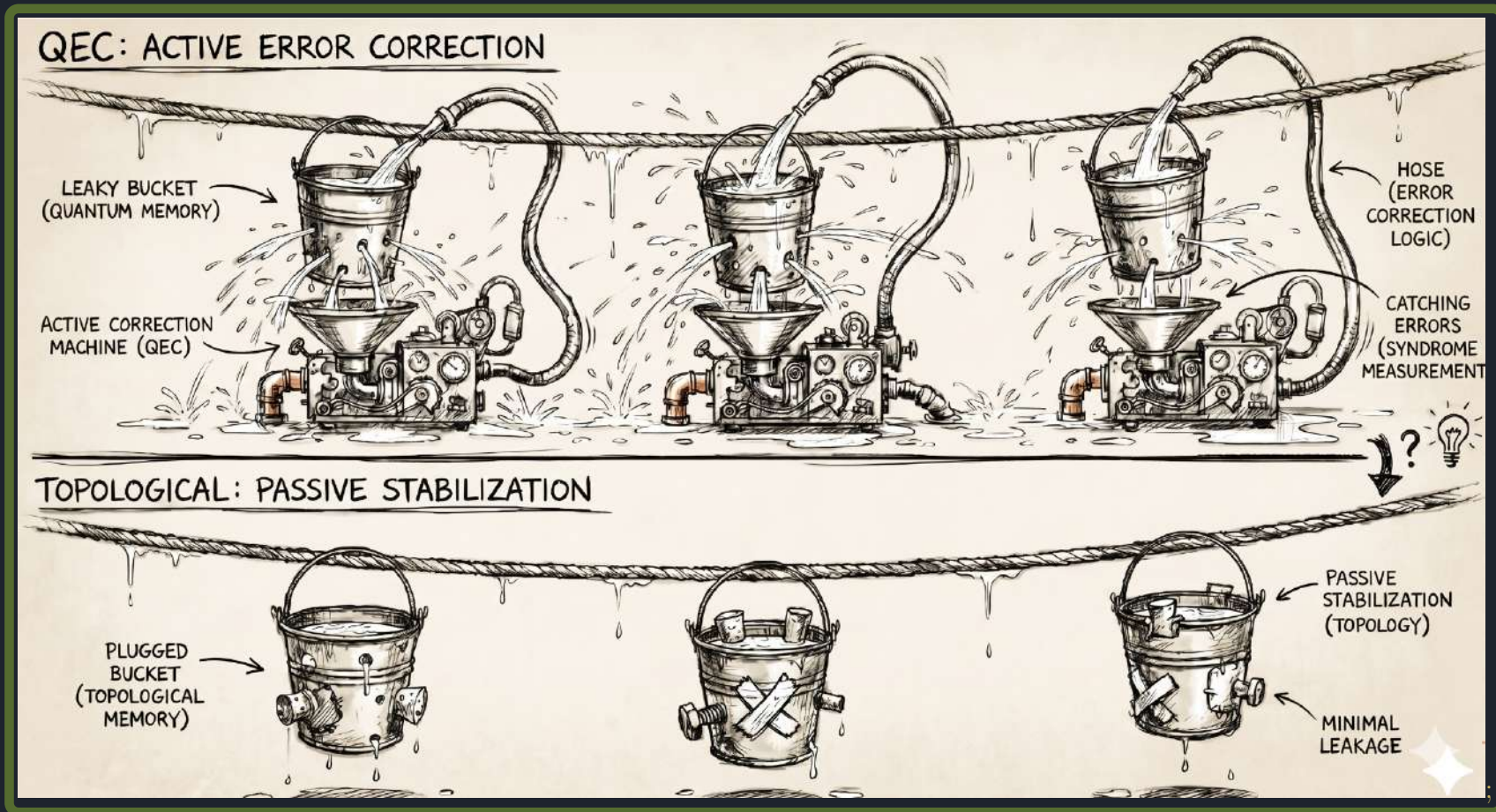
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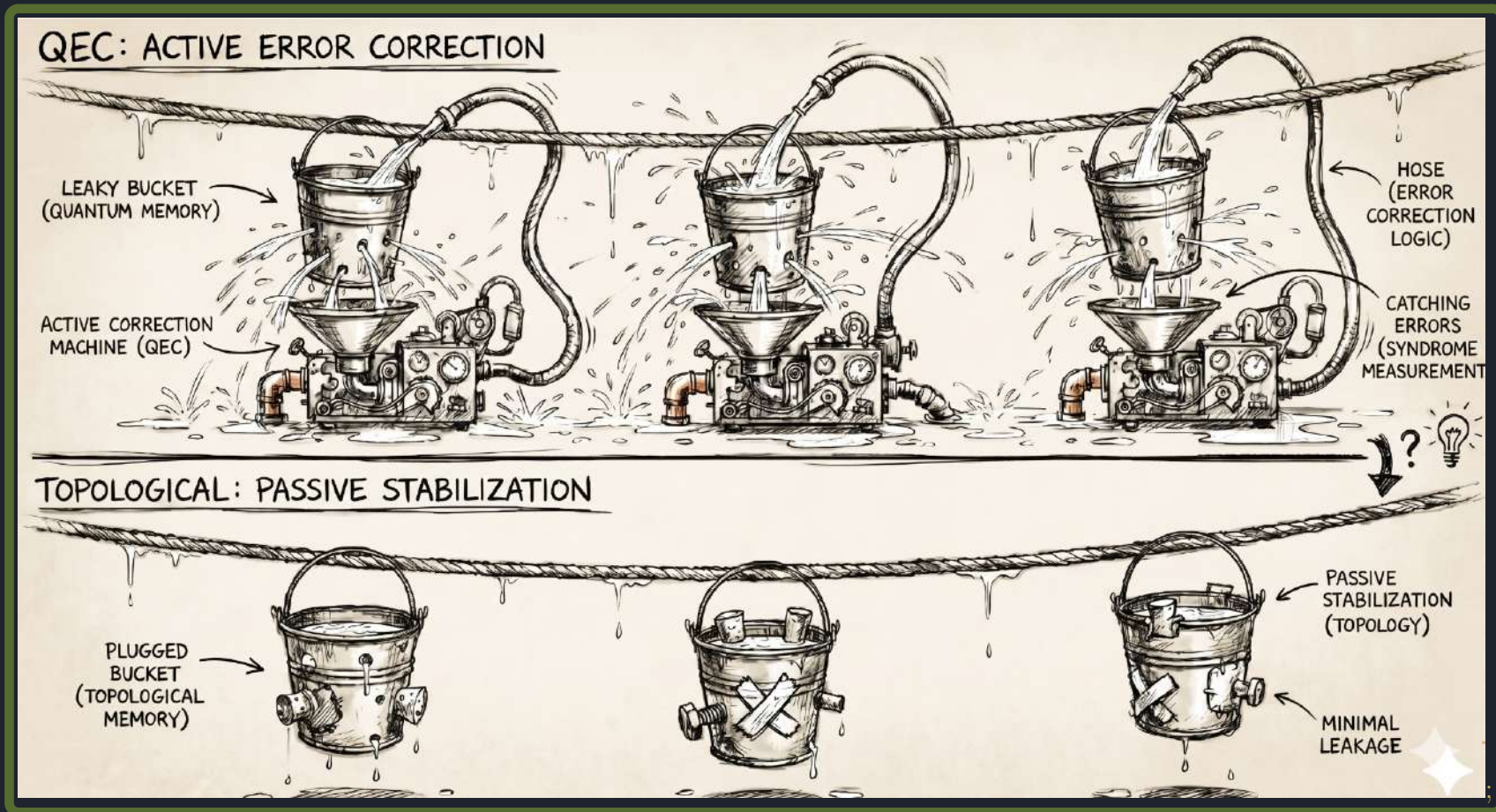


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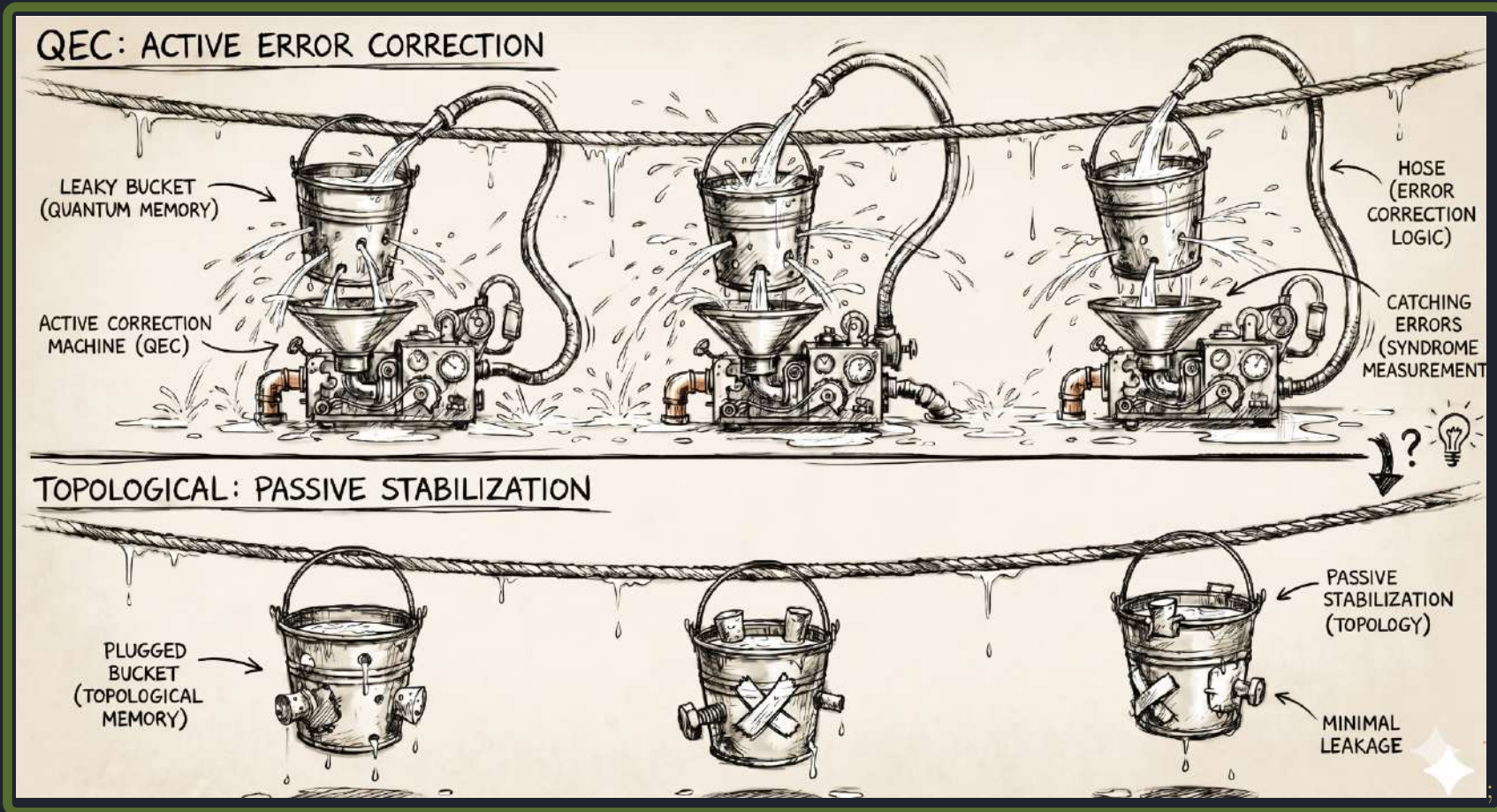
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Intrinsically stabilized quantum states by topology.

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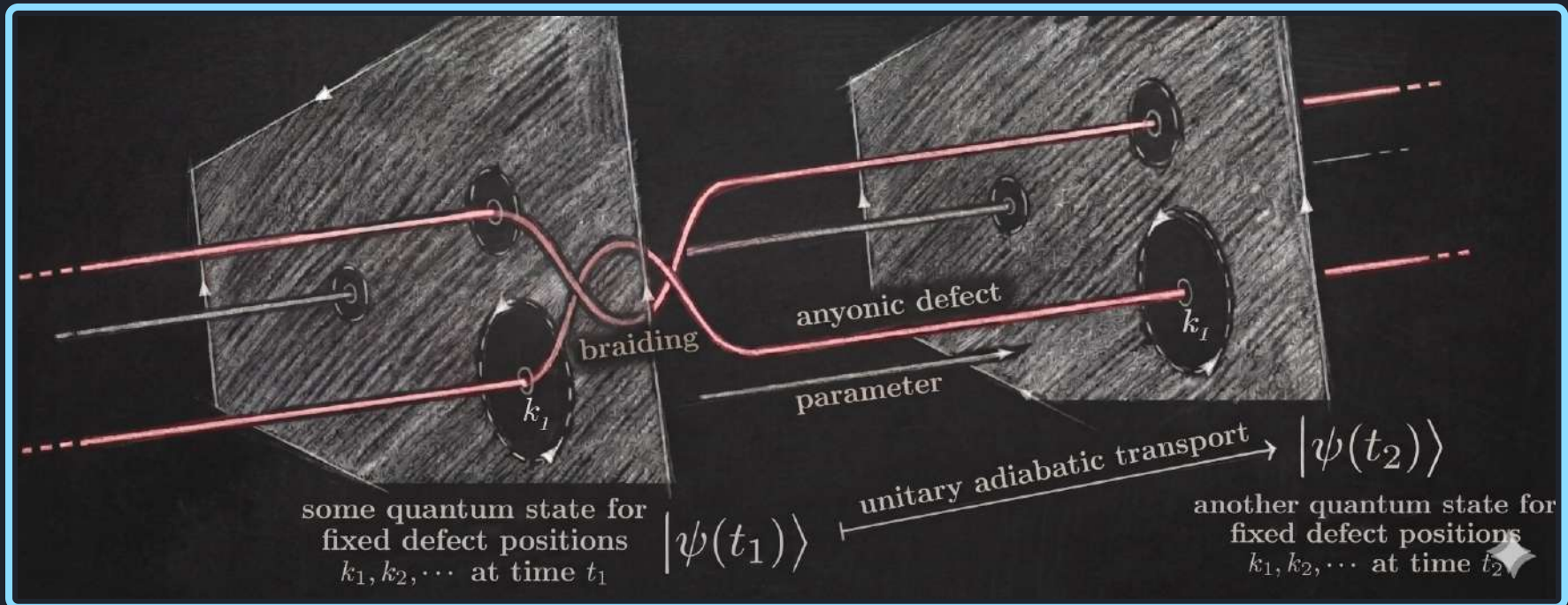


This fundamental fix is *topological quantum*:
Intrinsically stabilized quantum states by topology.

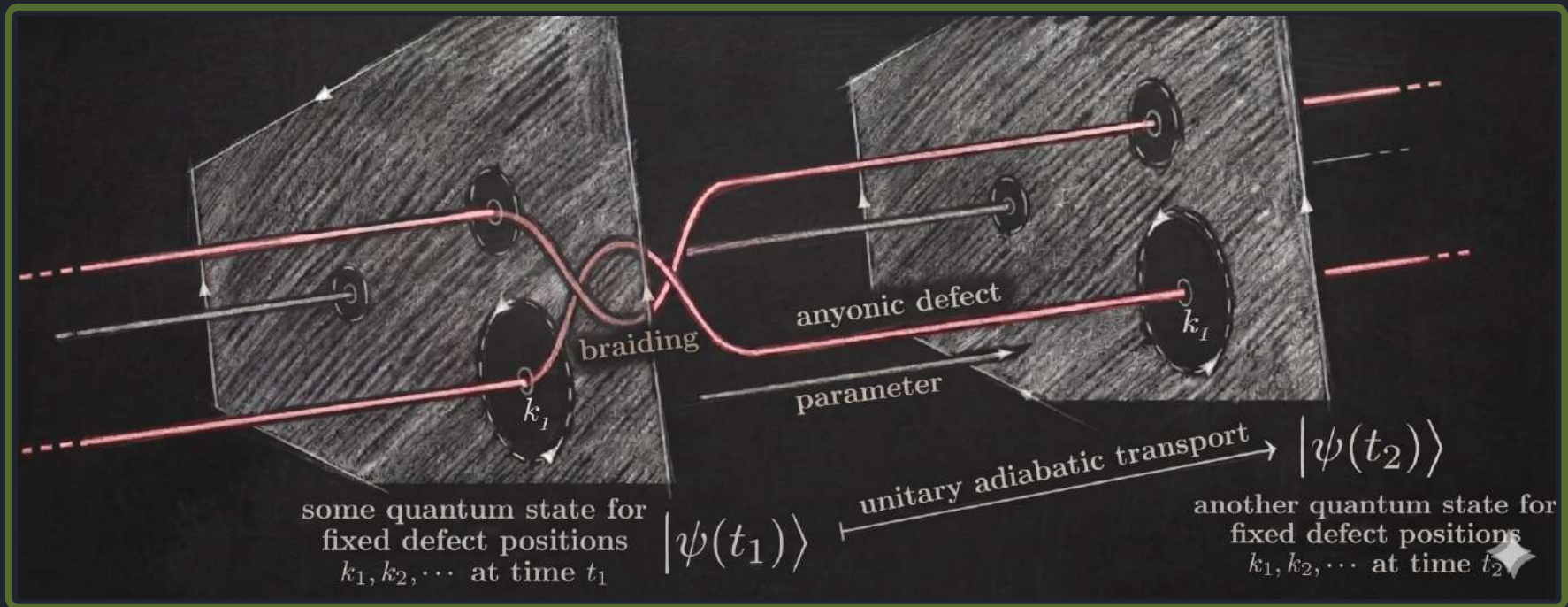
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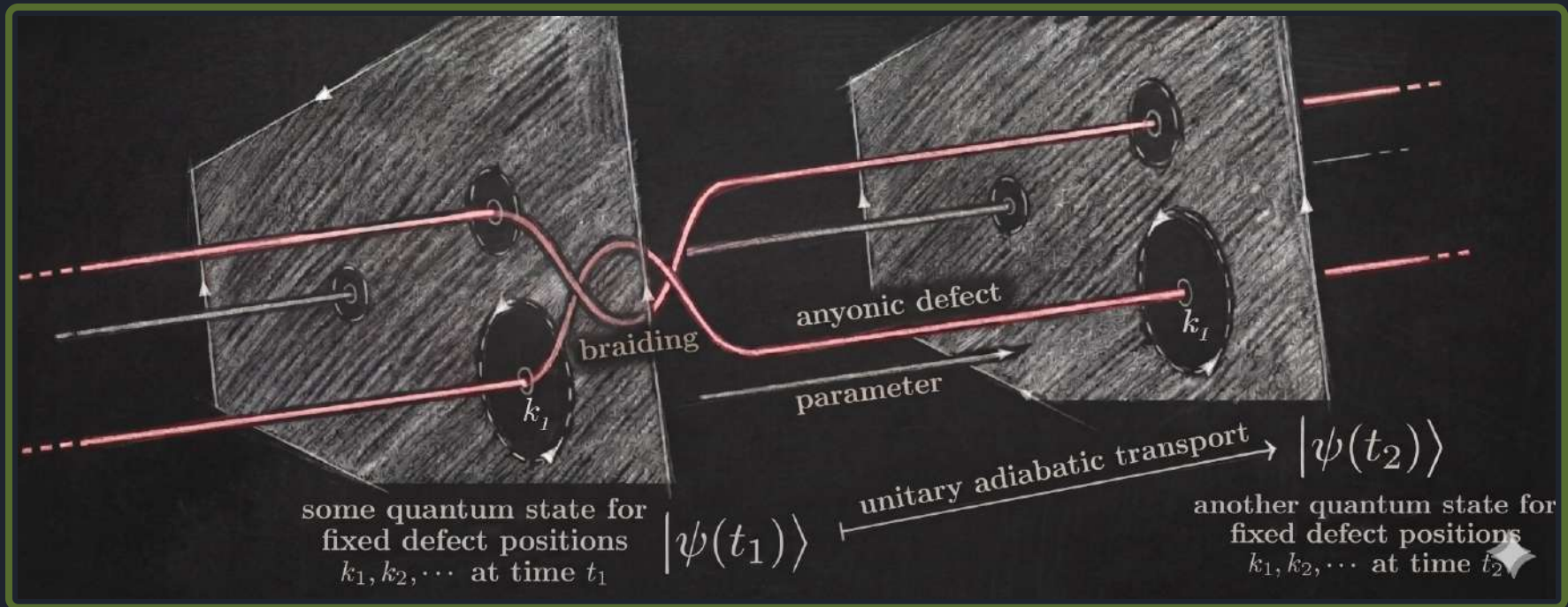


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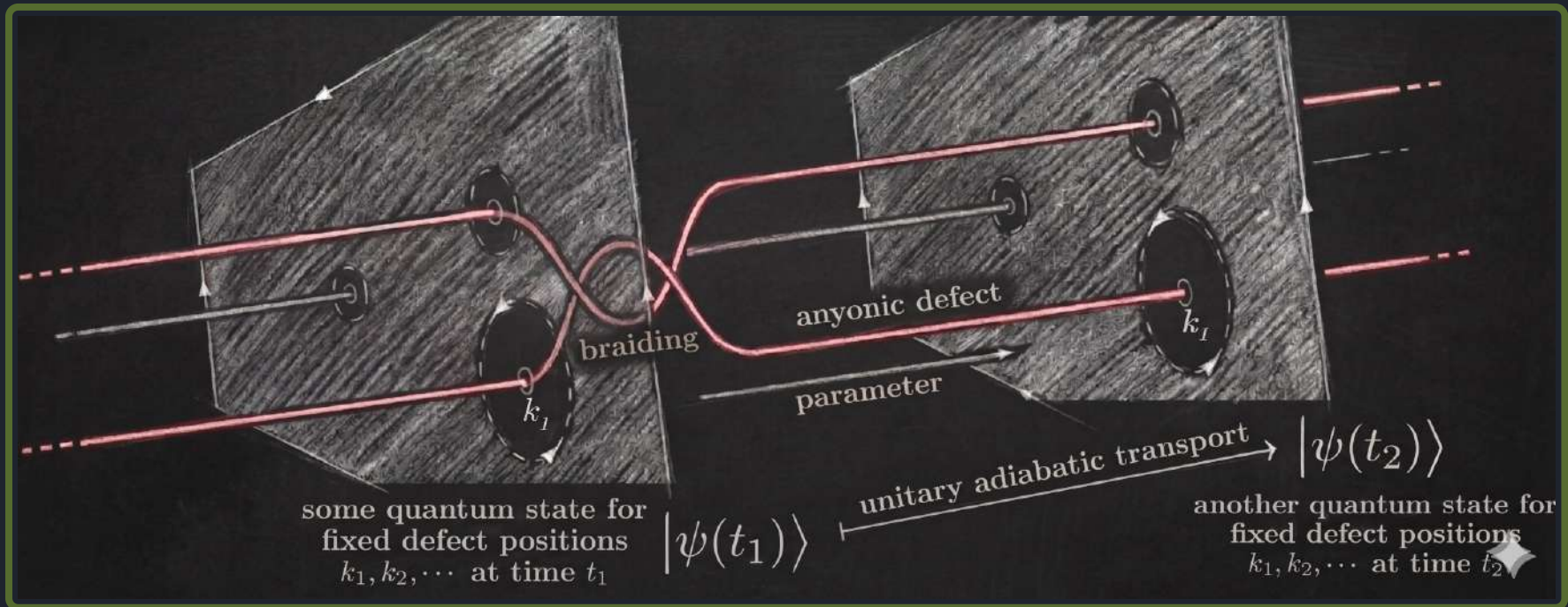
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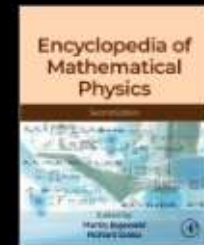
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Encyclopedia of Mathematical Physics (Second Edition)

Volume 4, 2025, Pages 281-324



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Hisham Sati, Urs Schreiber

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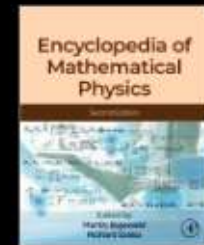
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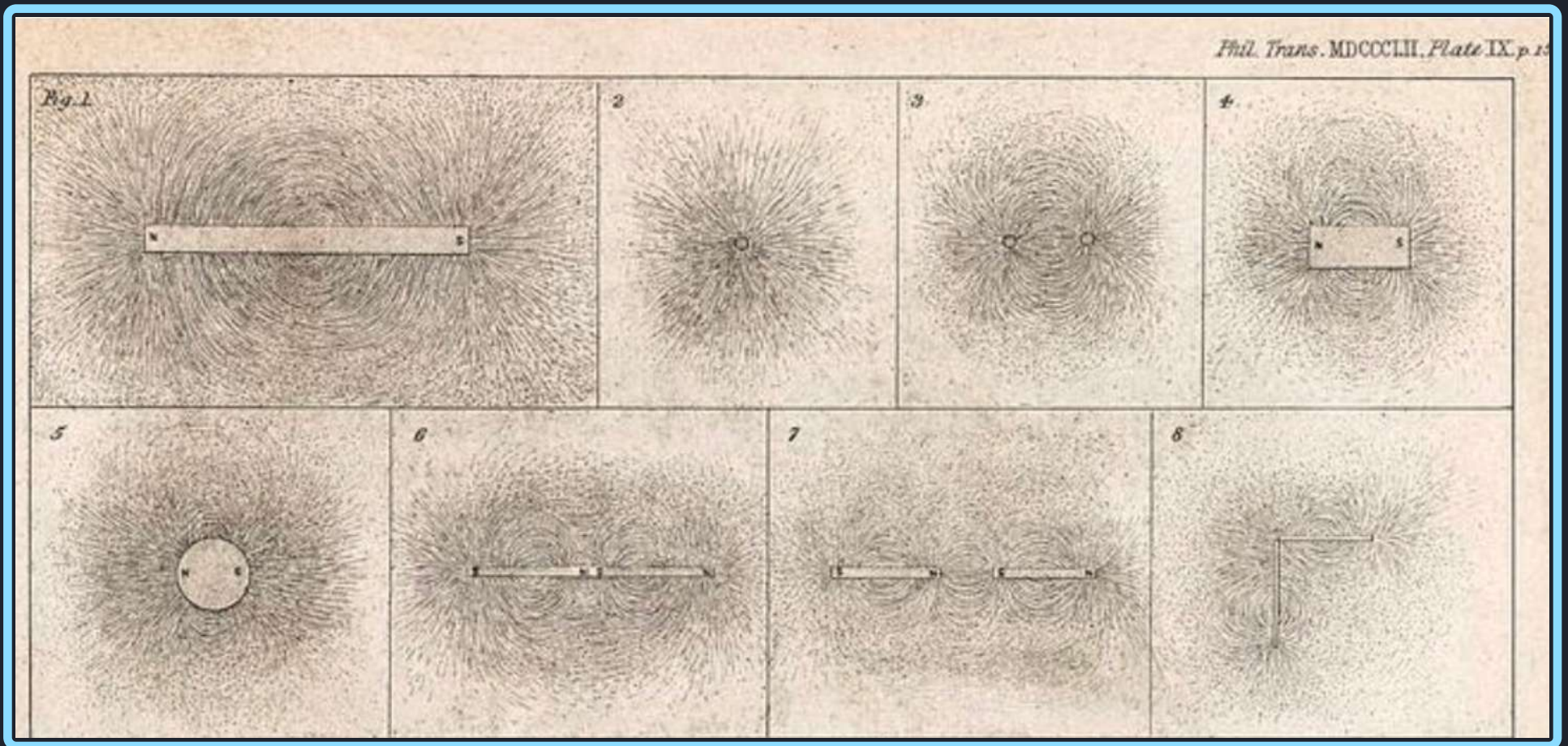


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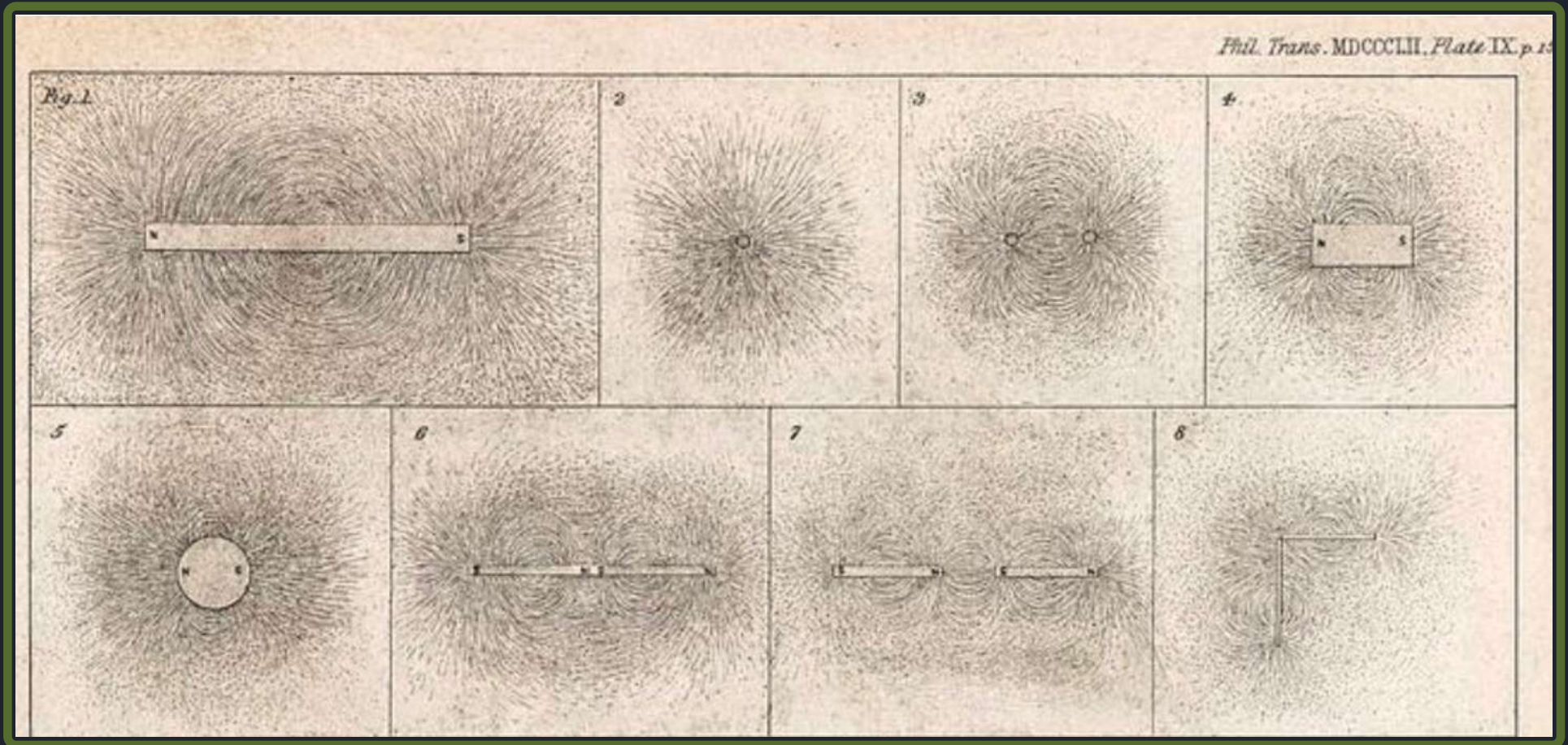
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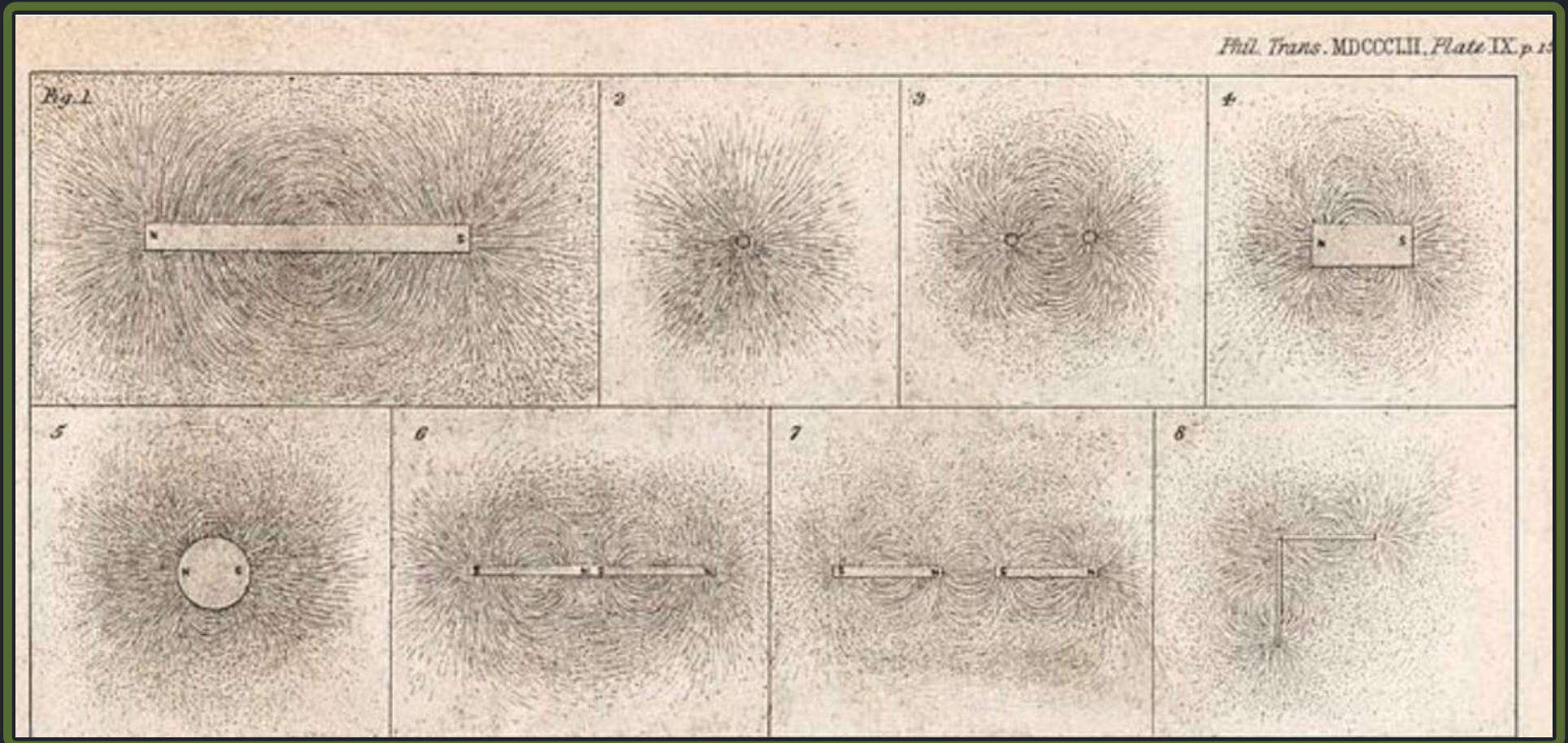


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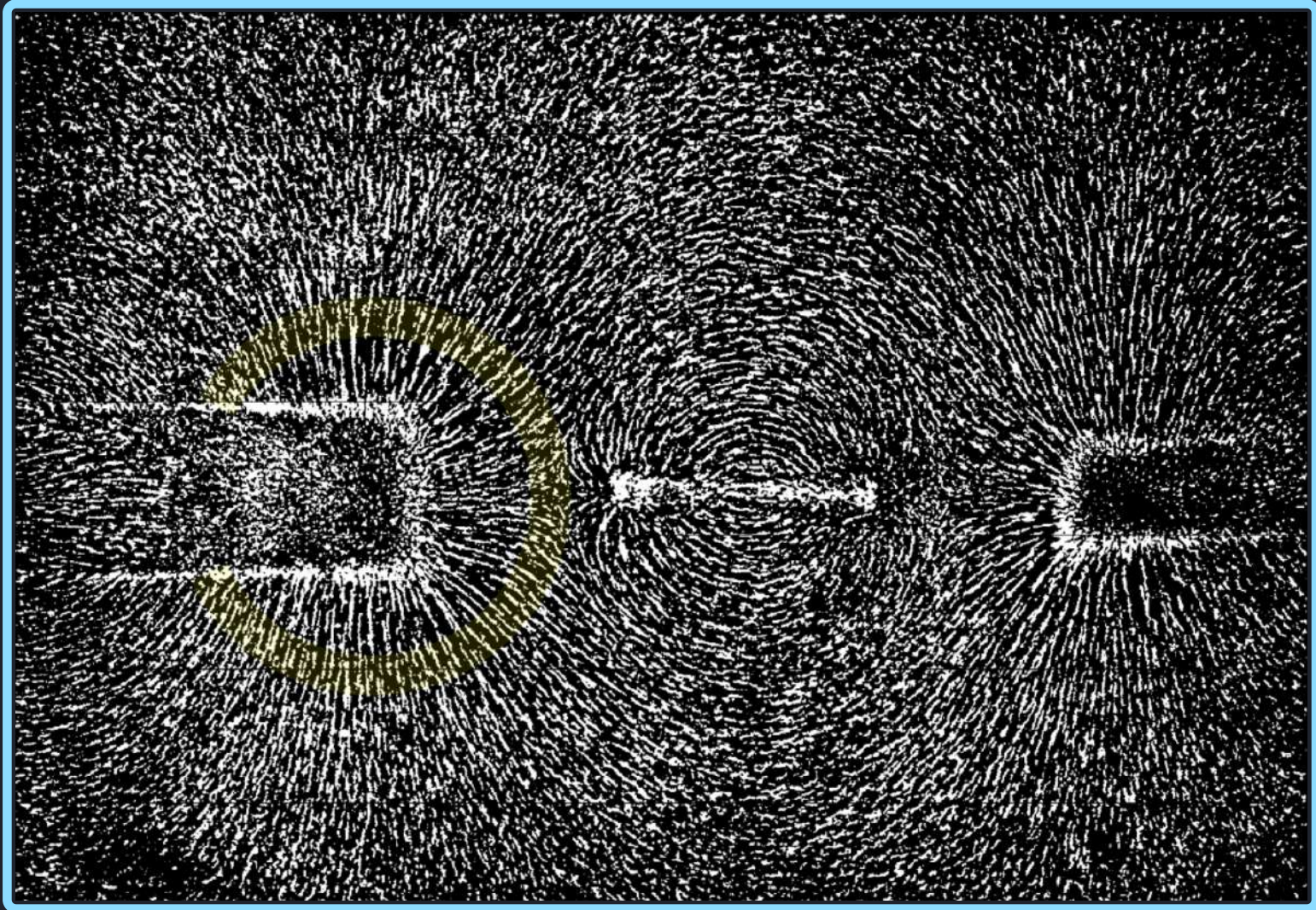
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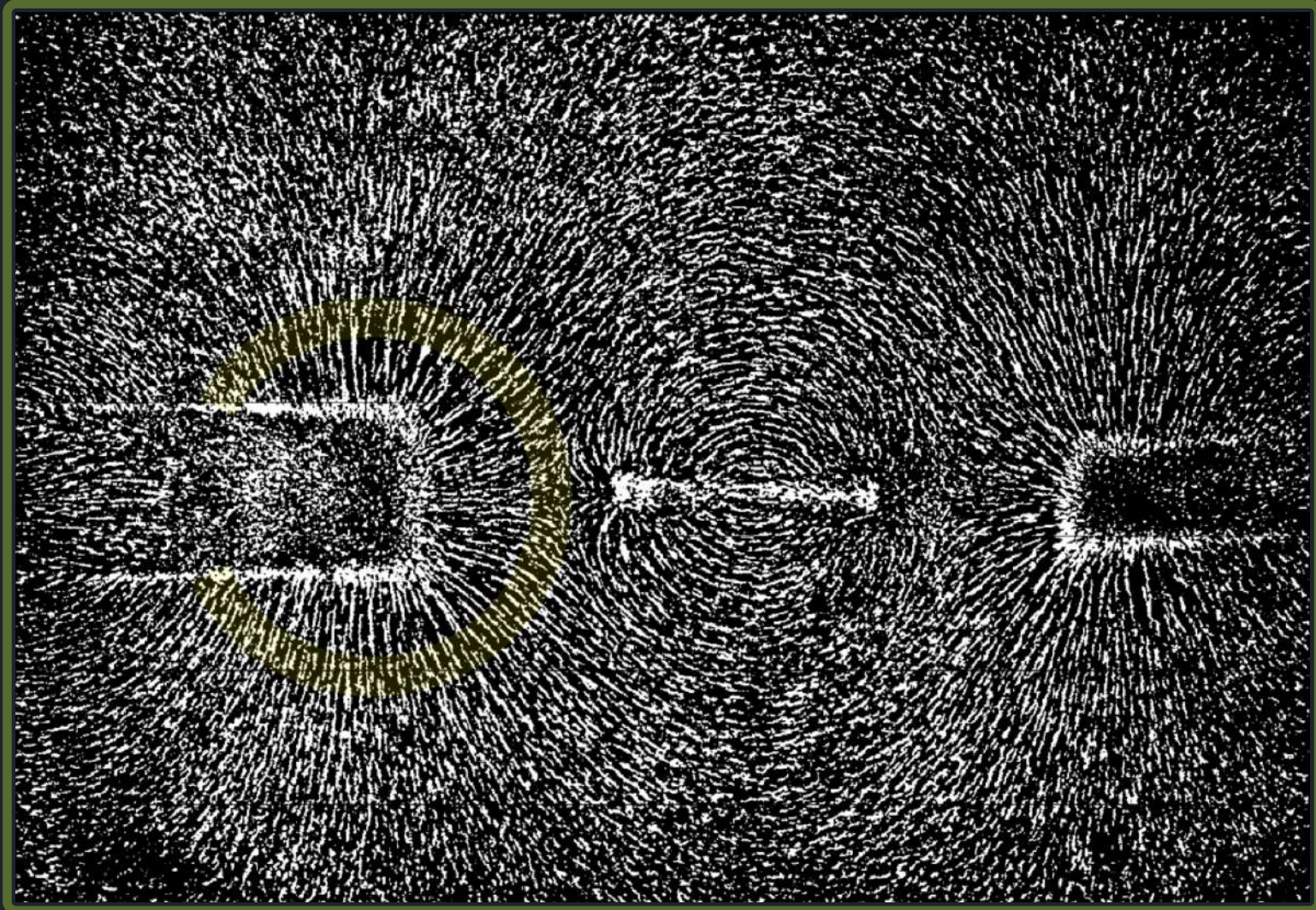
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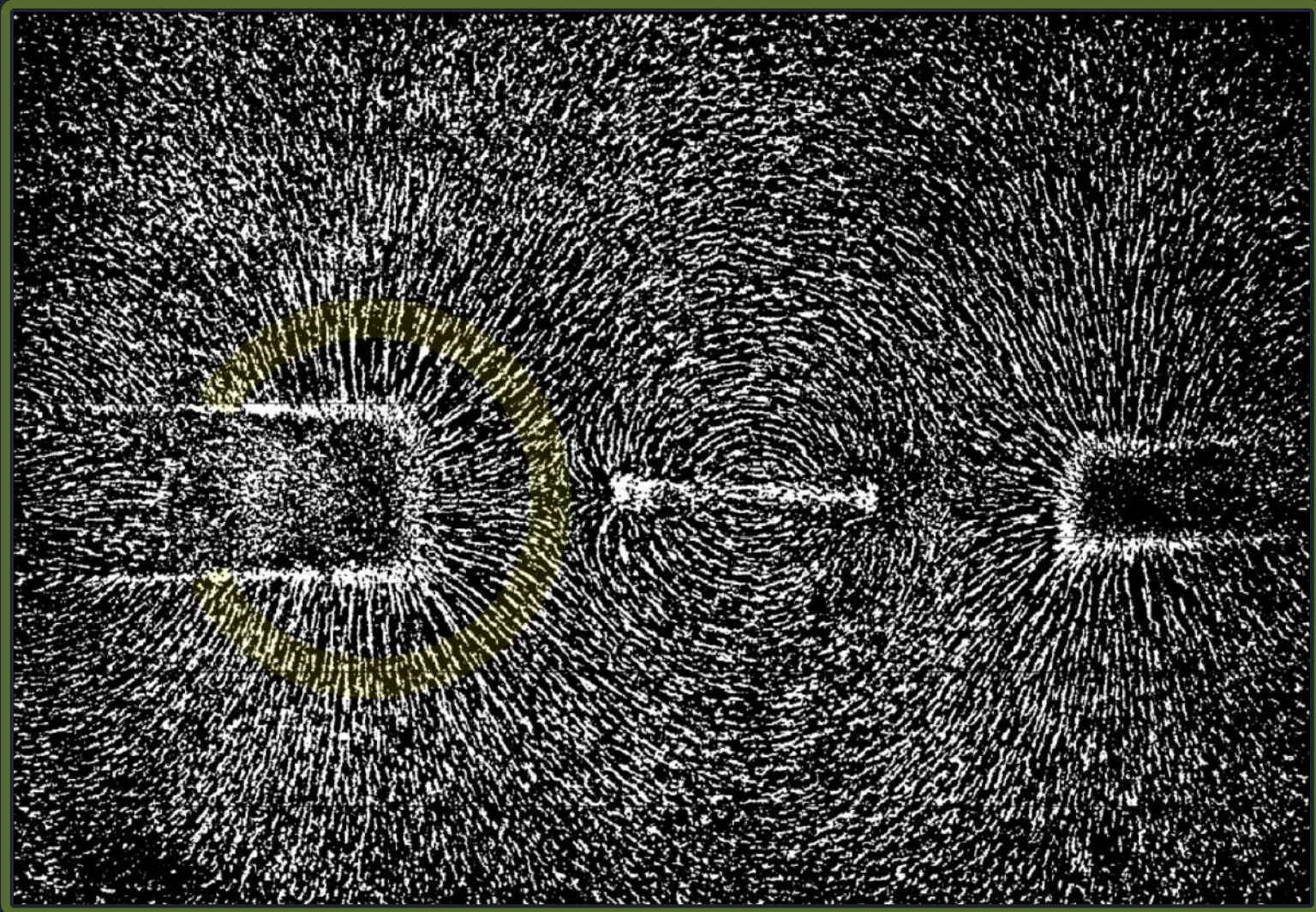
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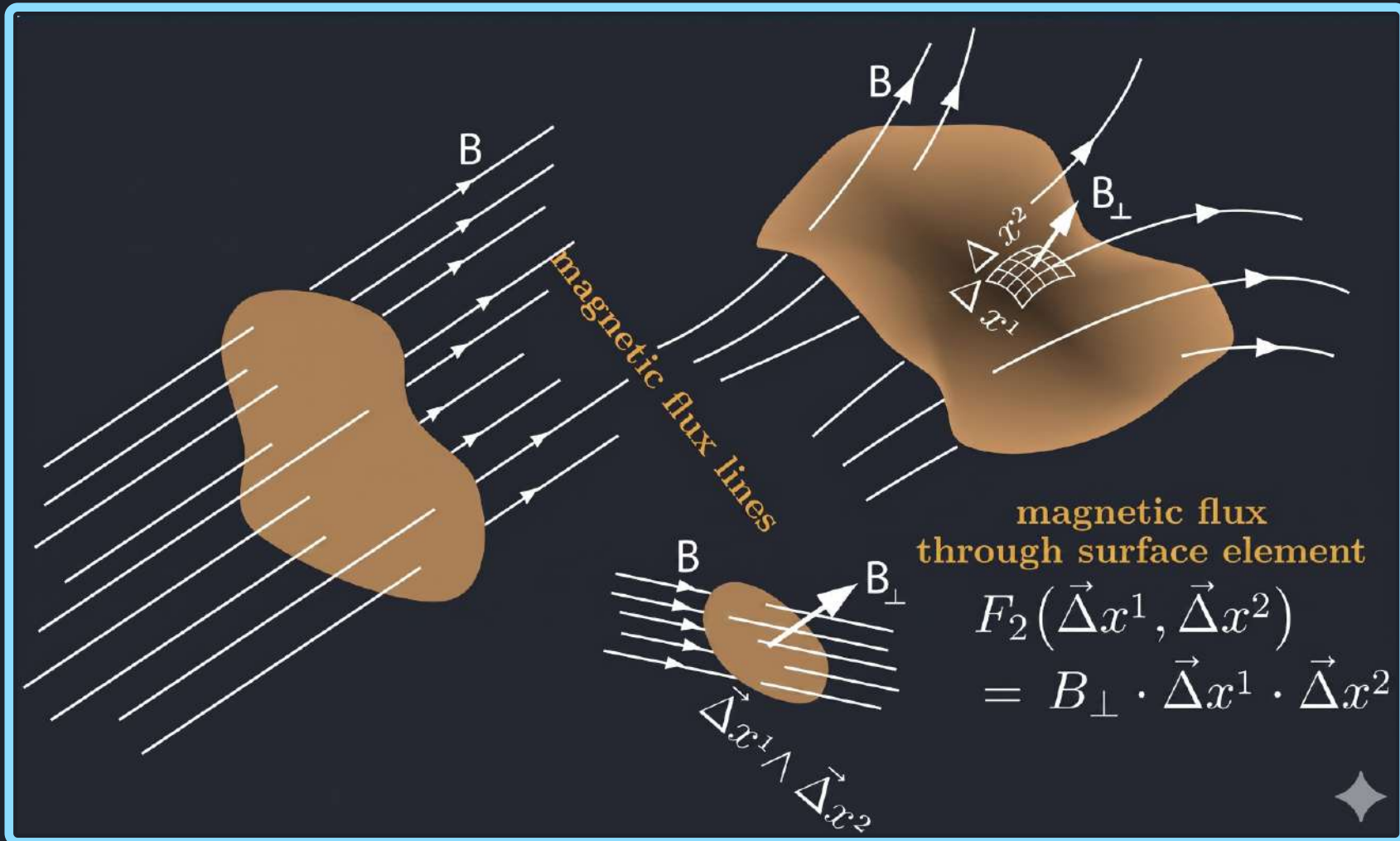


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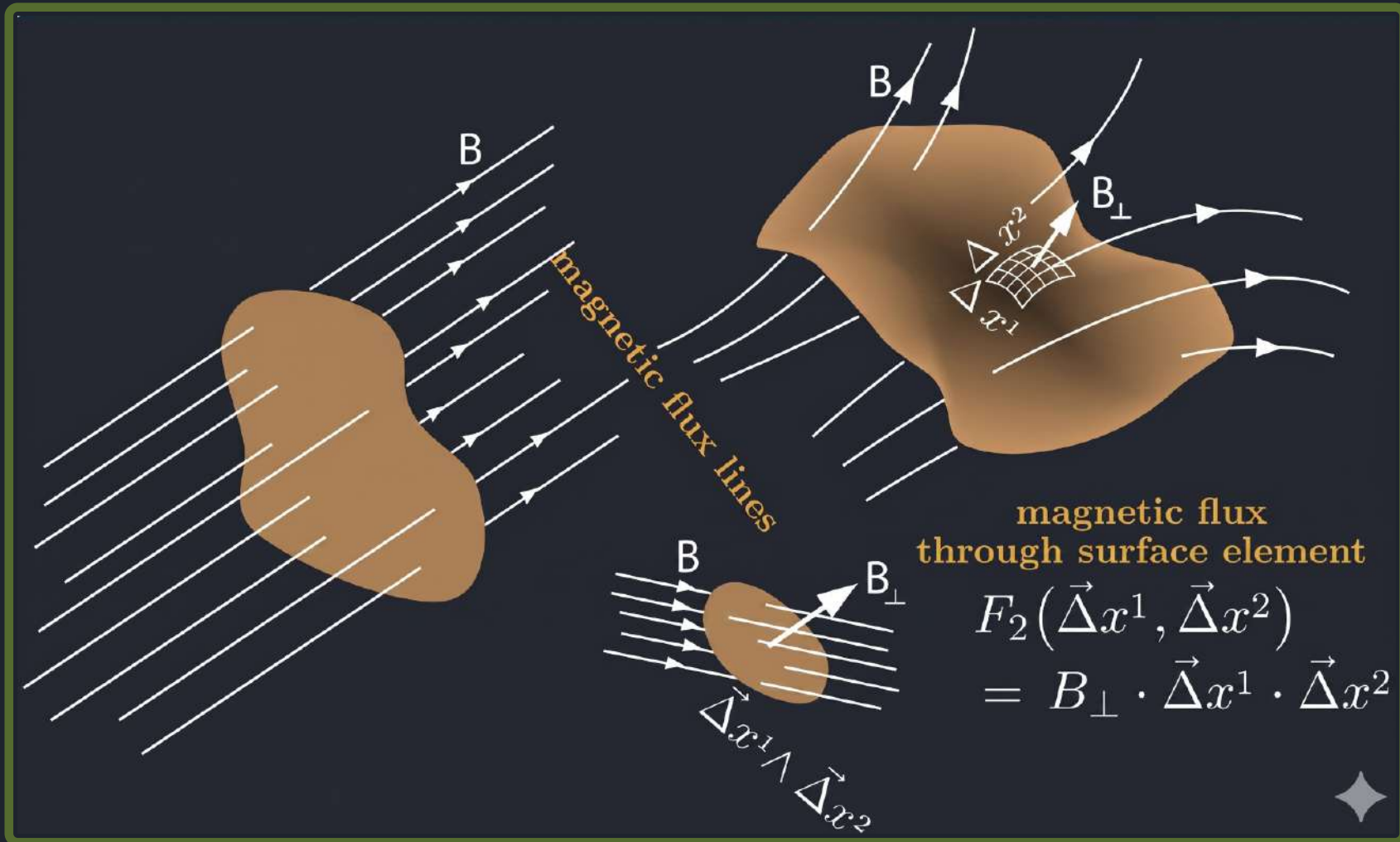
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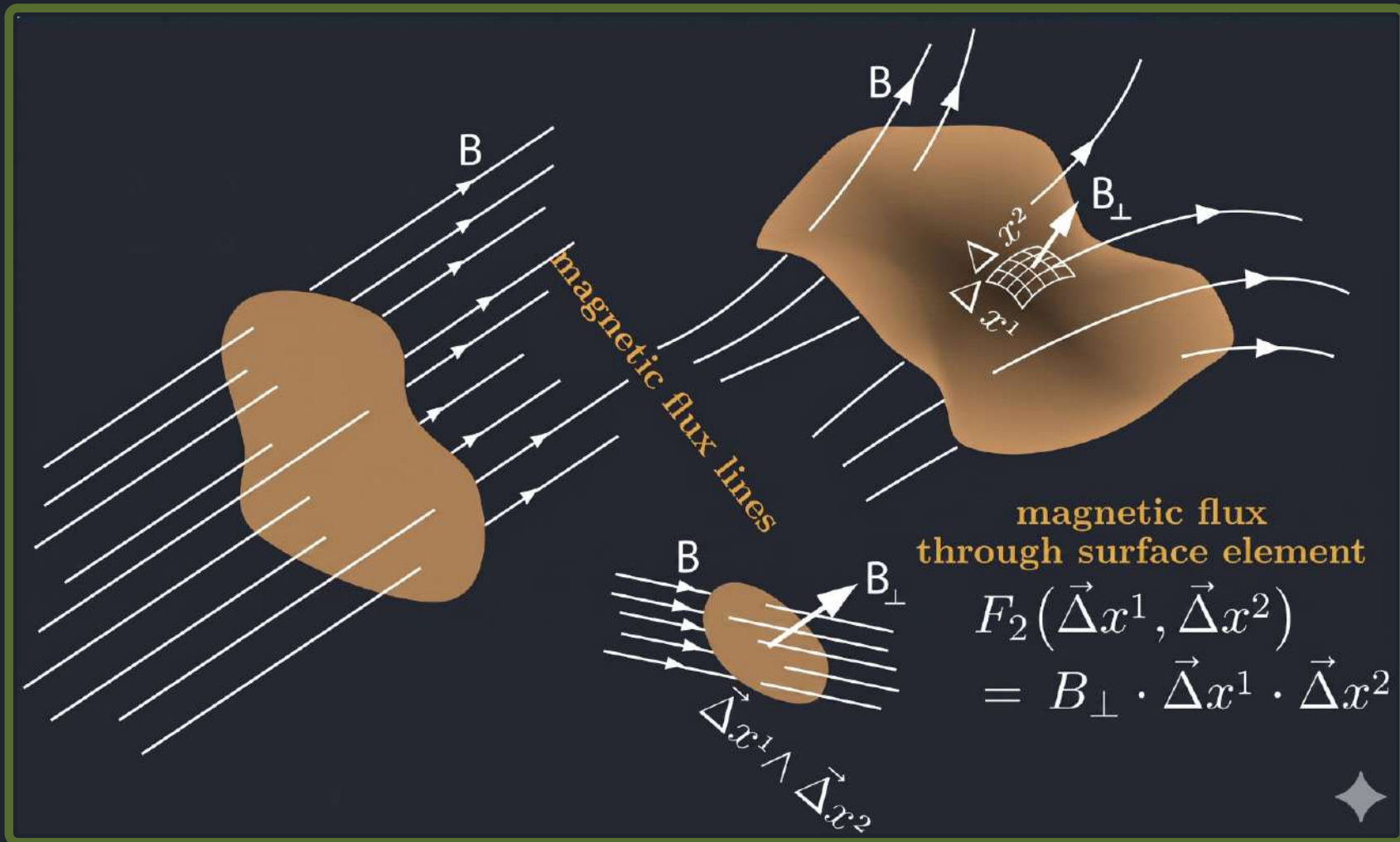


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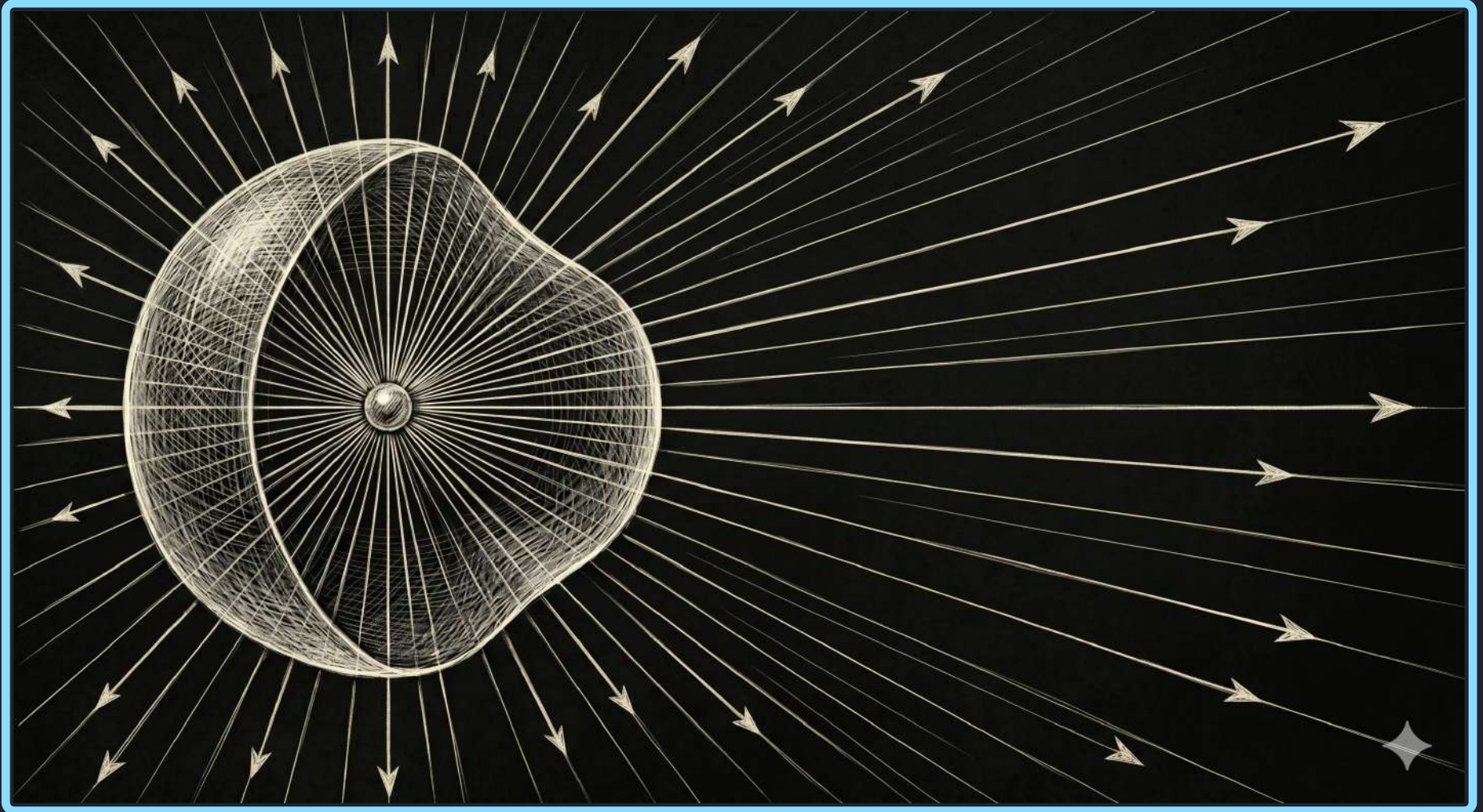
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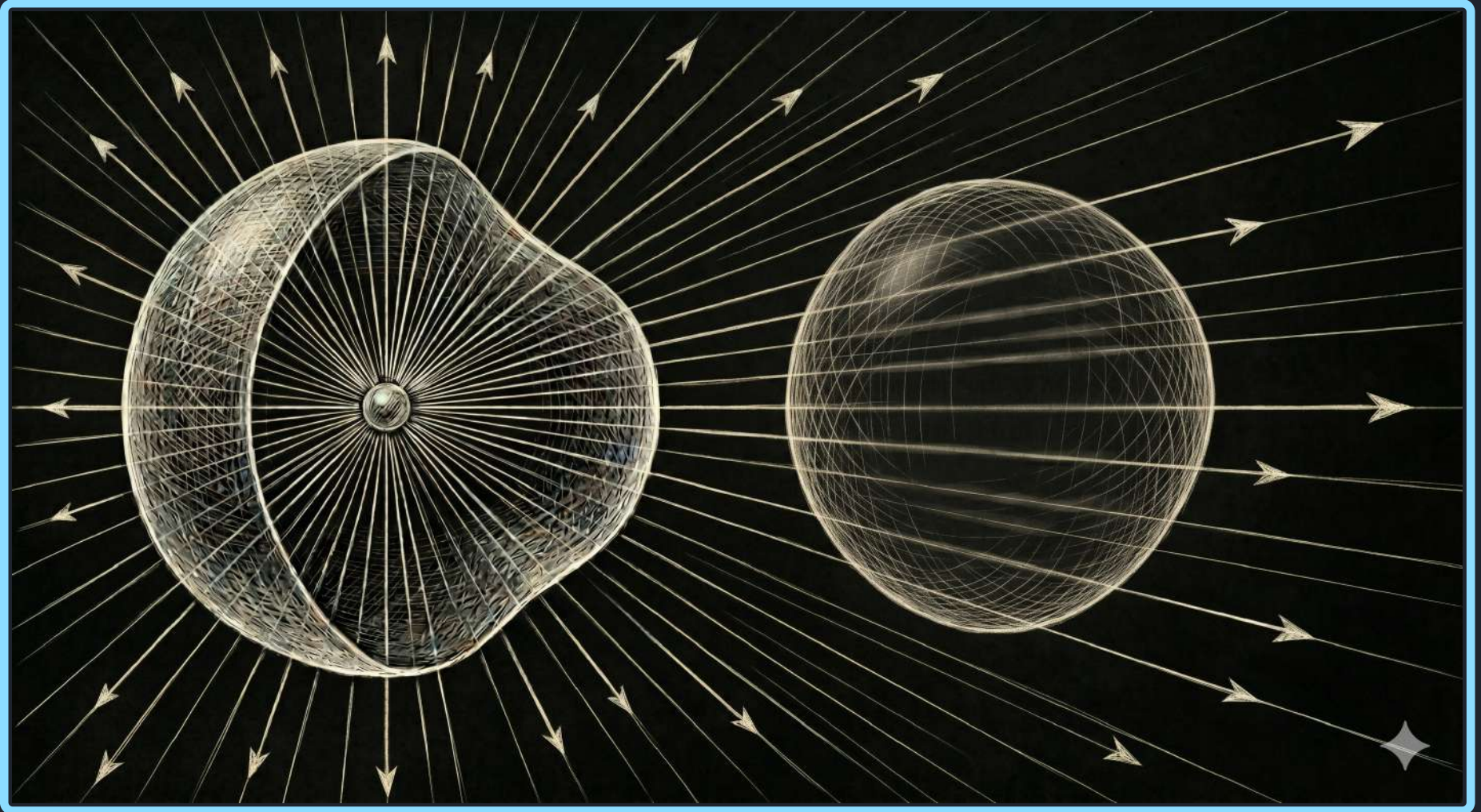


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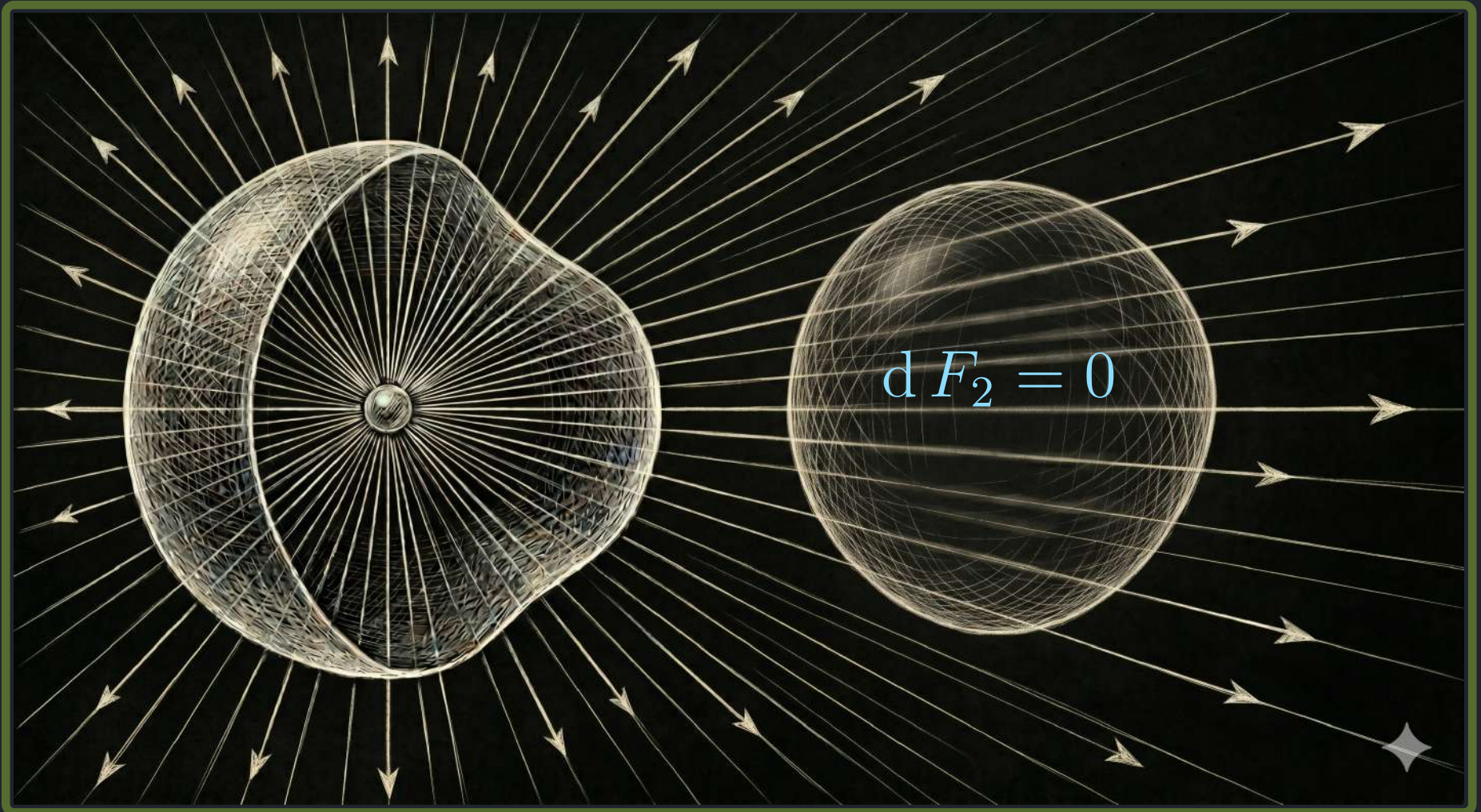
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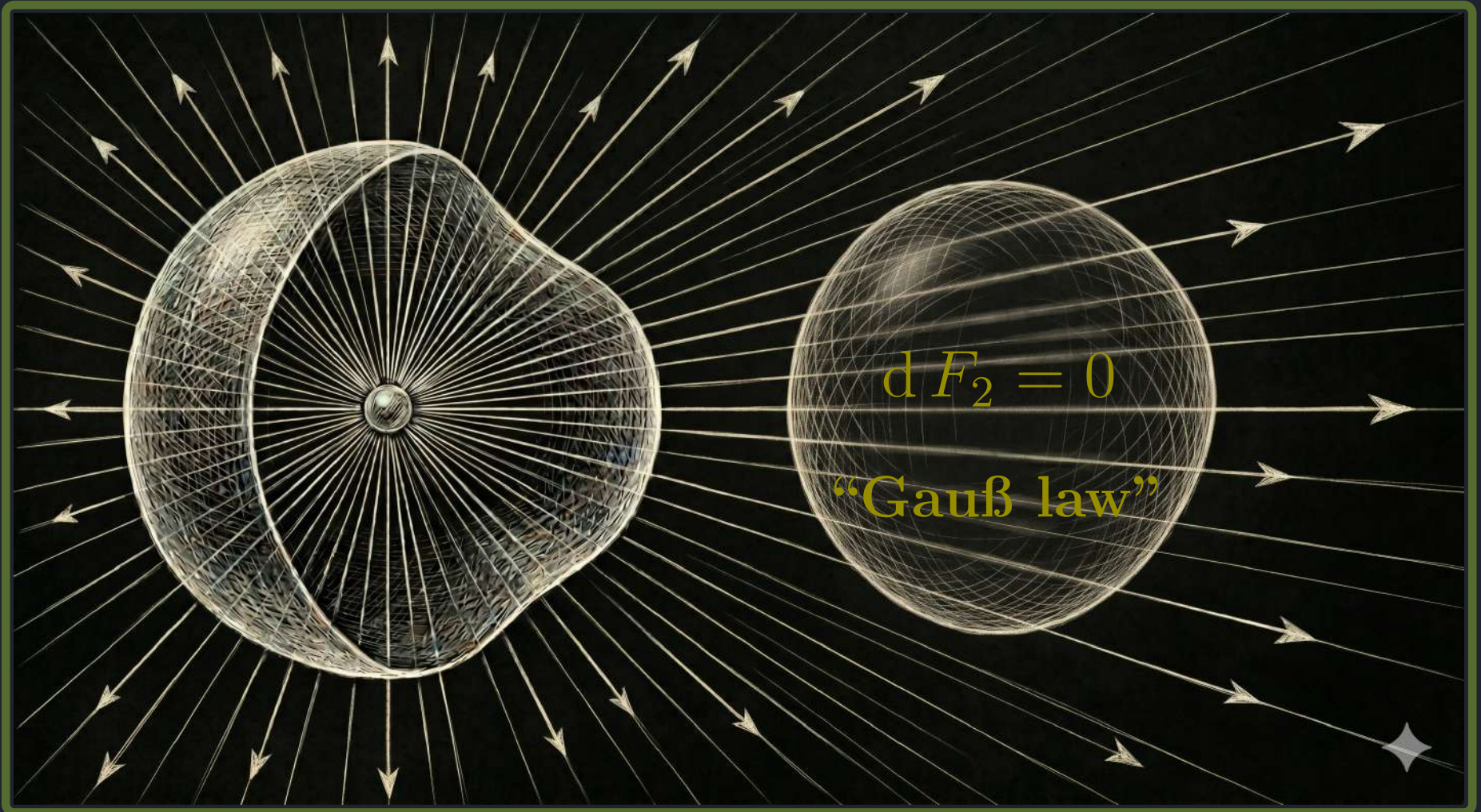
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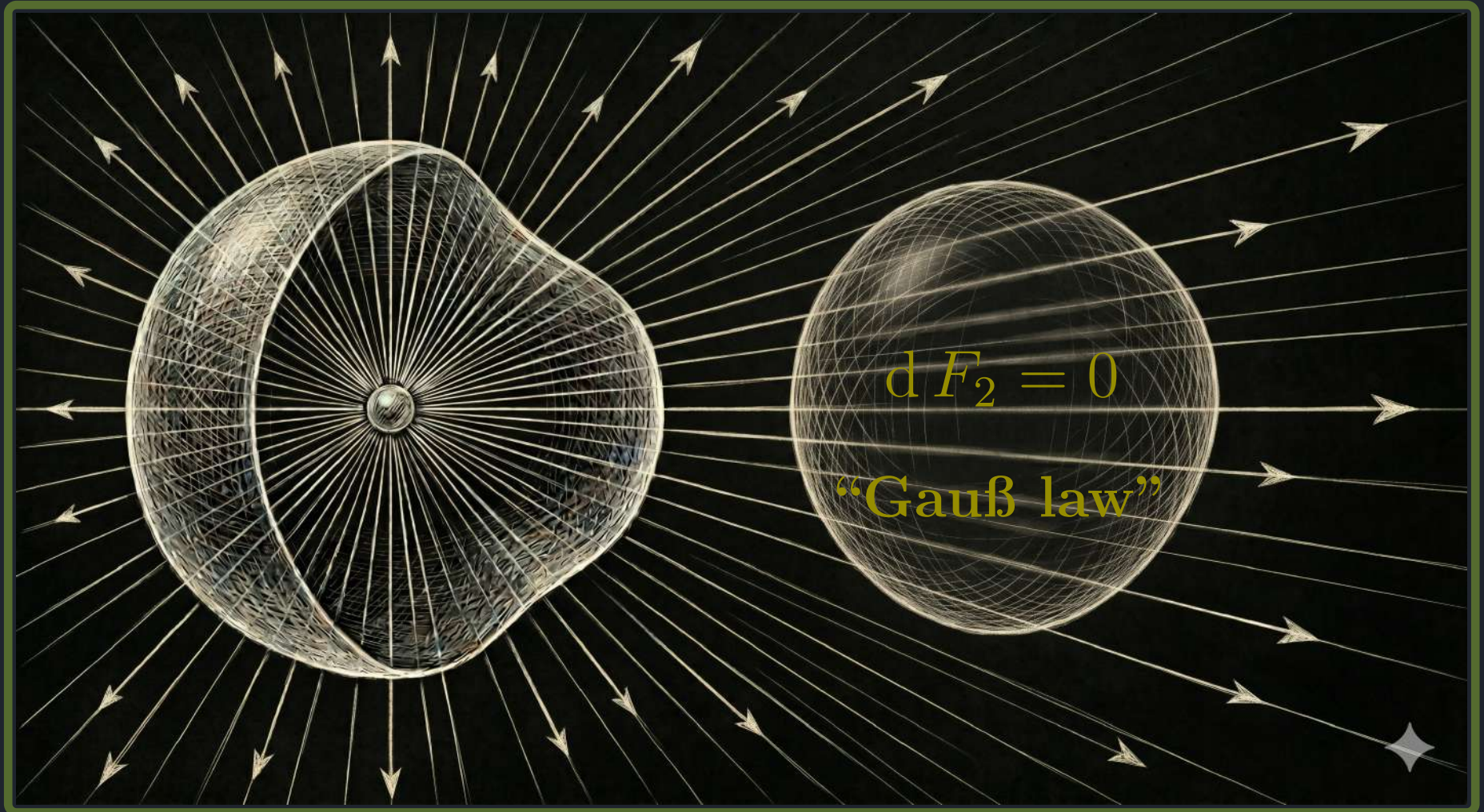
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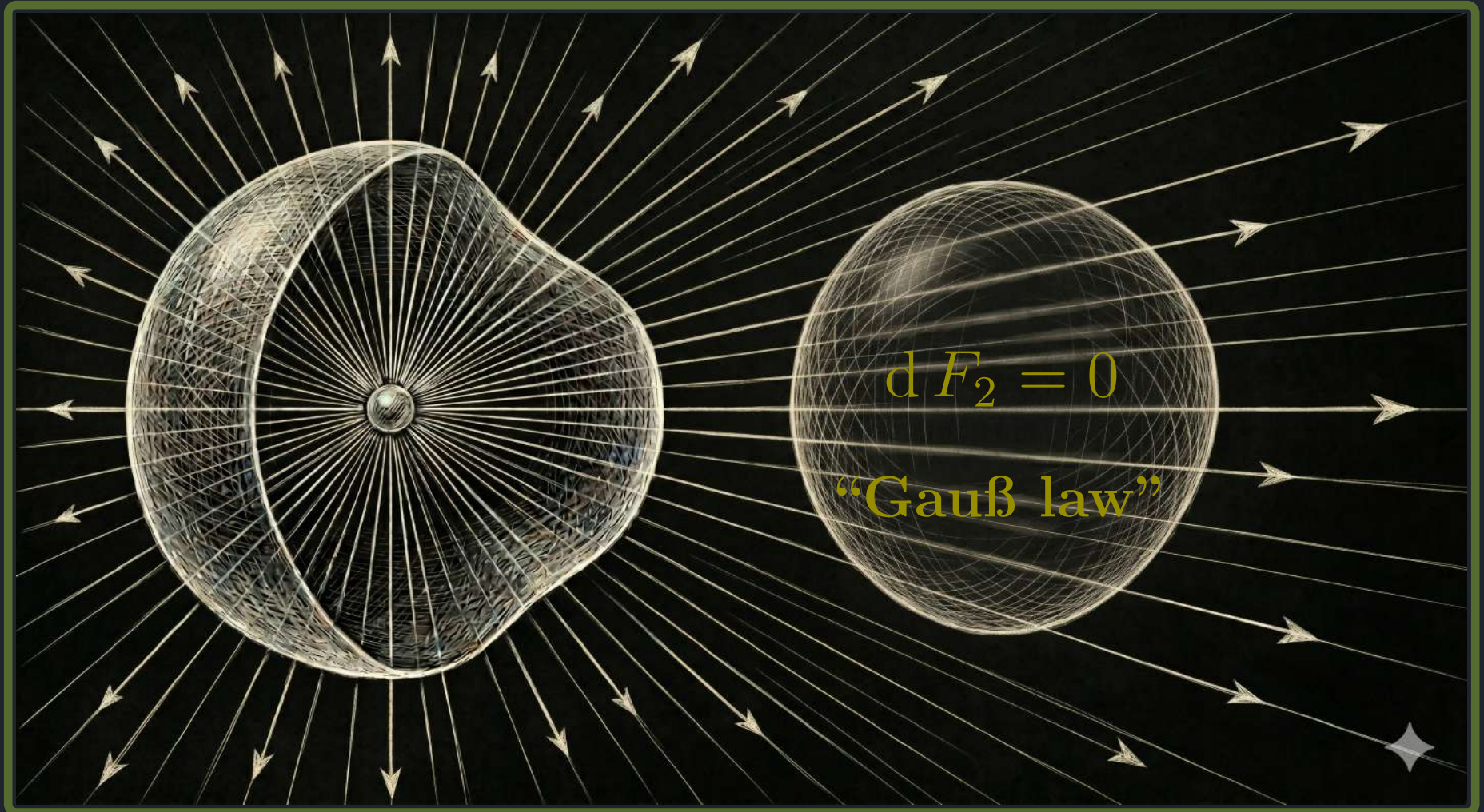


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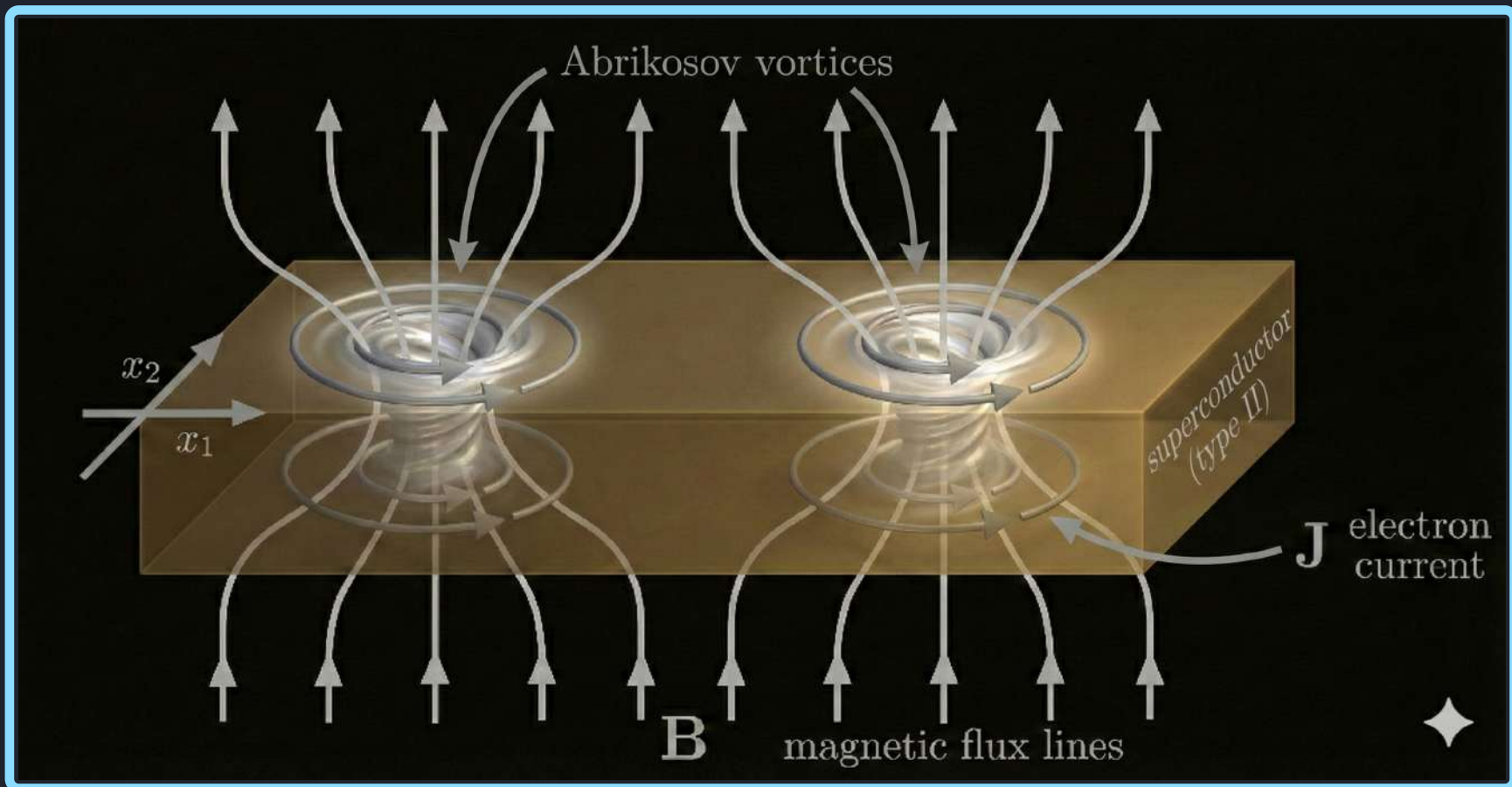
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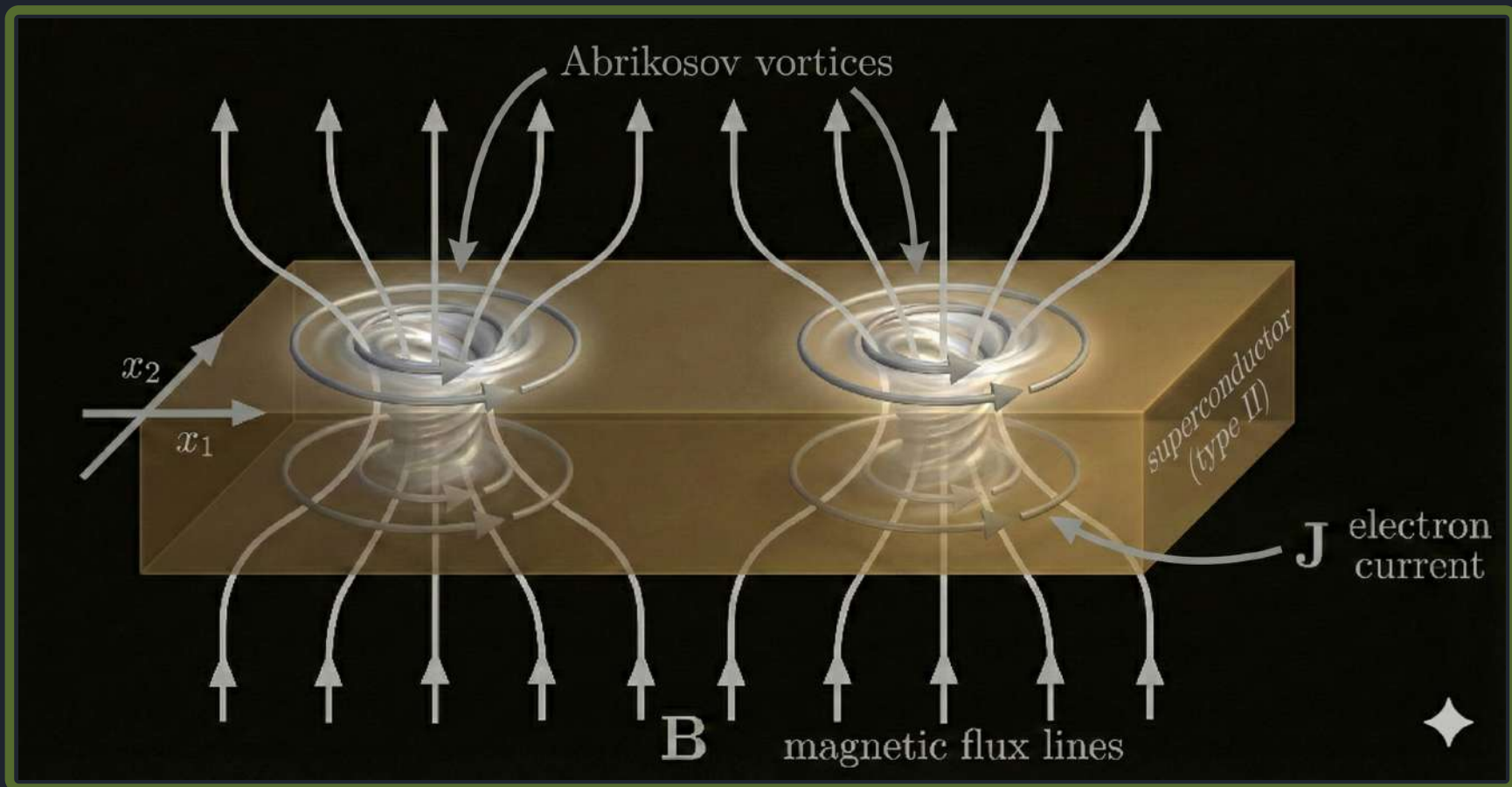


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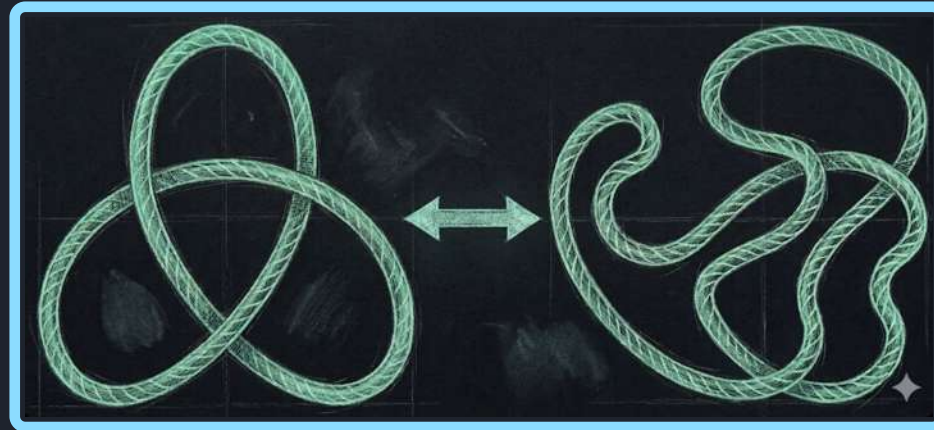
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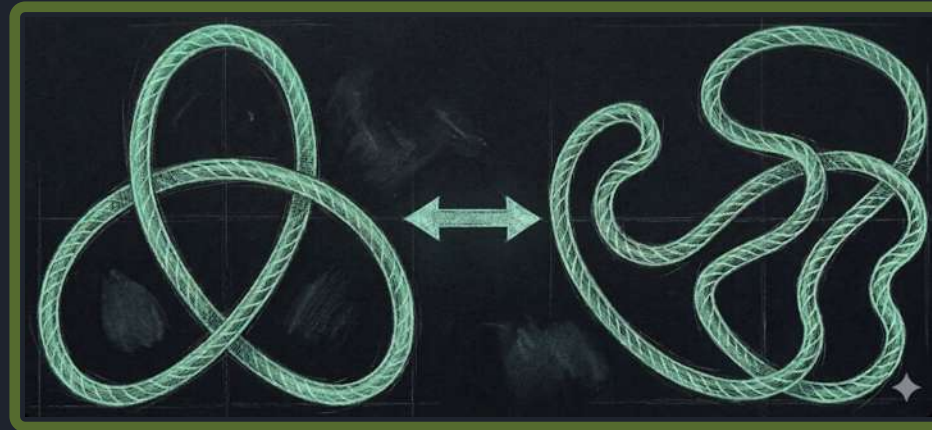
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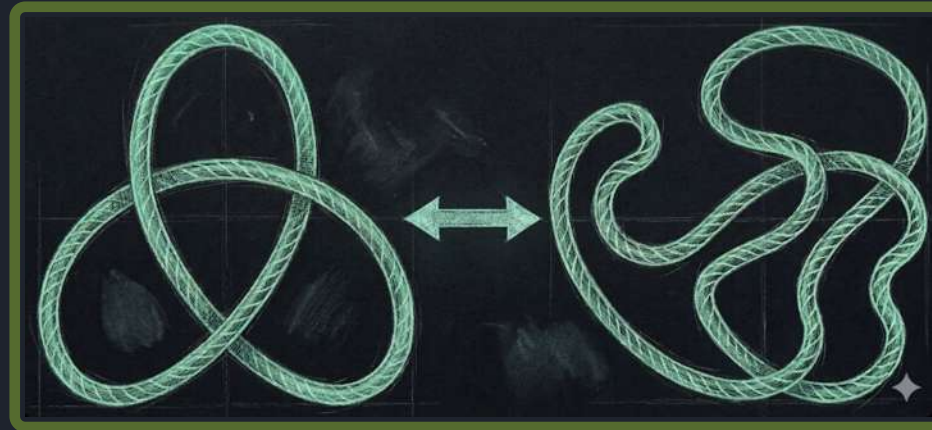
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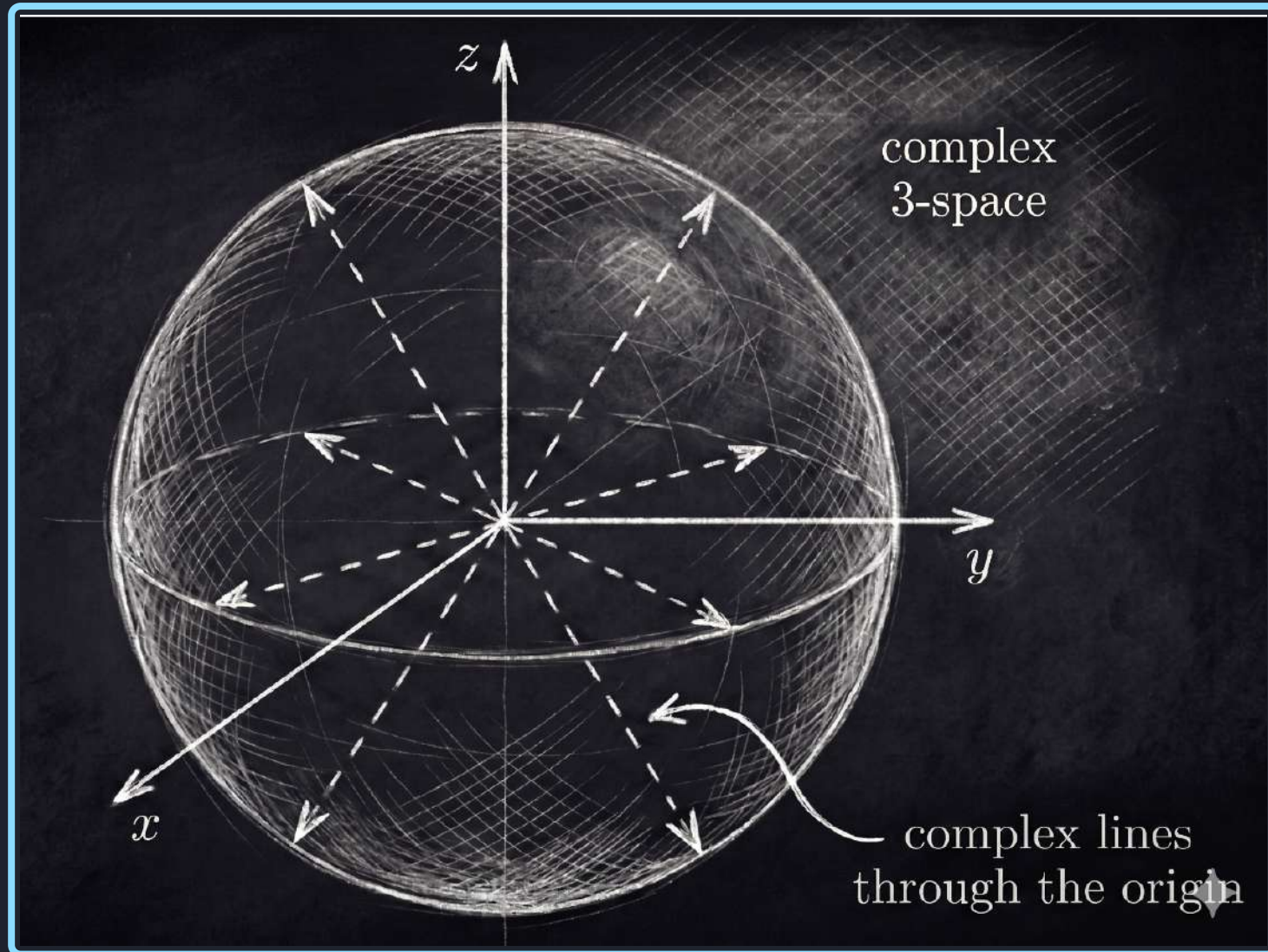
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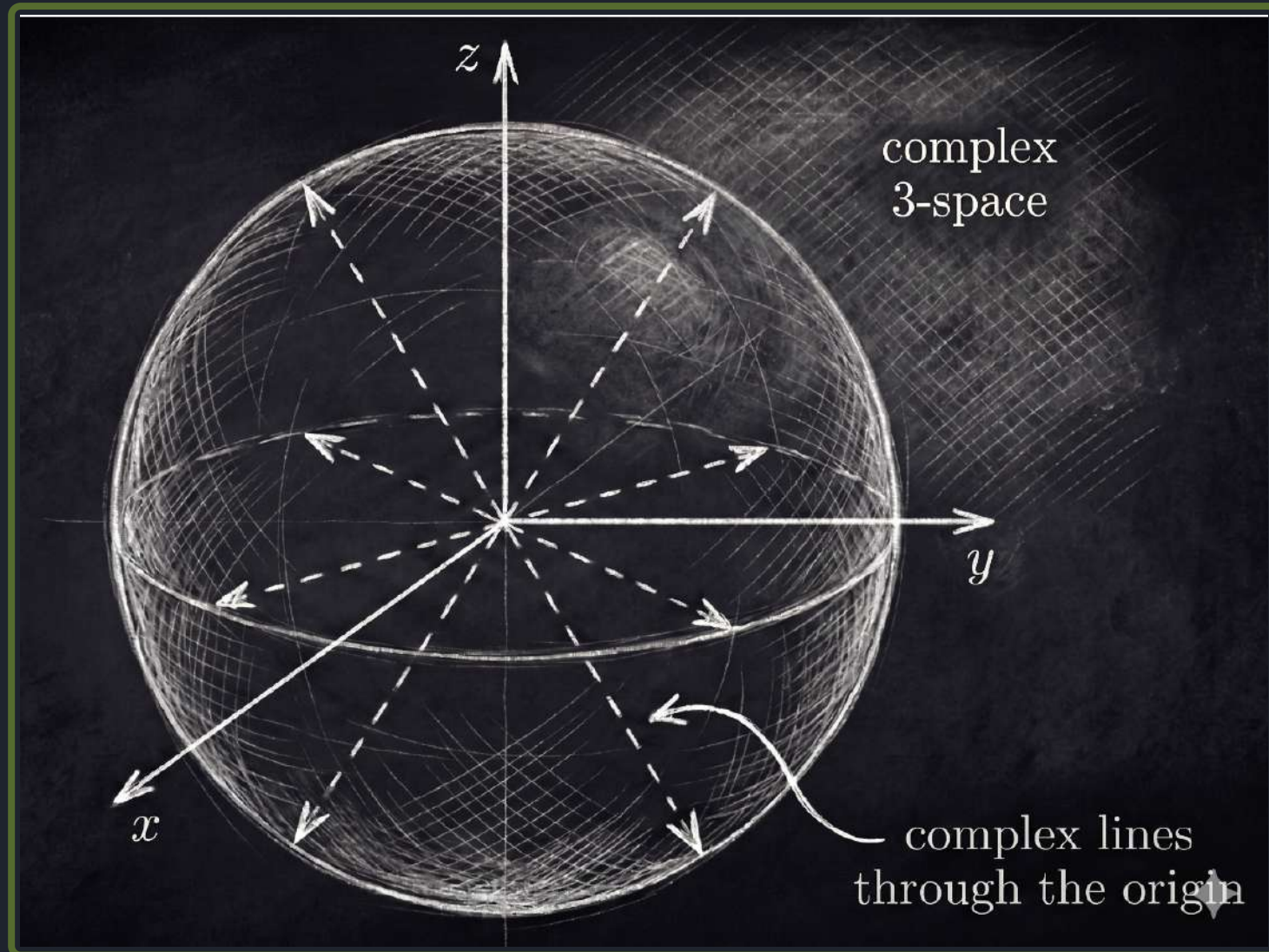
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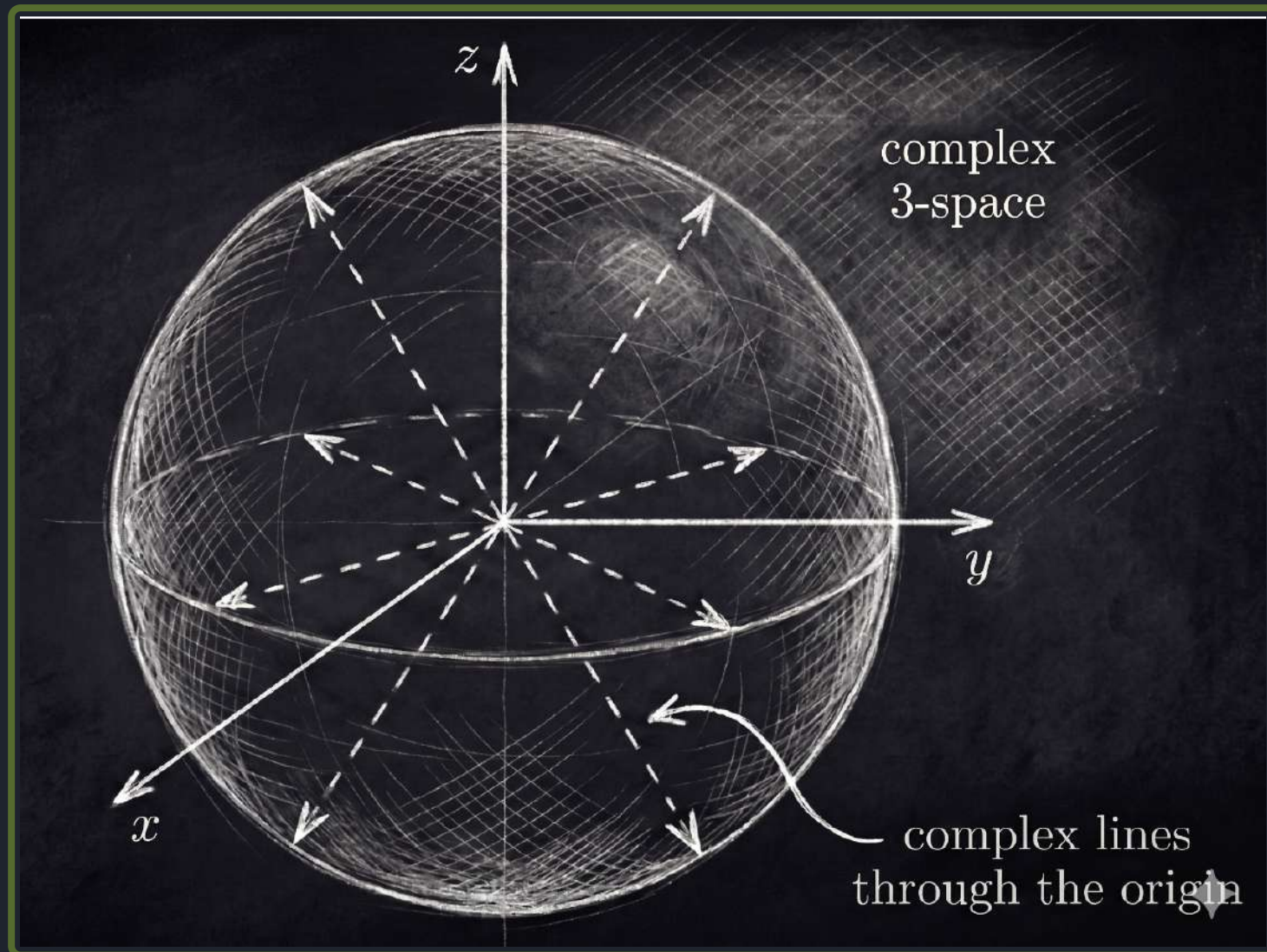
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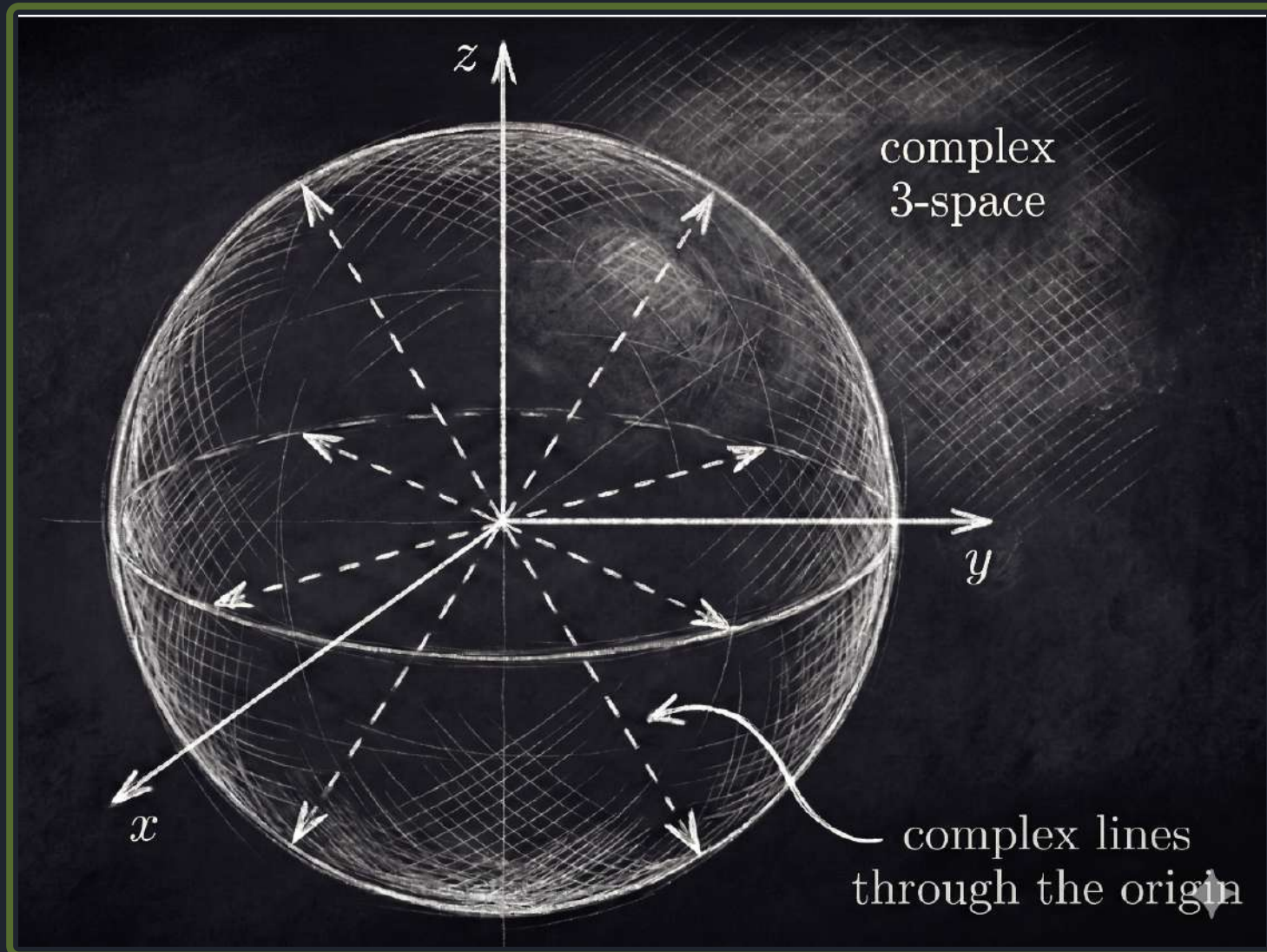
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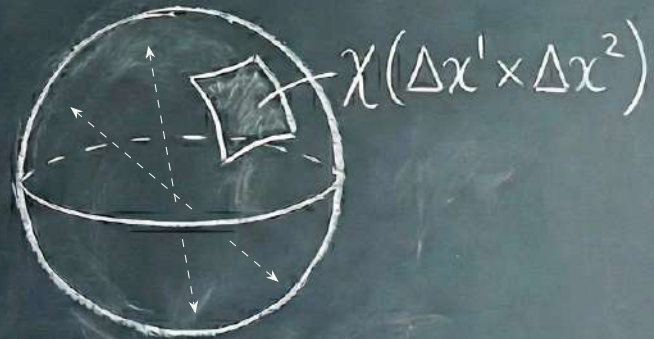
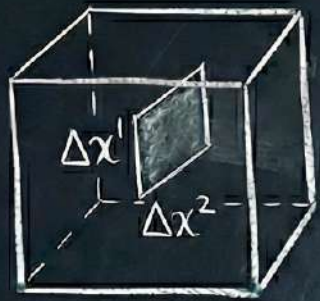


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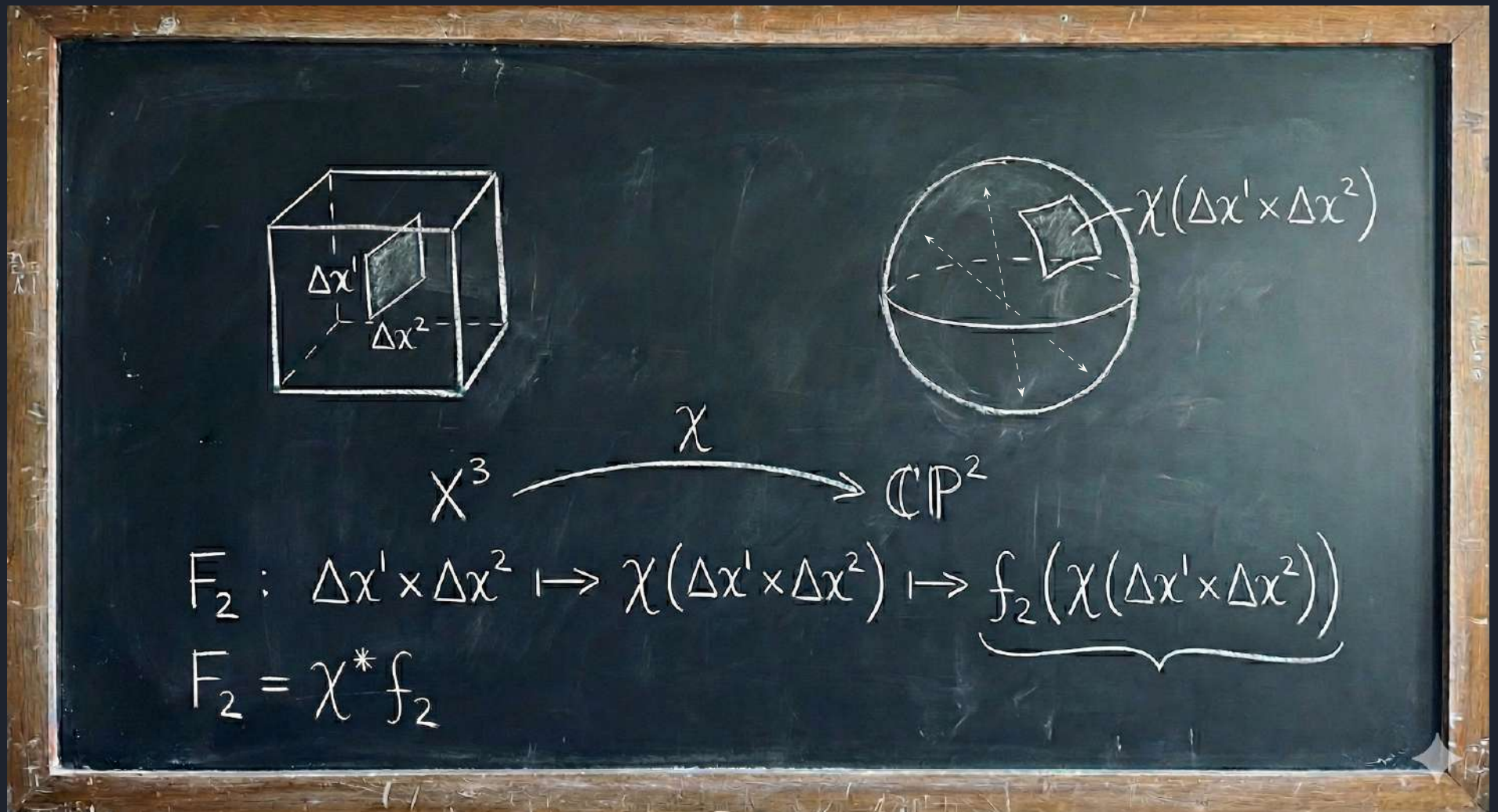


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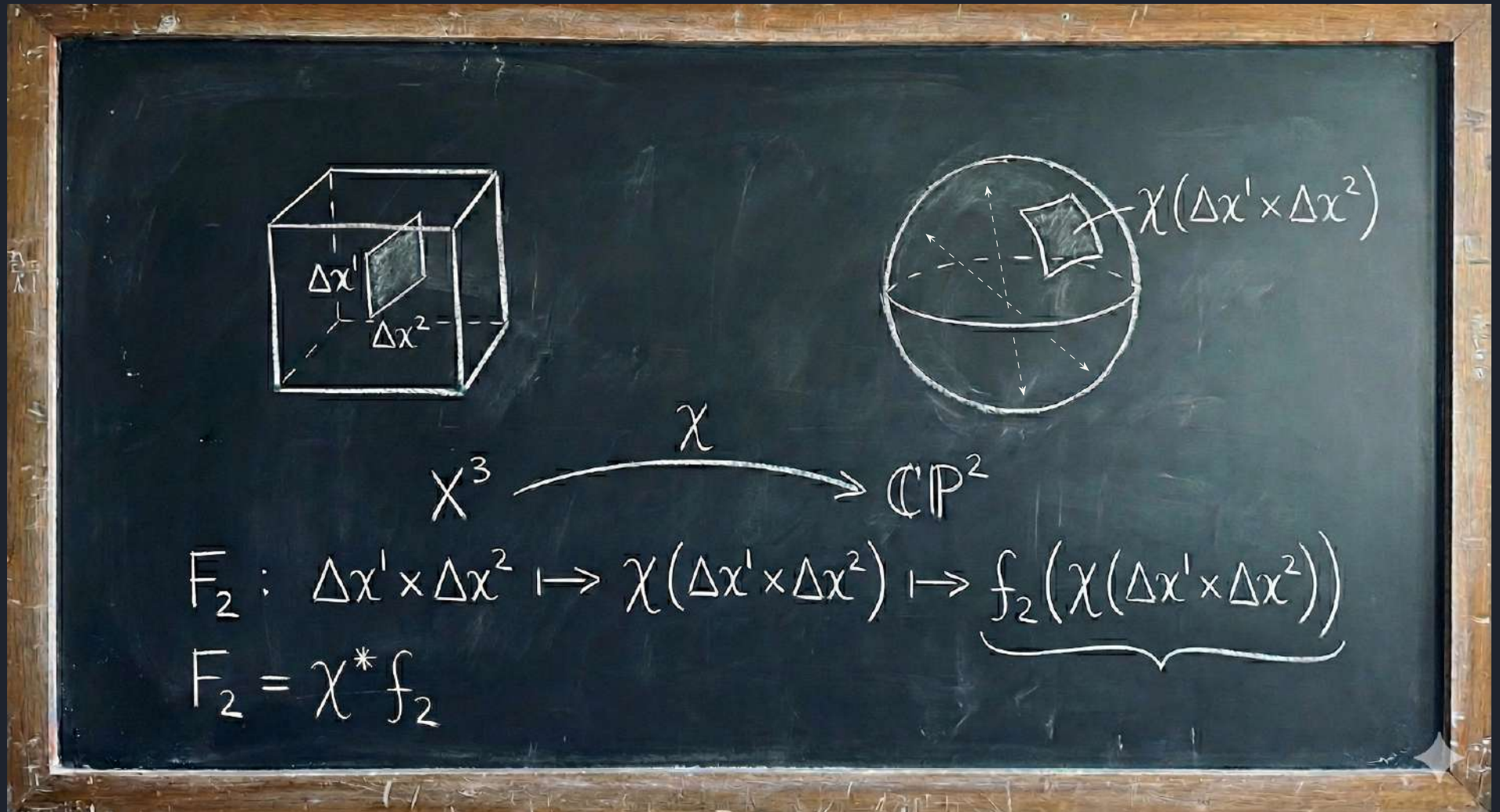
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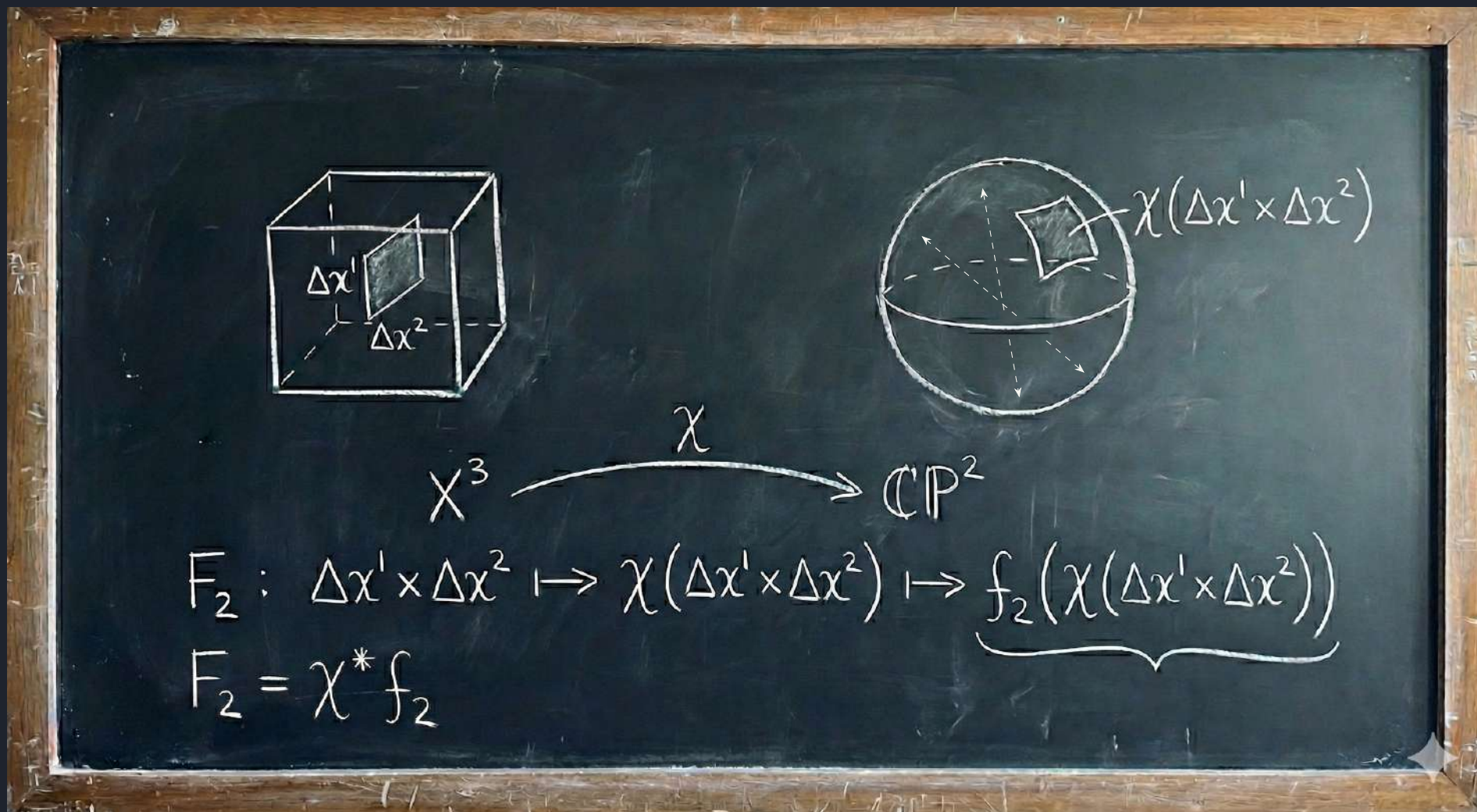
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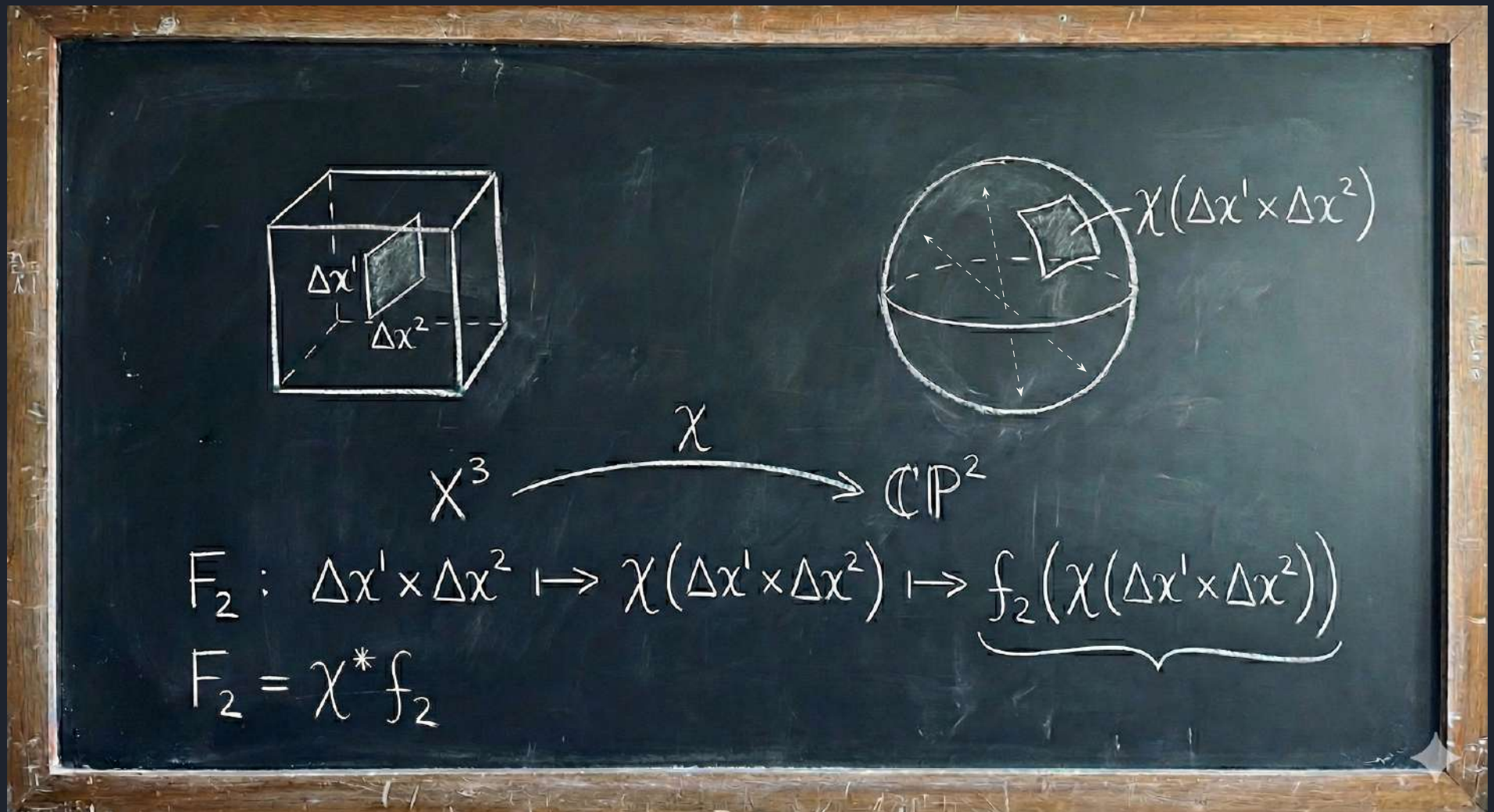
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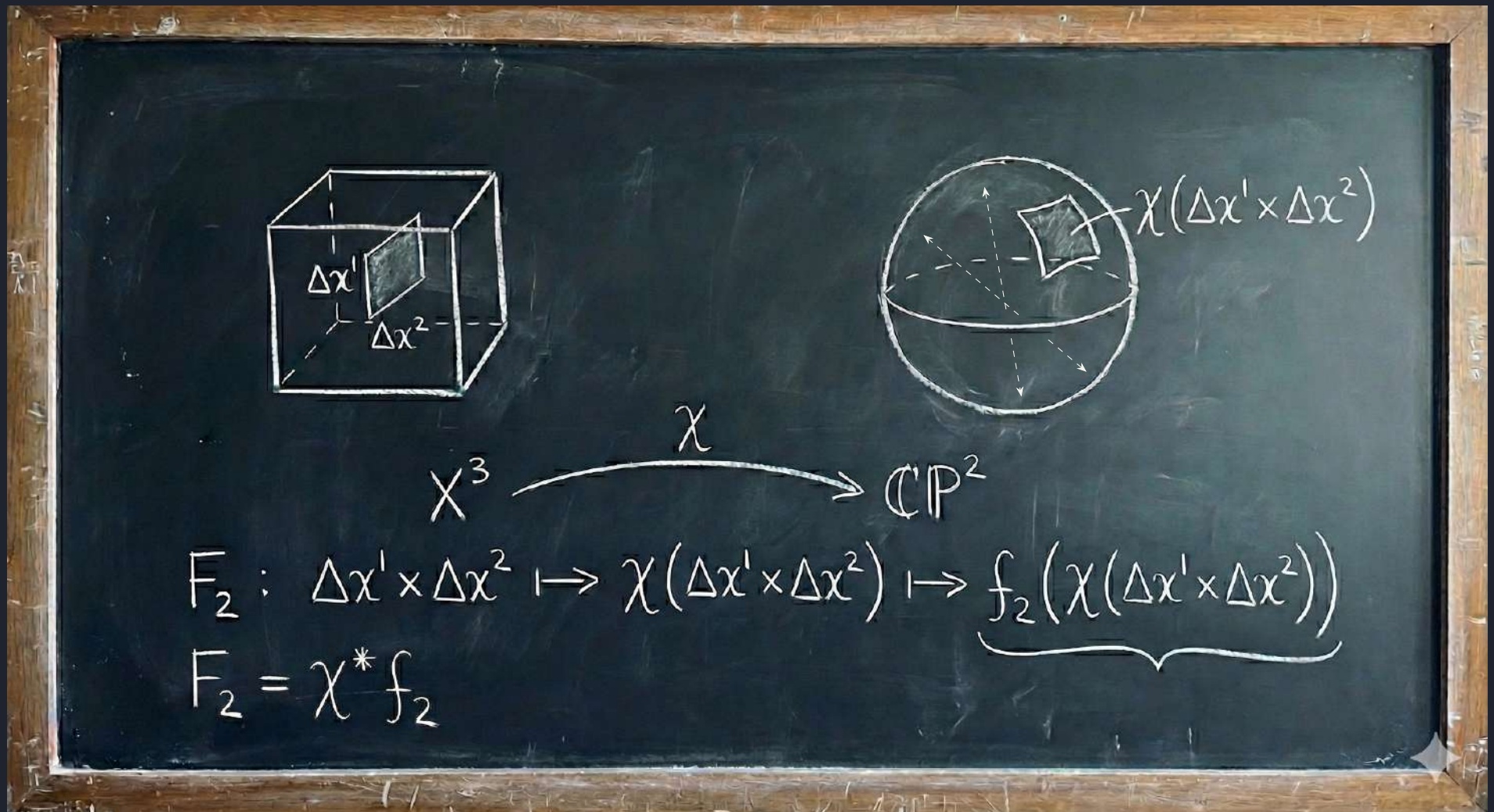
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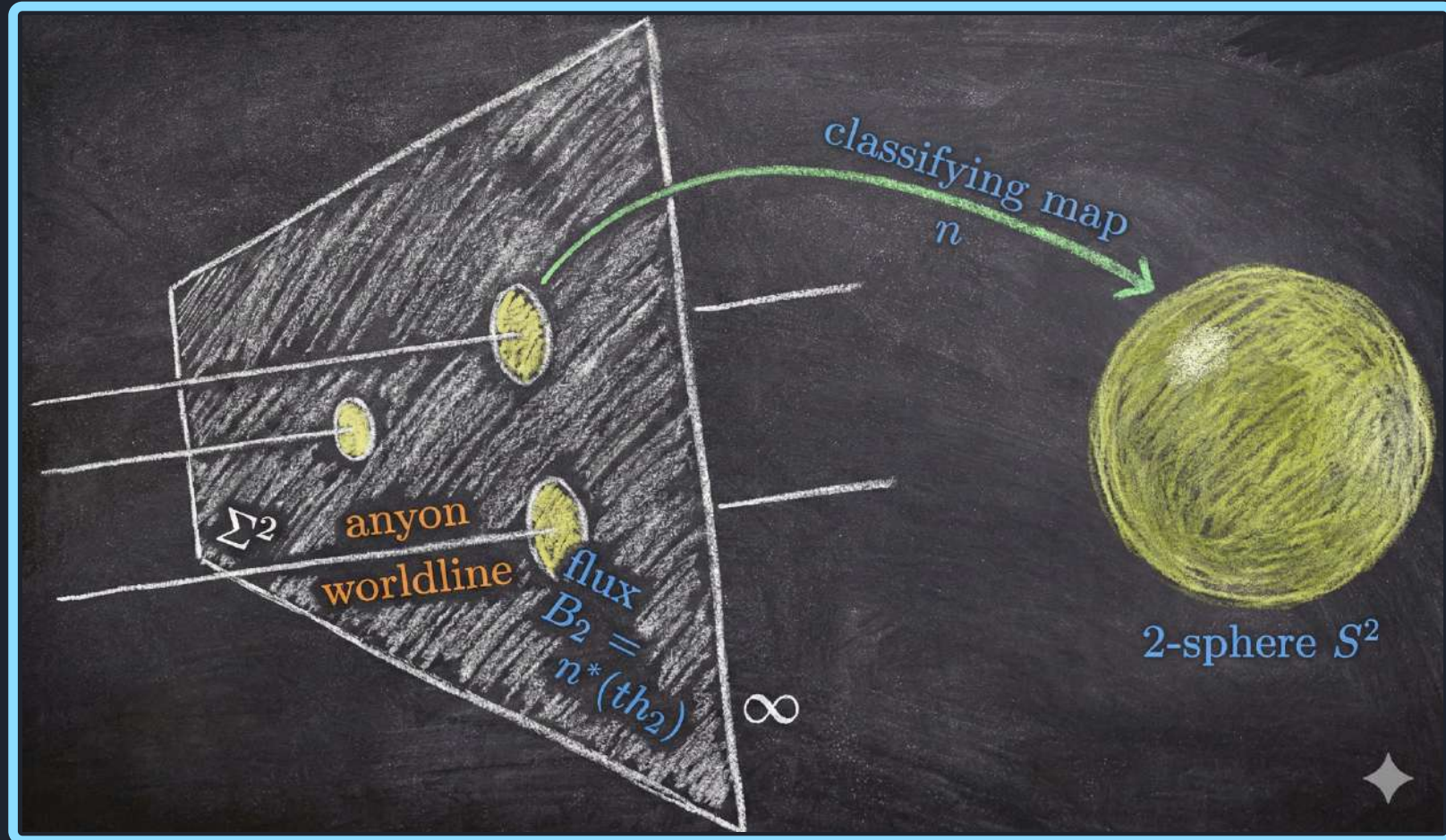
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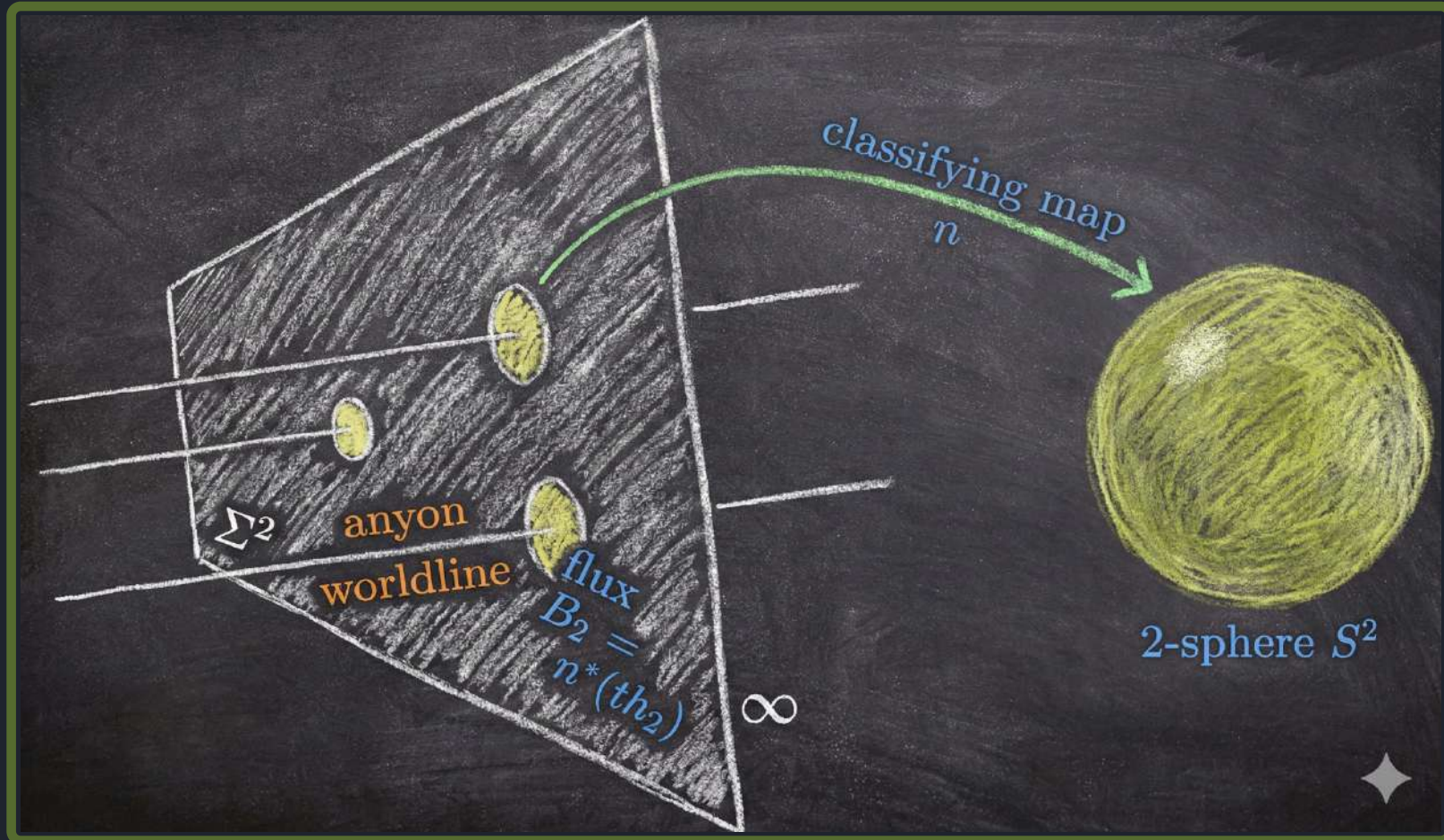
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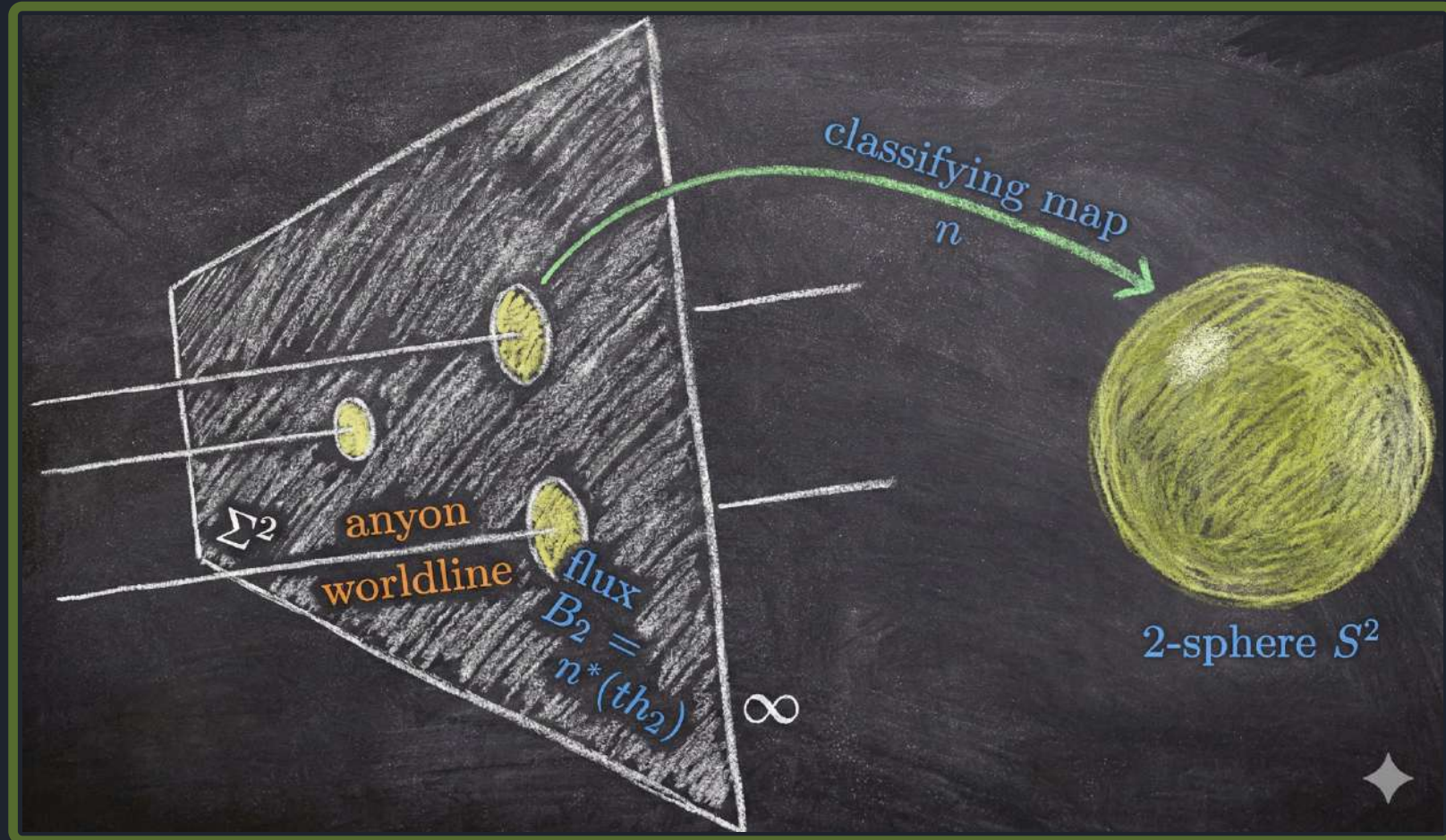


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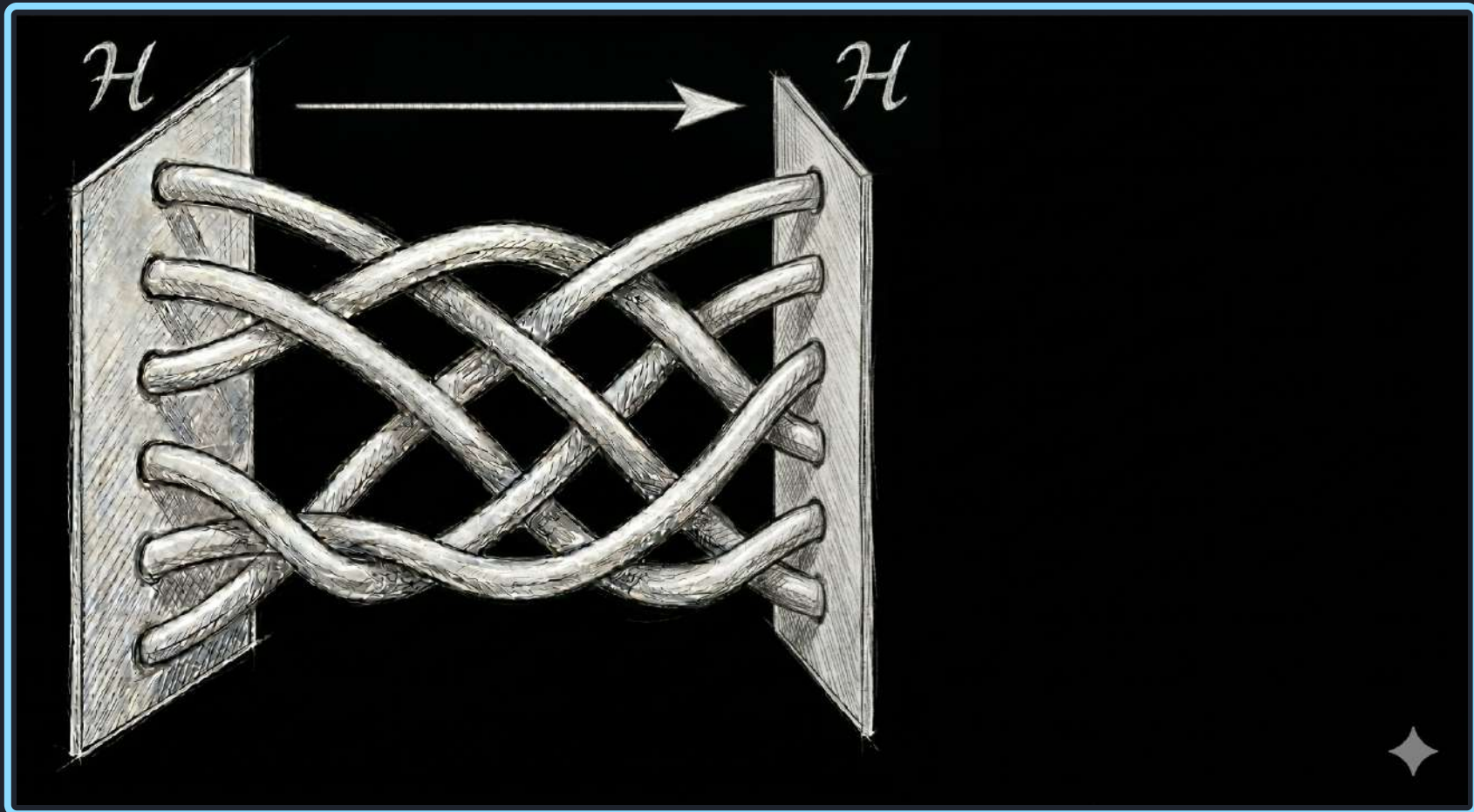
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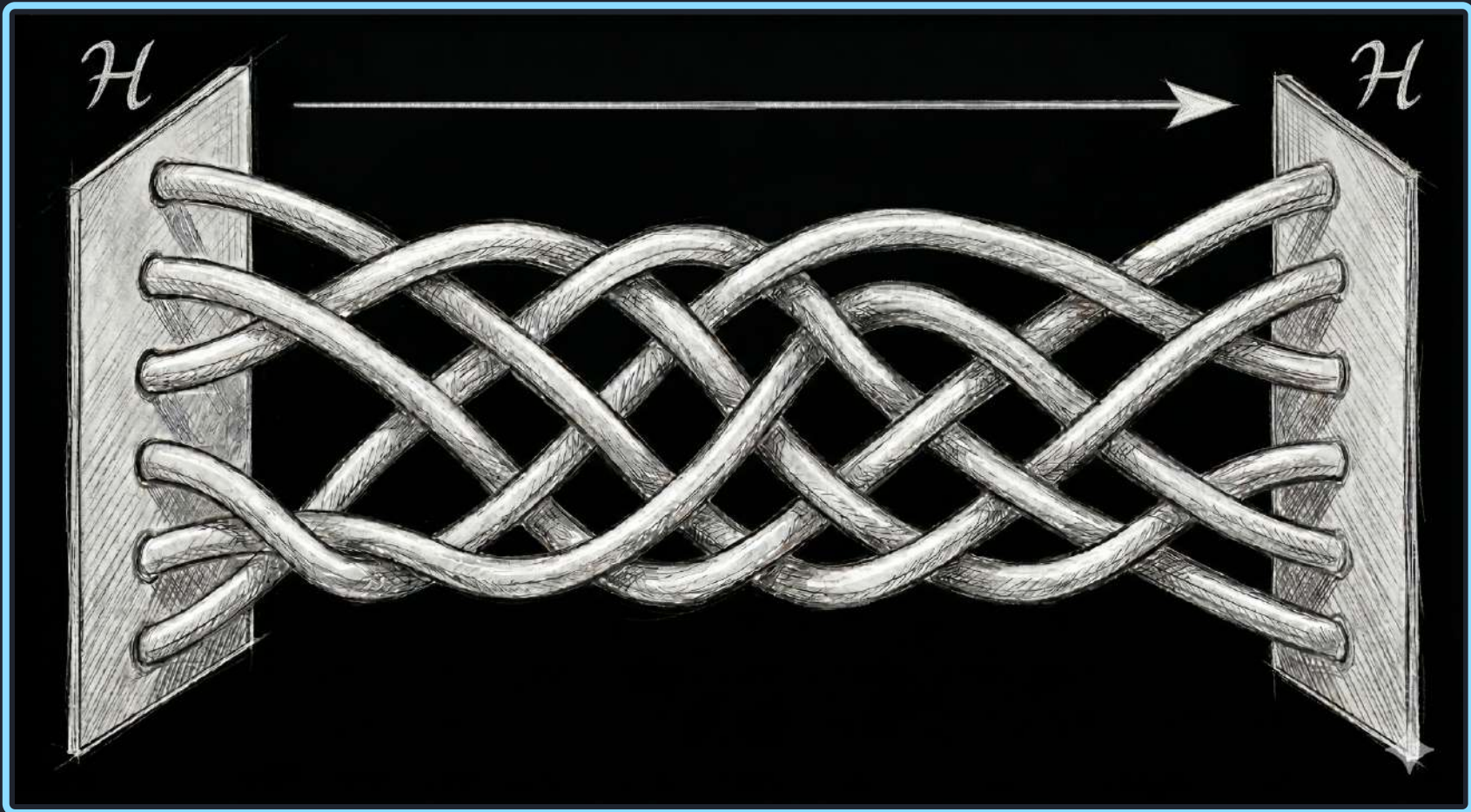
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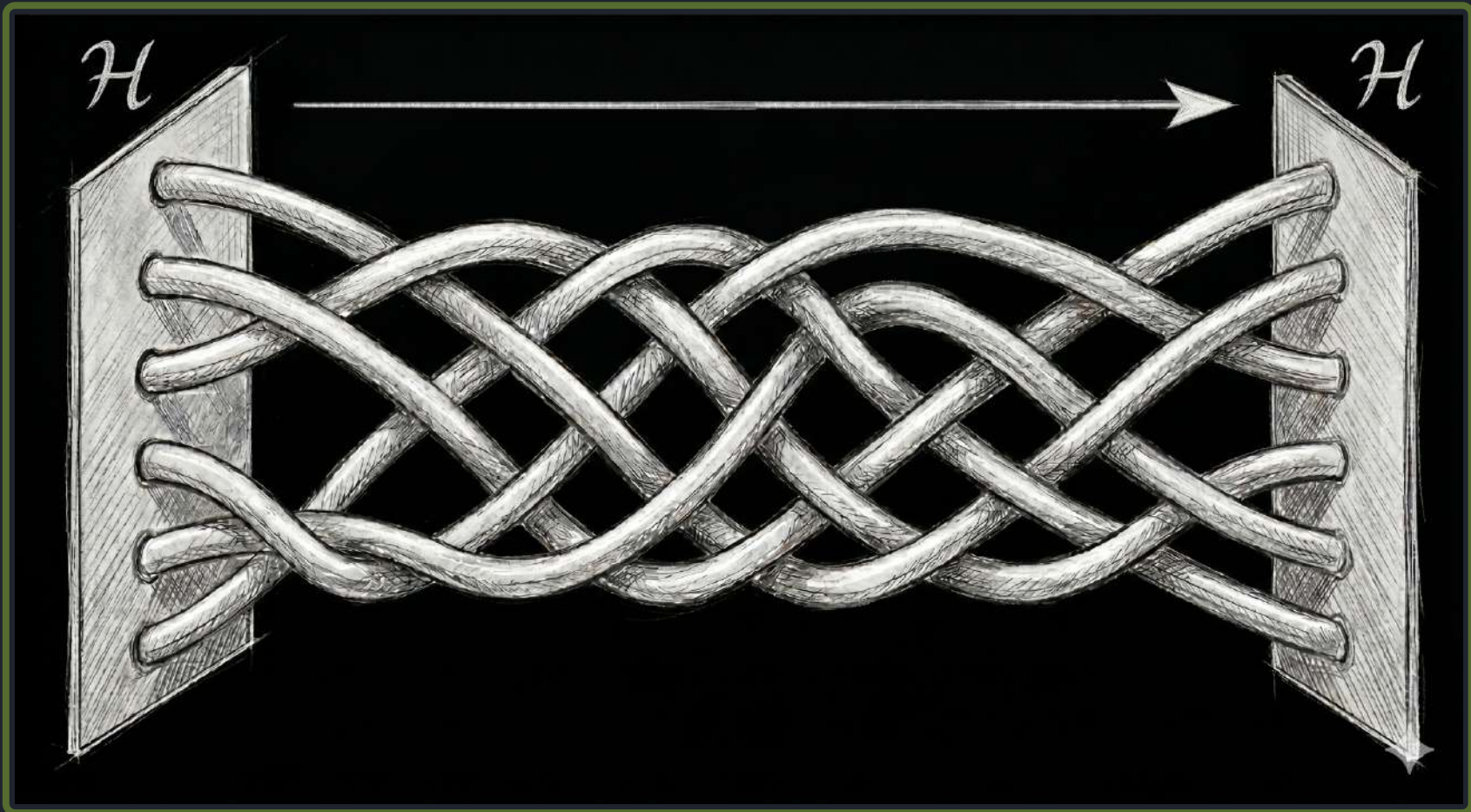
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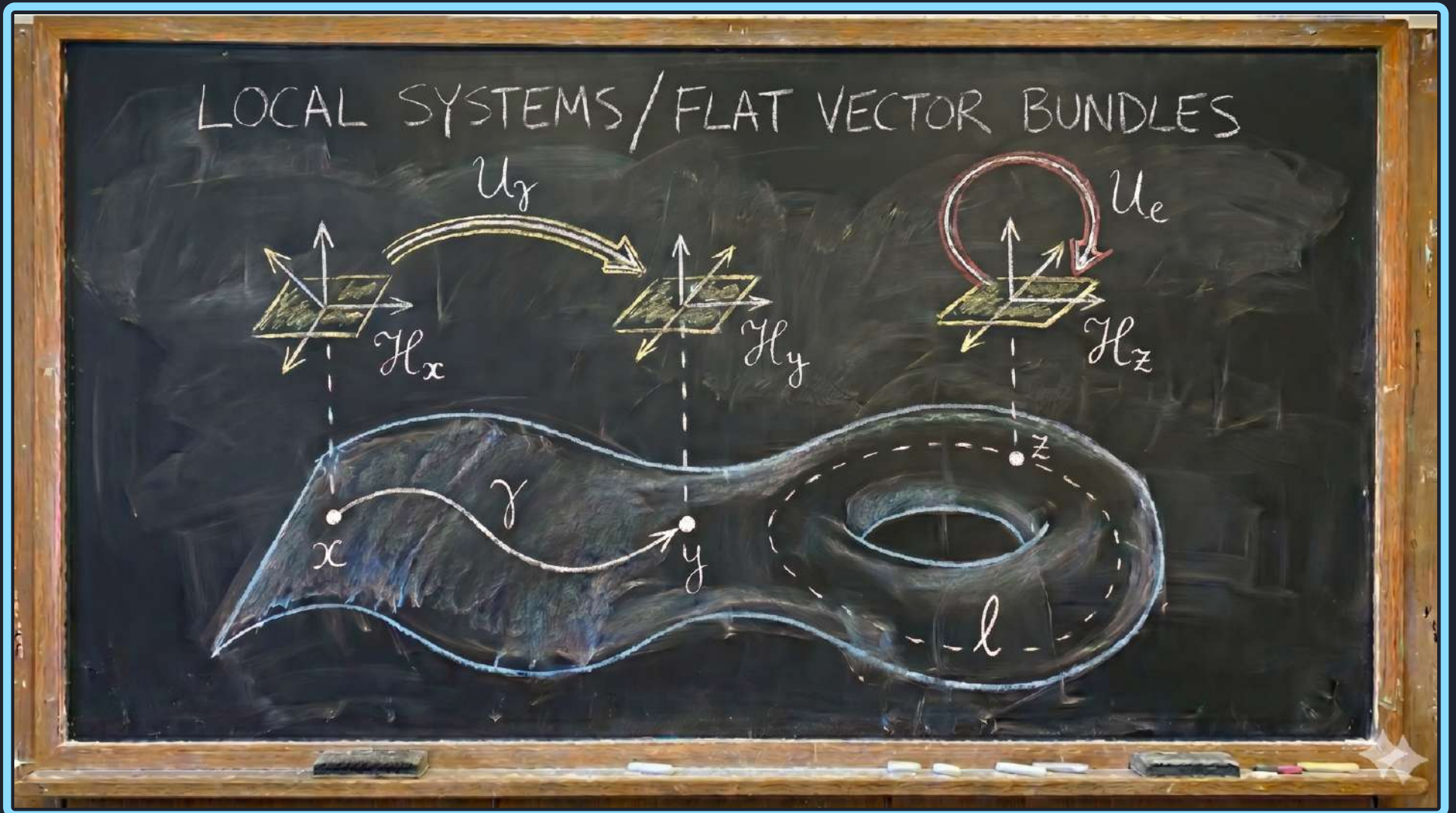
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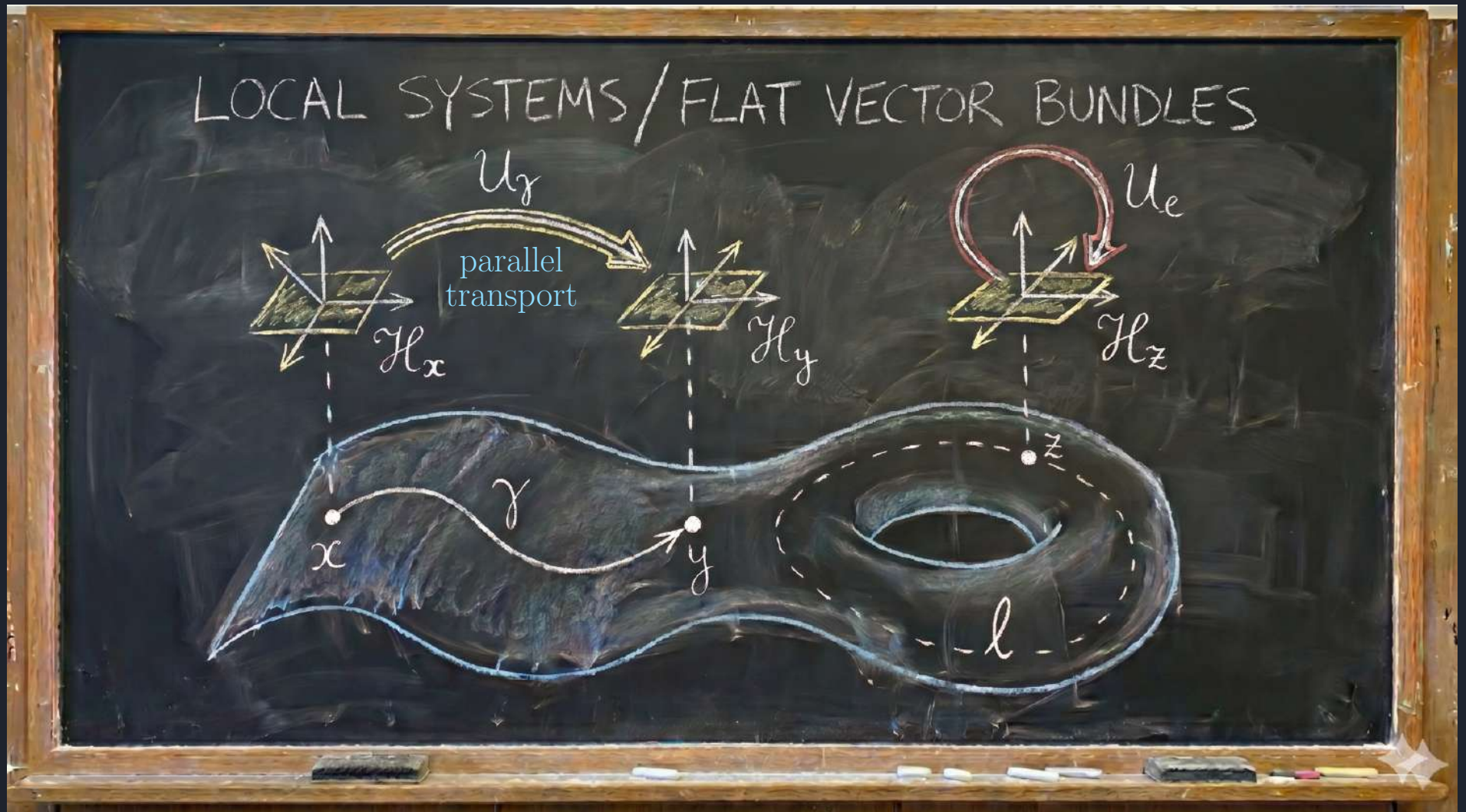
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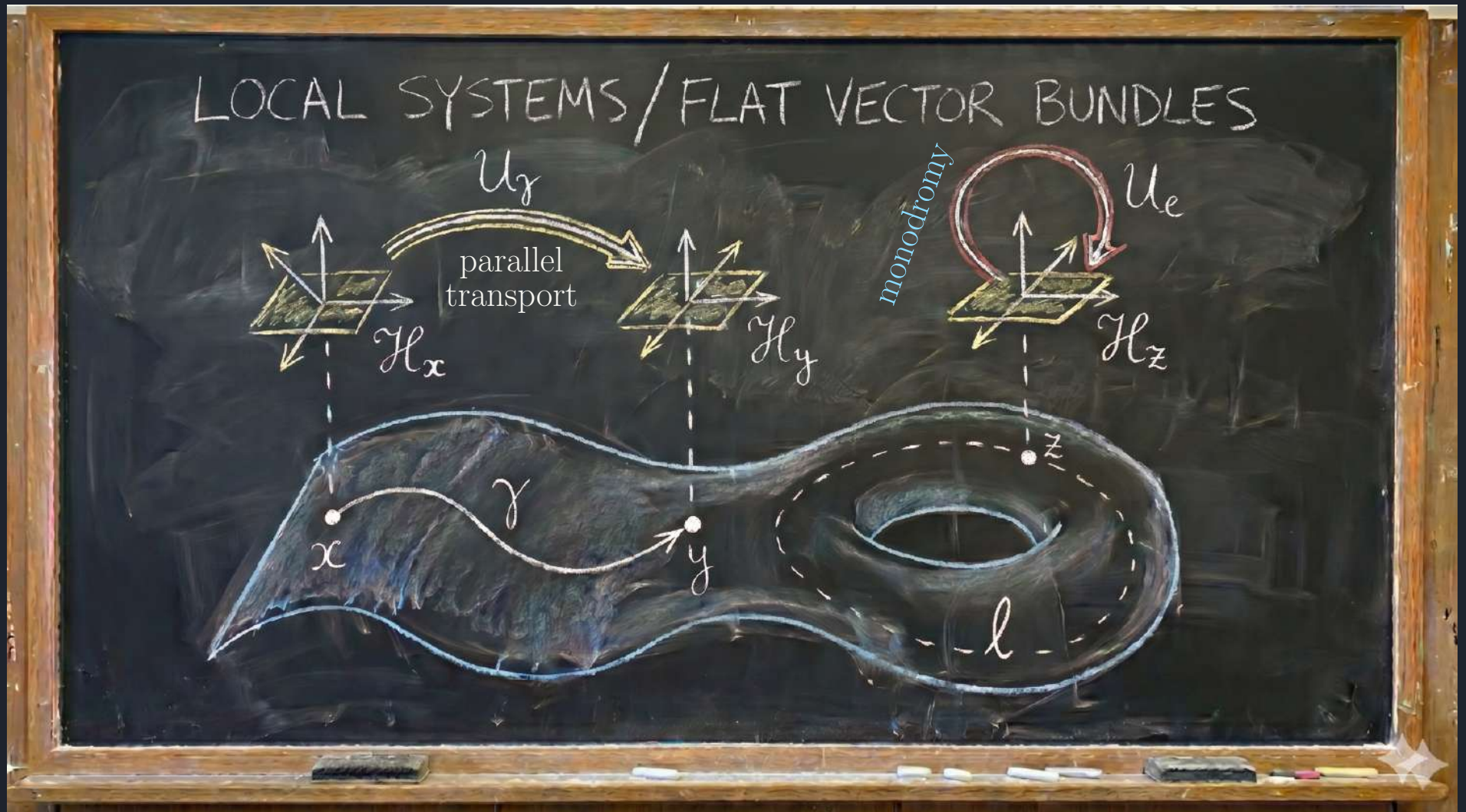
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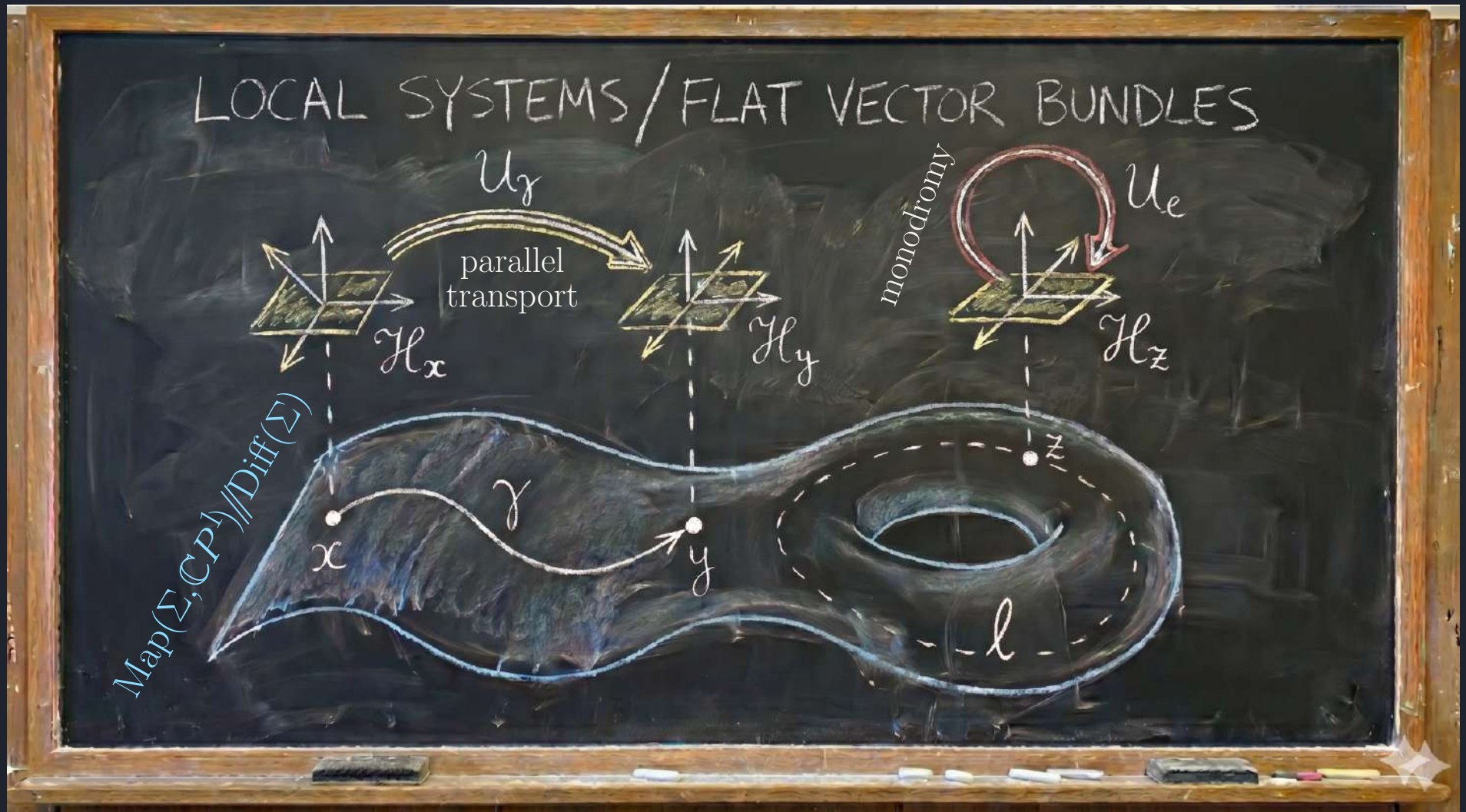
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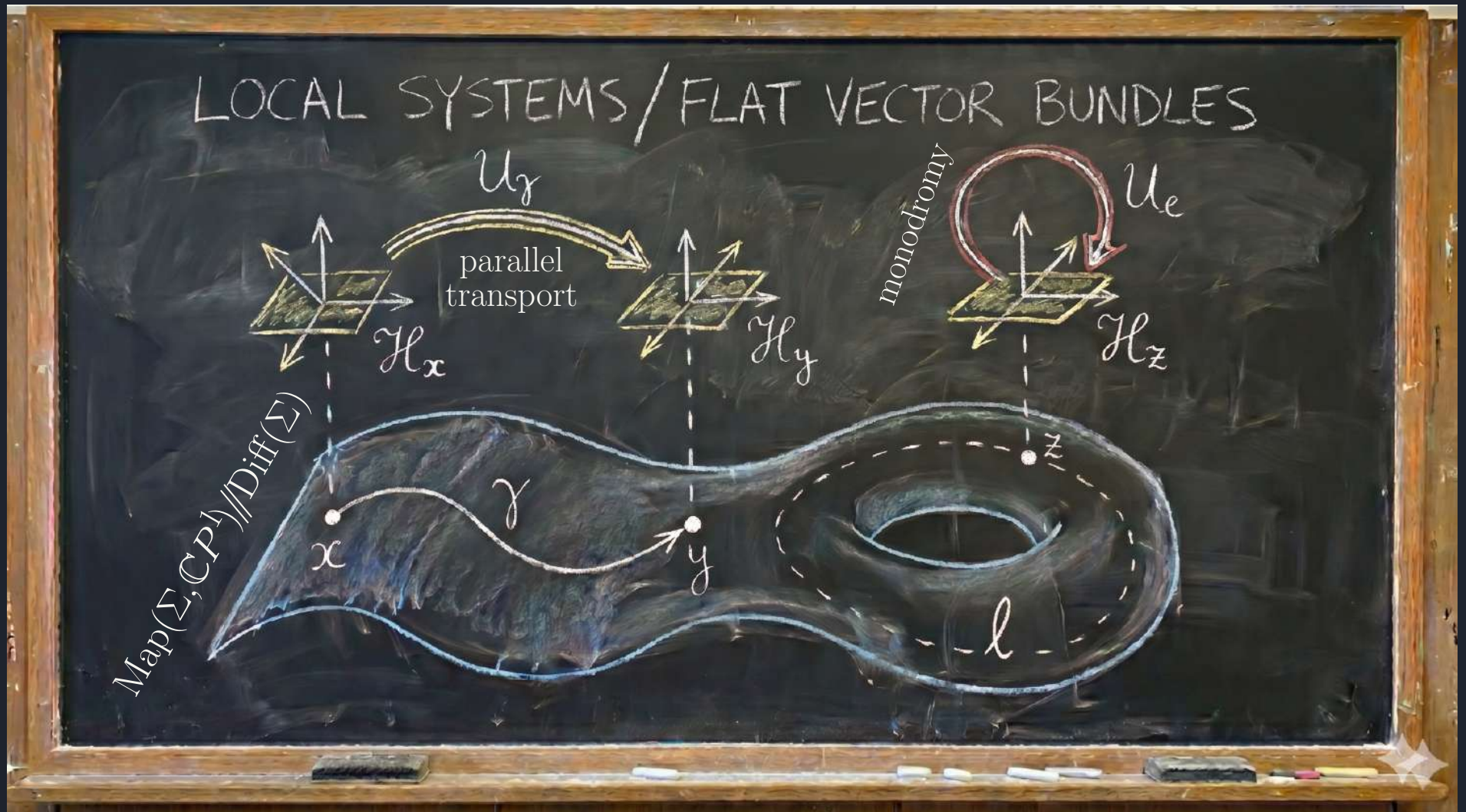
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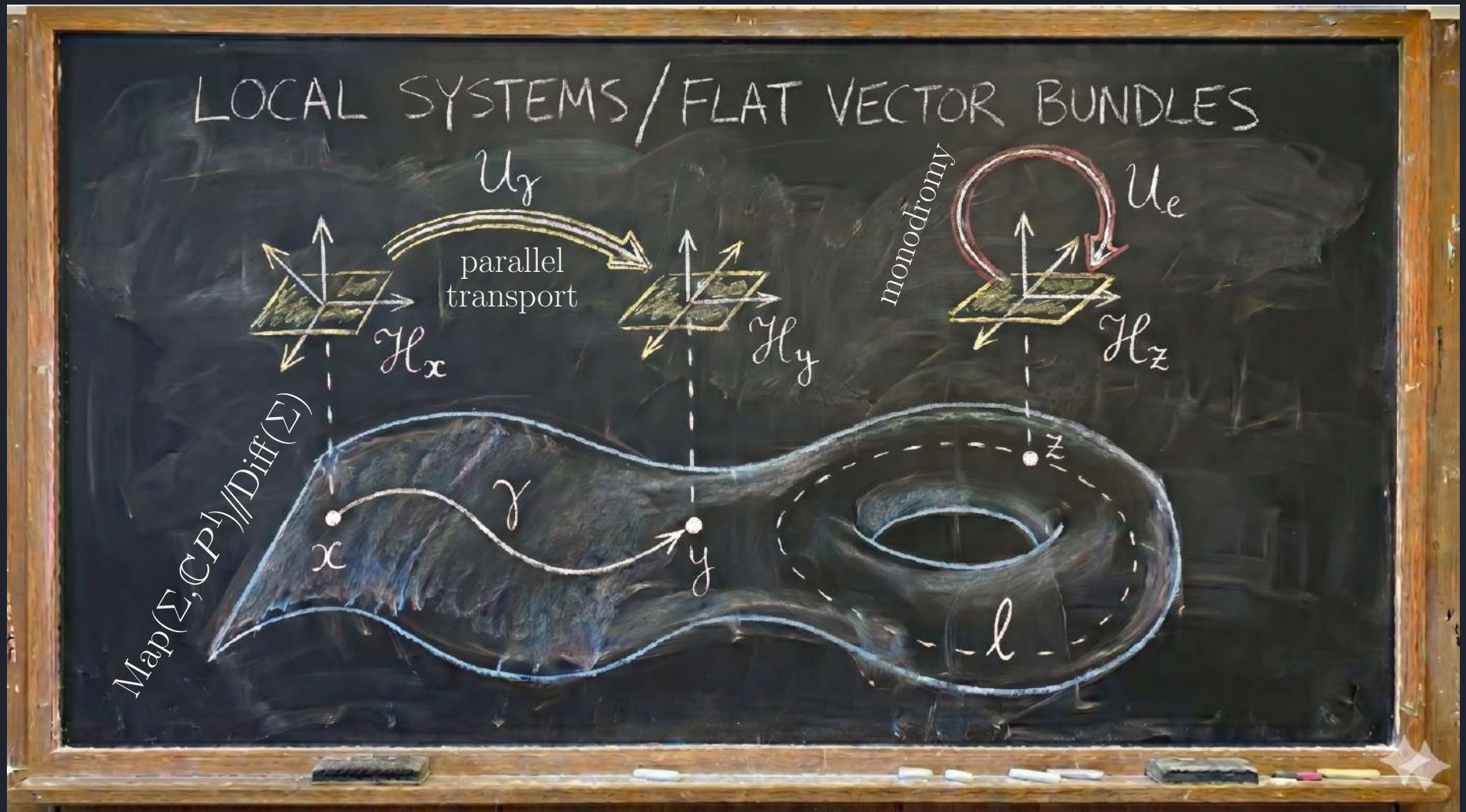
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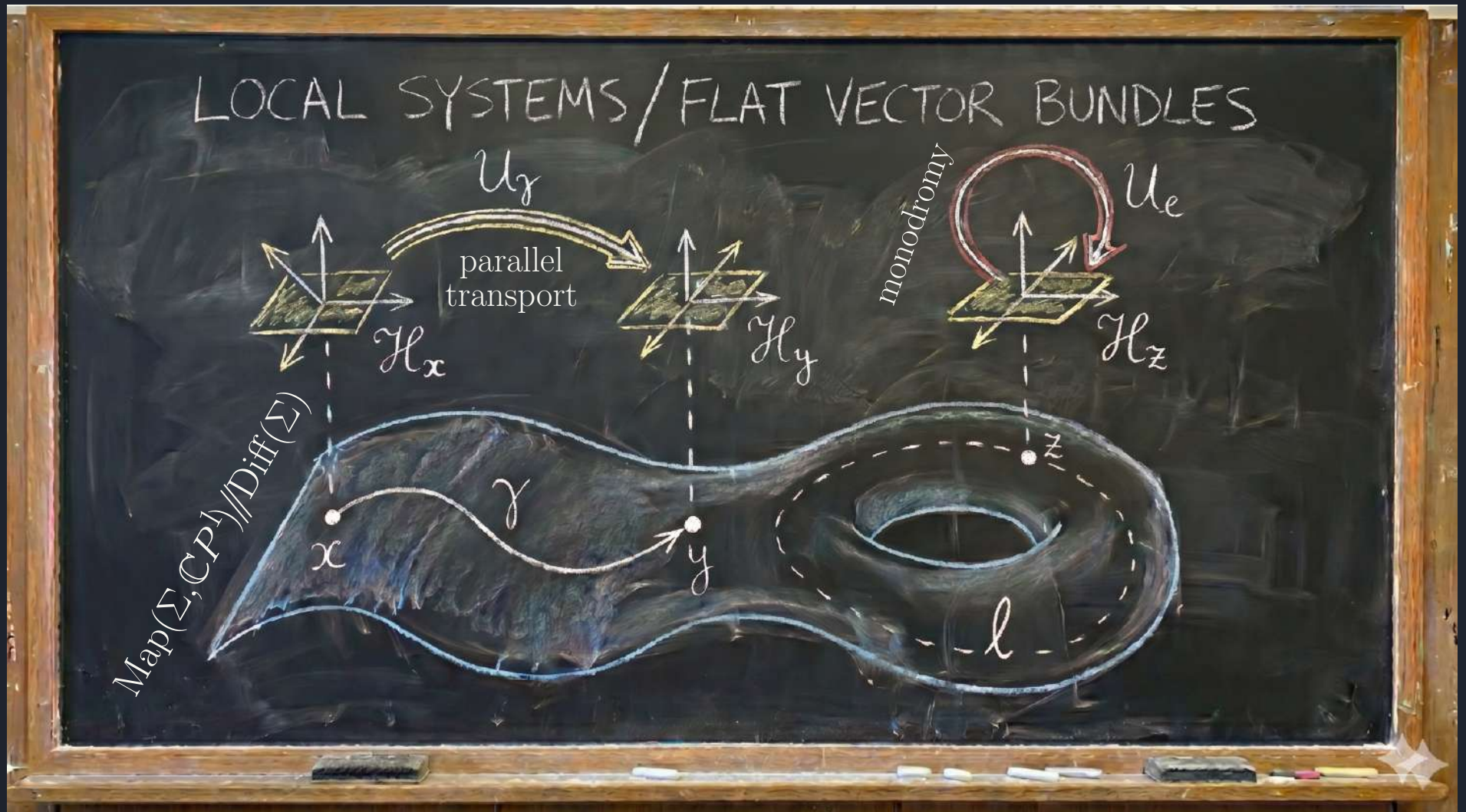
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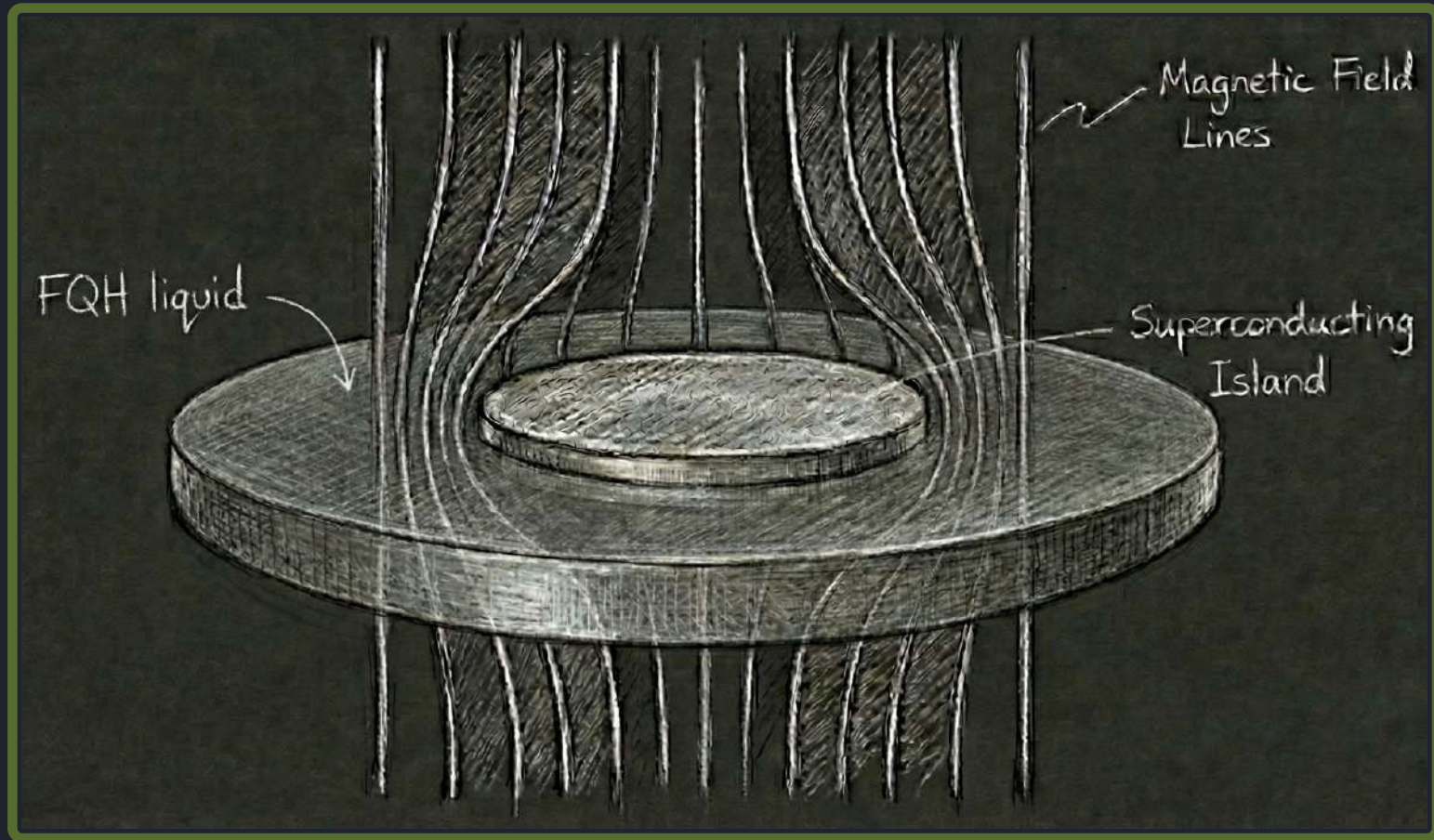
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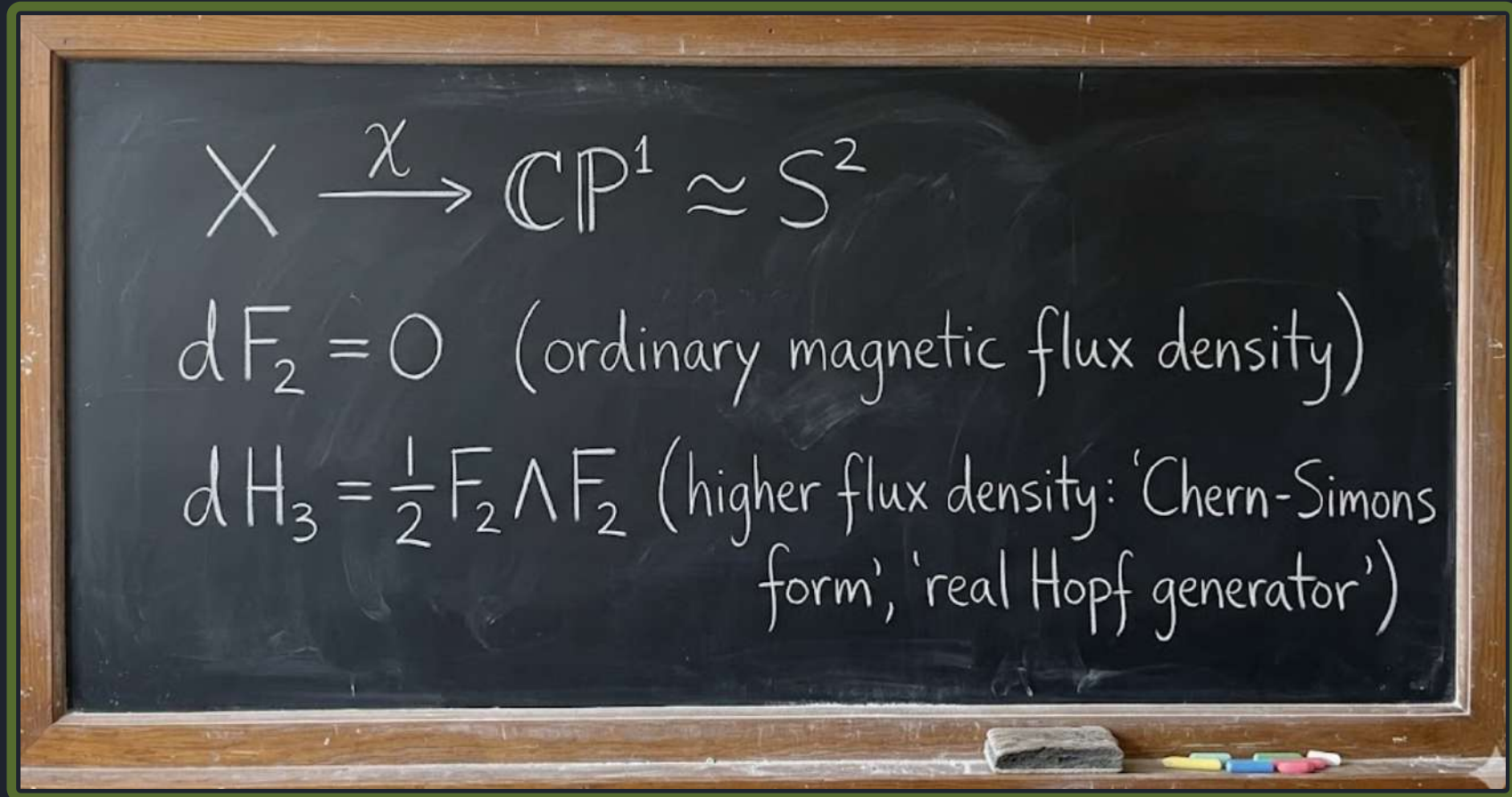
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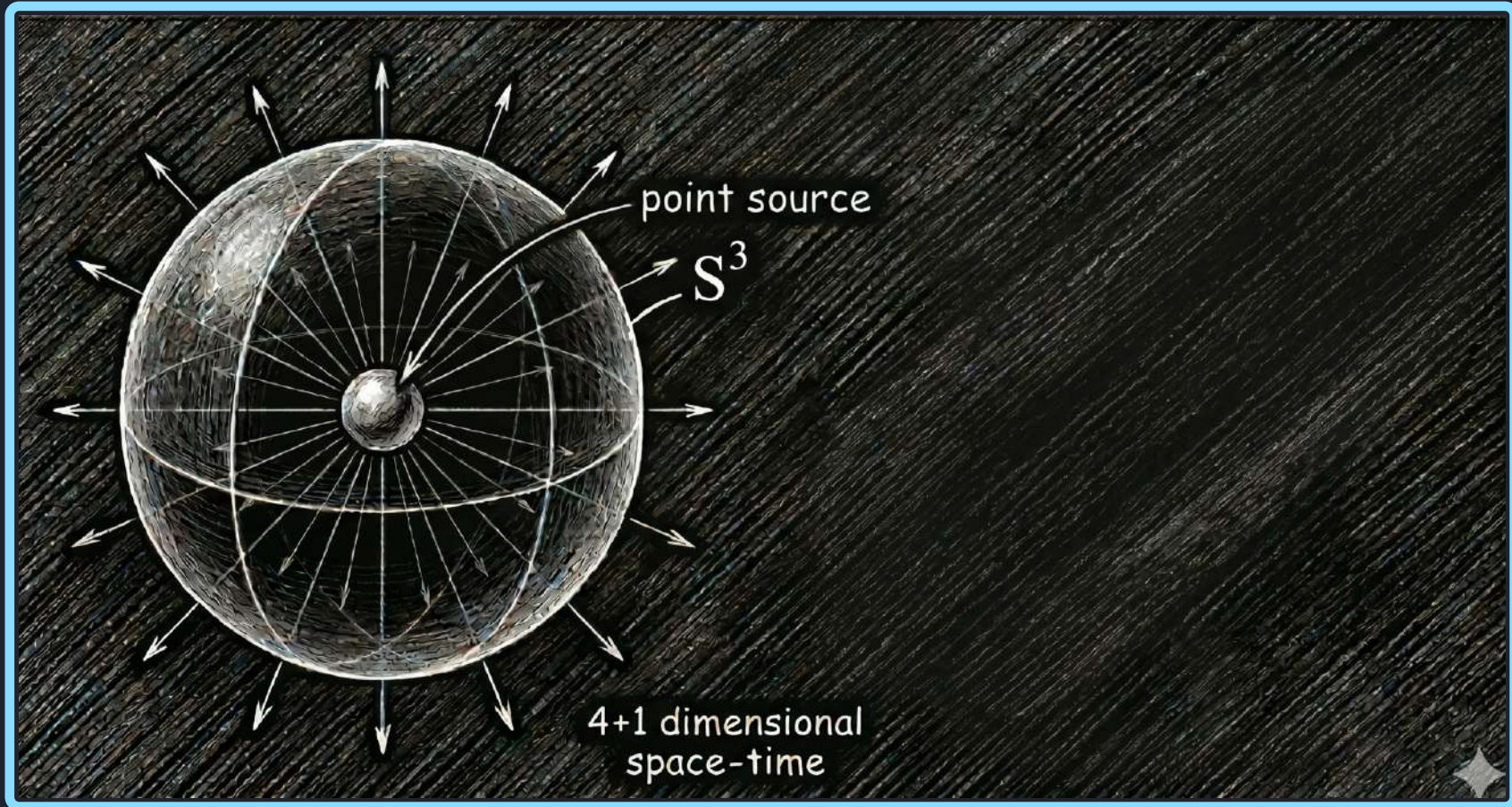
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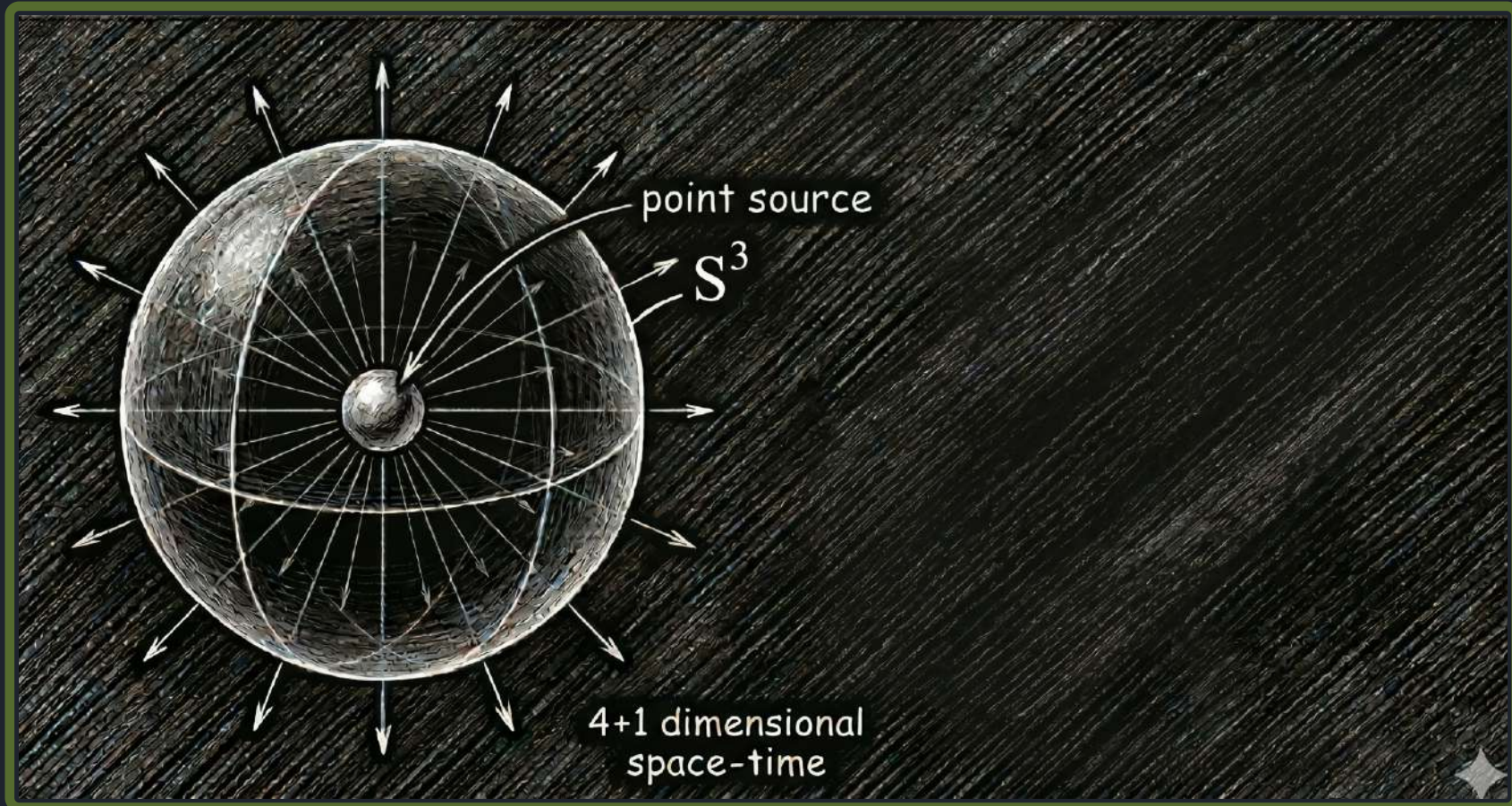
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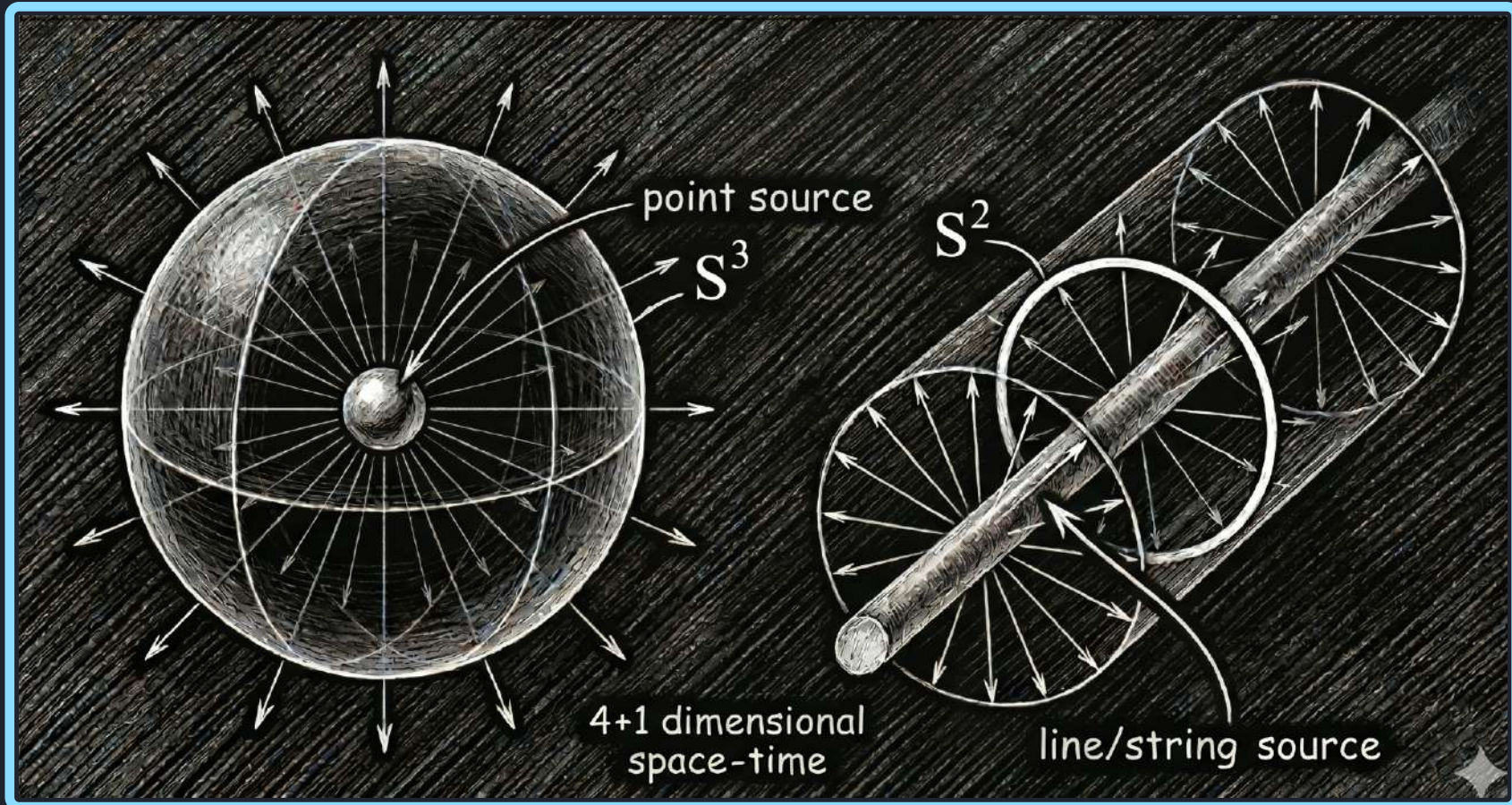
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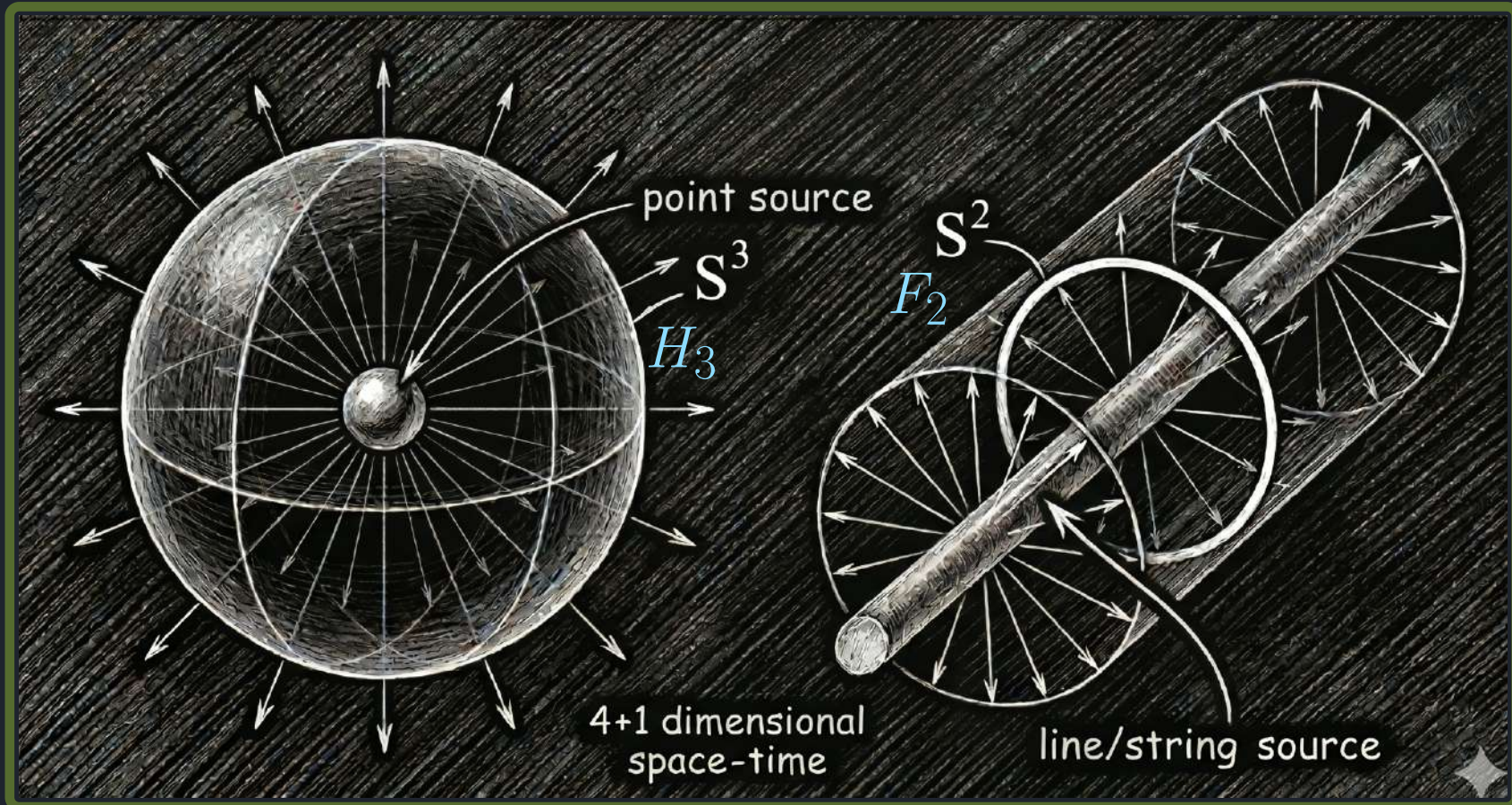
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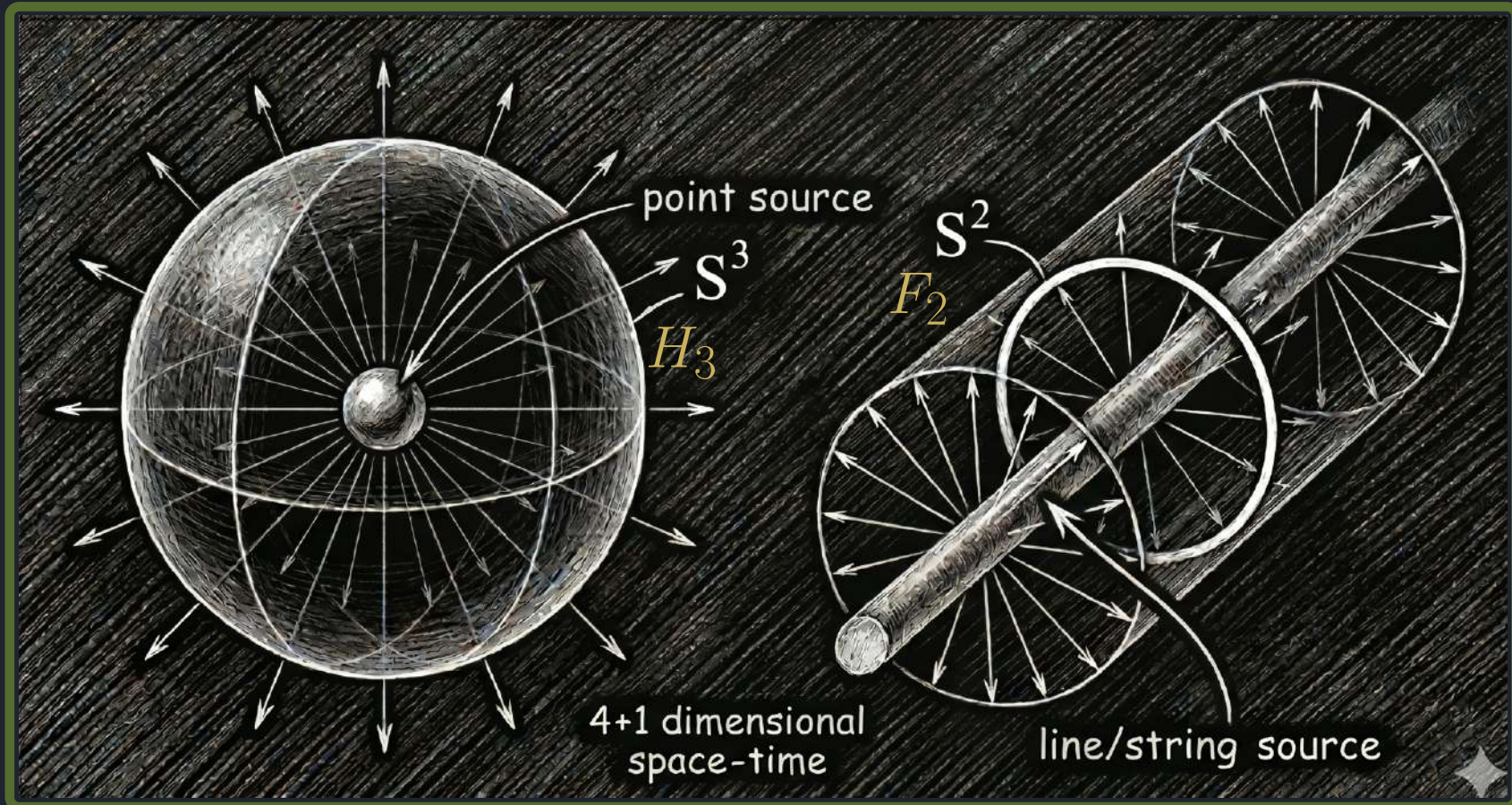


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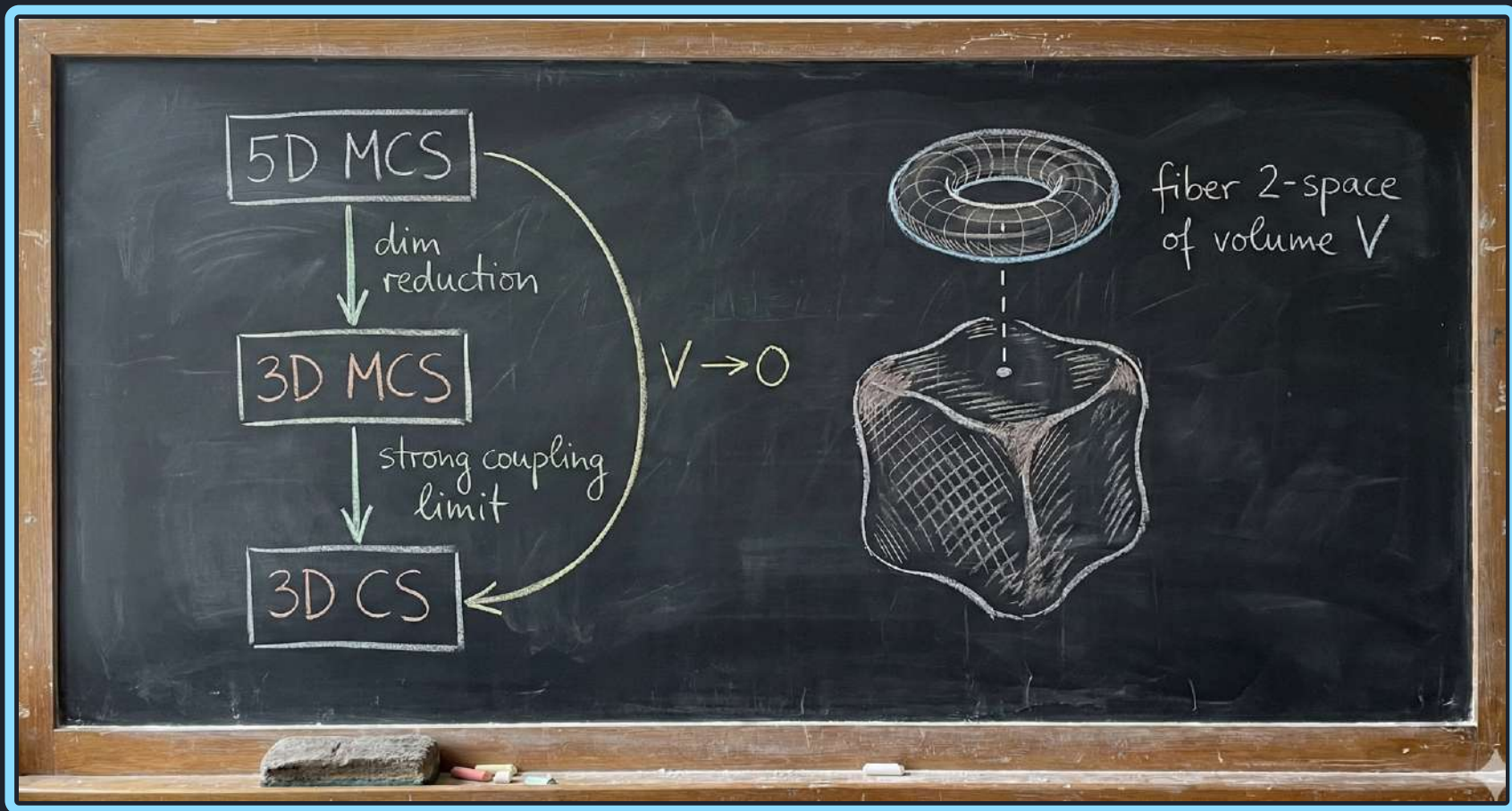
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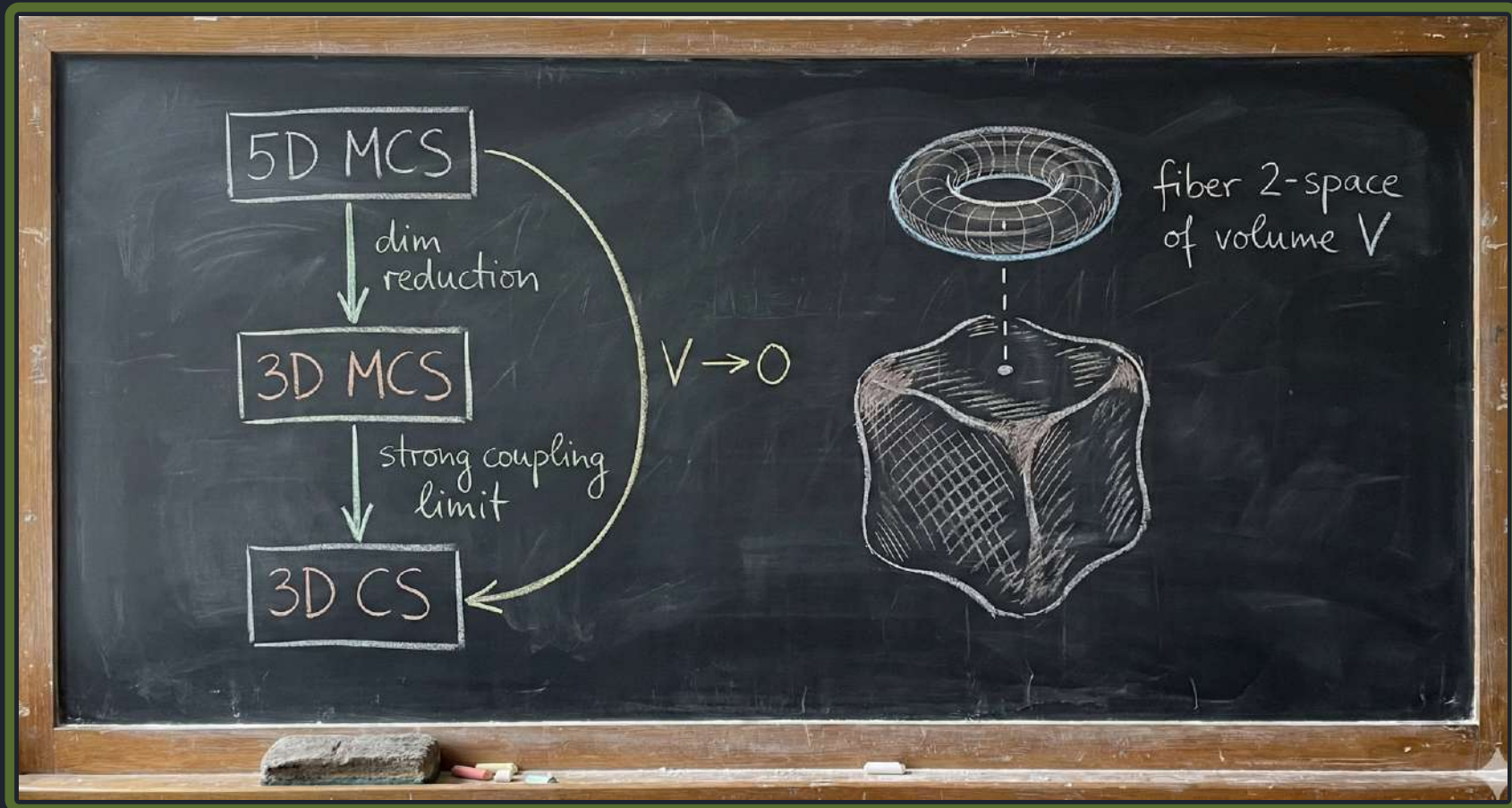
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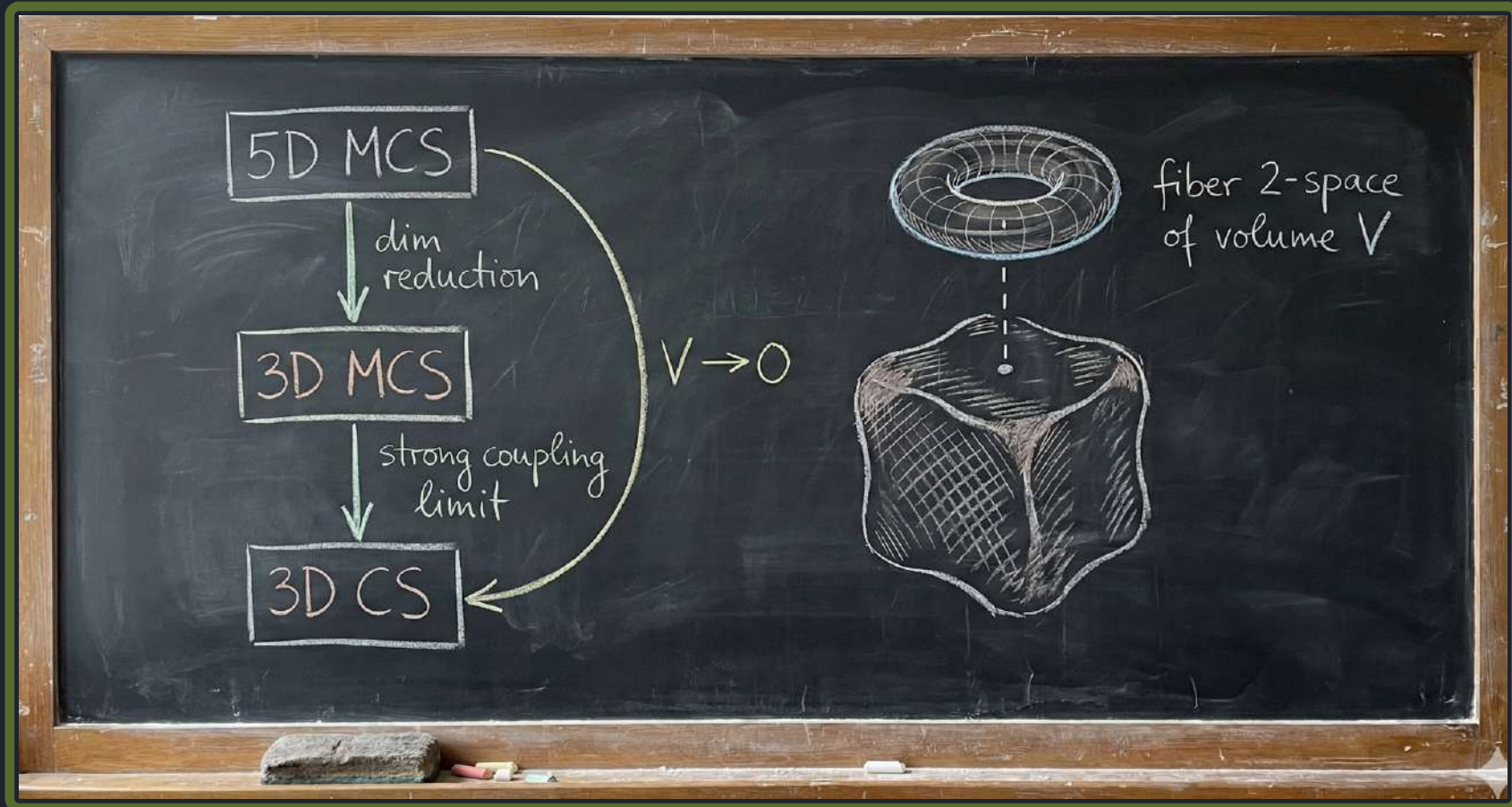
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Example: 11D Supergravity ("M-Theory")

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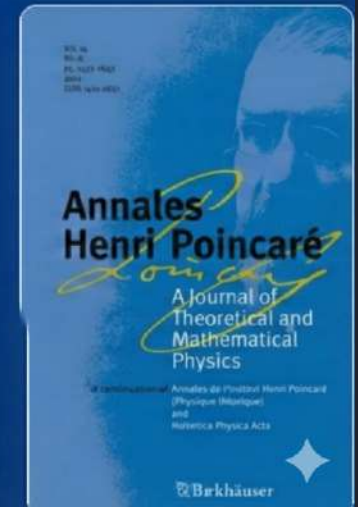
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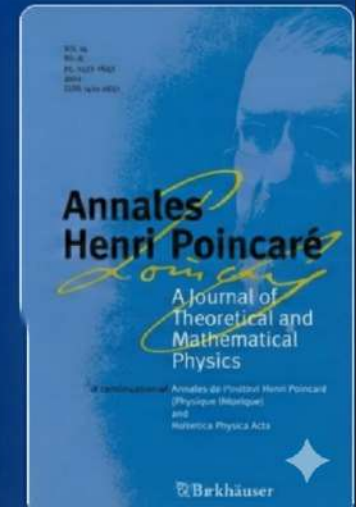
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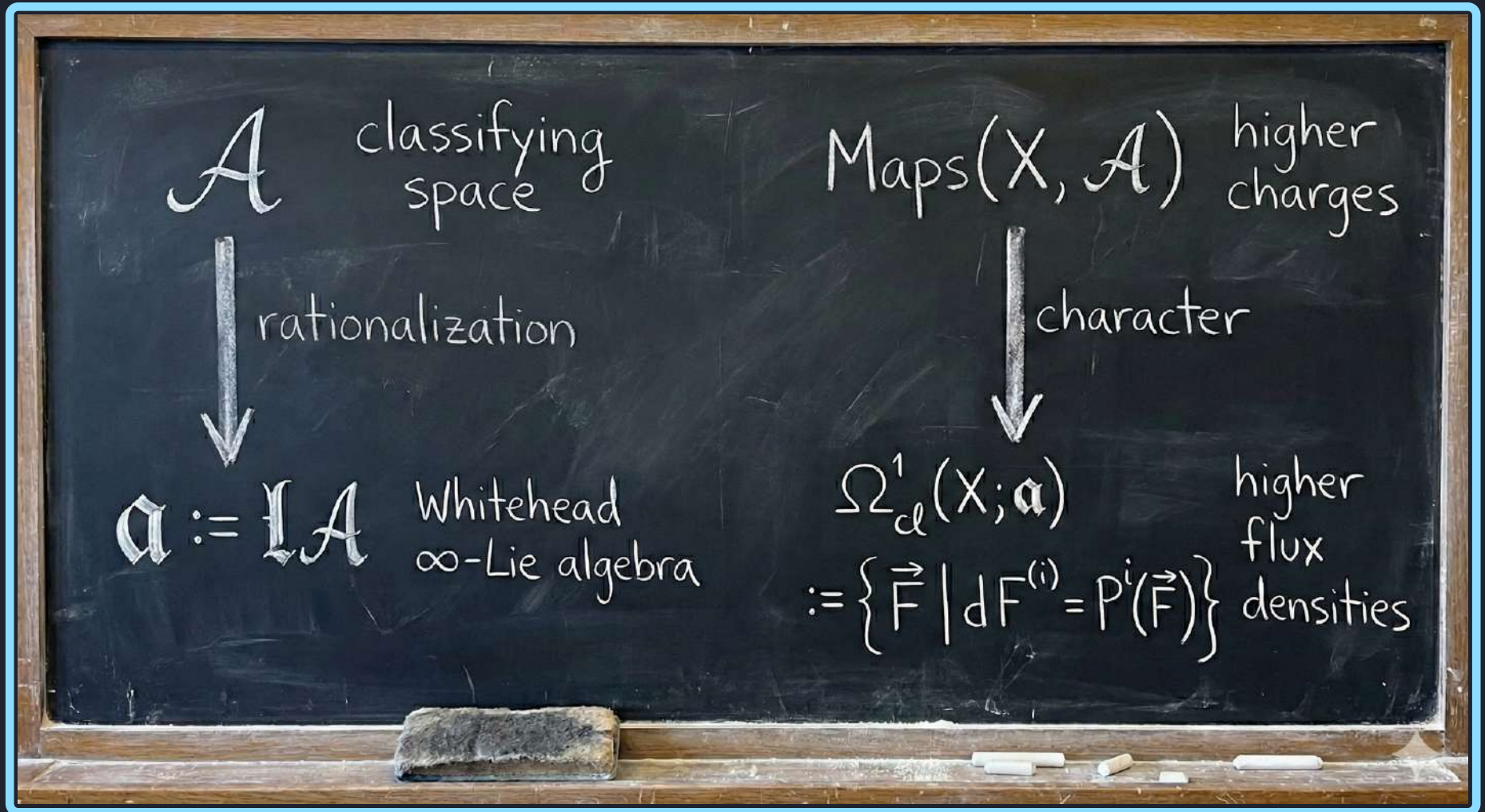


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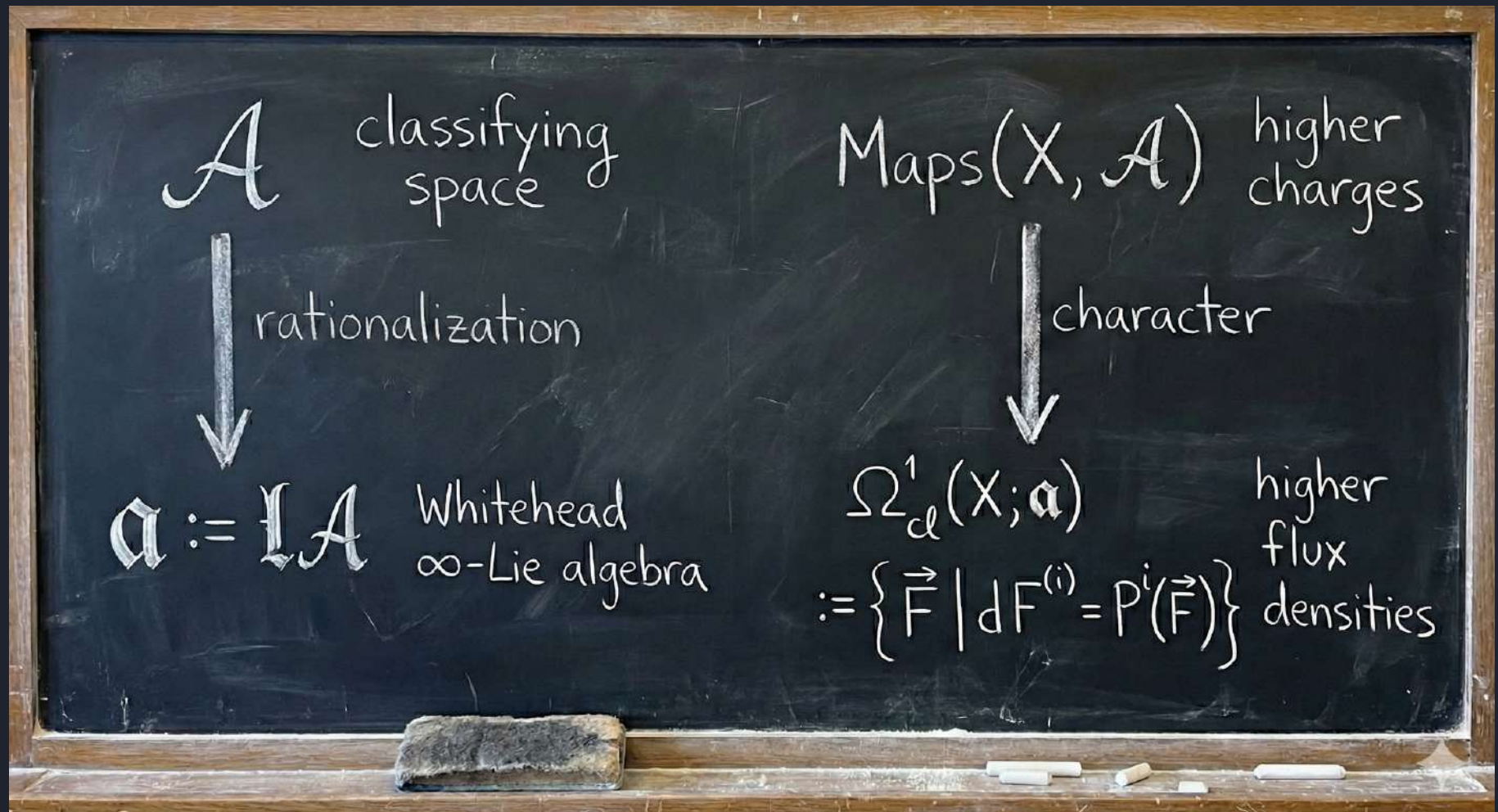
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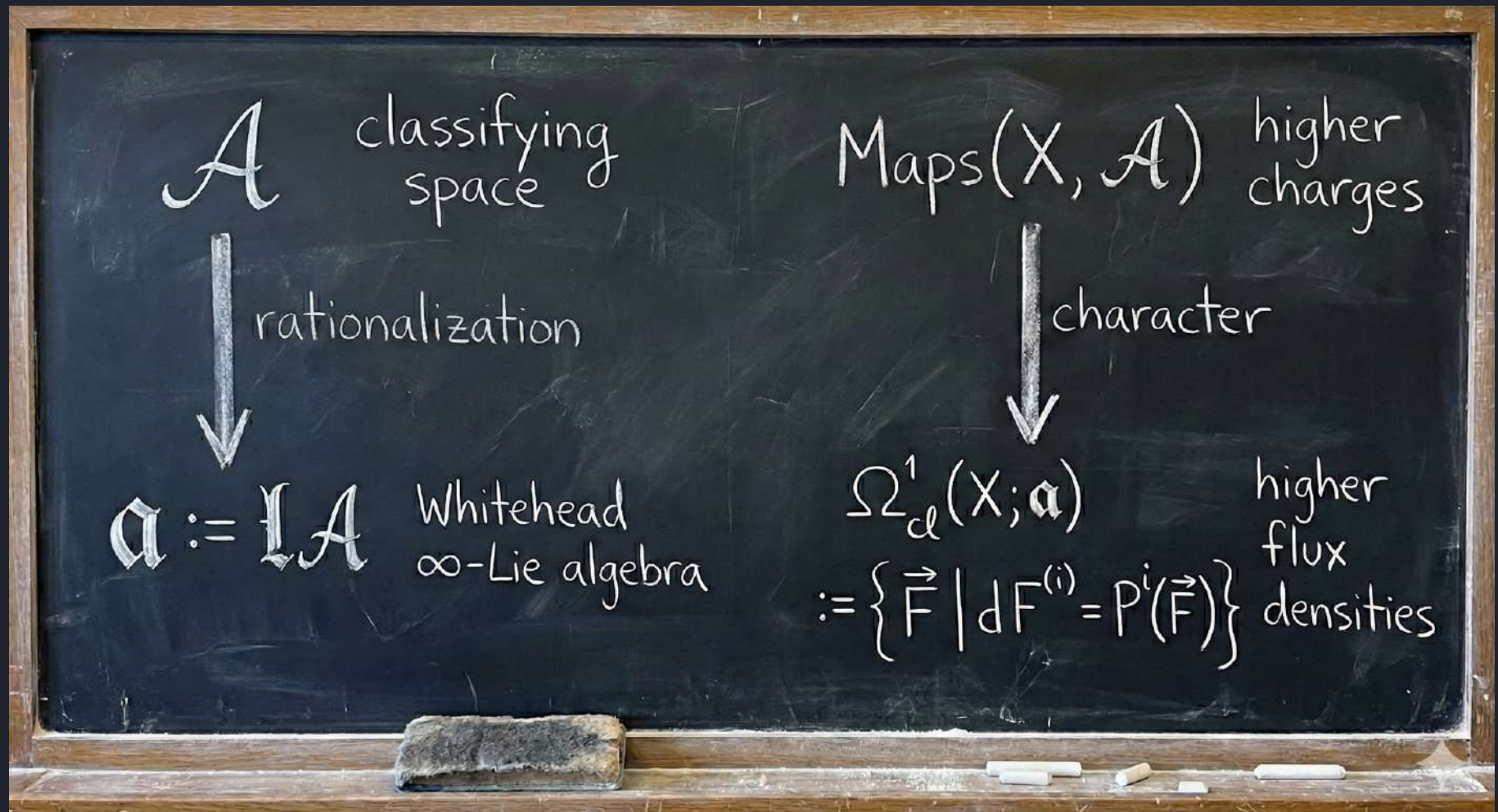


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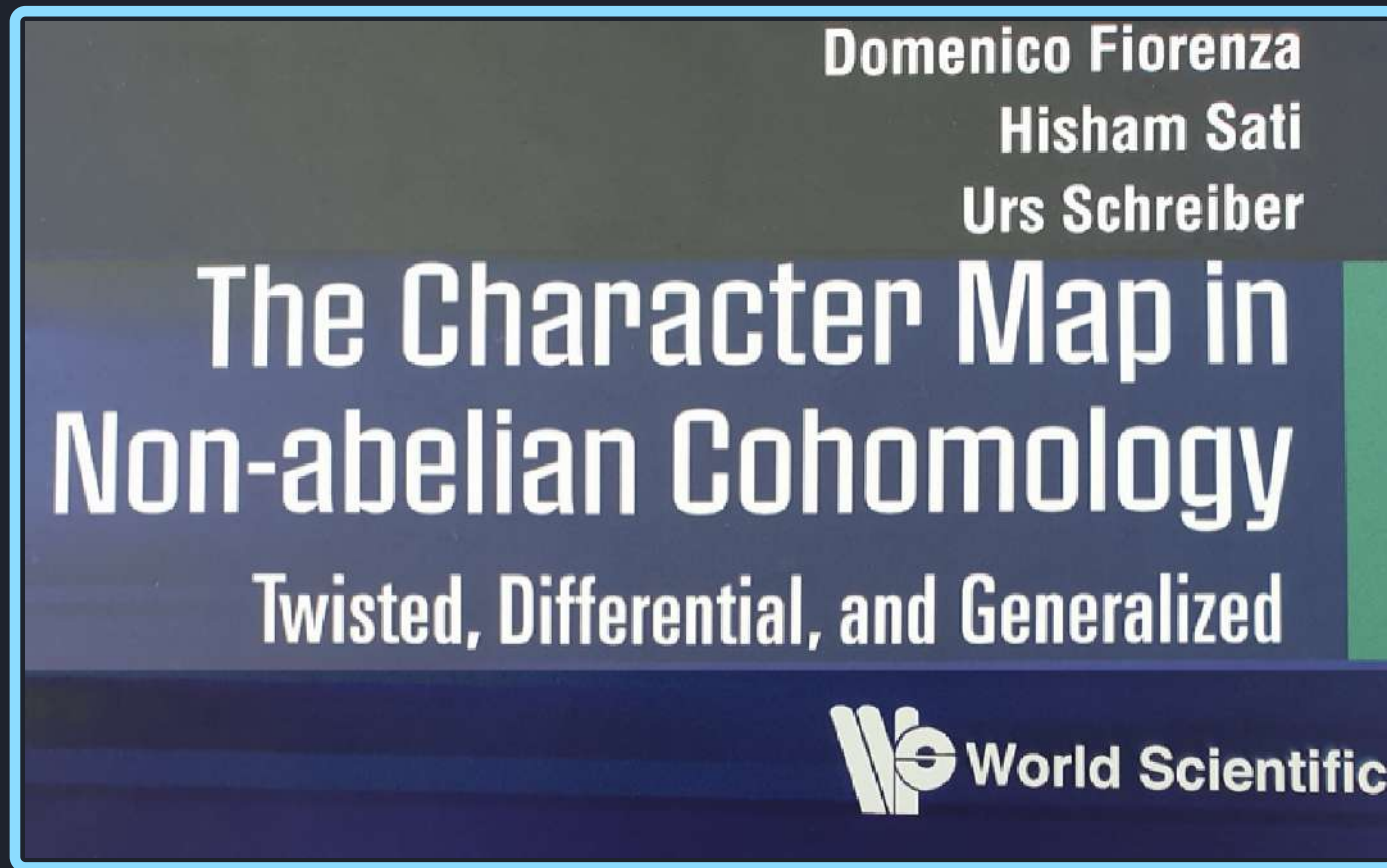
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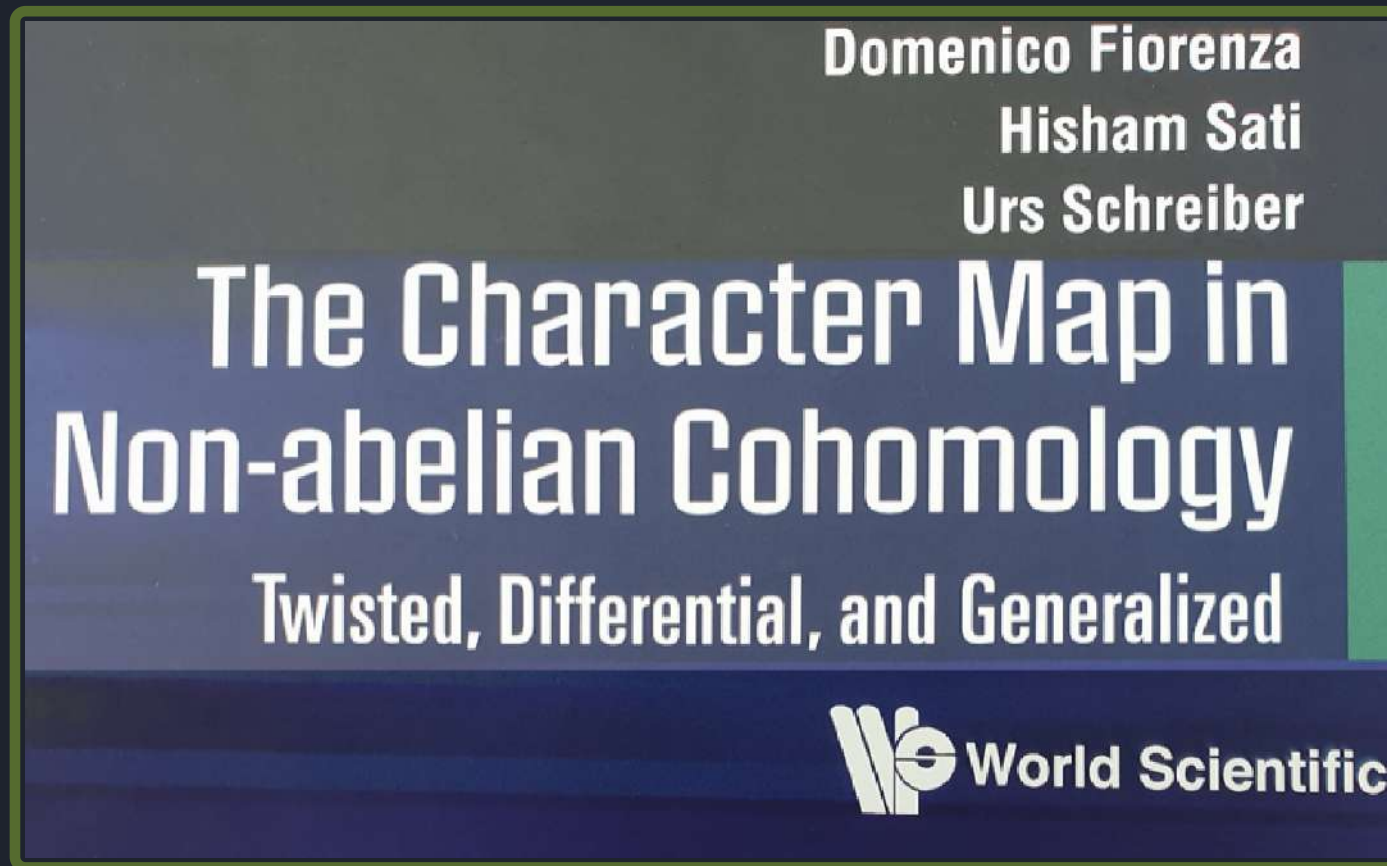
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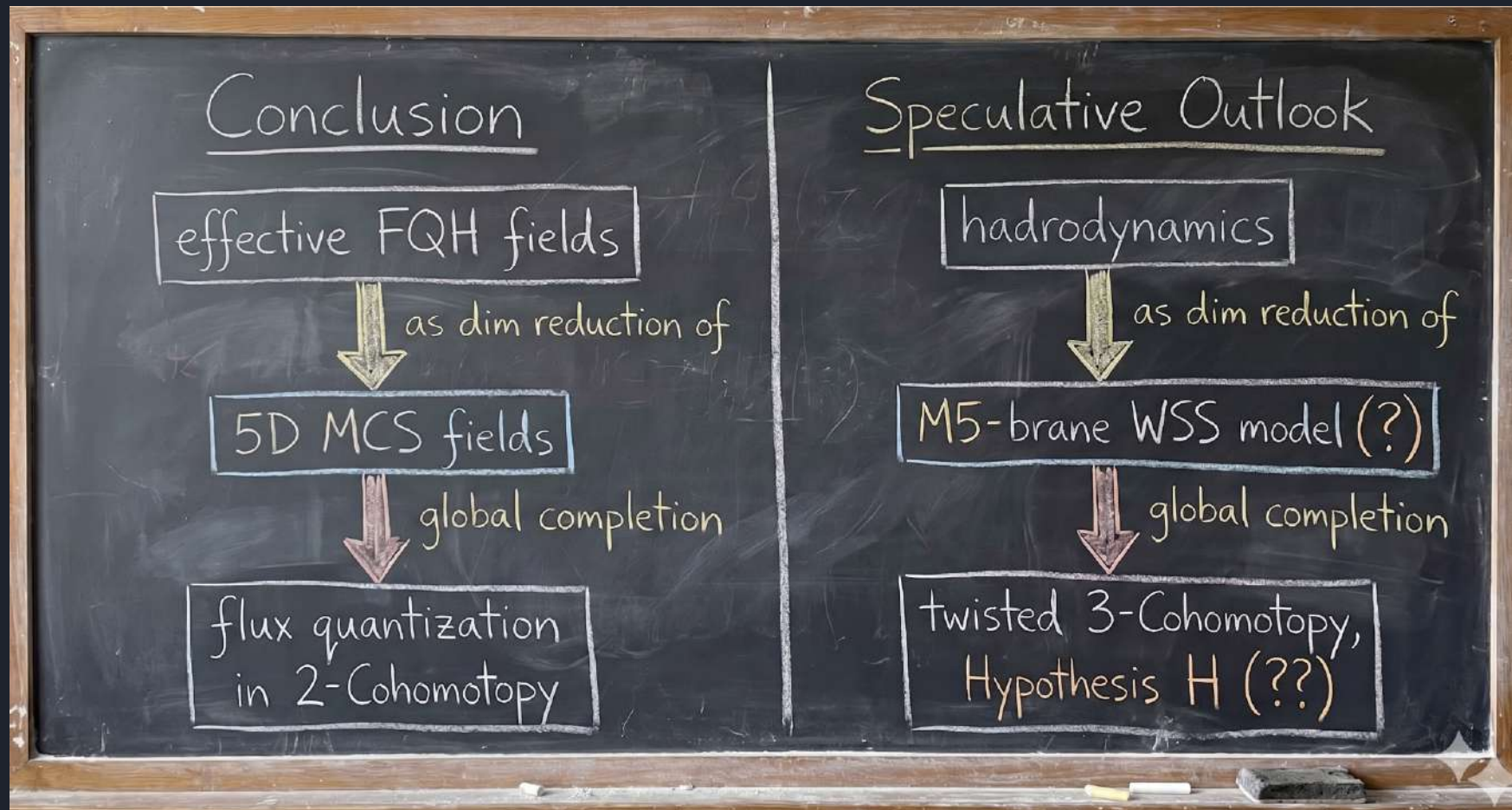
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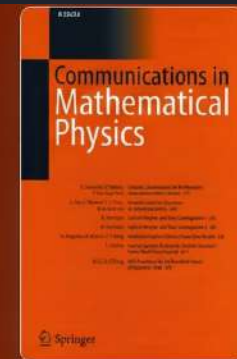


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Twisted Cohomotopy Implies M-Theory Anomaly Cancellation on 8-Manifolds

D. Fiorenza, H. Sati and U. Schreiber

Volume 377, pages 1961–2025, (2020) [Cite this article](#)



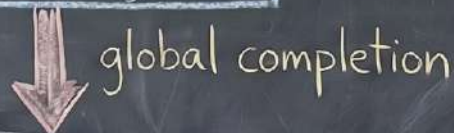
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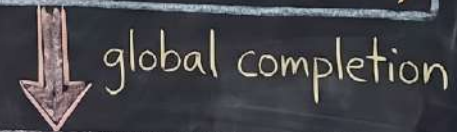
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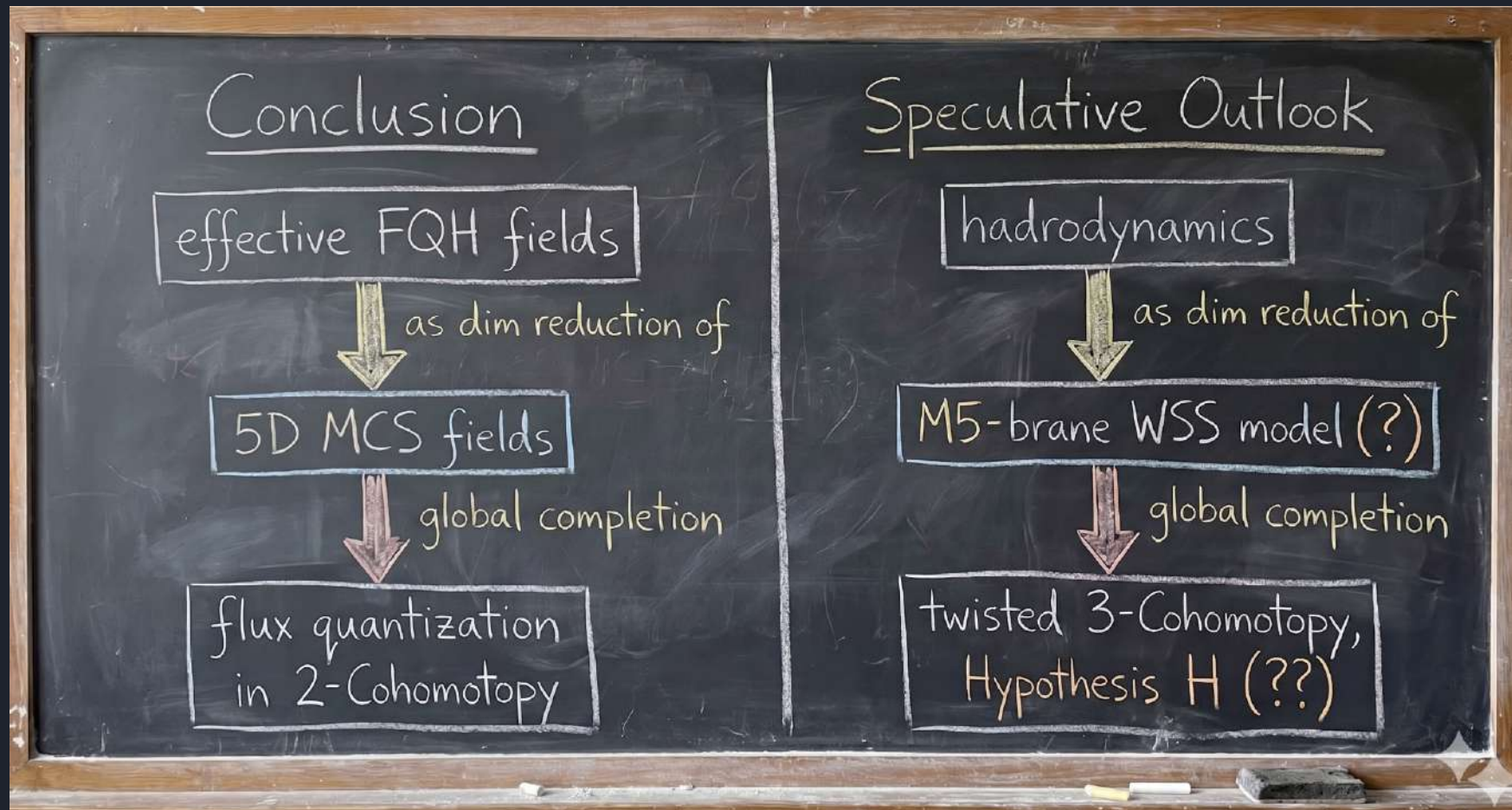


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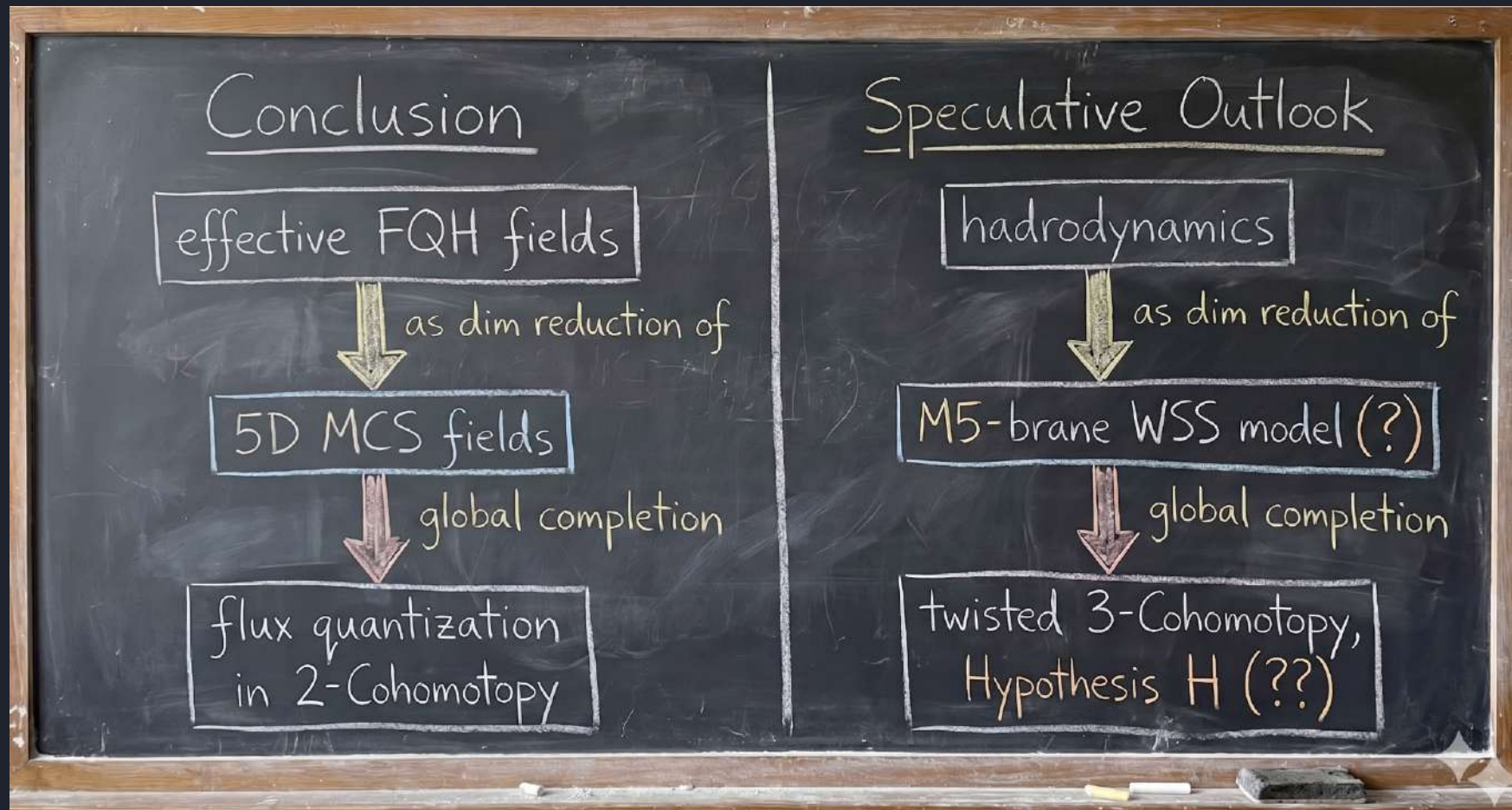
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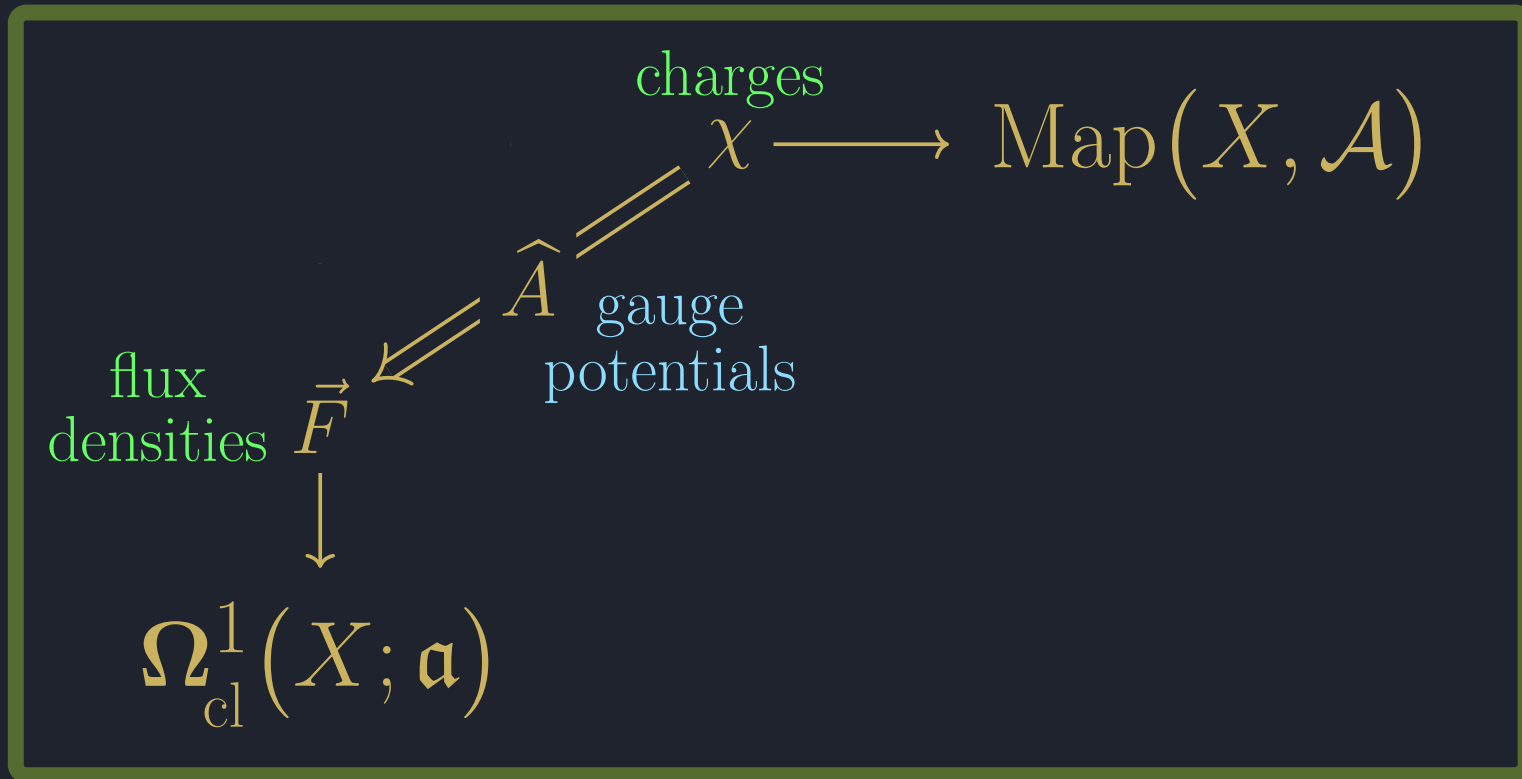
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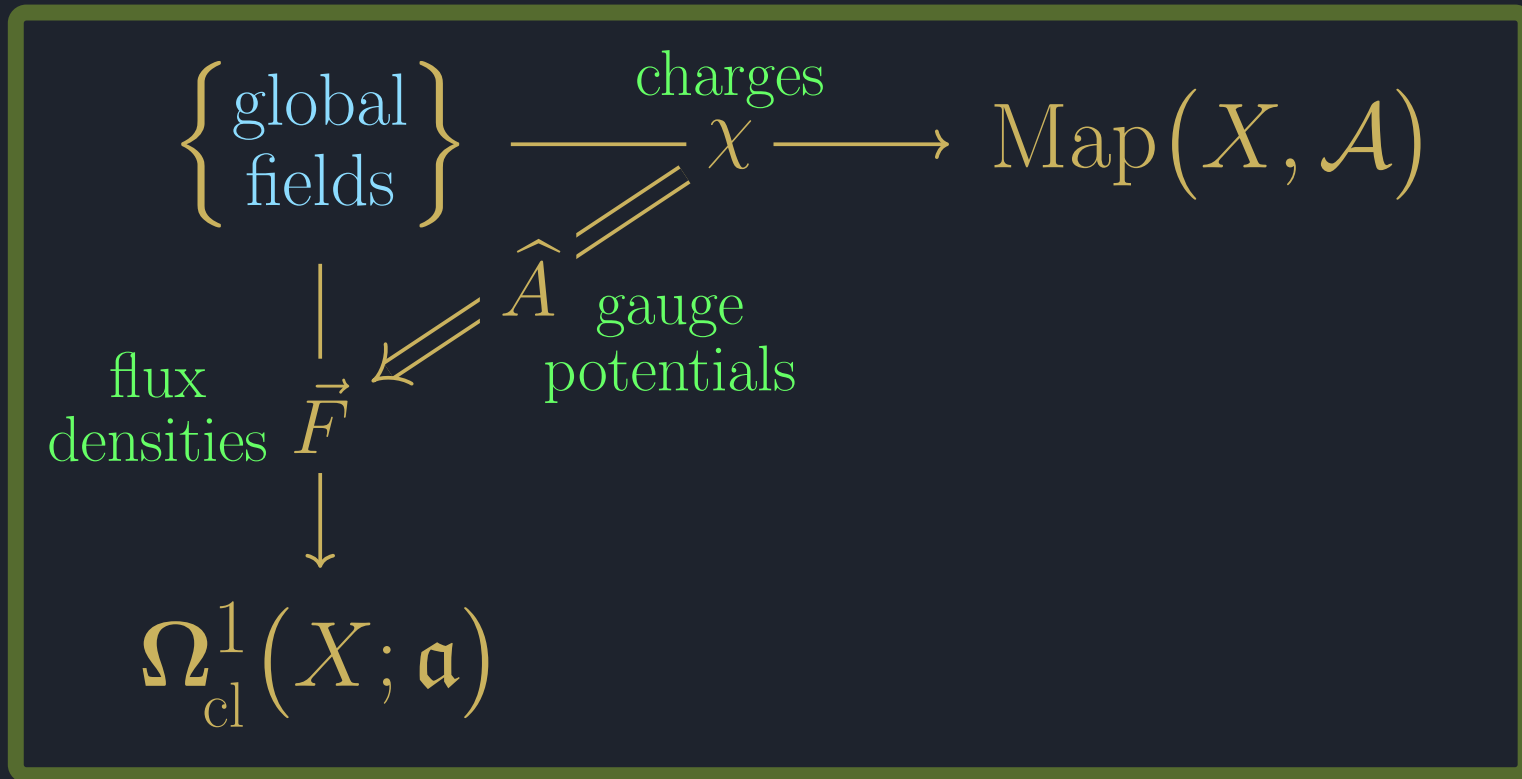
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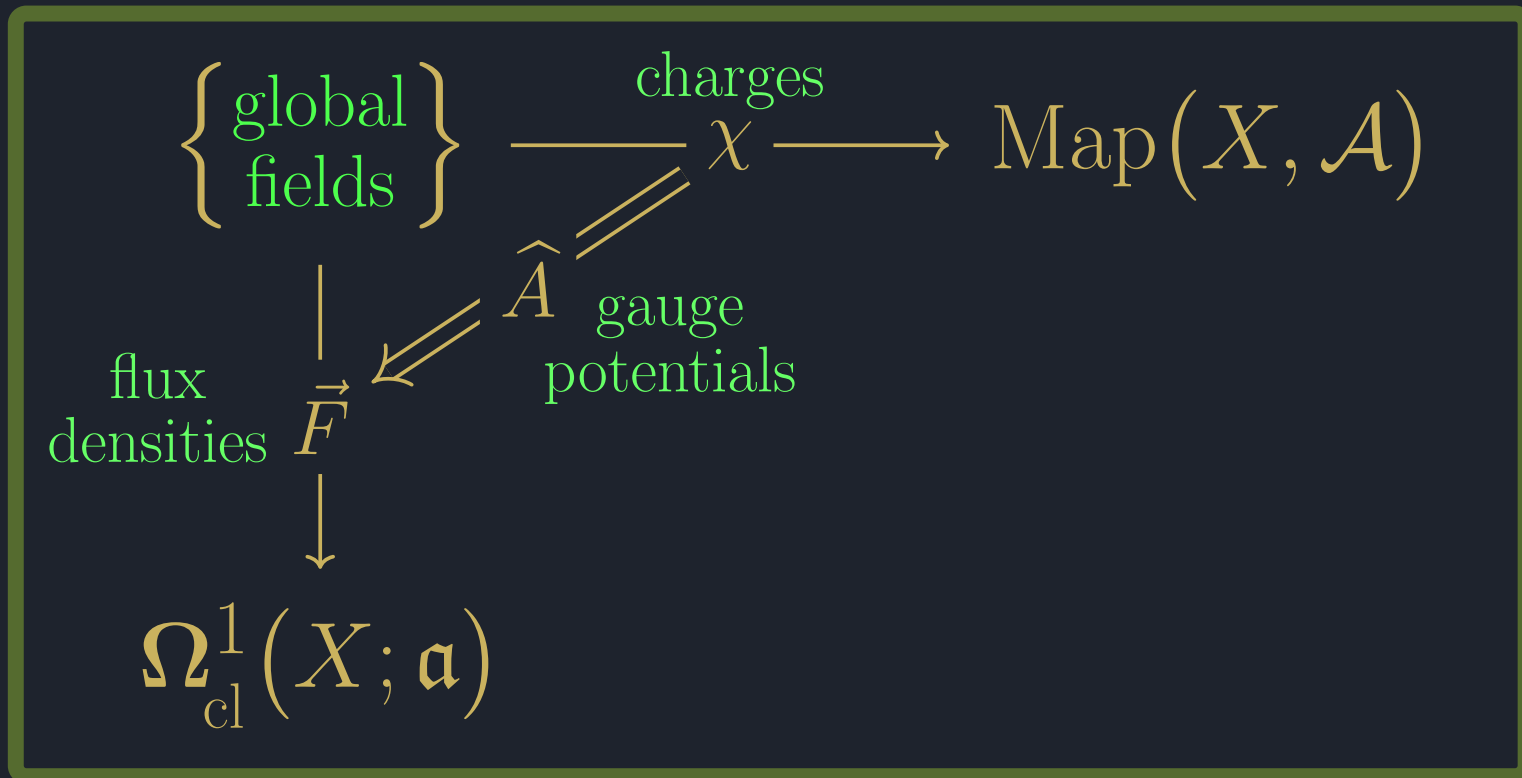
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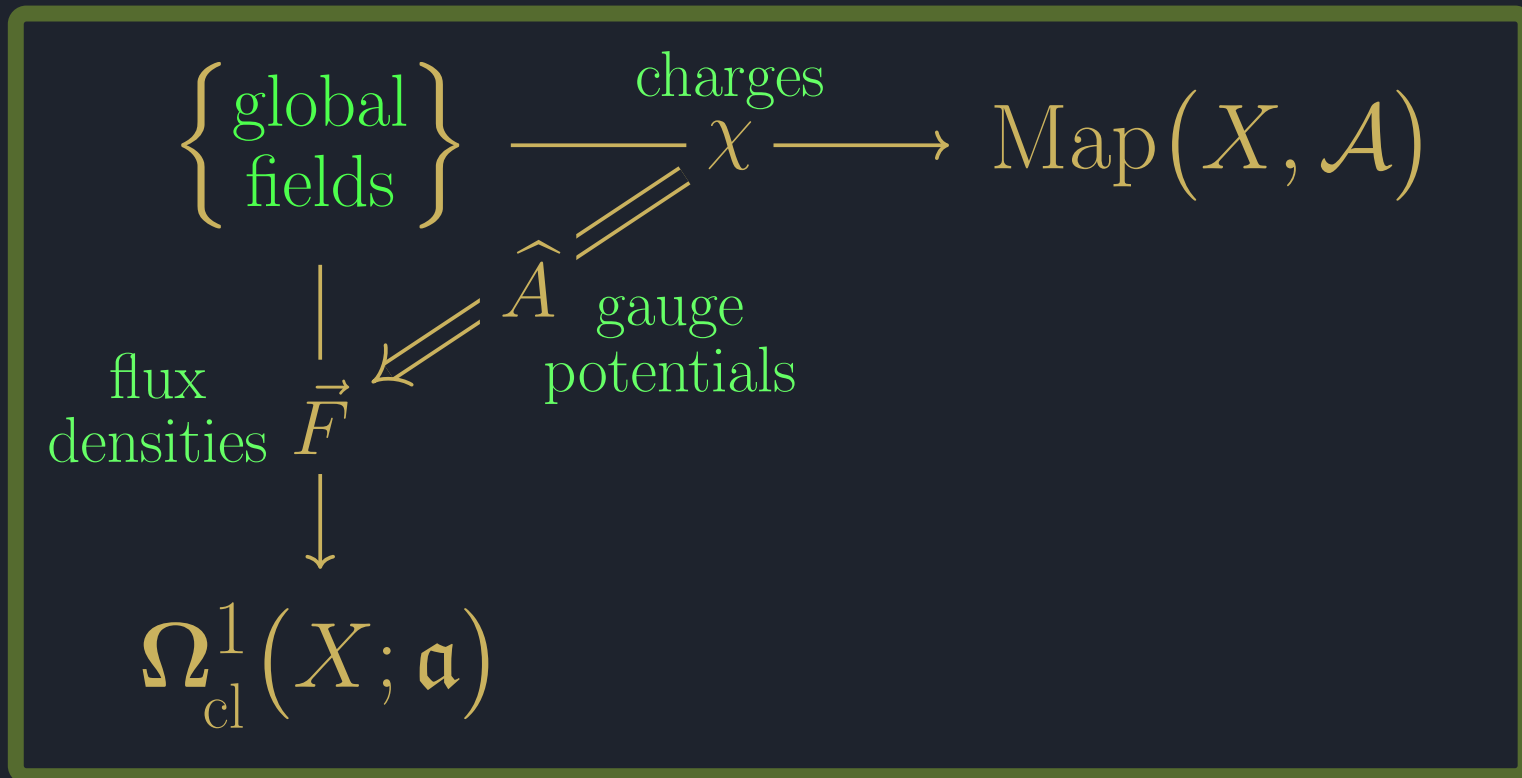


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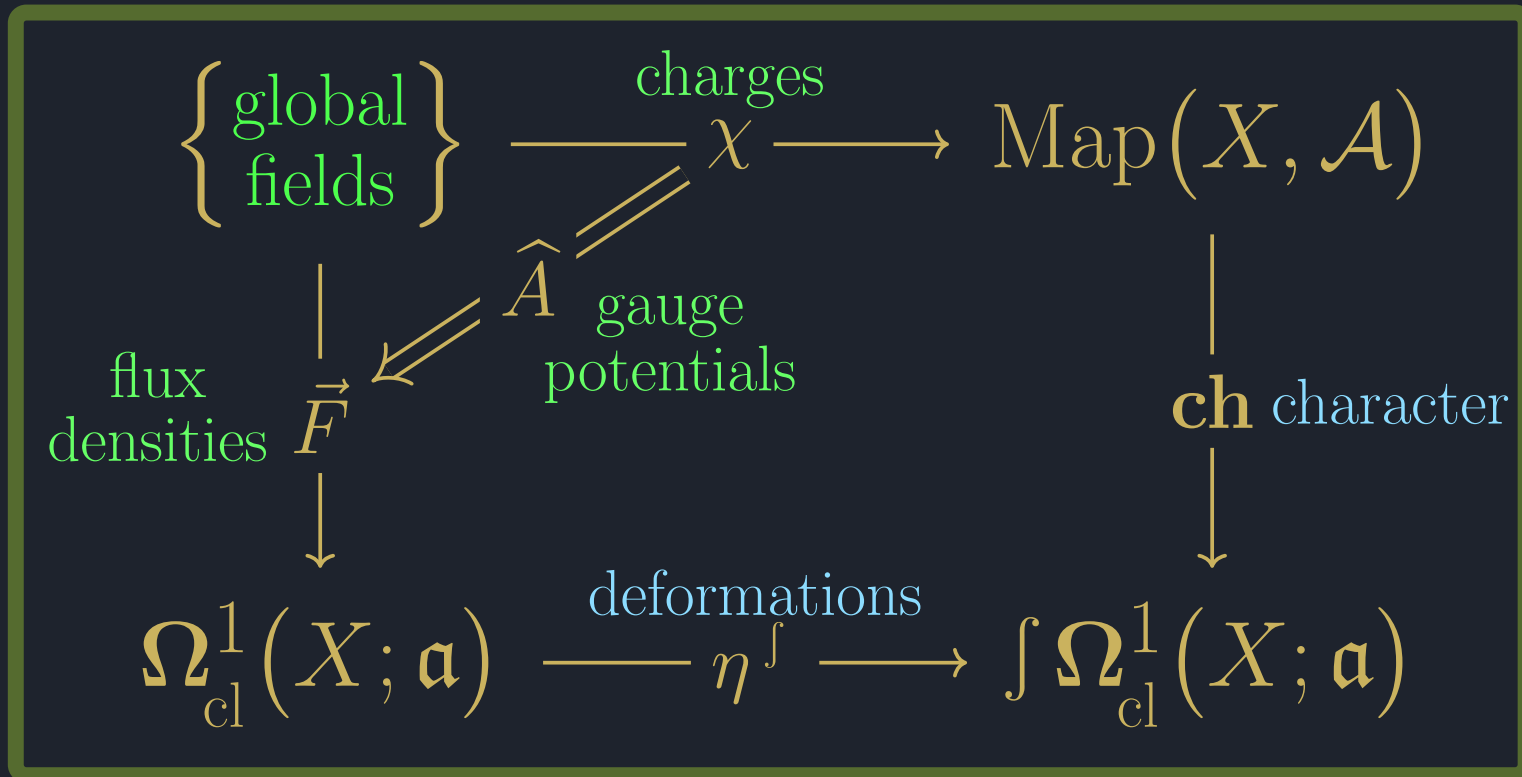


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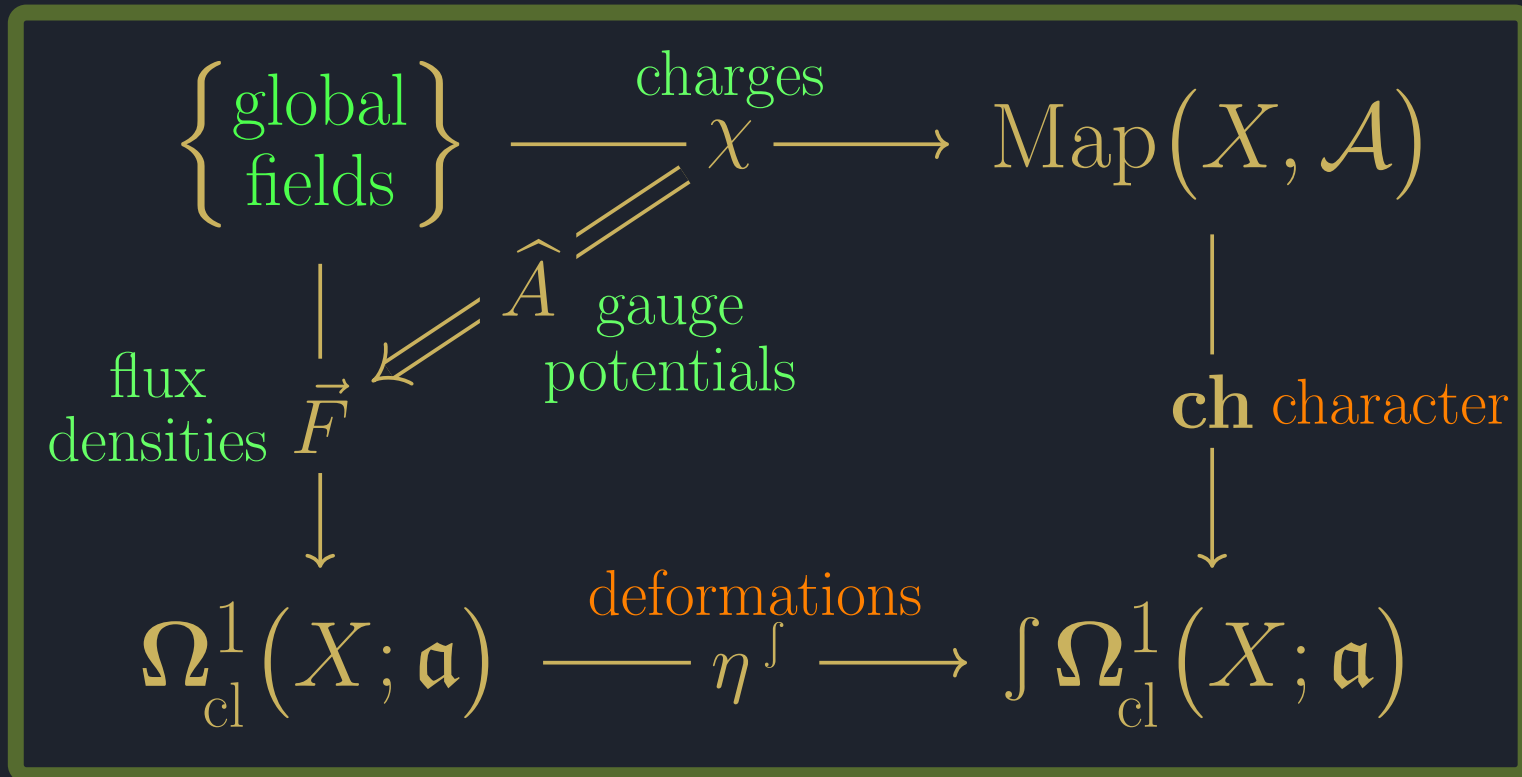


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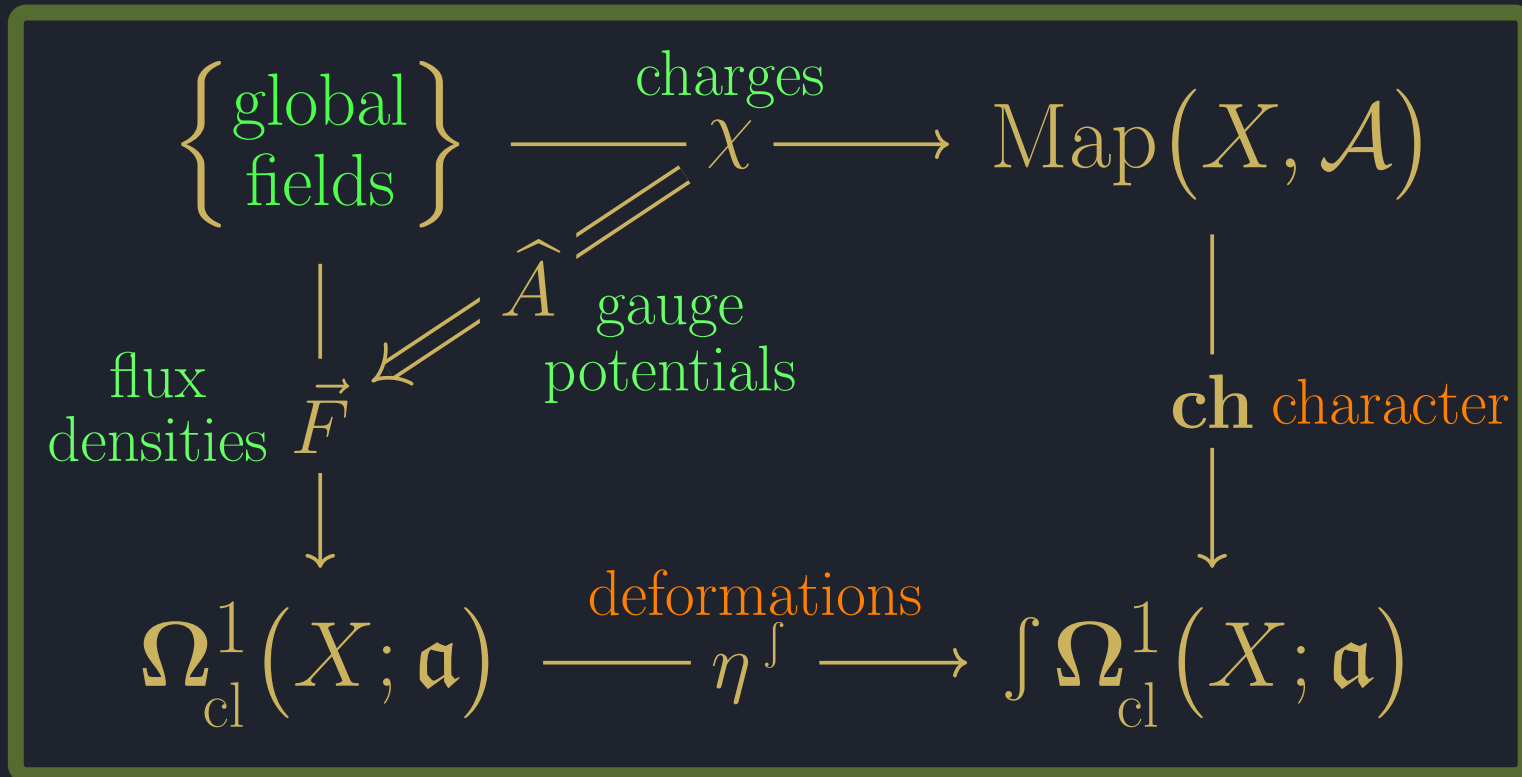


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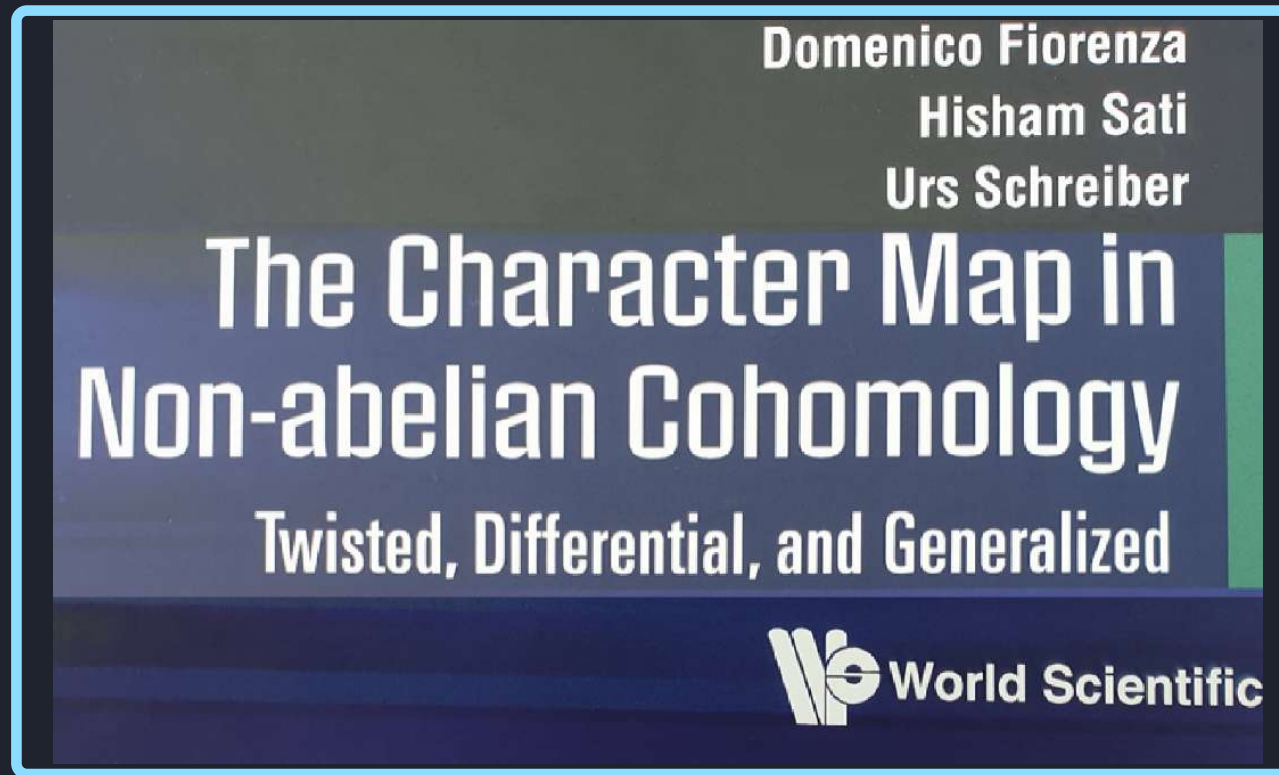


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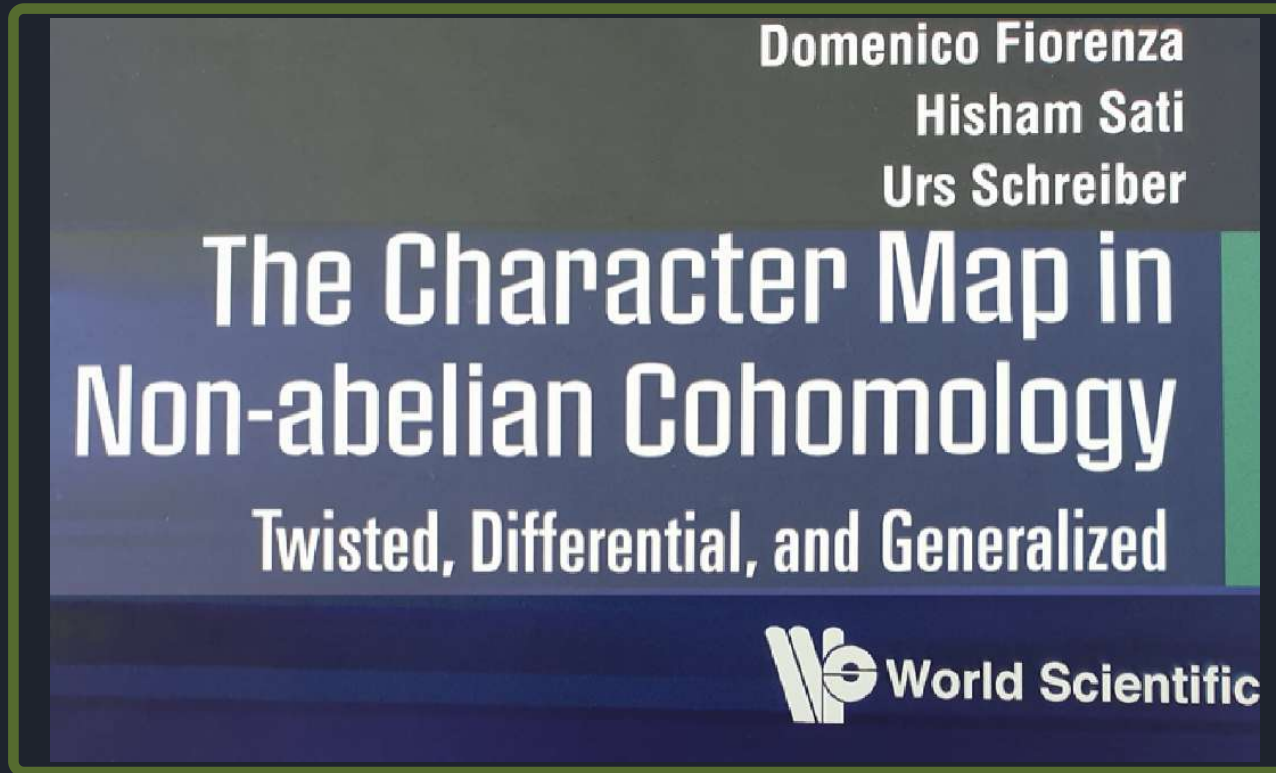


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It is a homotopy pullback in a *higher geometric topos*.

Nonperturbative Phase Spaces

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FLUX
DENSITIES

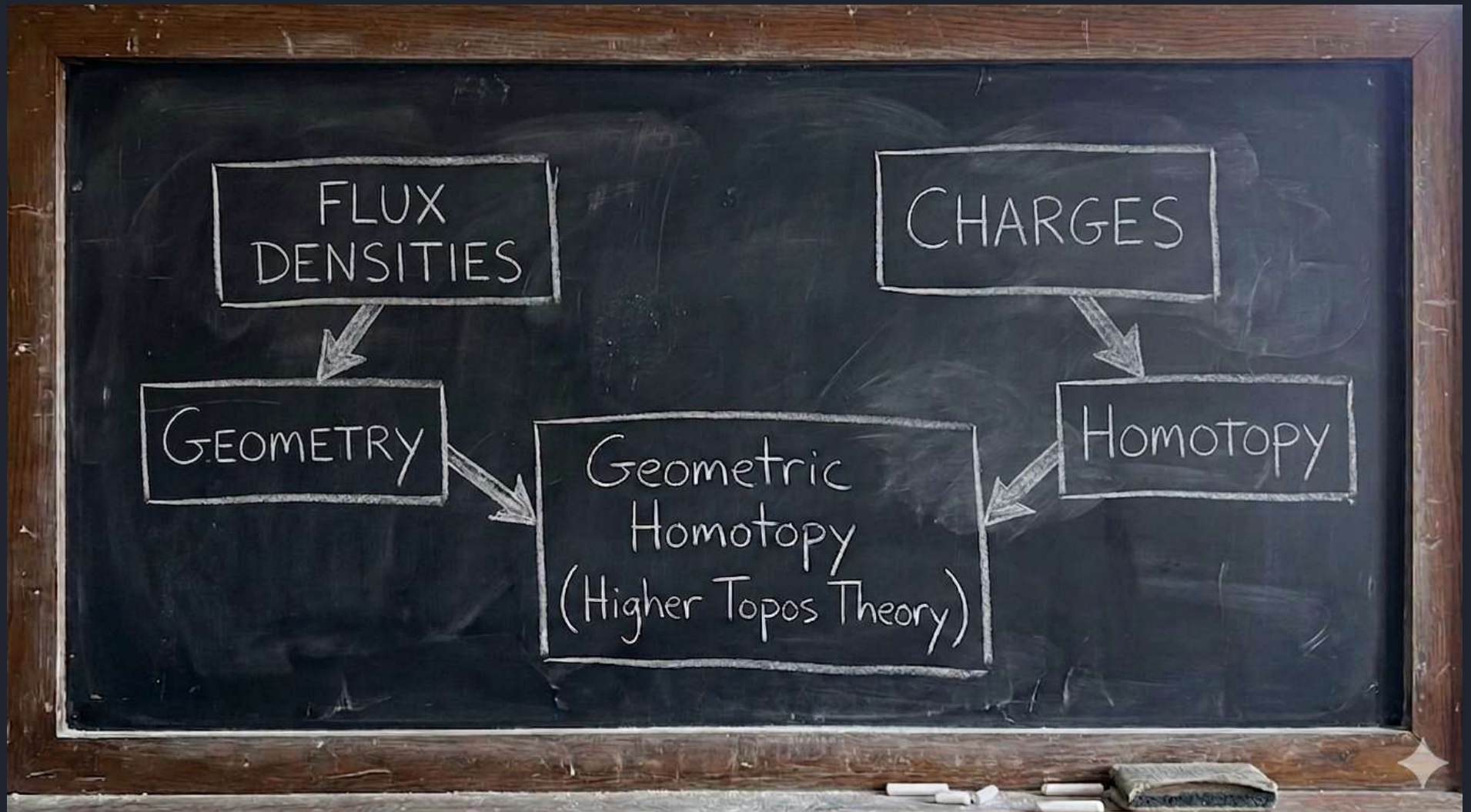
CHARGES

GEOMETRY


Geometric
Homotopy
(Higher Topos Theory)

Homotopy

Thus to formulate nonperturbative physics in higher topoi



Thus to formulate nonperturbative physics in higher topoi

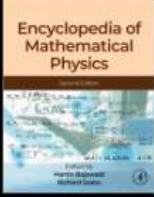


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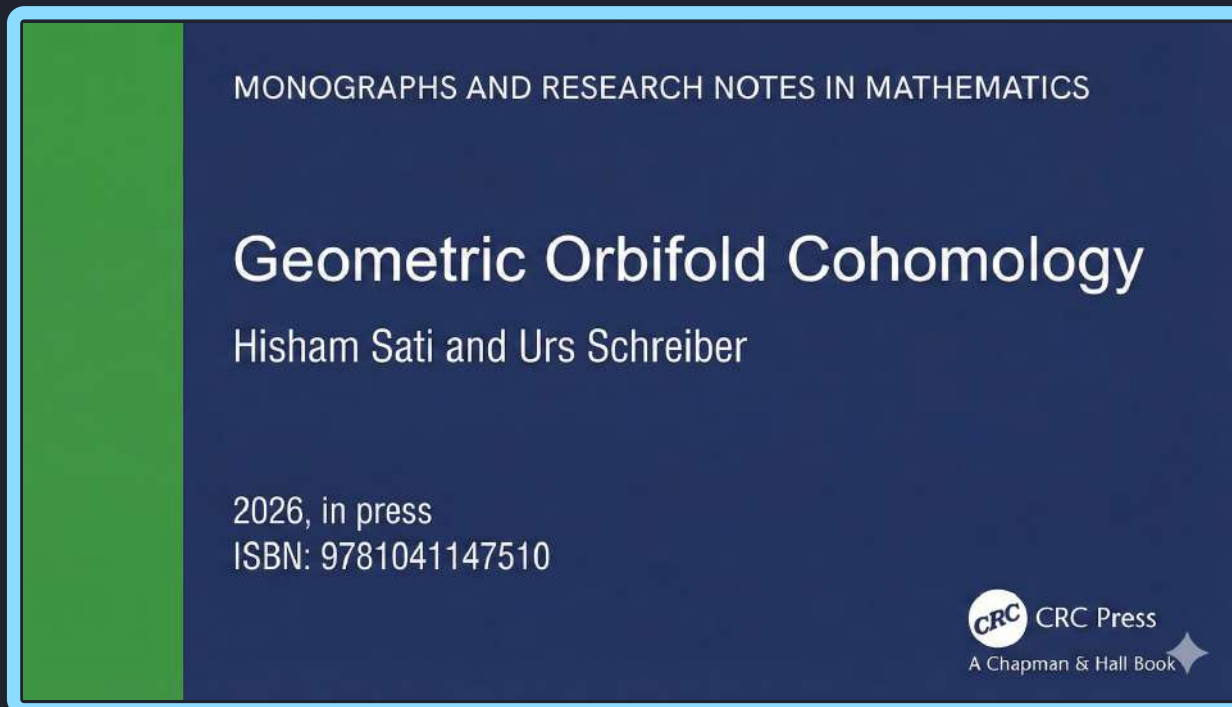
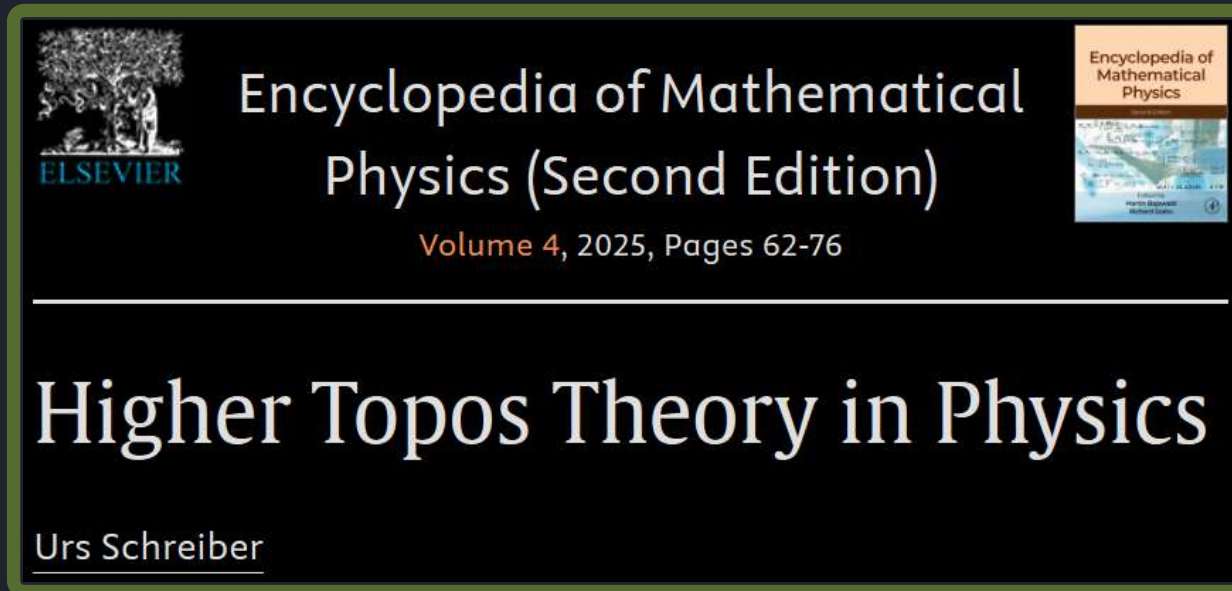
Volume 4, 2025, Pages 62-76

Higher Topos Theory in Physics

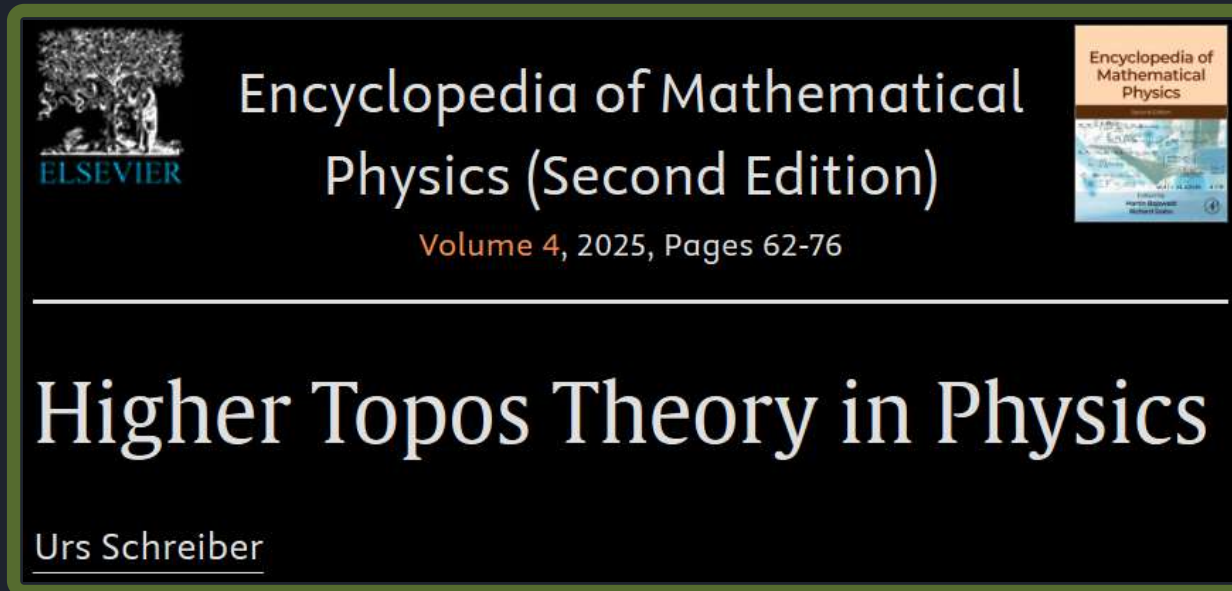
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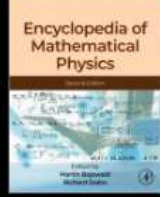


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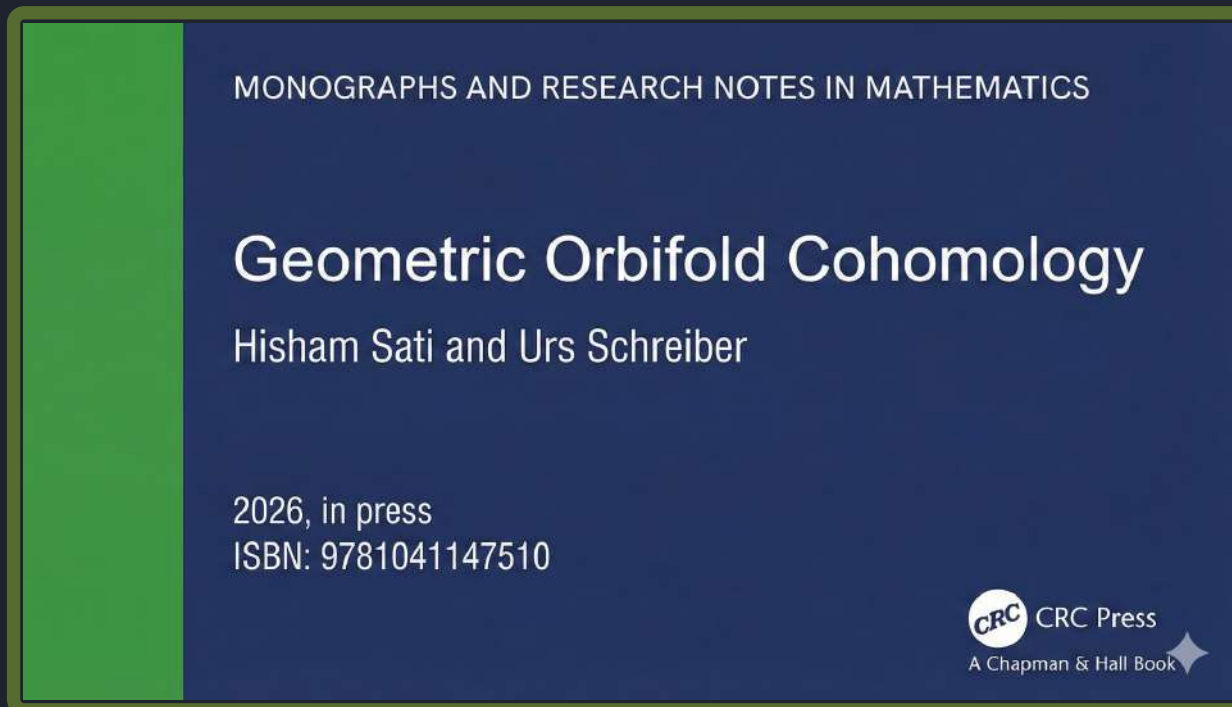
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Higher Topos Theory in Physics

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MONOGRAPHS AND RESEARCH NOTES IN MATHEMATICS

Geometric Orbifold Cohomology

Hisham Sati and Urs Schreiber

2026, in press
ISBN: 9781041147510

 CRC Press
A Chapman & Hall Book

Towards a programming language for topological physics

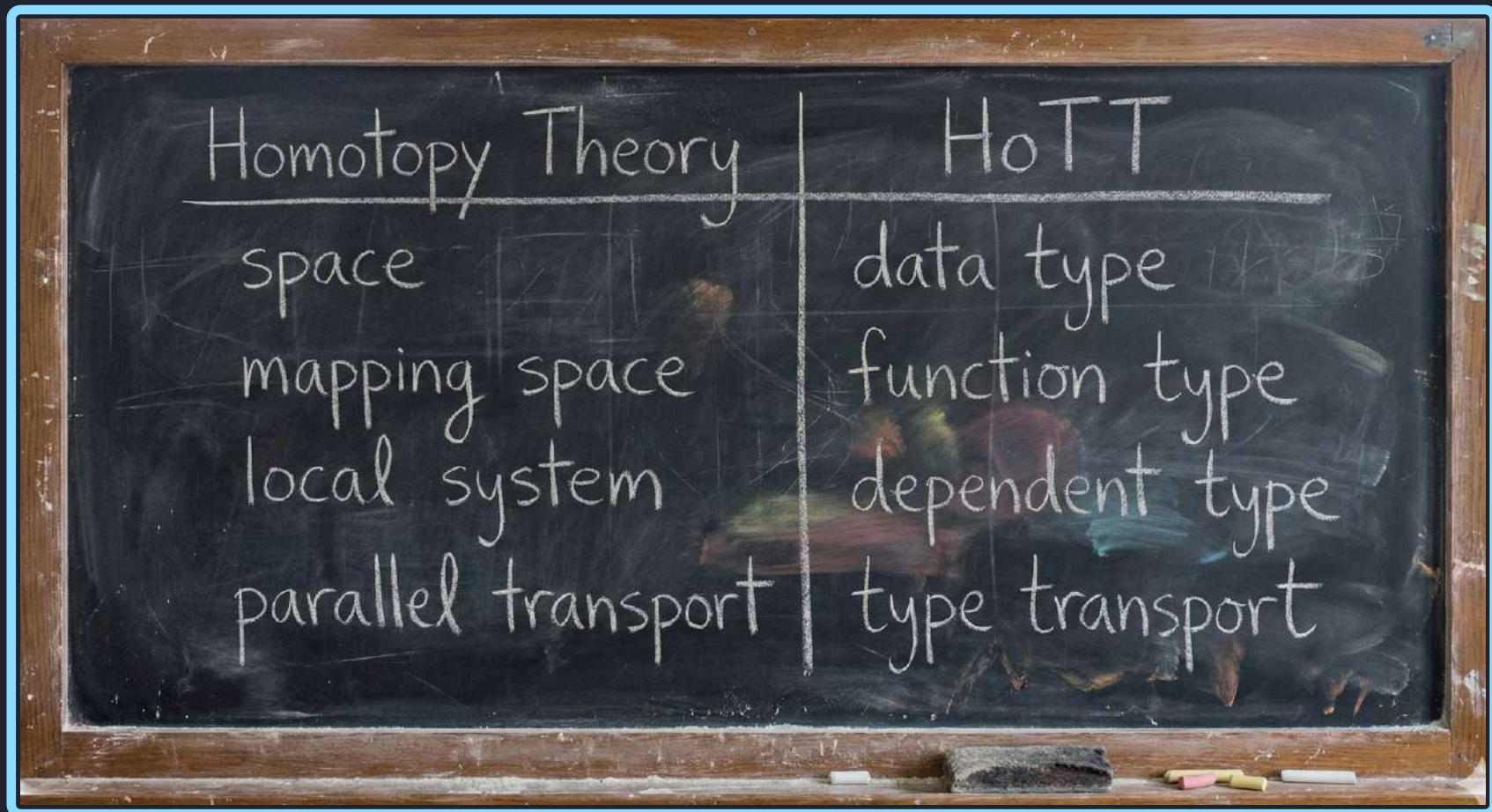
Even though higher topoi have a reputation of being involved
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Towards a programming language for topological physics

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indeed, the abstract language of higher topoi is so neat
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Towards a programming language for topological physics

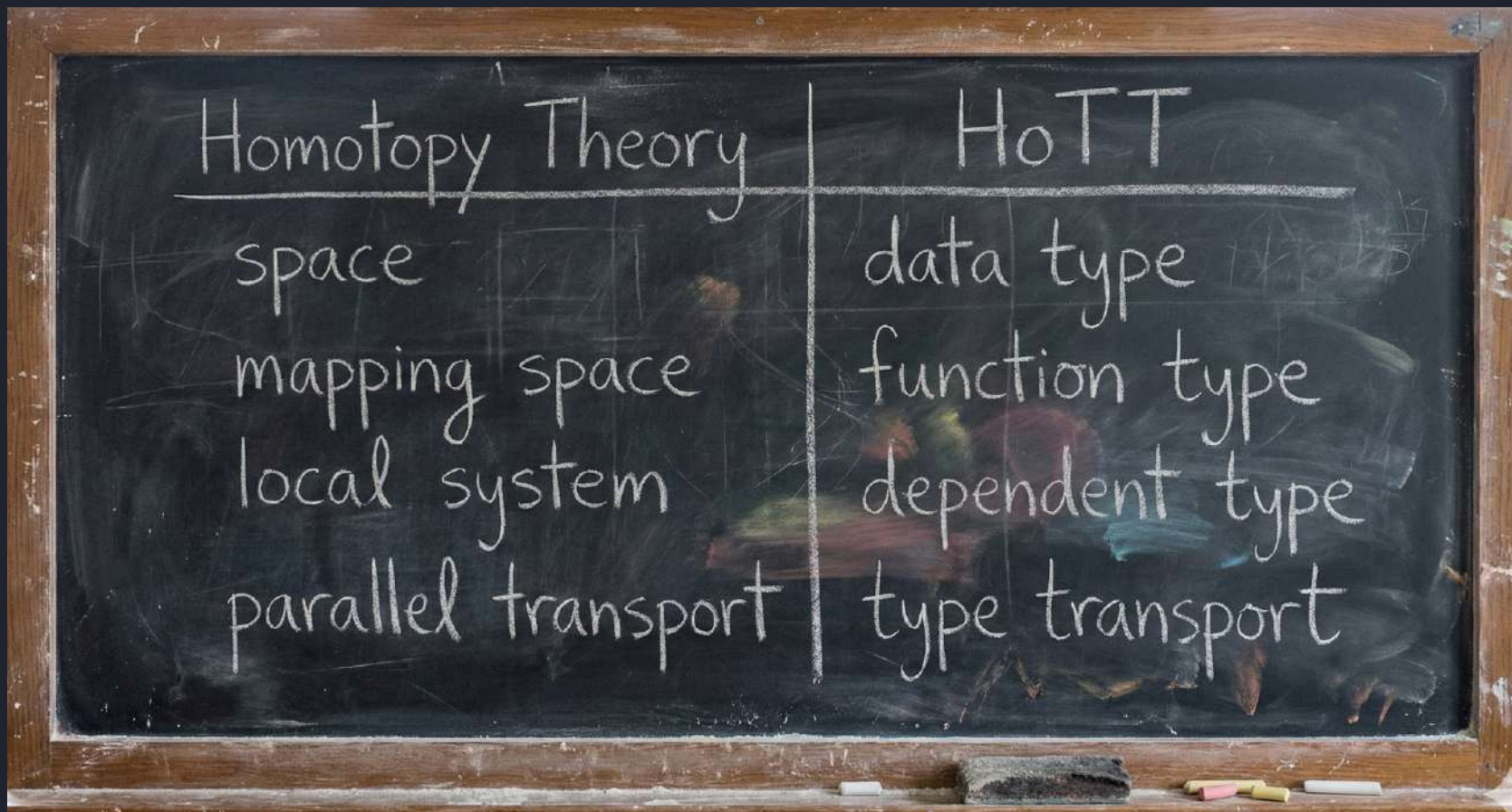
Even though higher topoi have a reputation of being involved this is really a property of their set-theoretic models indeed, the abstract language of higher topoi is so neat that it even exists as a programming language: **HoTT**



Homotopy Theory	HoTT
space	data type
mapping space	function type
local system	dependent type
parallel transport	type transport

Towards a programming language for topological physics

Even though higher topoi have a reputation of being involved this is really a property of their set-theoretic models indeed, the abstract language of higher topoi is so neat that it even exists as a programming language: **HoTT**



A chalkboard with a wooden frame, divided into two columns by a vertical line. The left column is titled 'Homotopy Theory' and the right column is titled 'HoTT'. Both titles are underlined. The table lists corresponding concepts in each field.

<u>Homotopy Theory</u>	<u>HoTT</u>
space	data type
mapping space	function type
local system	dependent type
parallel transport	type transport

This reflects exactly the structures that showed up above.

Towards a programming language for topological physics

Even though higher topoi have a reputation of being involved this is really a property of their set-theoretic models indeed, the abstract language of higher topoi is so neat that it even exists as a programming language: HoTT

Communications in Mathematical Physics

D.J. Myers, H. Sati and U. Schreiber:
Topological Quantum Gates in HoTT
Commun. Math. Phys. **405**, 172 (2024)
Springer Nature

 Springer Nature



Summary and Outlook

Grand Physics Problem of 21st Century:
nonperturbative global physics

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Systems

The End

materials at: ncatlab.org/schreiber/show/WIKO+2026

