

Urs Schreiber

New York University Abu Dhabi
Center for Quantum & Topological
Systems

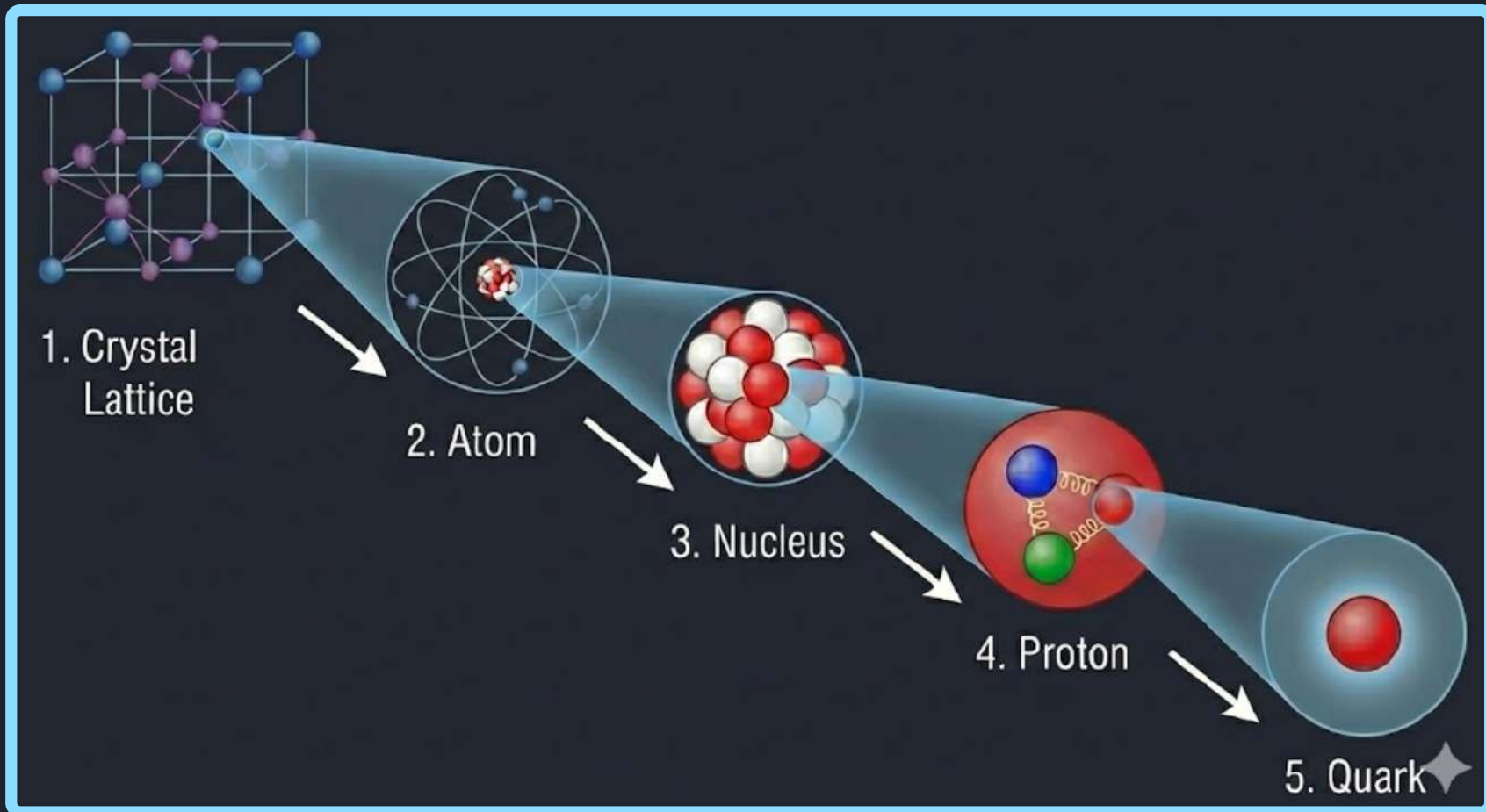
The \$1 Million Puzzle: Hadrons and Quantum Computers

Why Modern Physics Needs a New Global Mathematics

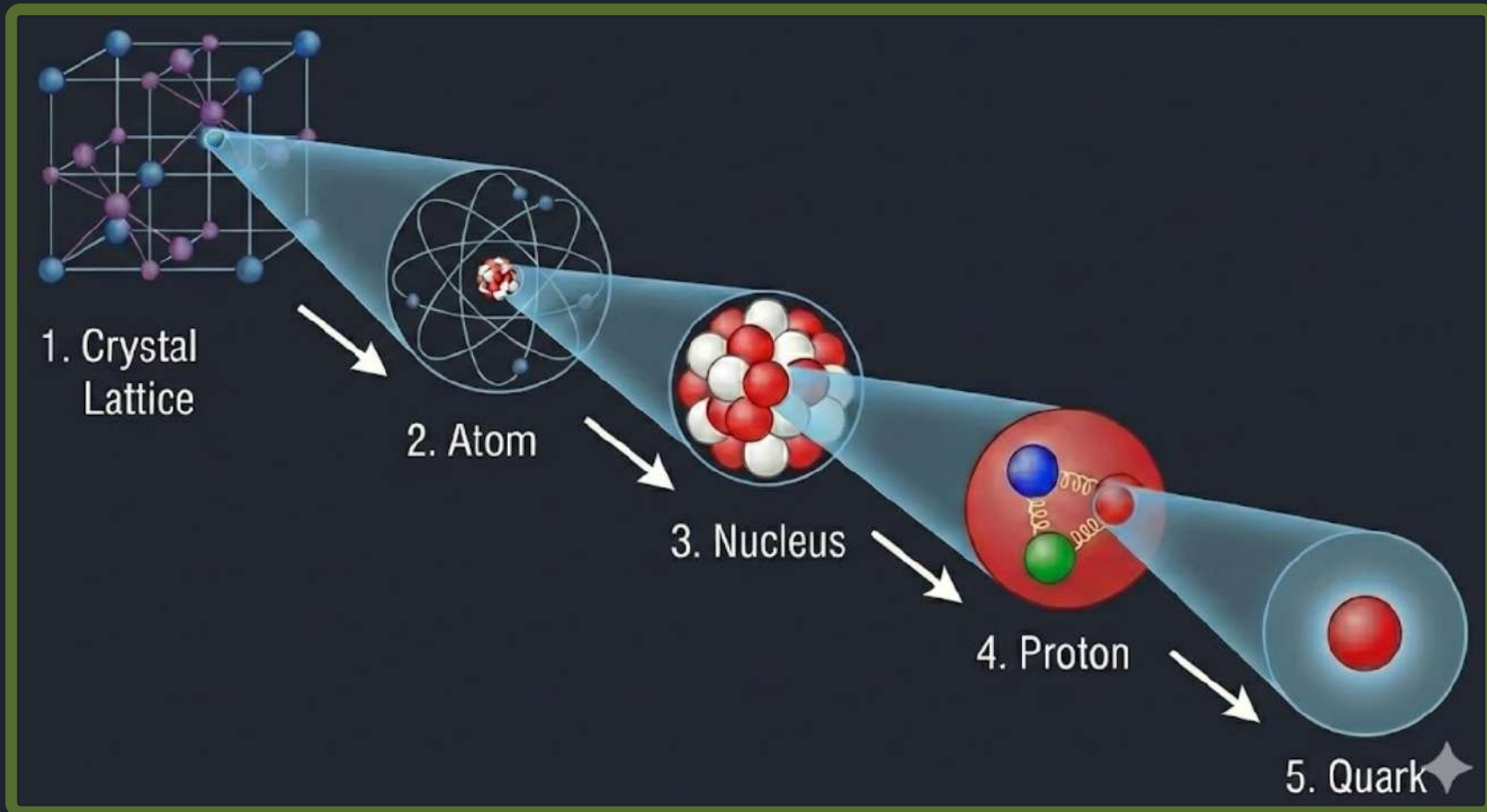


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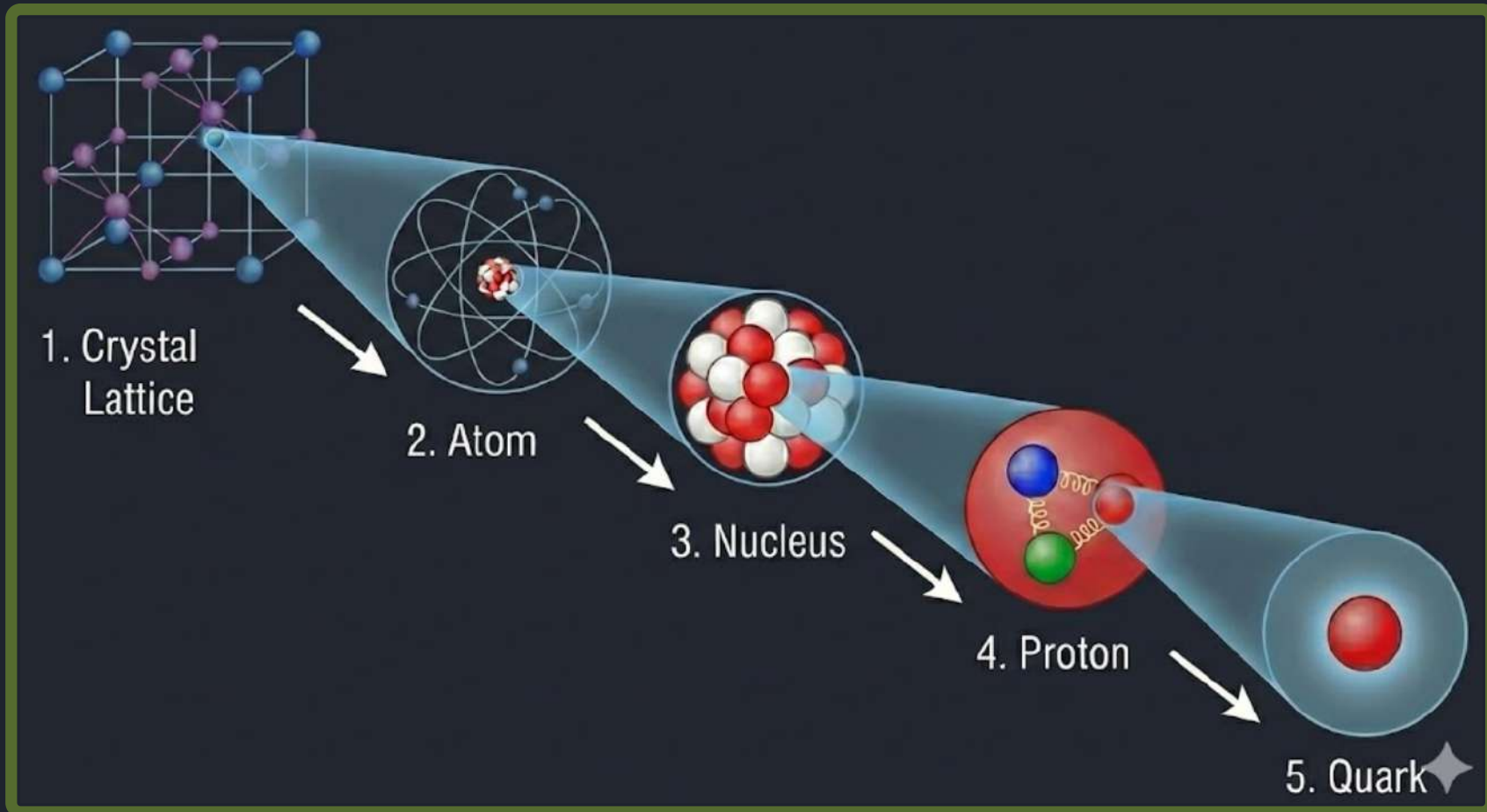


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Siegel 2025

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Wired 2016

A screenshot of a Wired article header. The background is black with white and orange text. At the top left is the Wired logo. To the right is a user icon and the word 'SUBSCRIBE'. Below the logo is the author's name 'BRENDAN COLE', the category 'SCIENCE', and the date 'AUG 5, 2016 8:02 AM'. The main title is 'Sorry, Folks. The LHC Didn't Find a New Particle After All'. Below the title is a sub-headline: 'Physicists keeping on trying to prove the Standard Model wrong, and they keep failing.'

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A screenshot of a Science article from 2022. The article is titled "Ten years after the Higgs, physicists face the nightmare of finding nothing else" by Adrian Cho, published on June 13, 2022, at 1:30 PM ET. The article's main text reads: "Unless Europe's Large Hadron Collider coughs up a surprise, the field of particle physics may wheeze to its end."

NEWS | PHYSICS

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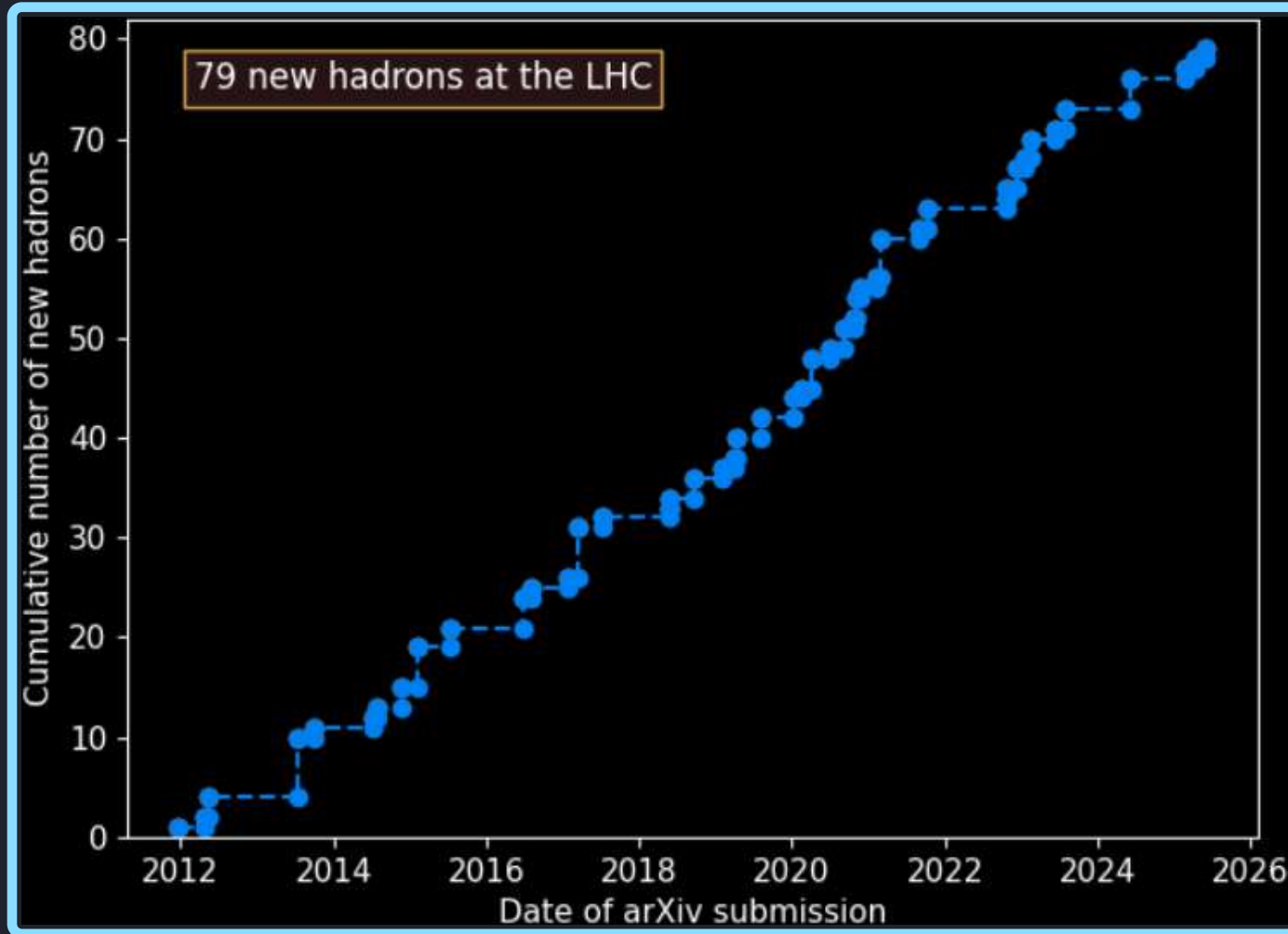


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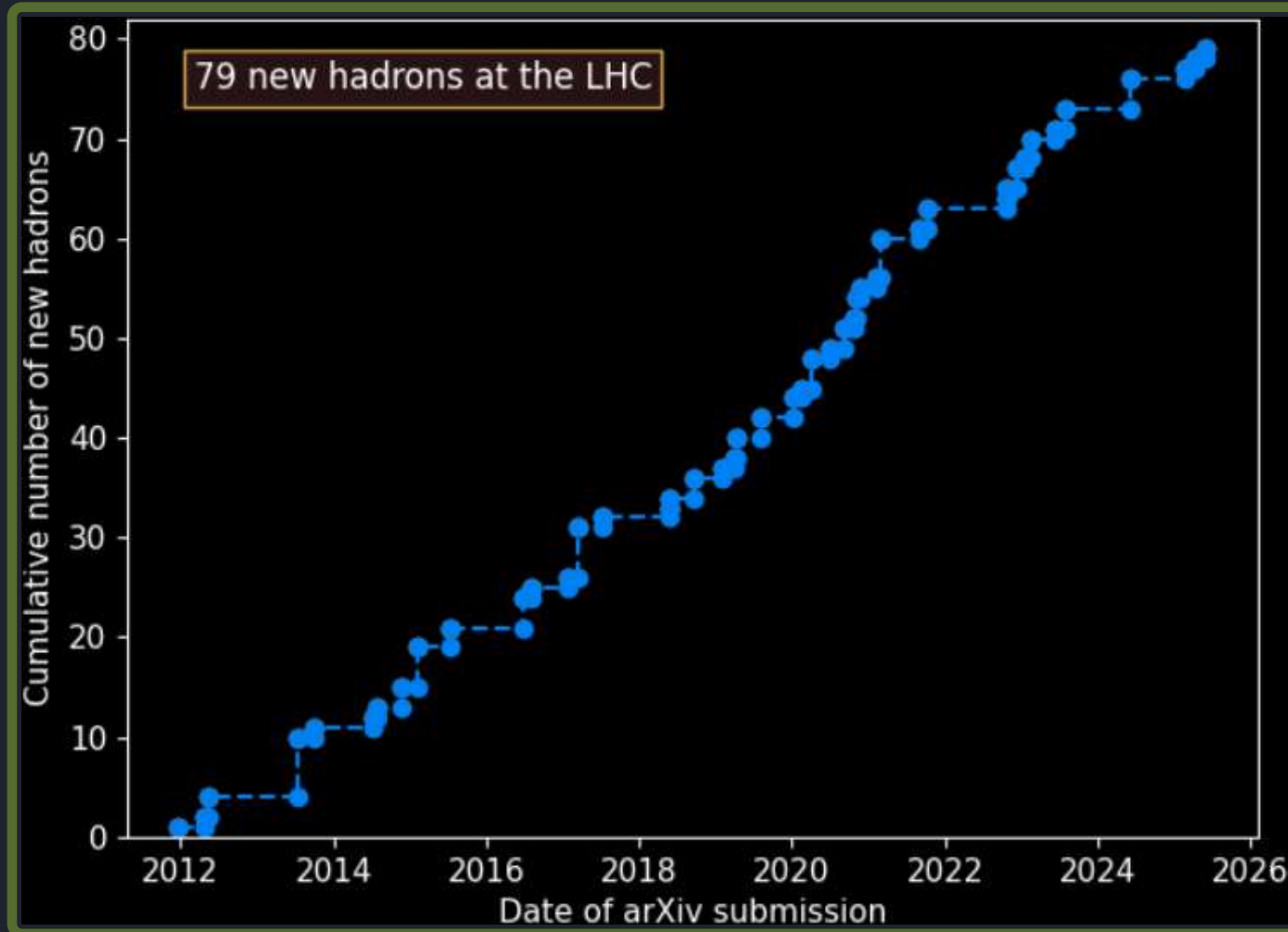
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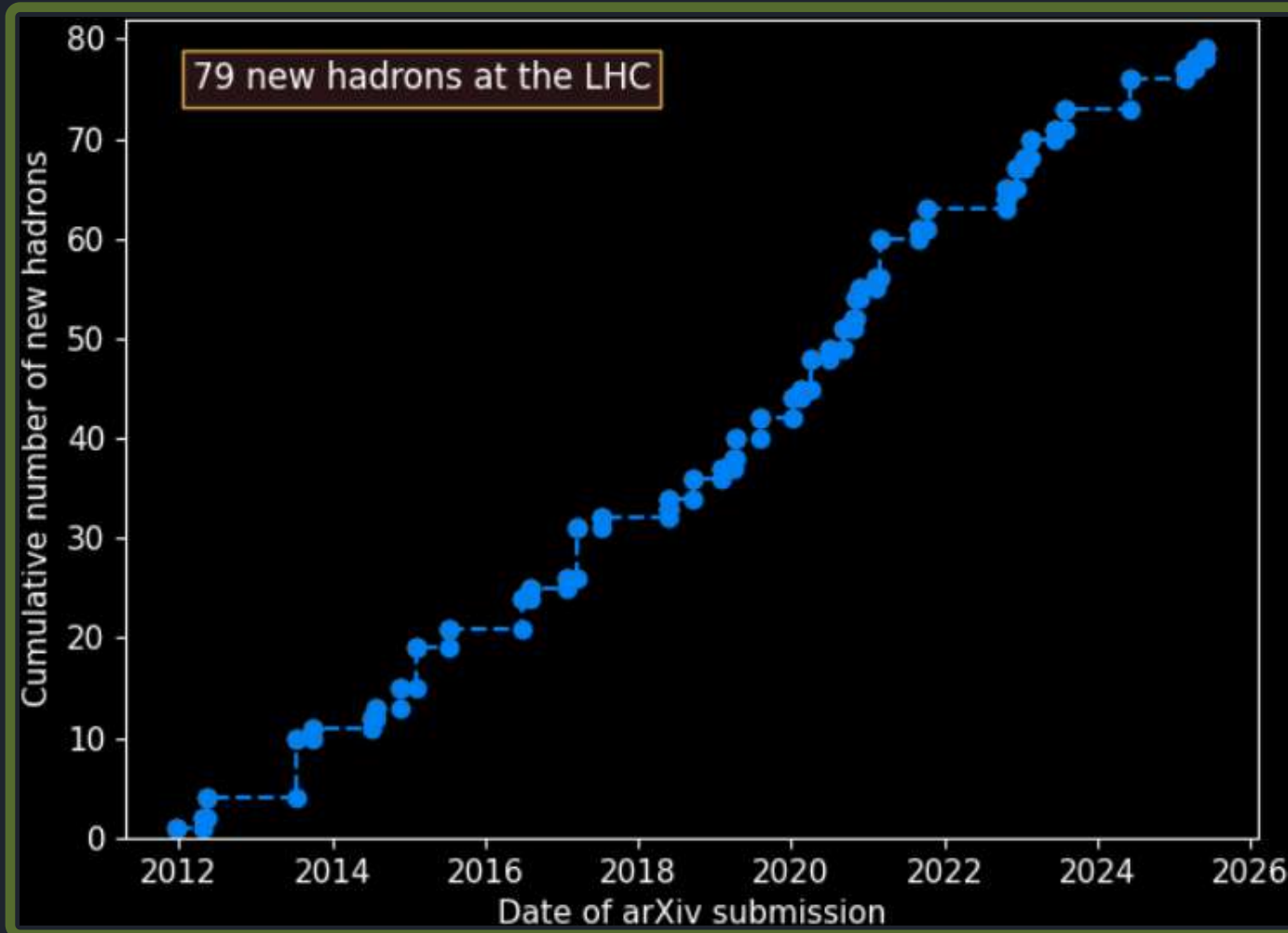
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Although the QCD Lagrangian is expected to completely describe the spectrum of hadrons and all of their properties, there is no rigorous first-principle way of expressing this mathematically. The quark confinement conjecture is experimentally well tested, but mathematically still unproven. And it is still unknown which combinations of quarks may or may not form hadrons. **Experimental guidance is needed** to help improving theoretical models. These models are then in turn needed to constrain hadronic uncertainties which affect searches for New Physics phenomena.

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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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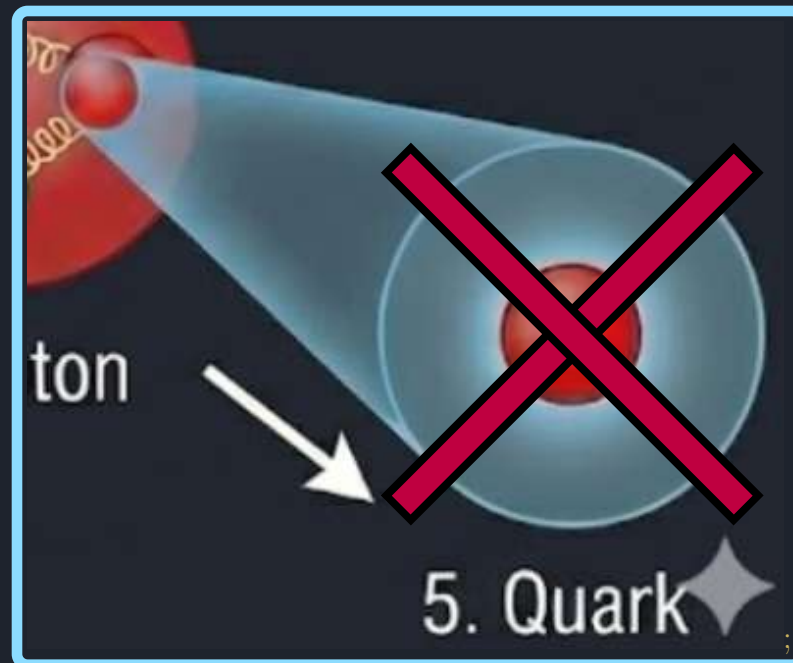
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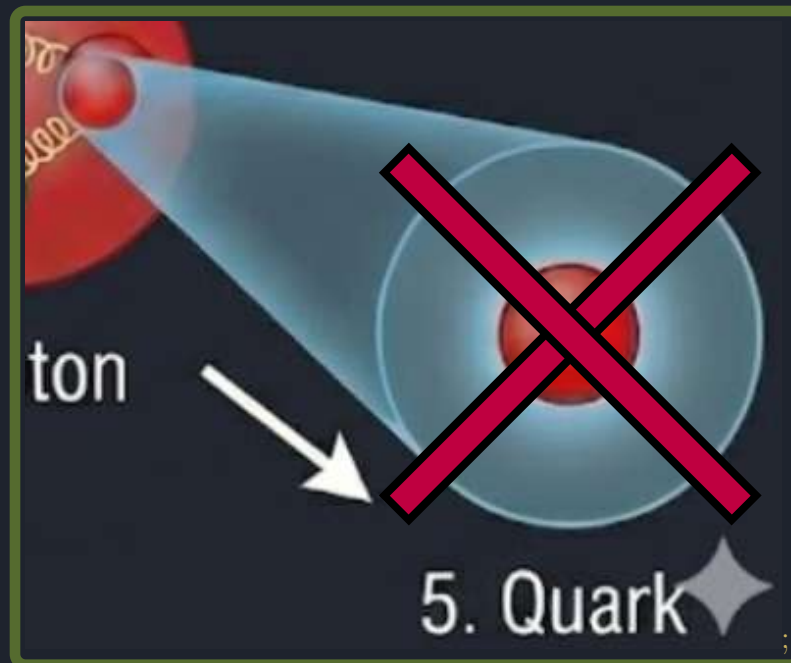
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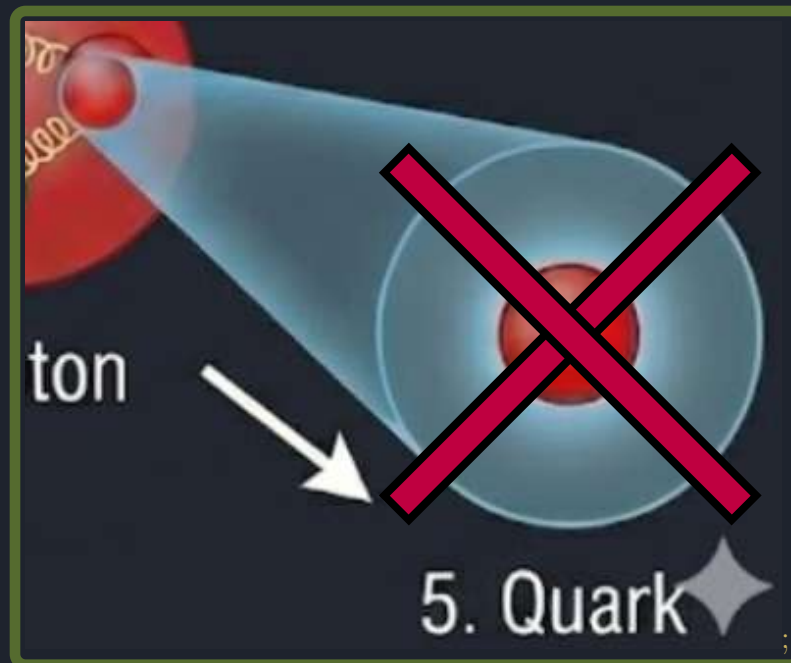
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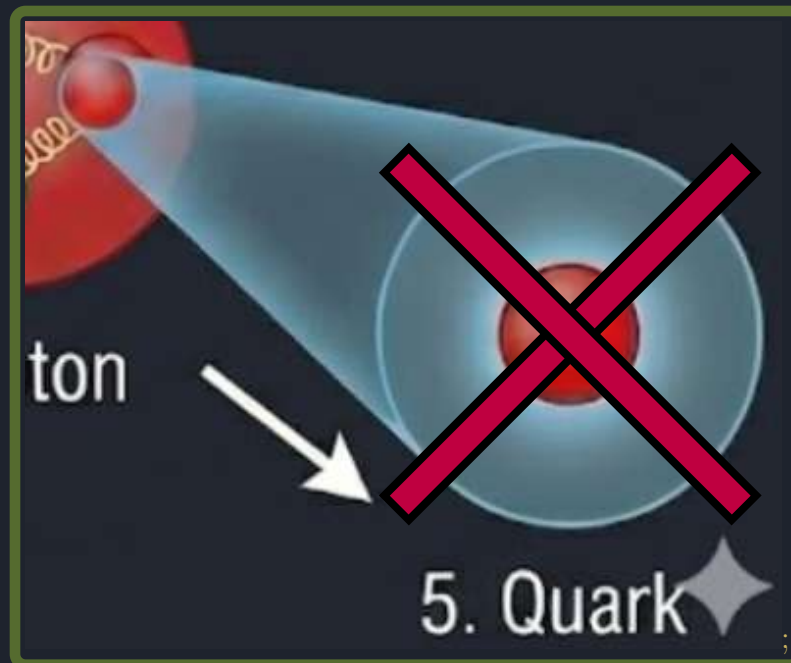
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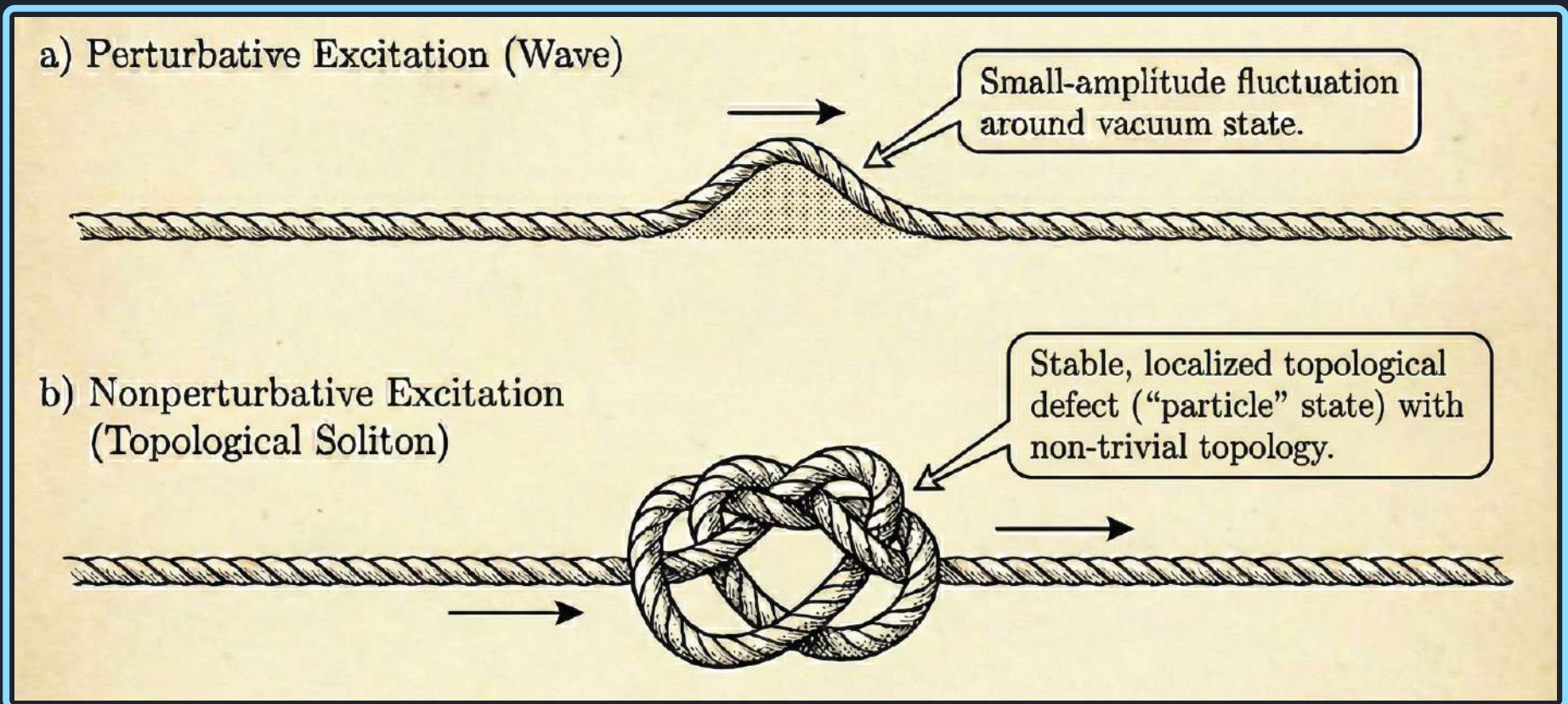
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Hadrons are *non-perturbative* effects:
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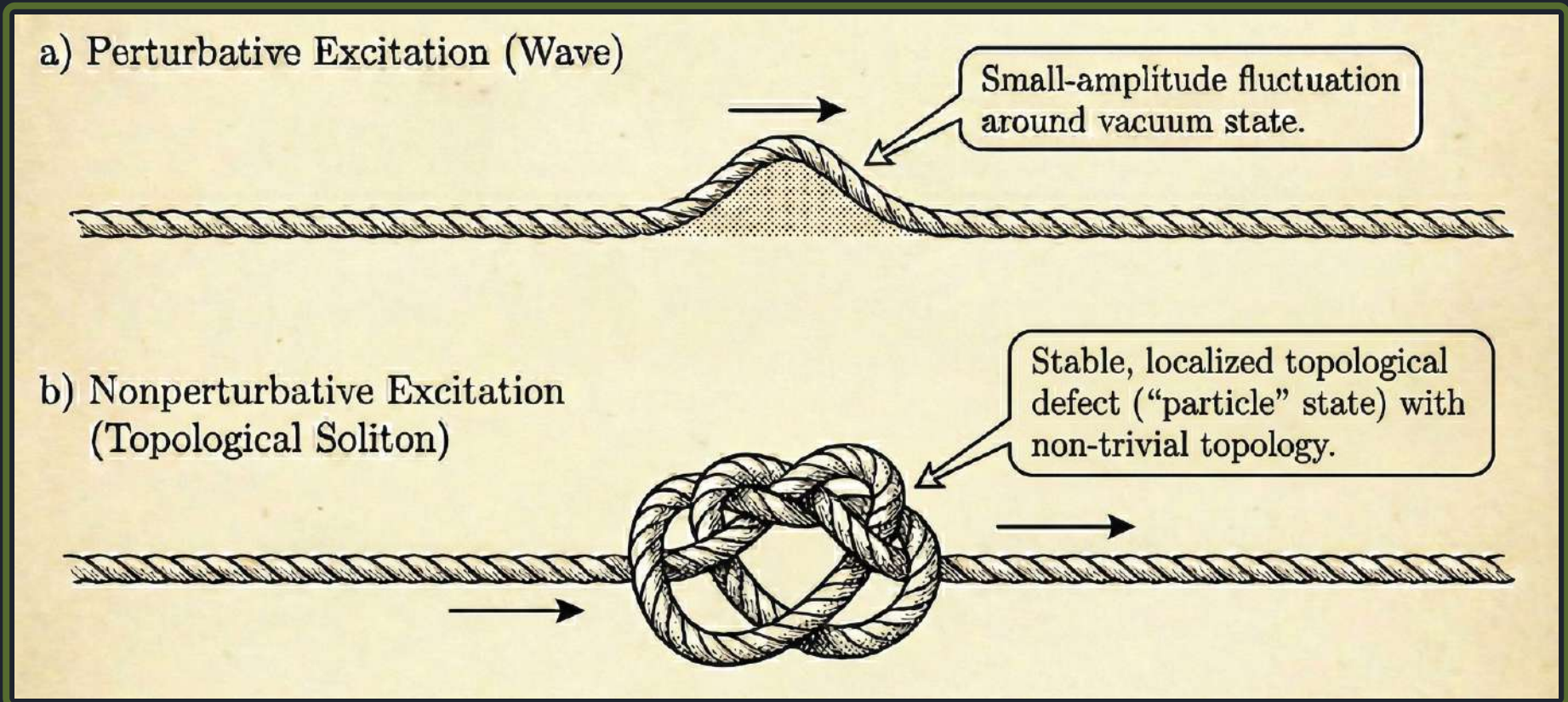
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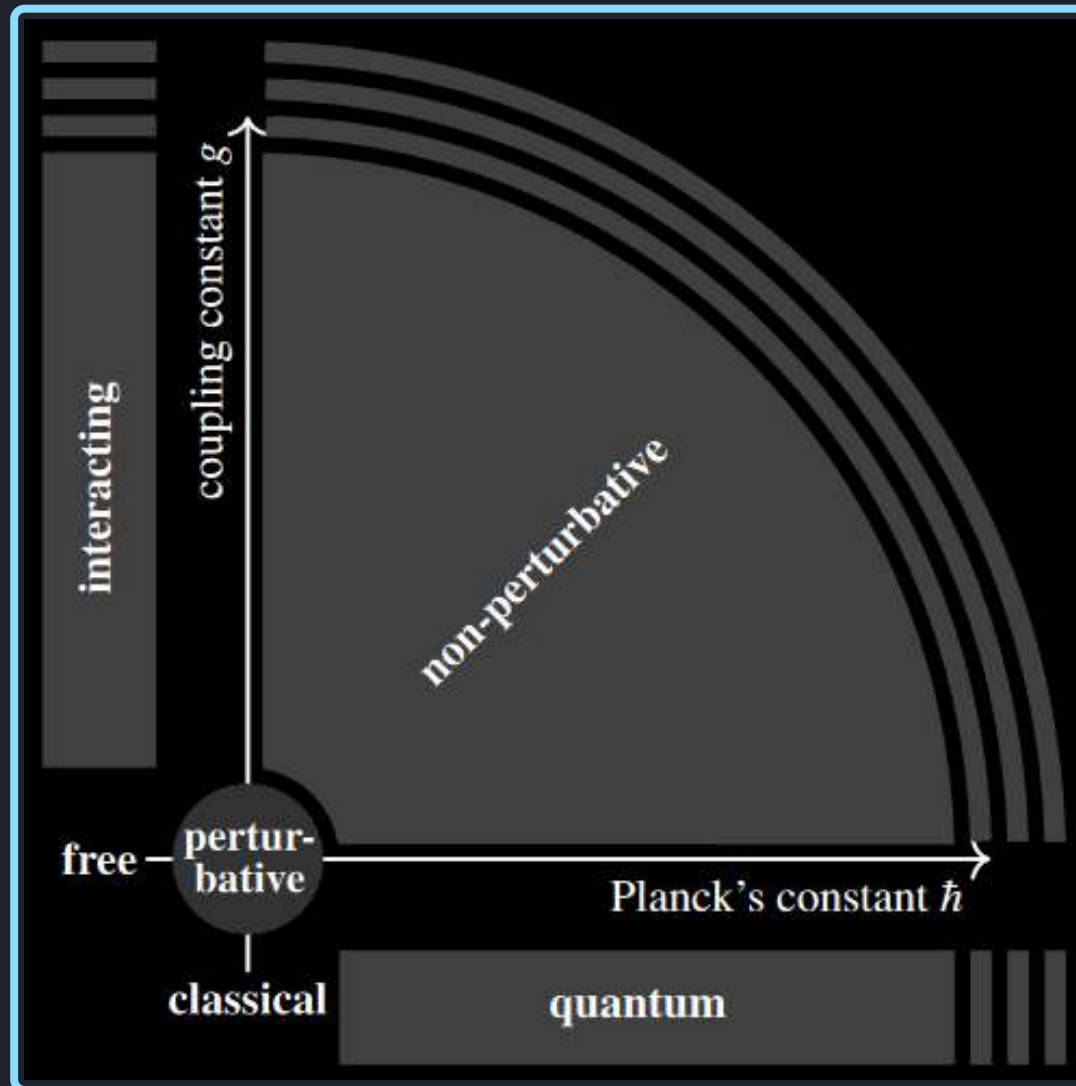
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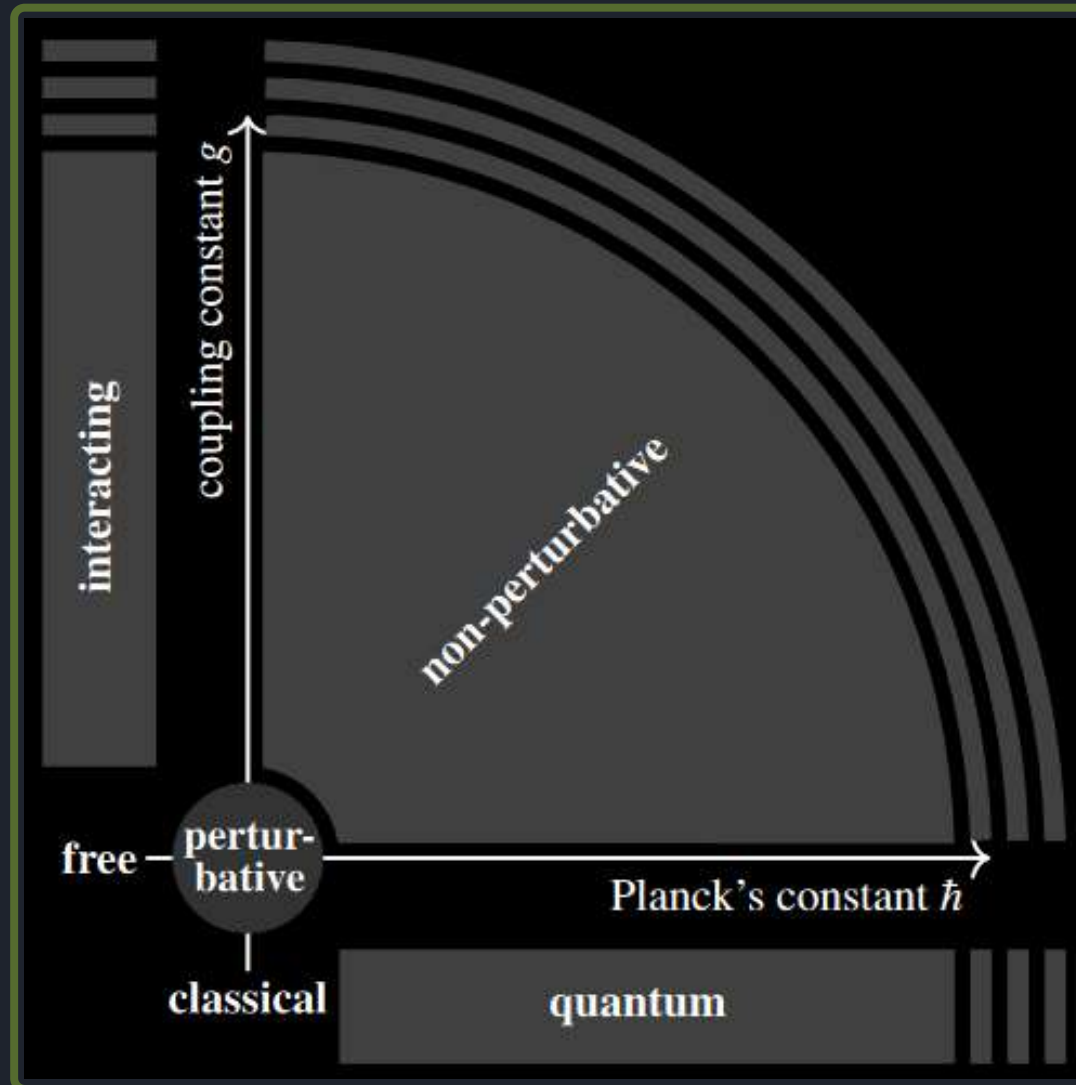
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where many particles condense to solids or fluids

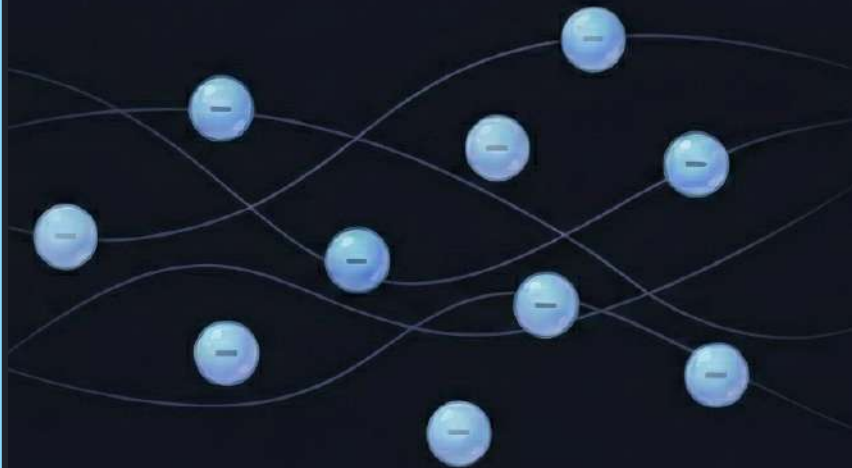
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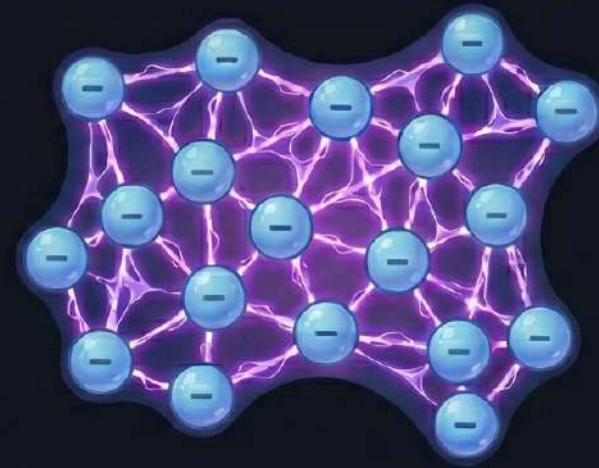
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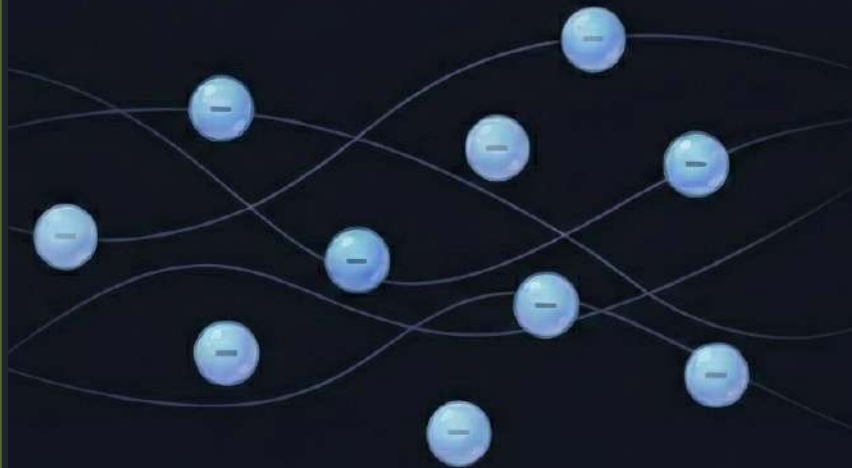


Like a dense mosh pit, movements
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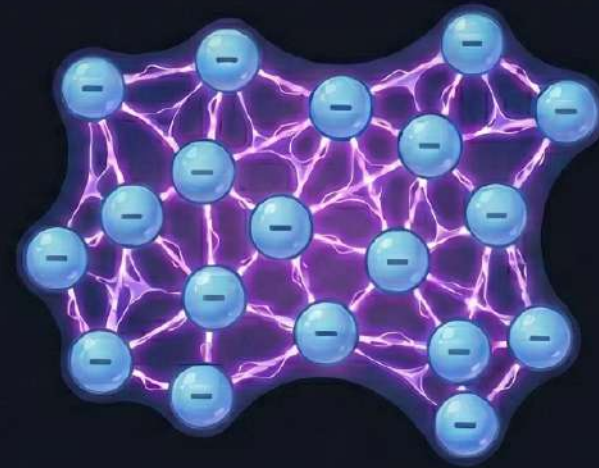
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Feature: Strong correlations

physicsworld.com

The strong-correlations puzzle

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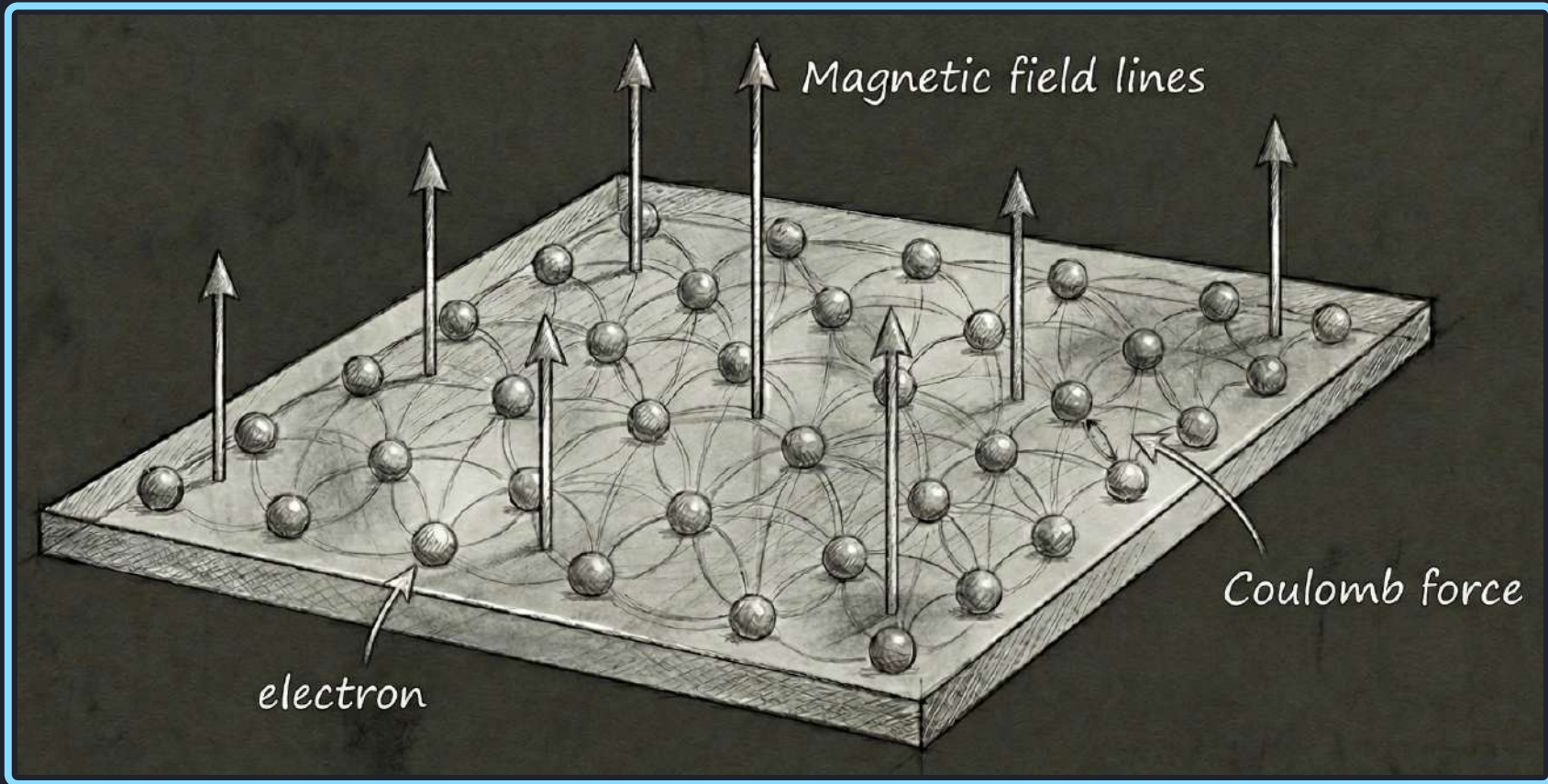
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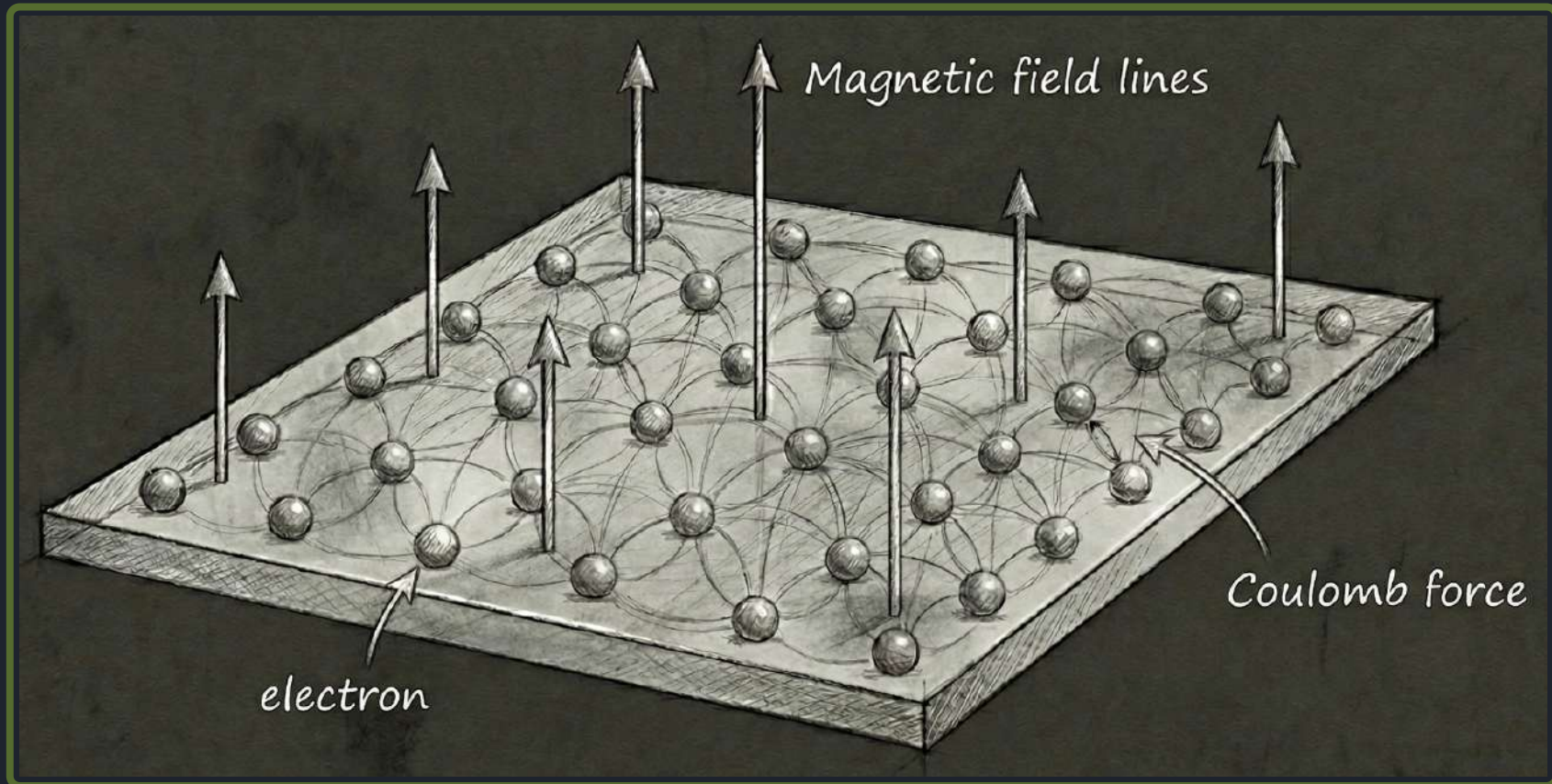
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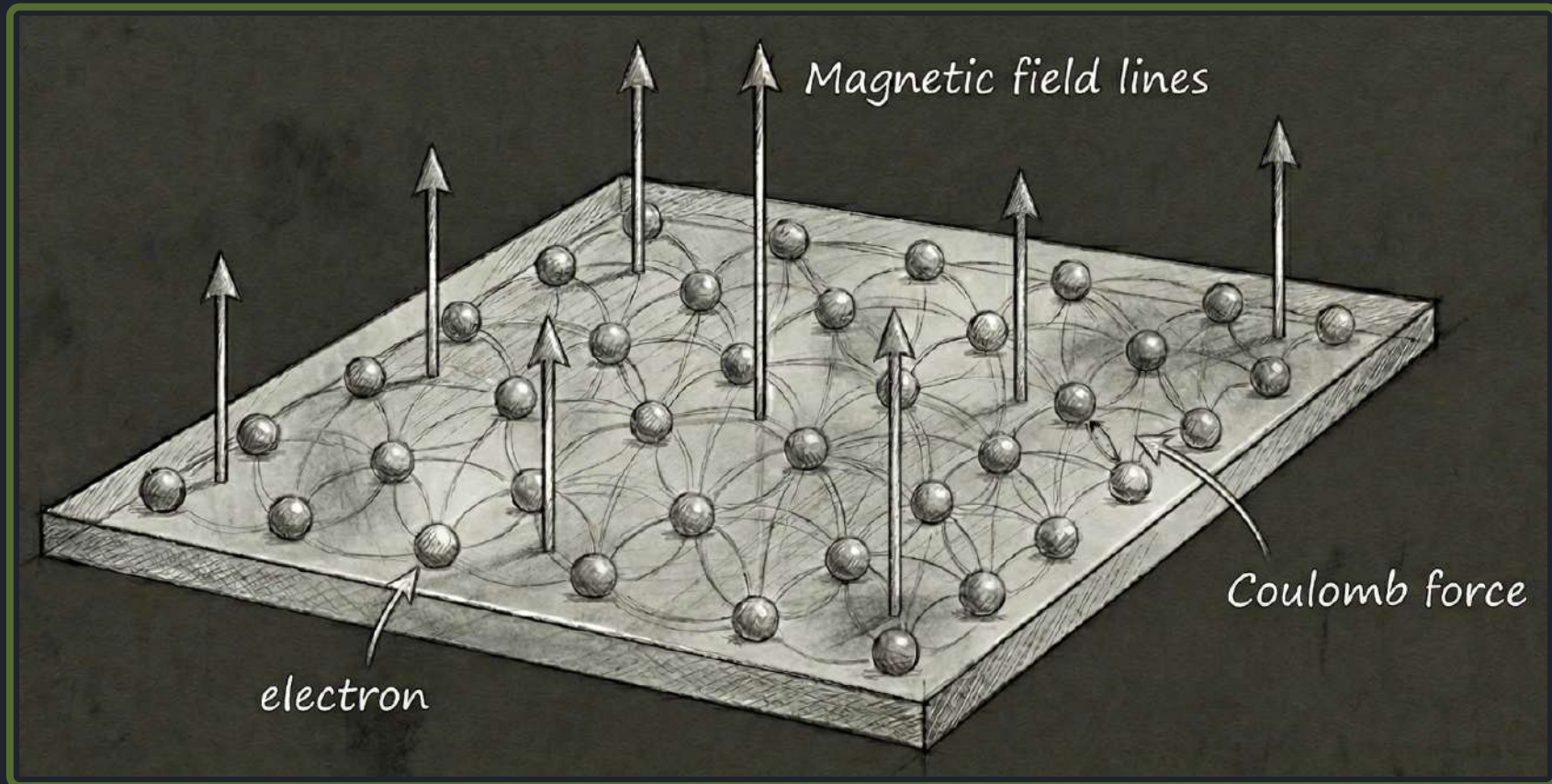
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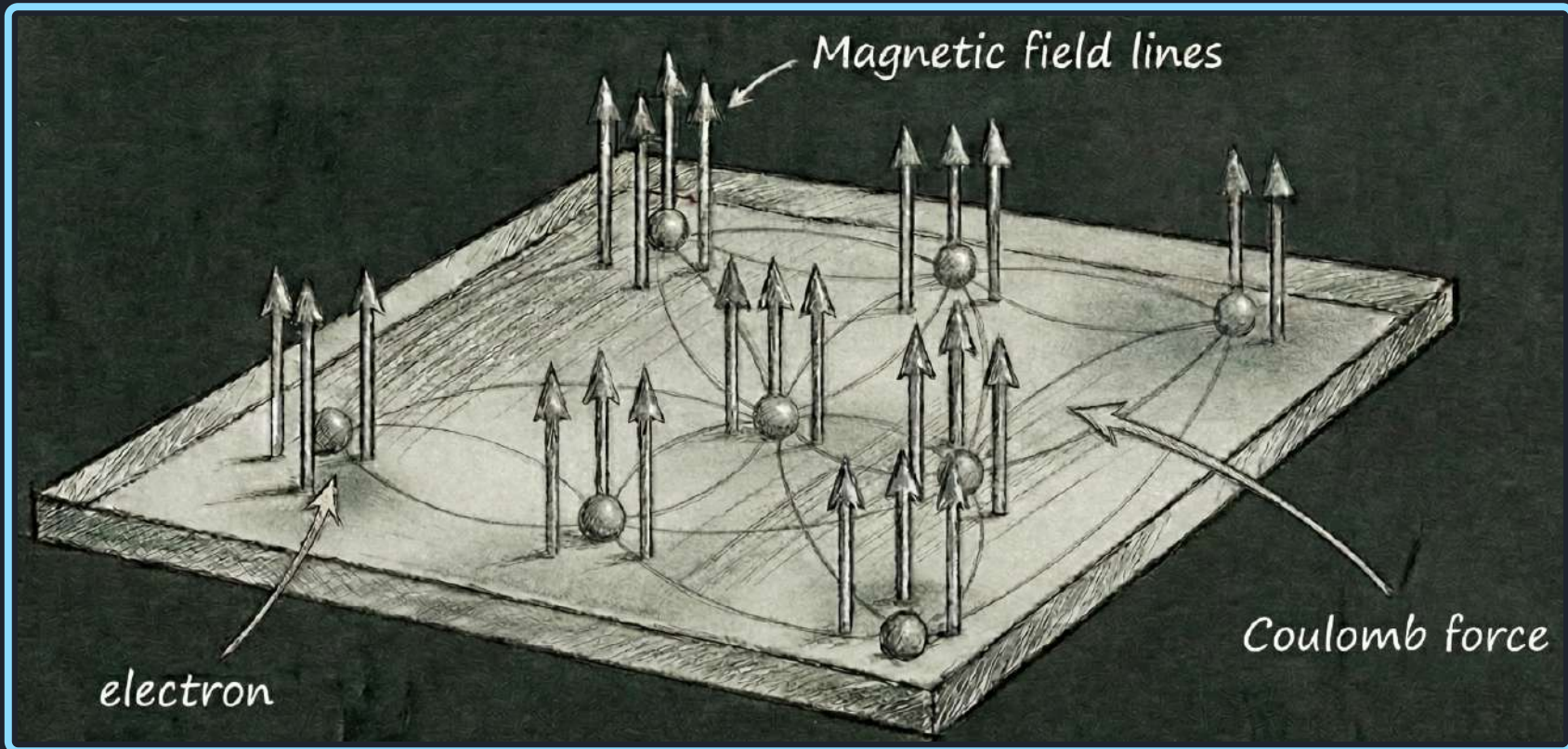
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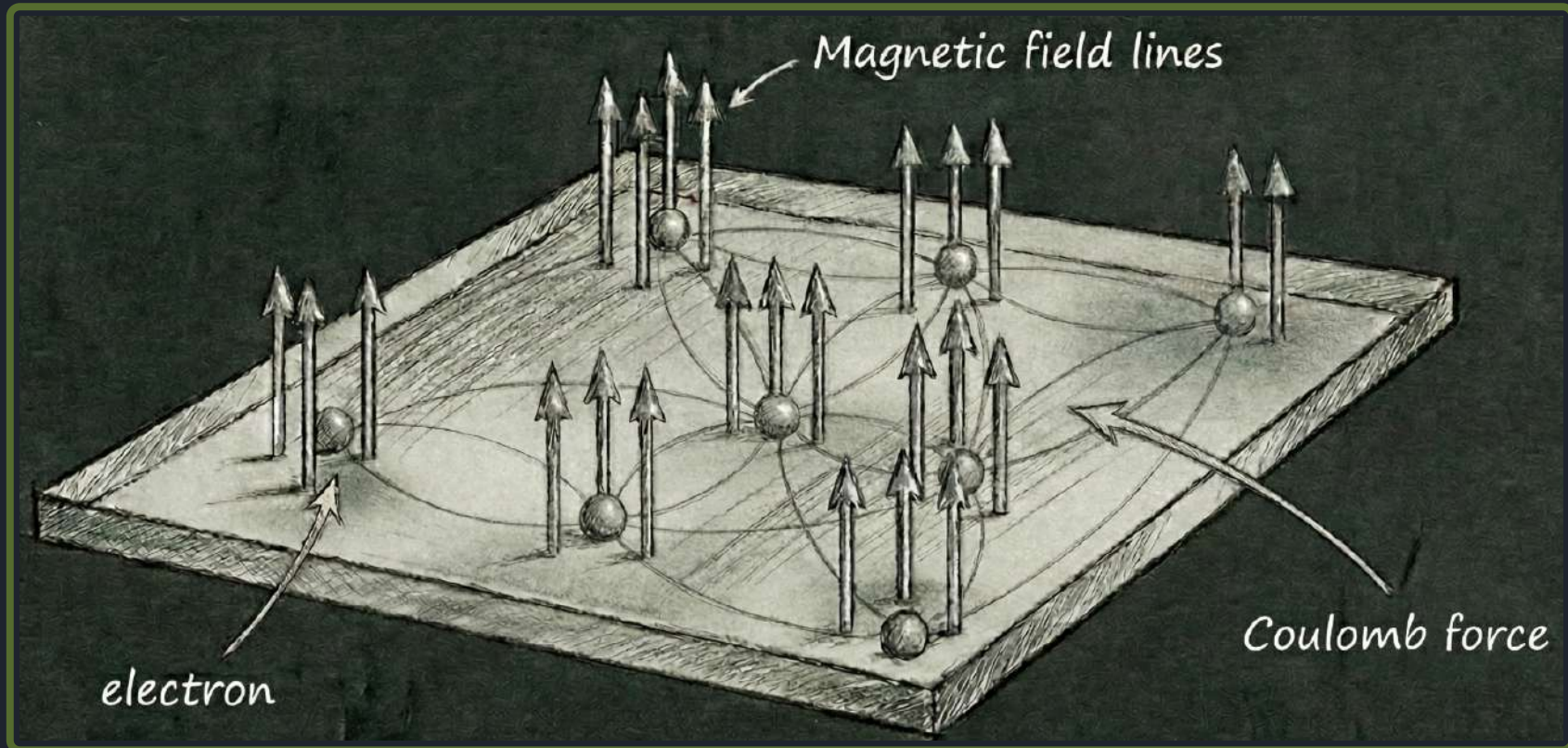
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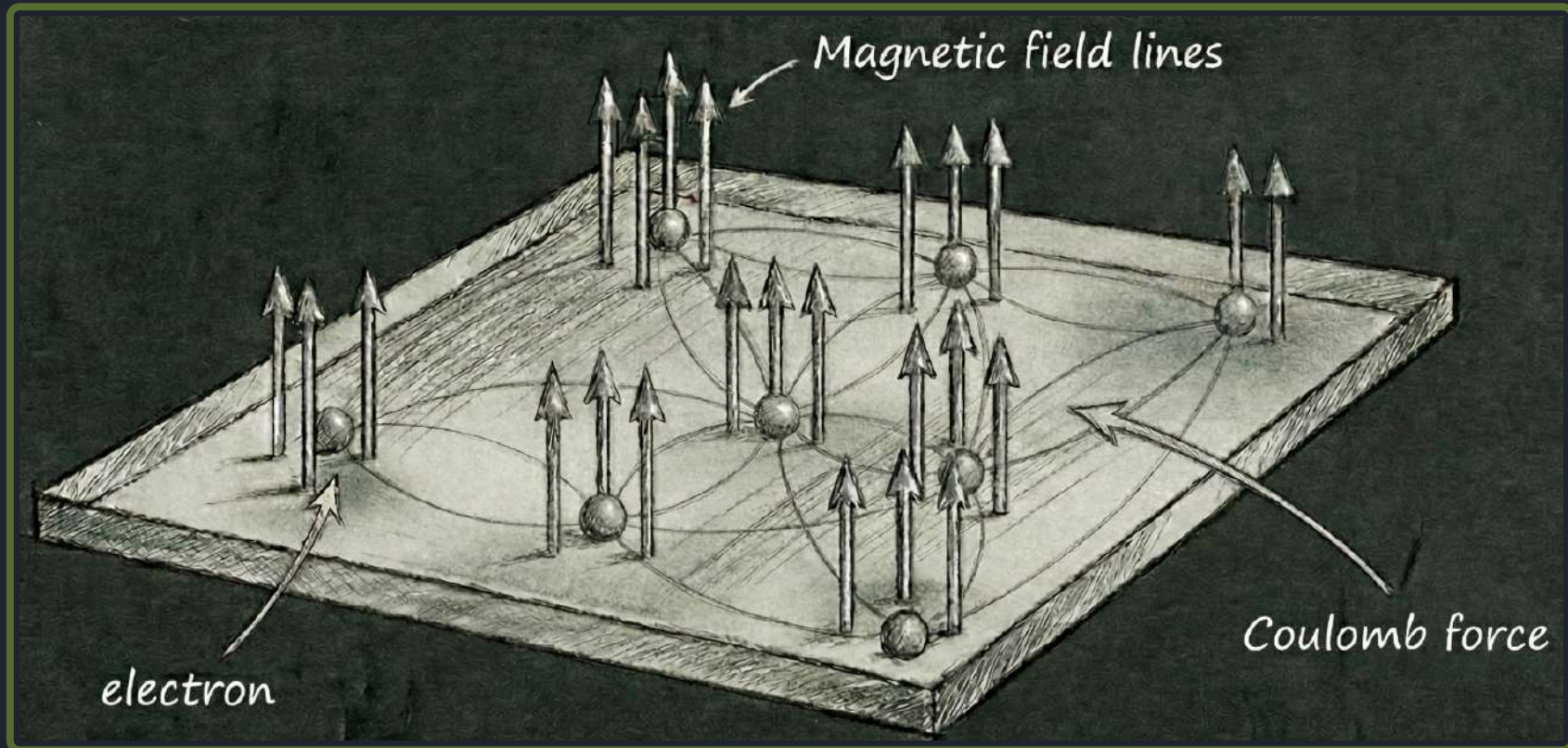


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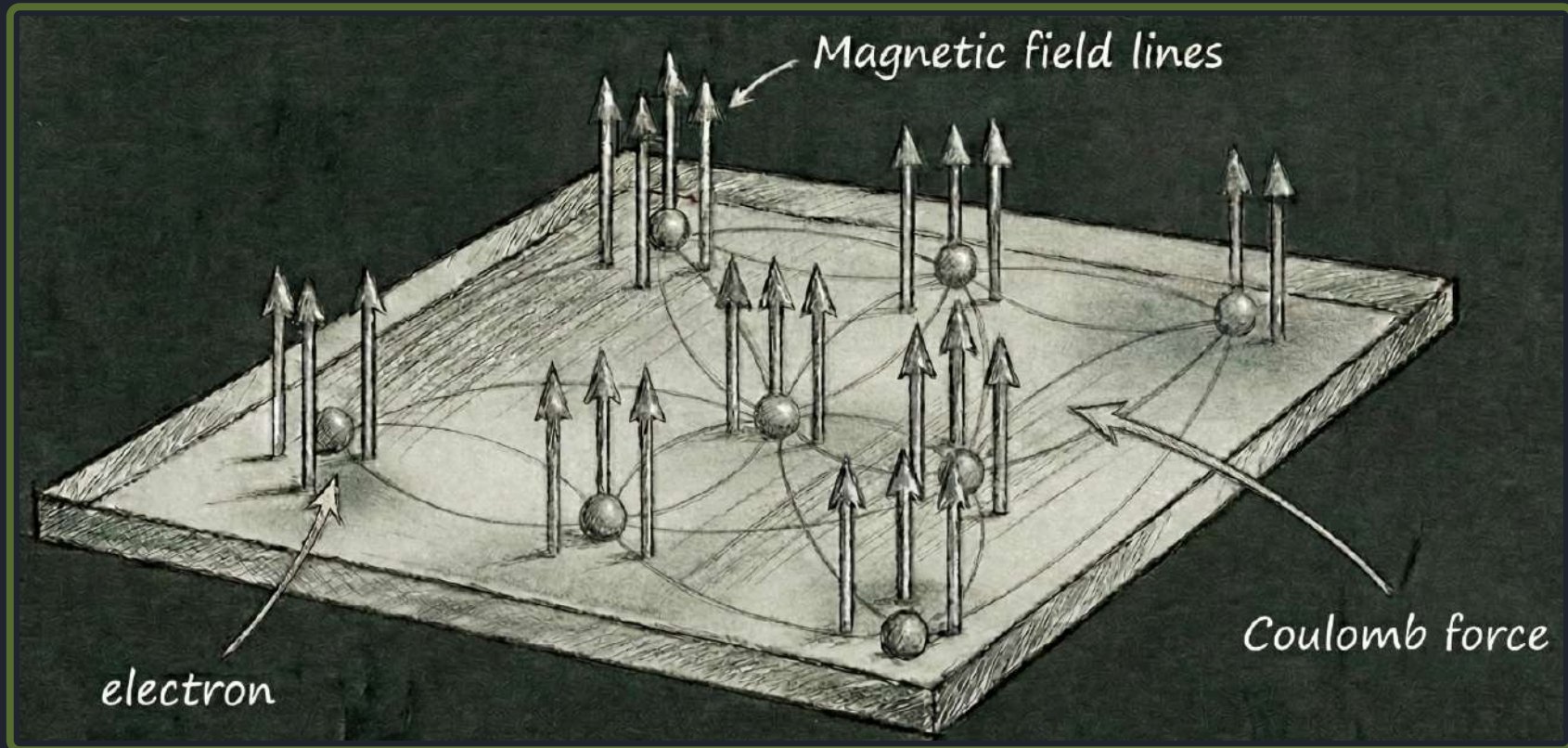
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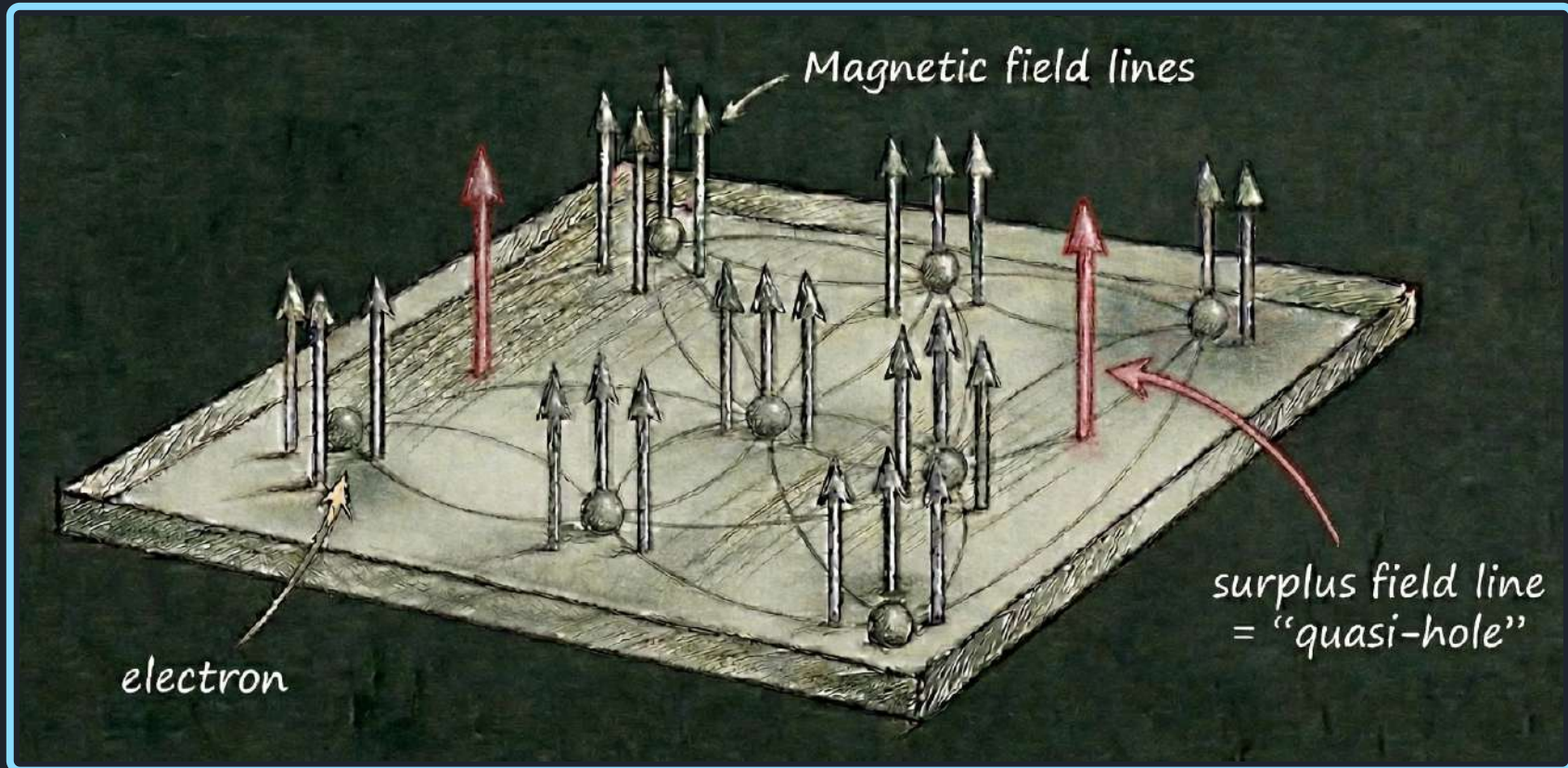


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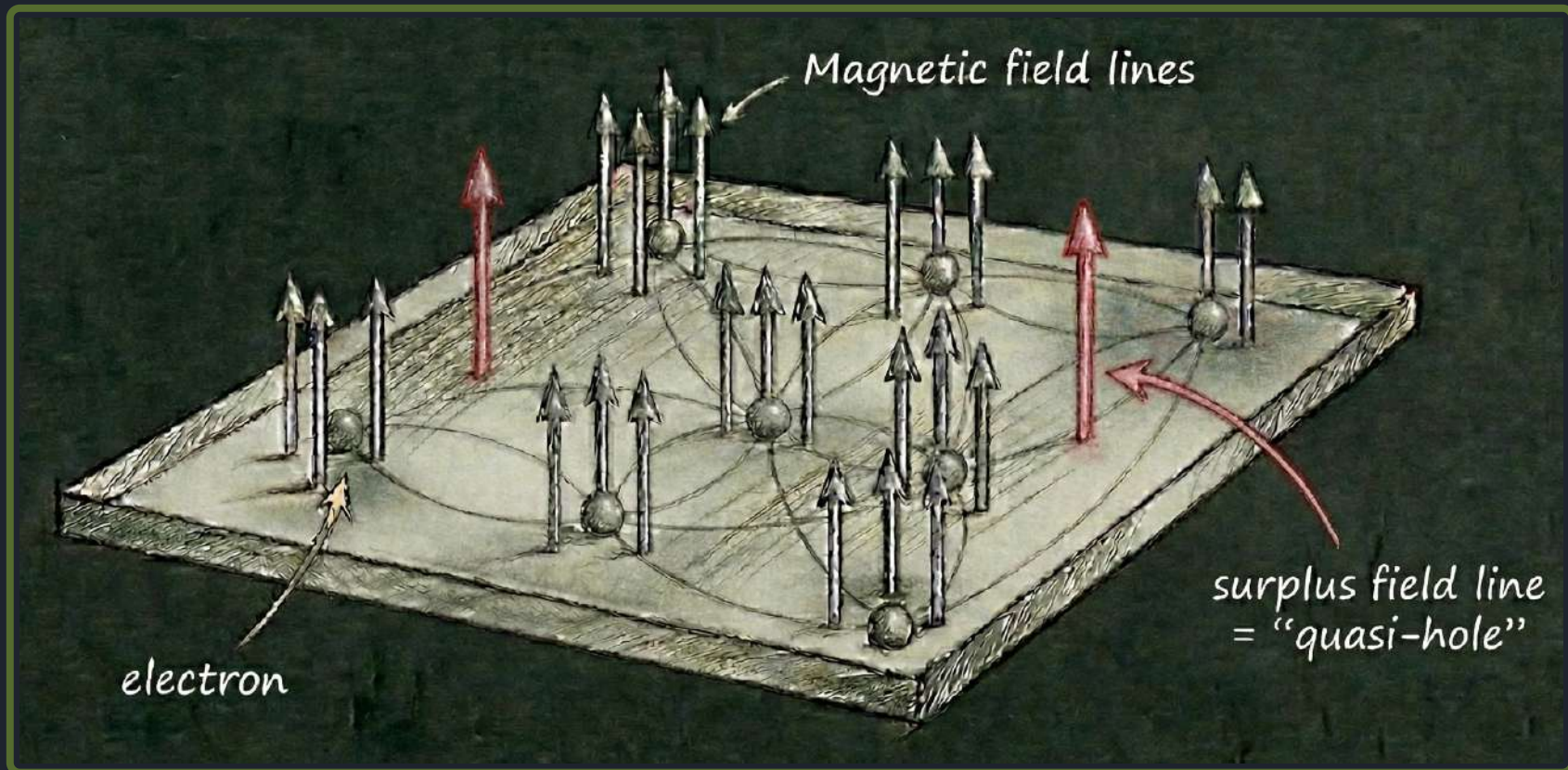
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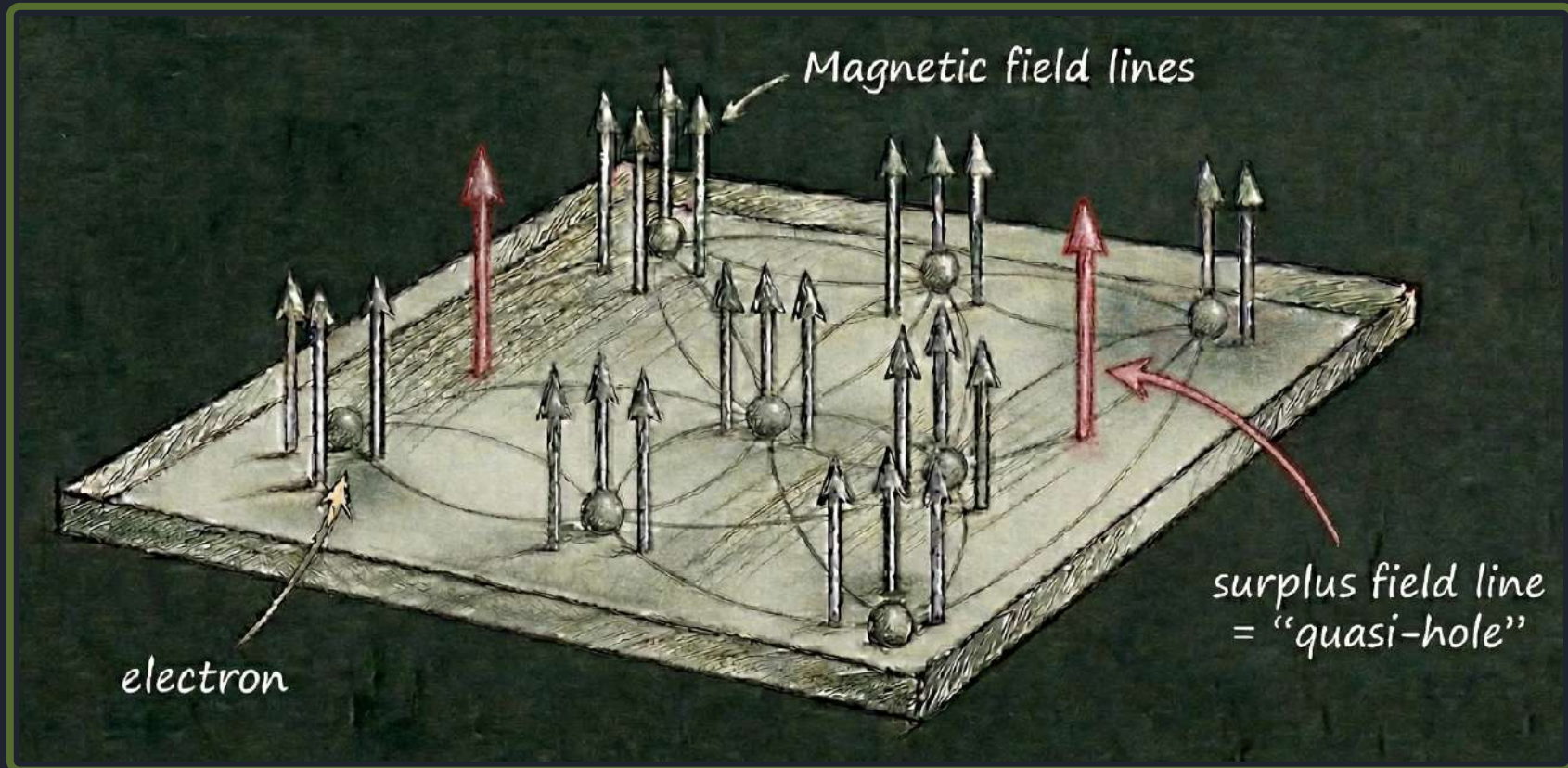


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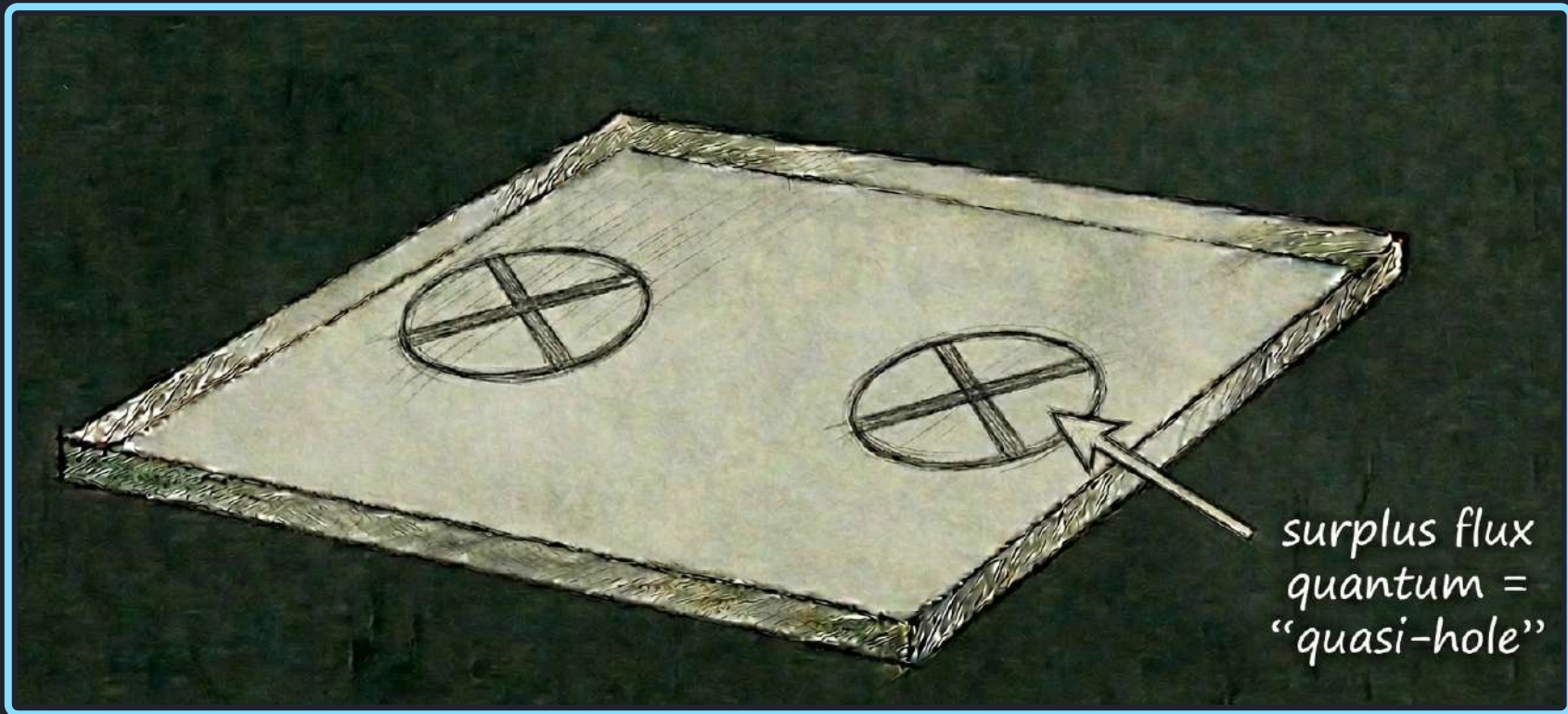


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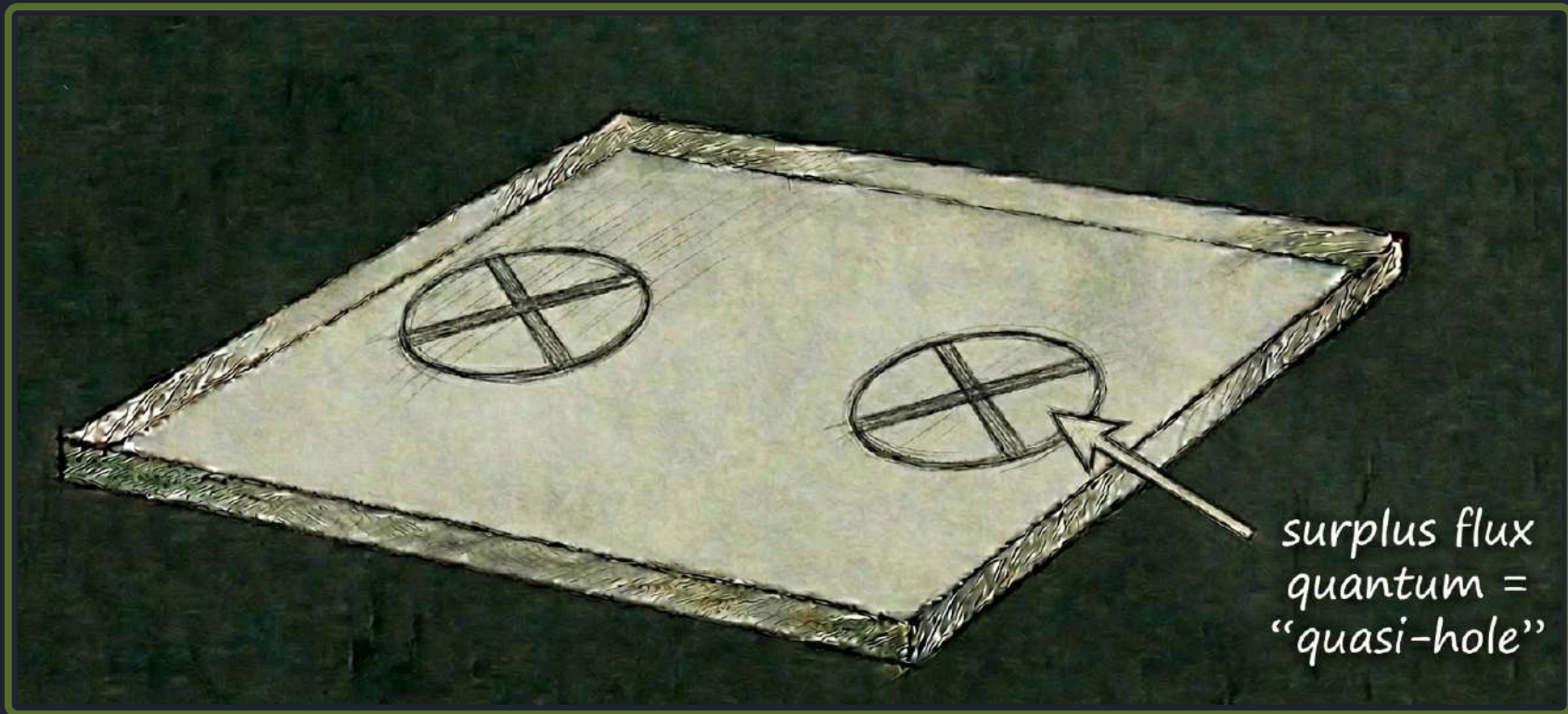
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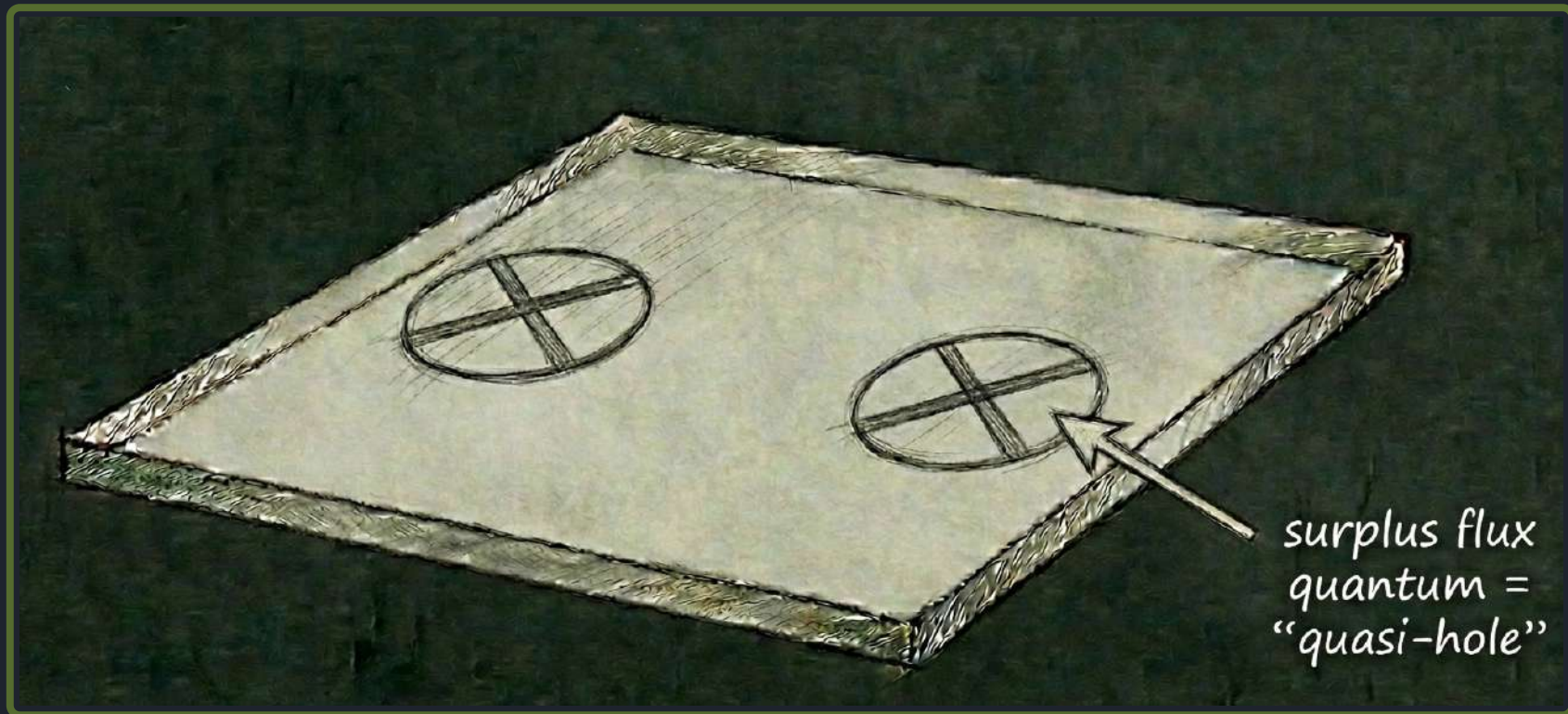


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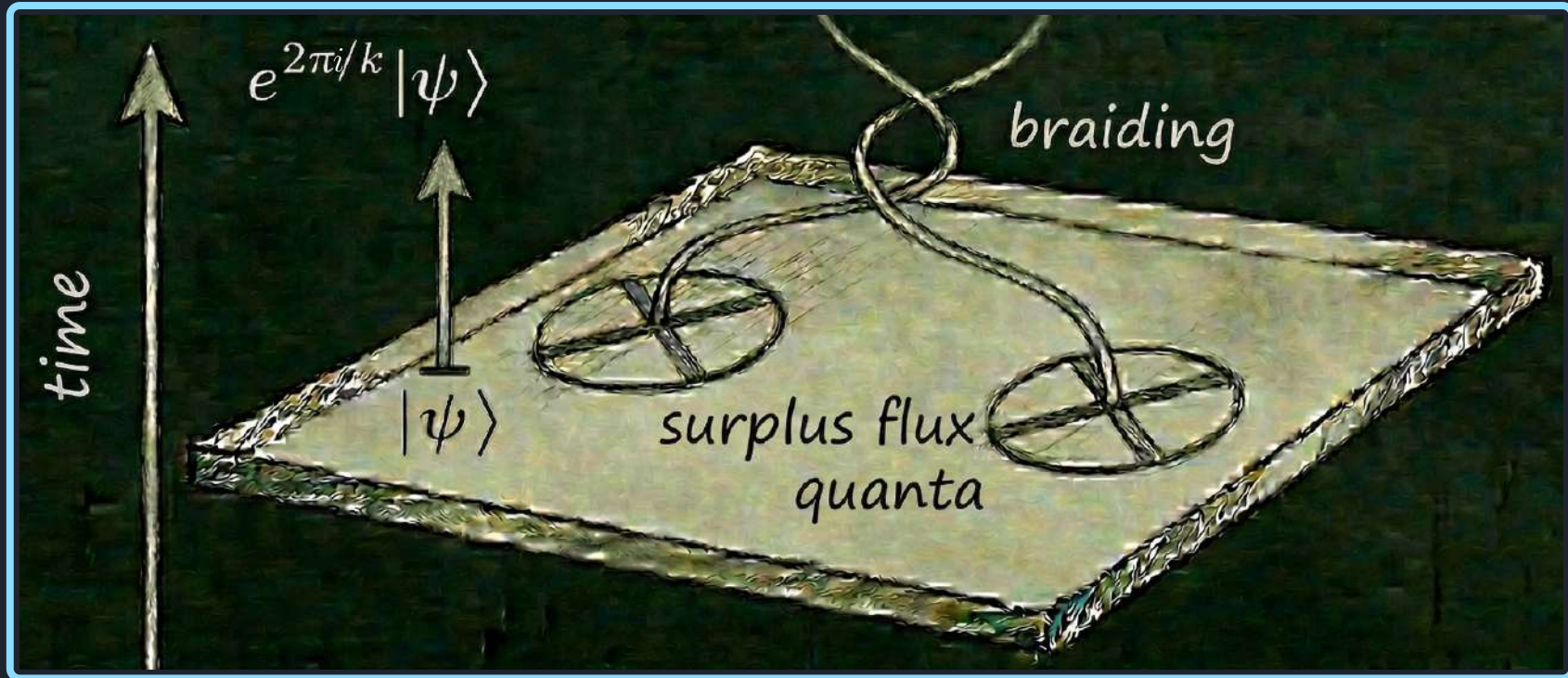


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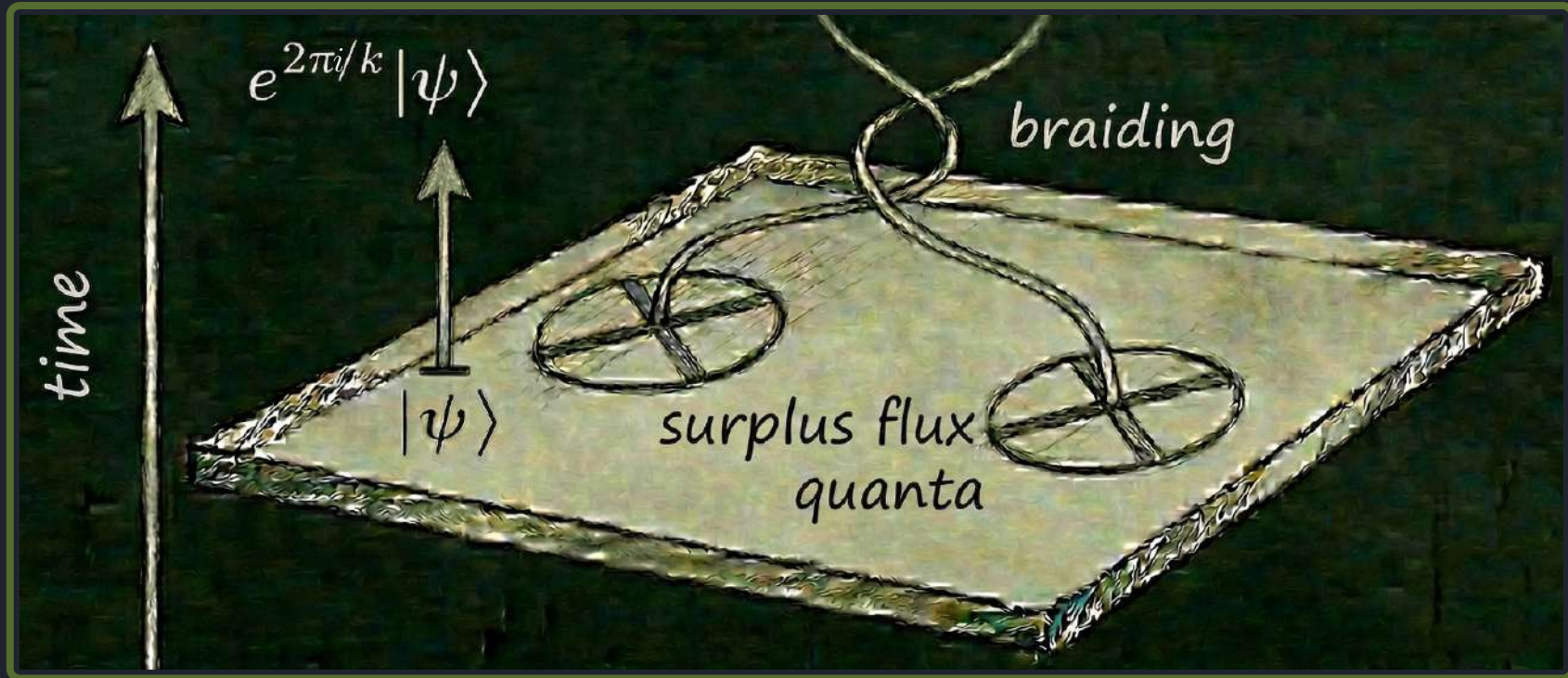
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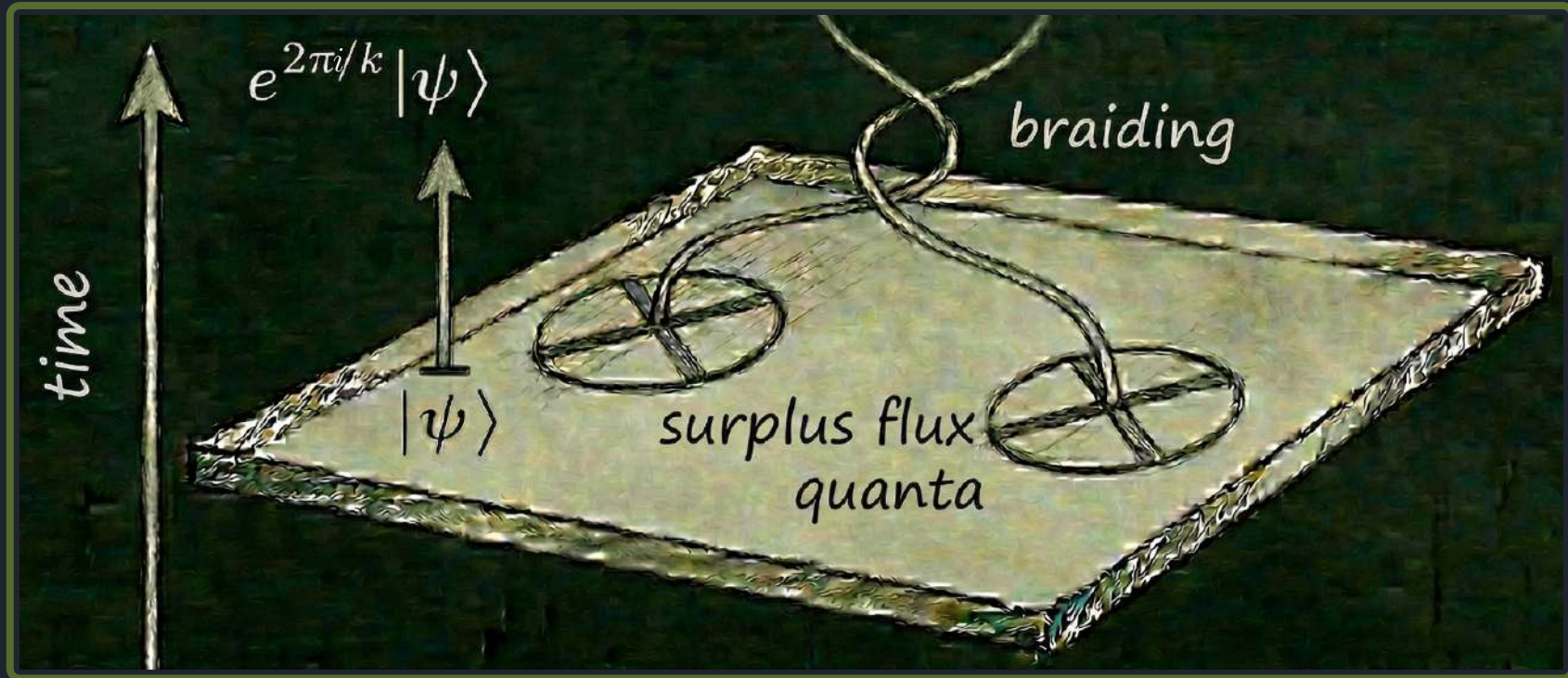


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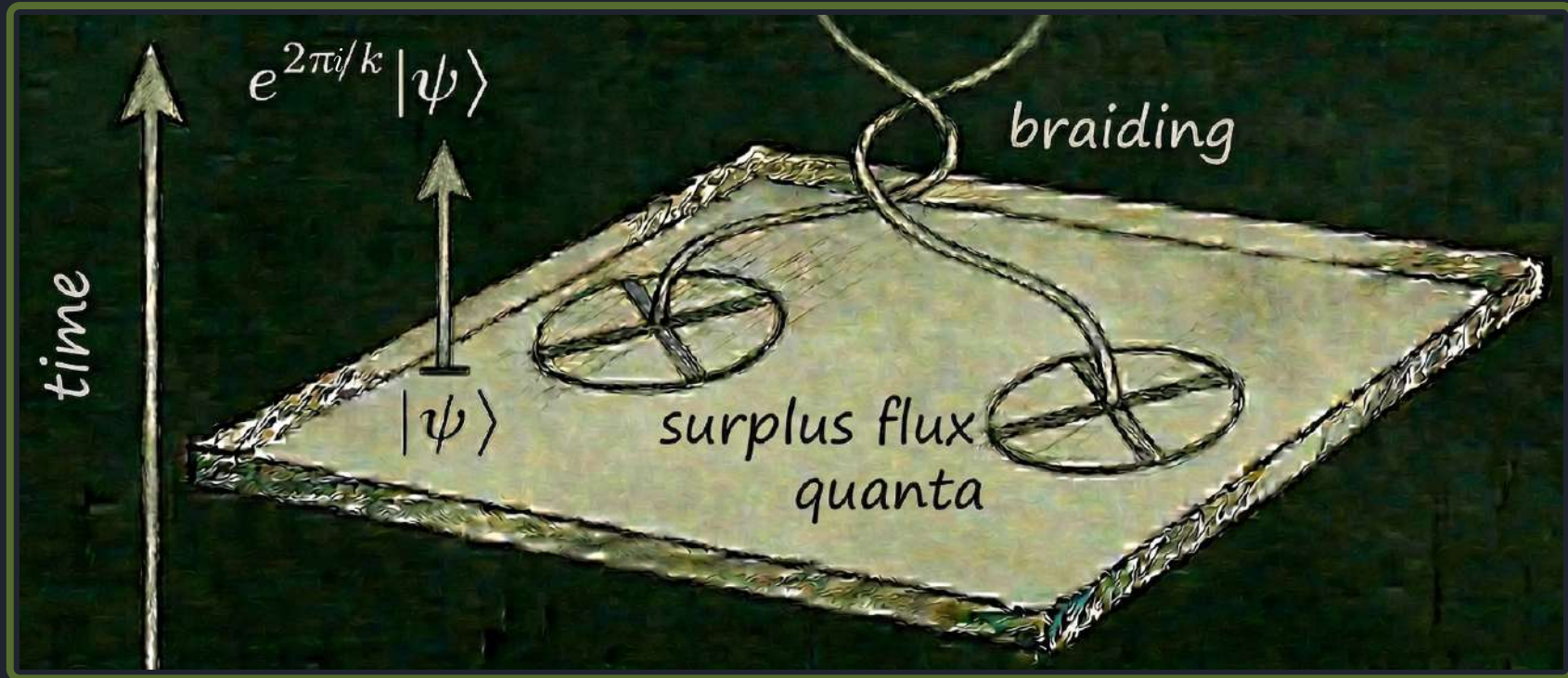
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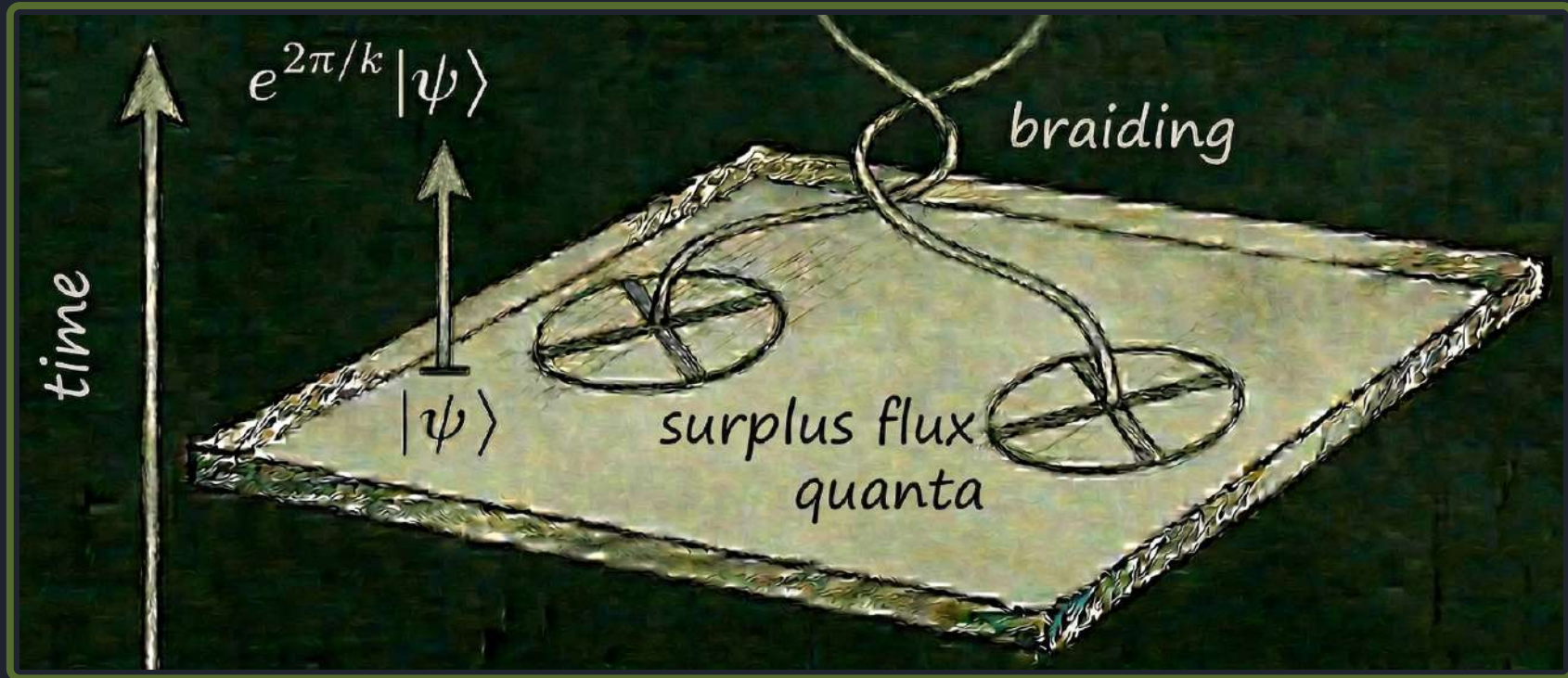
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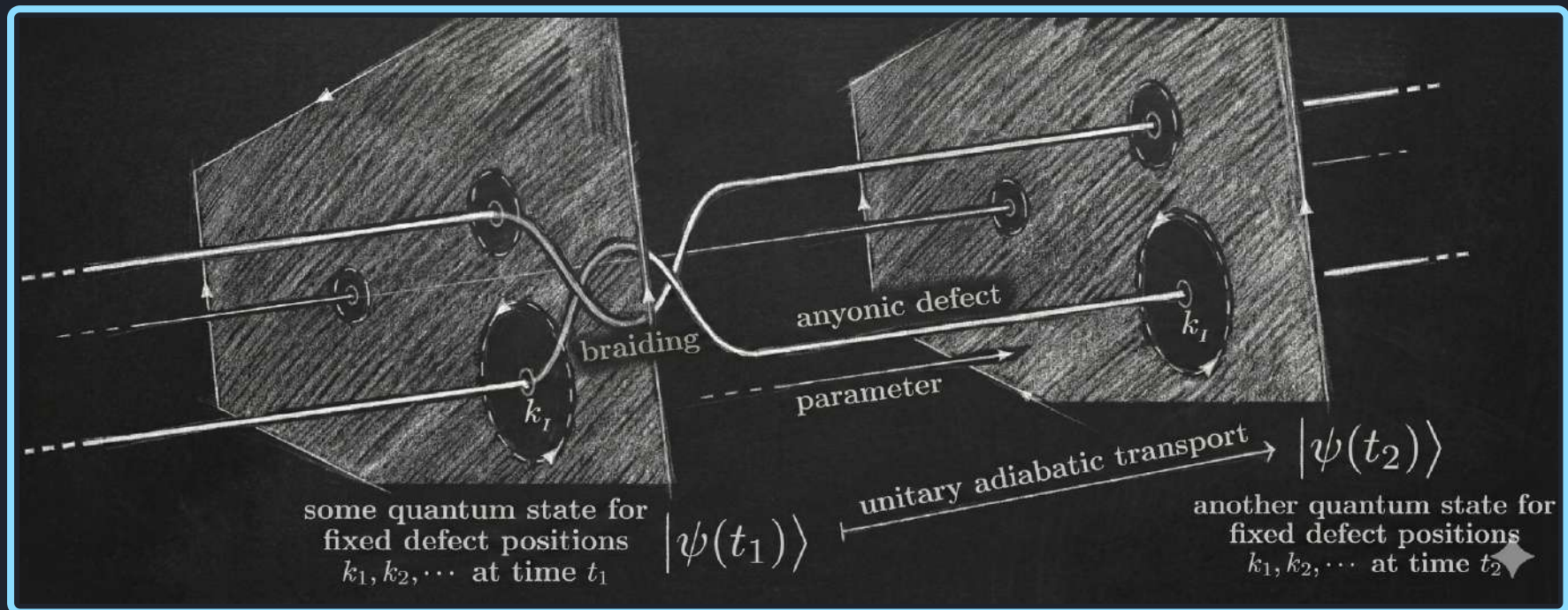


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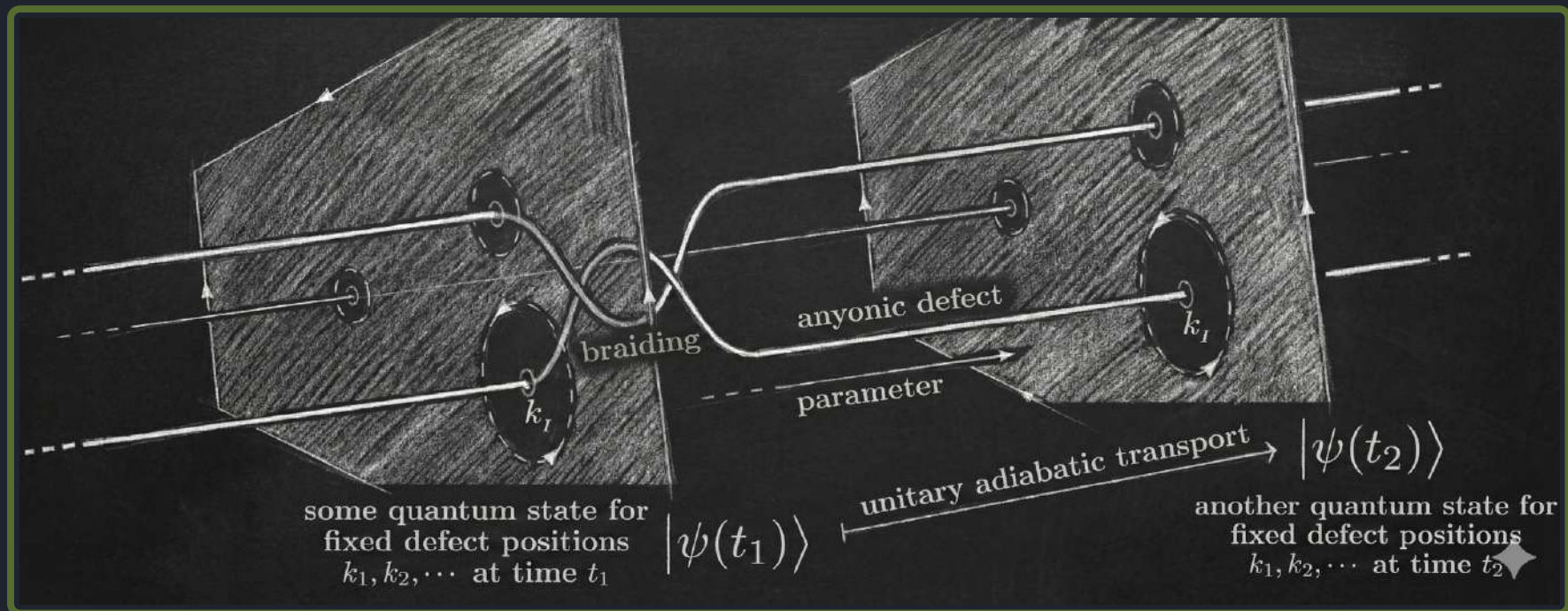
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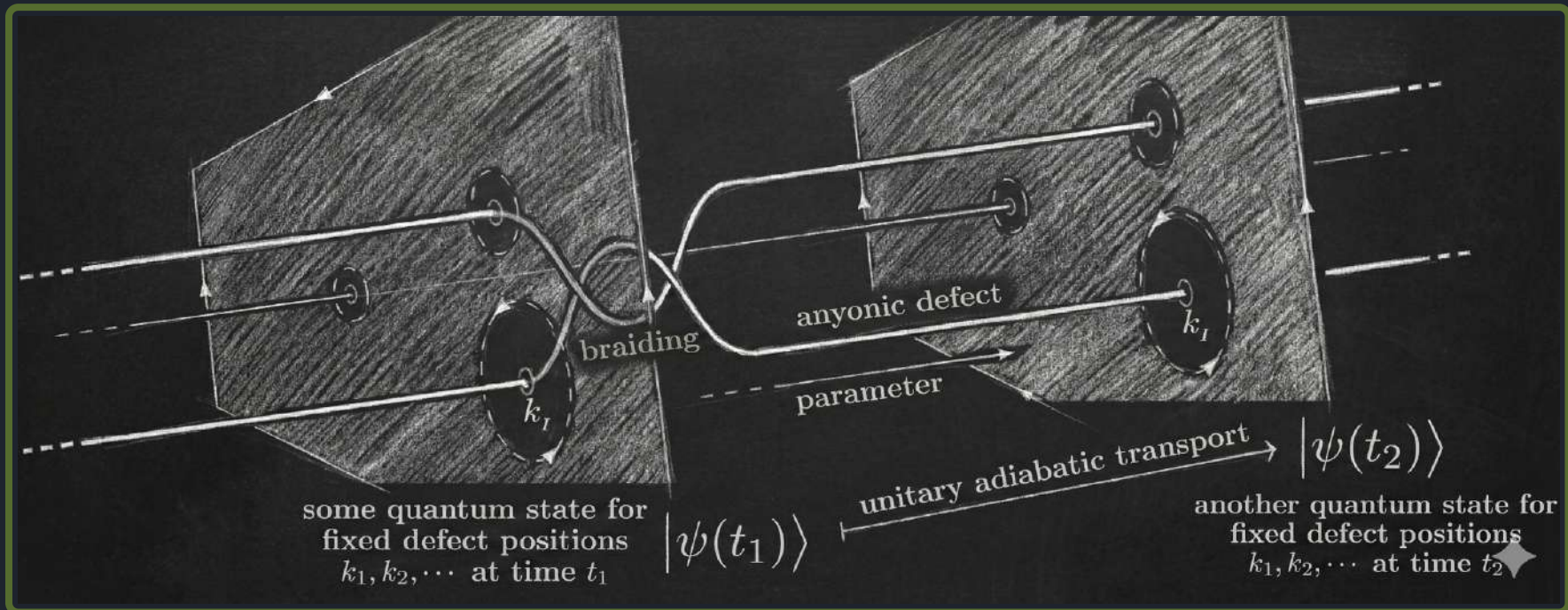


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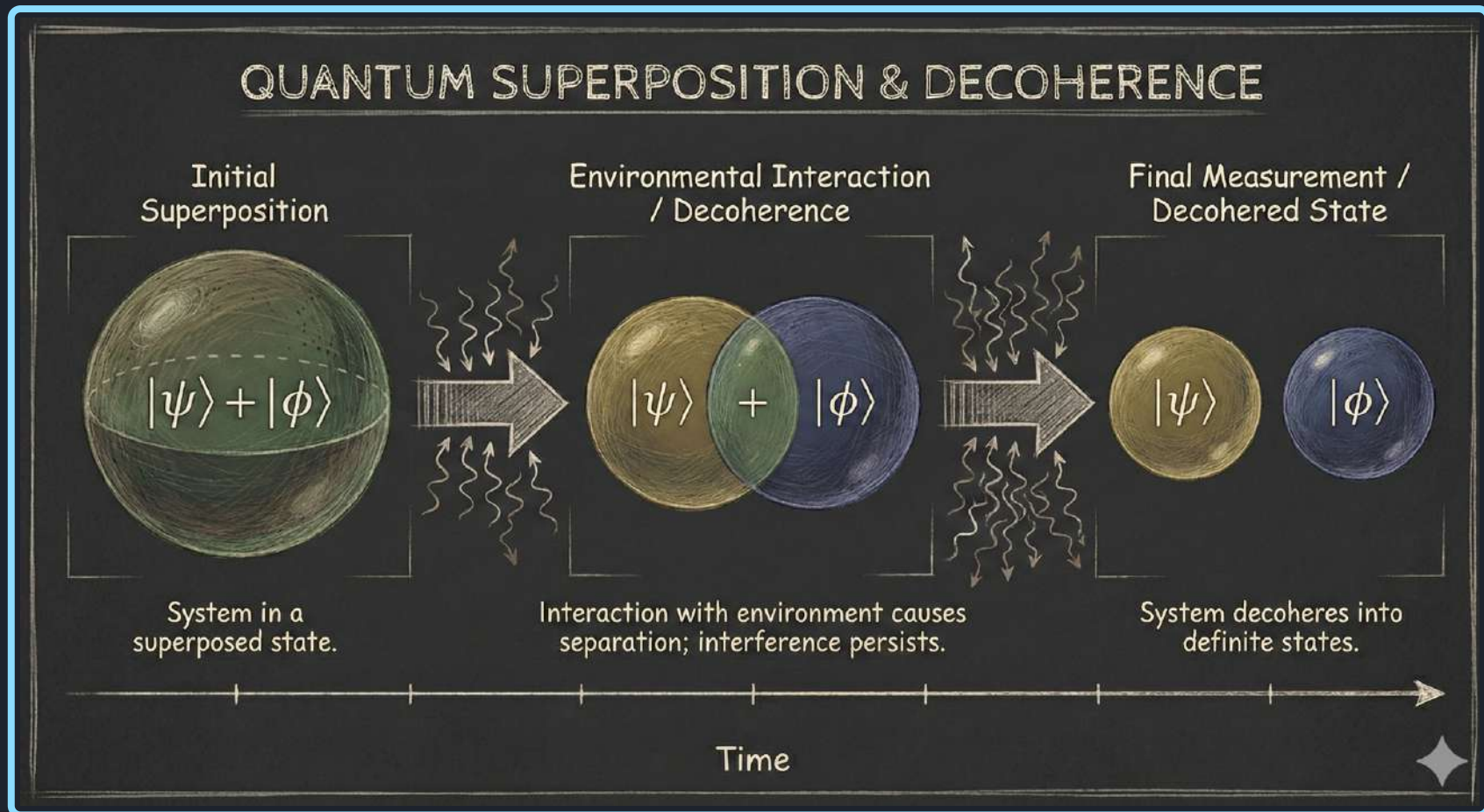
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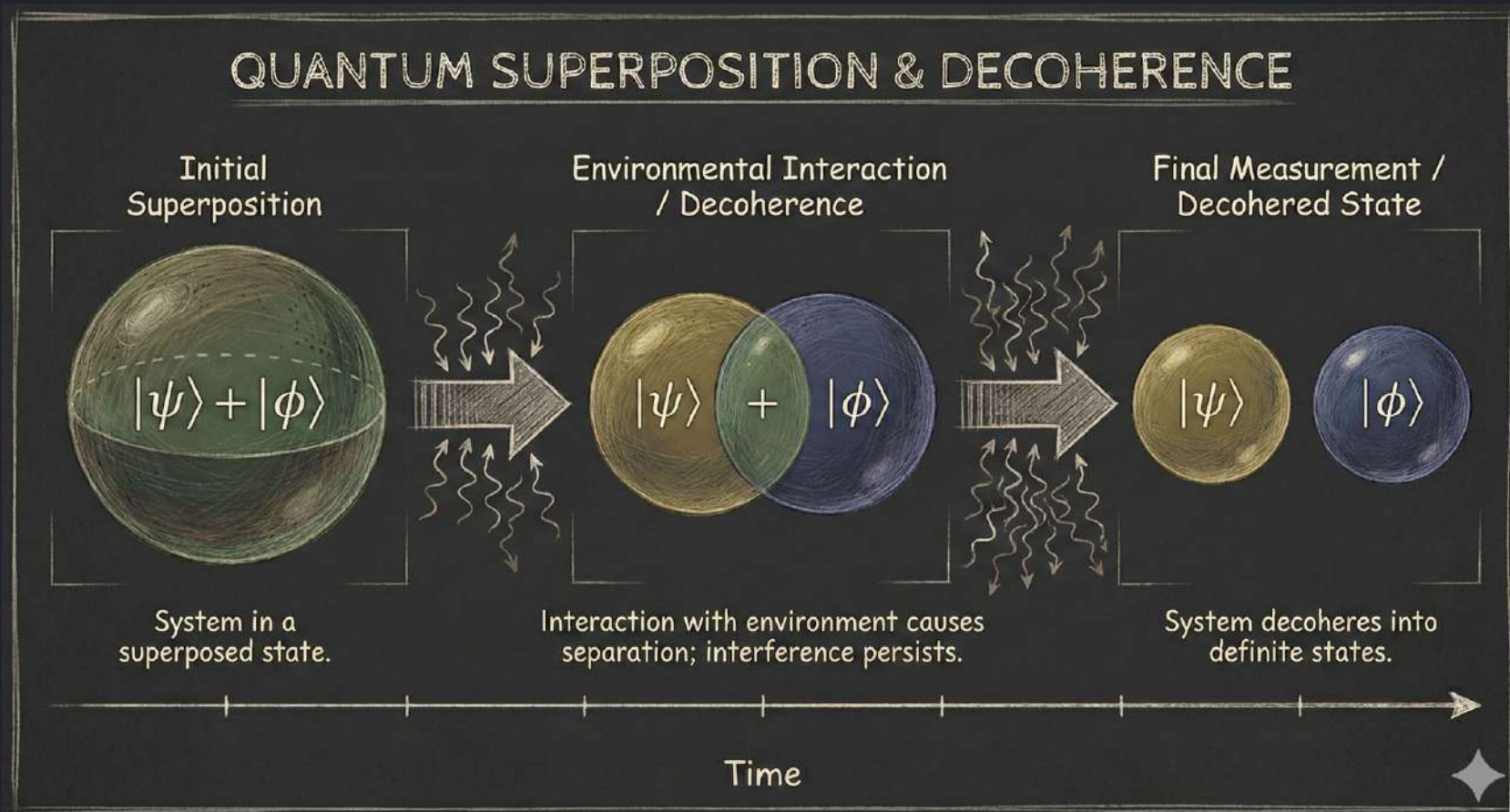
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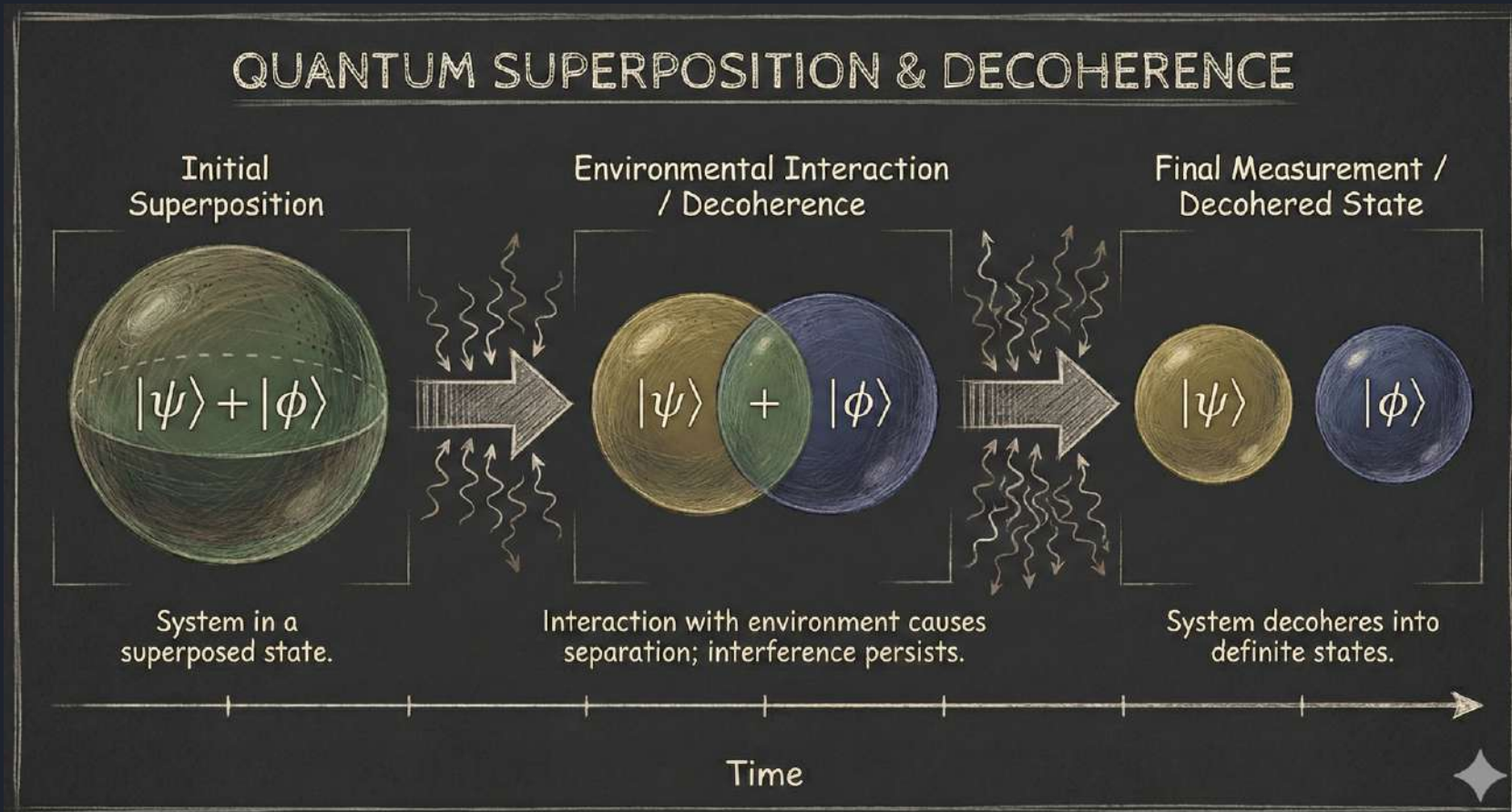


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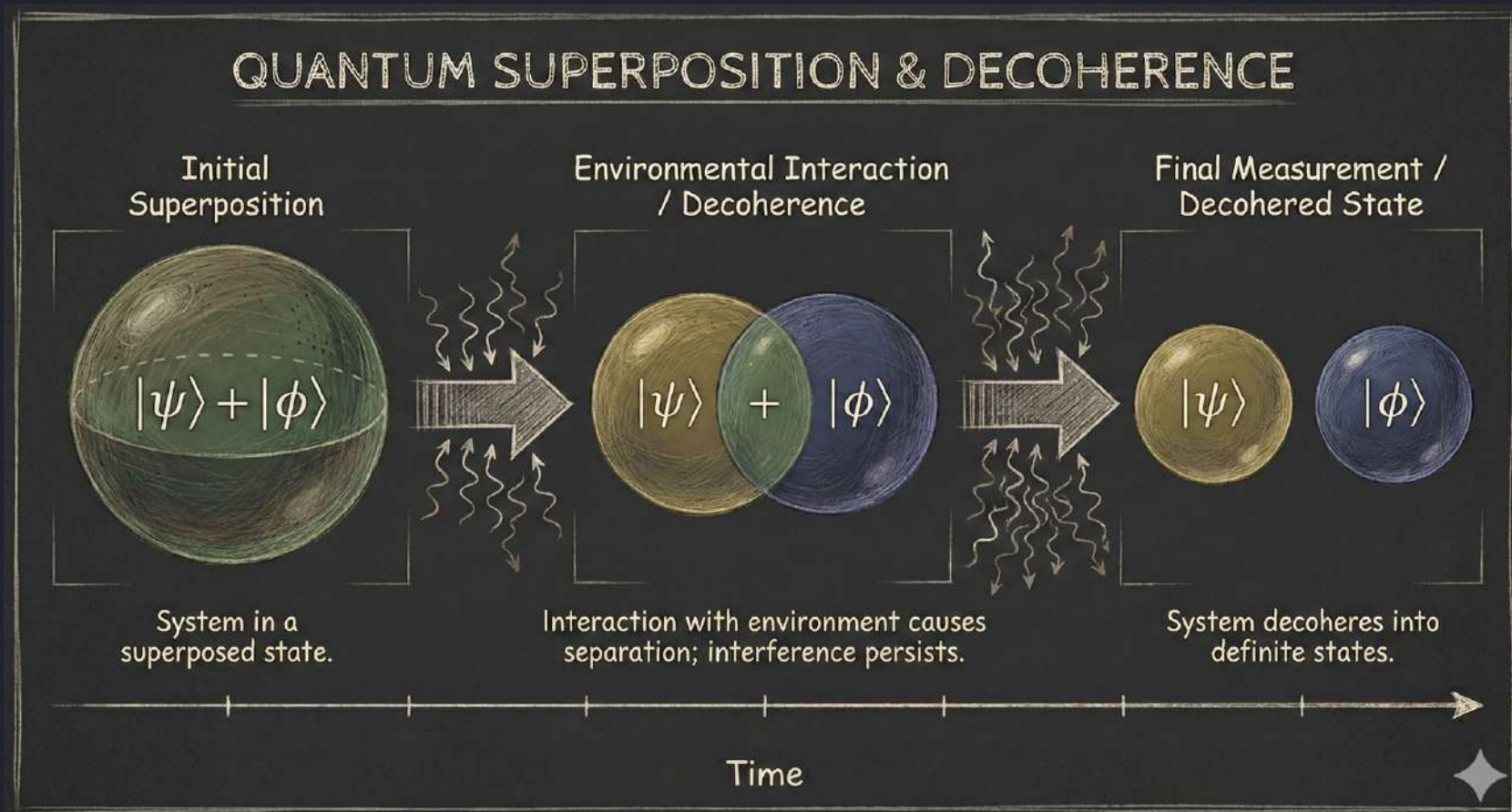
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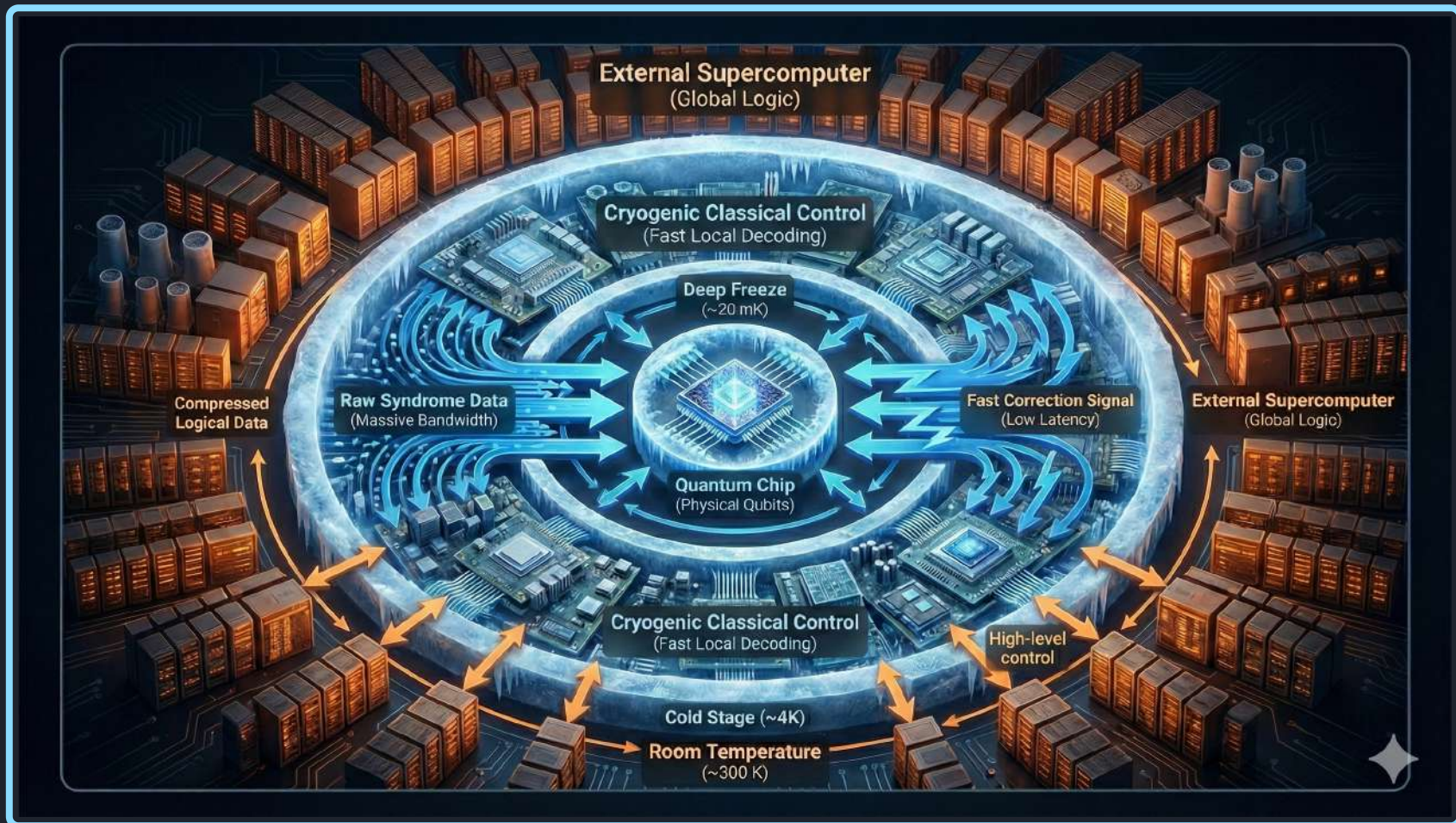
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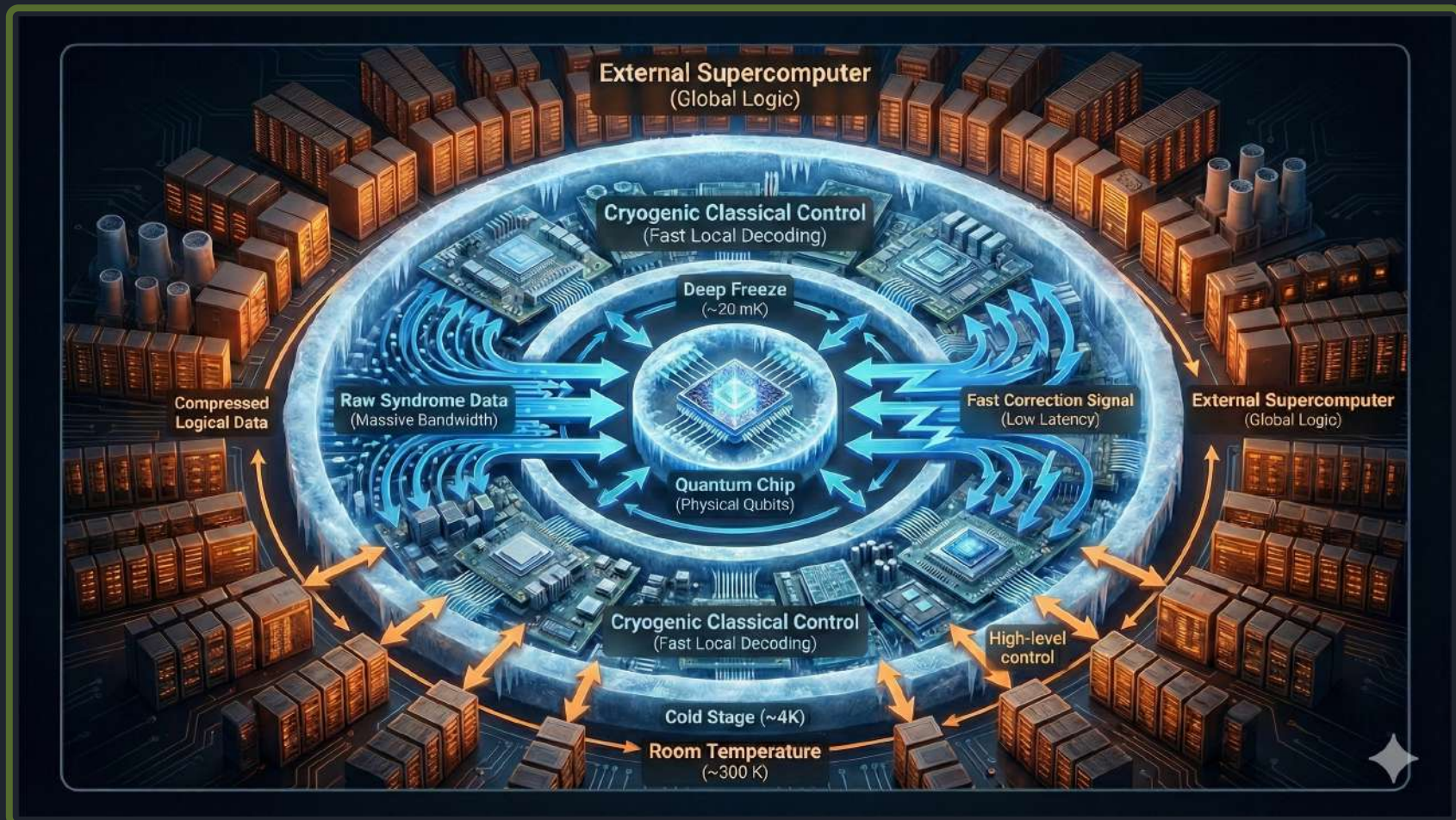
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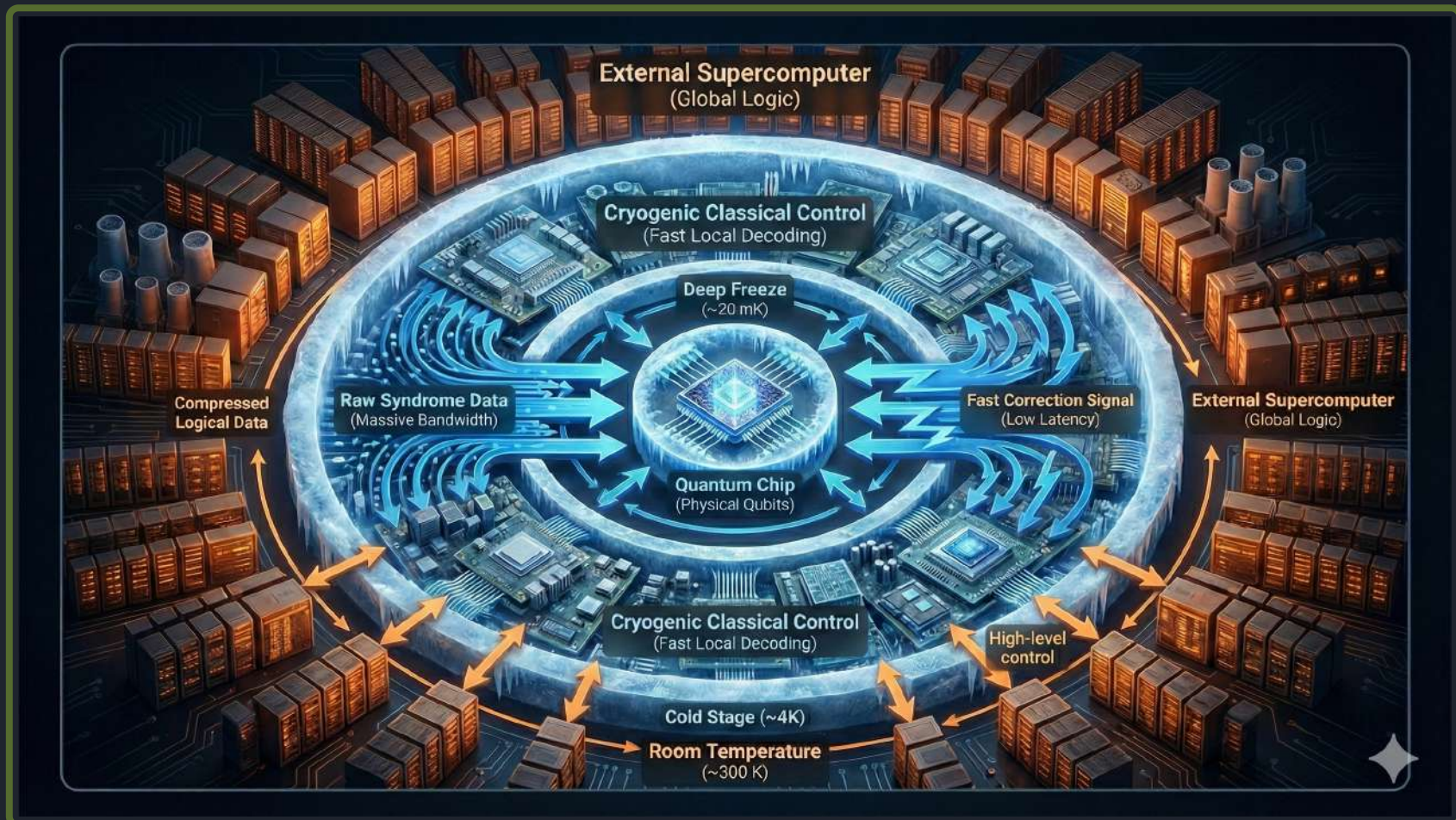
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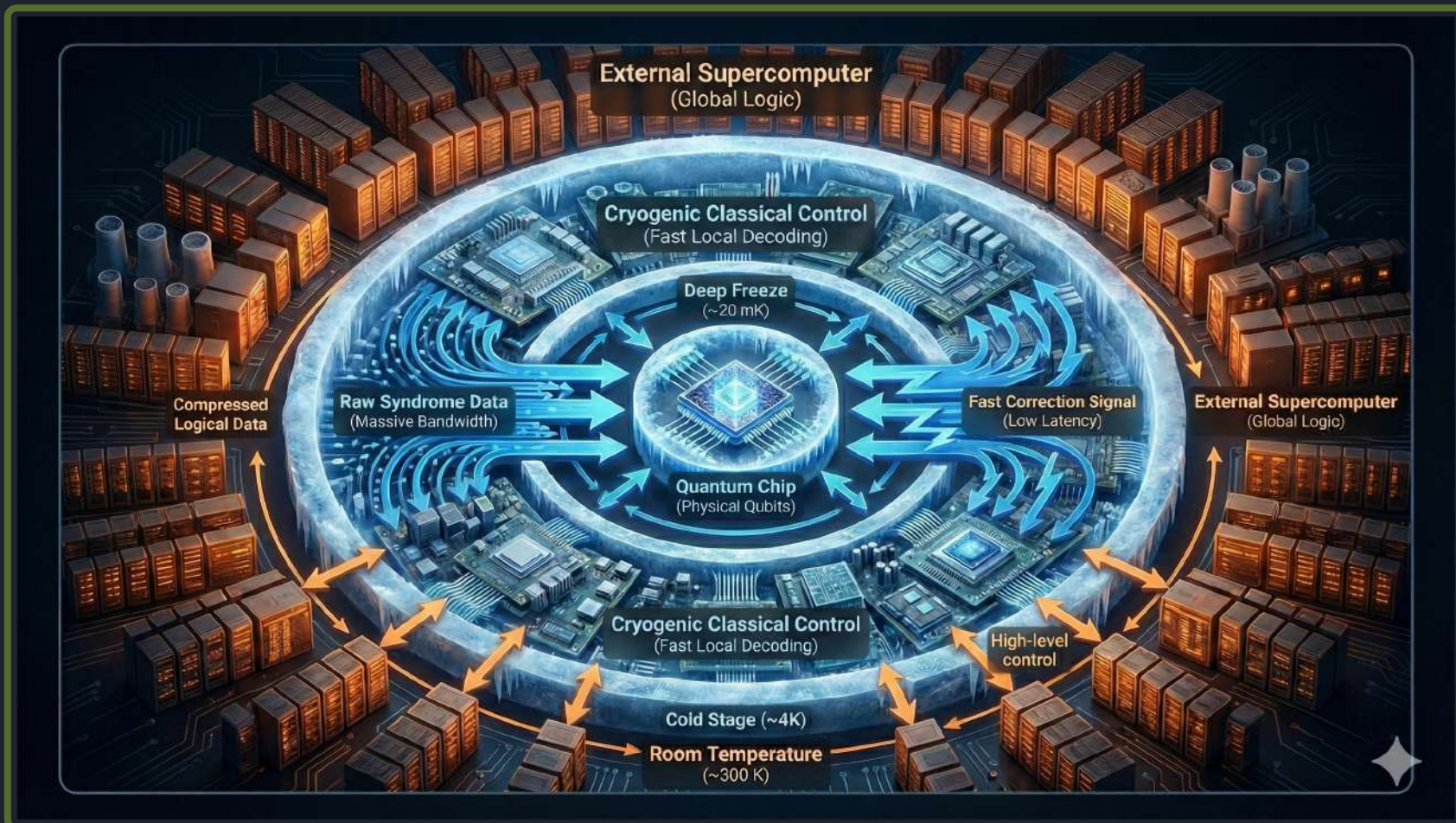
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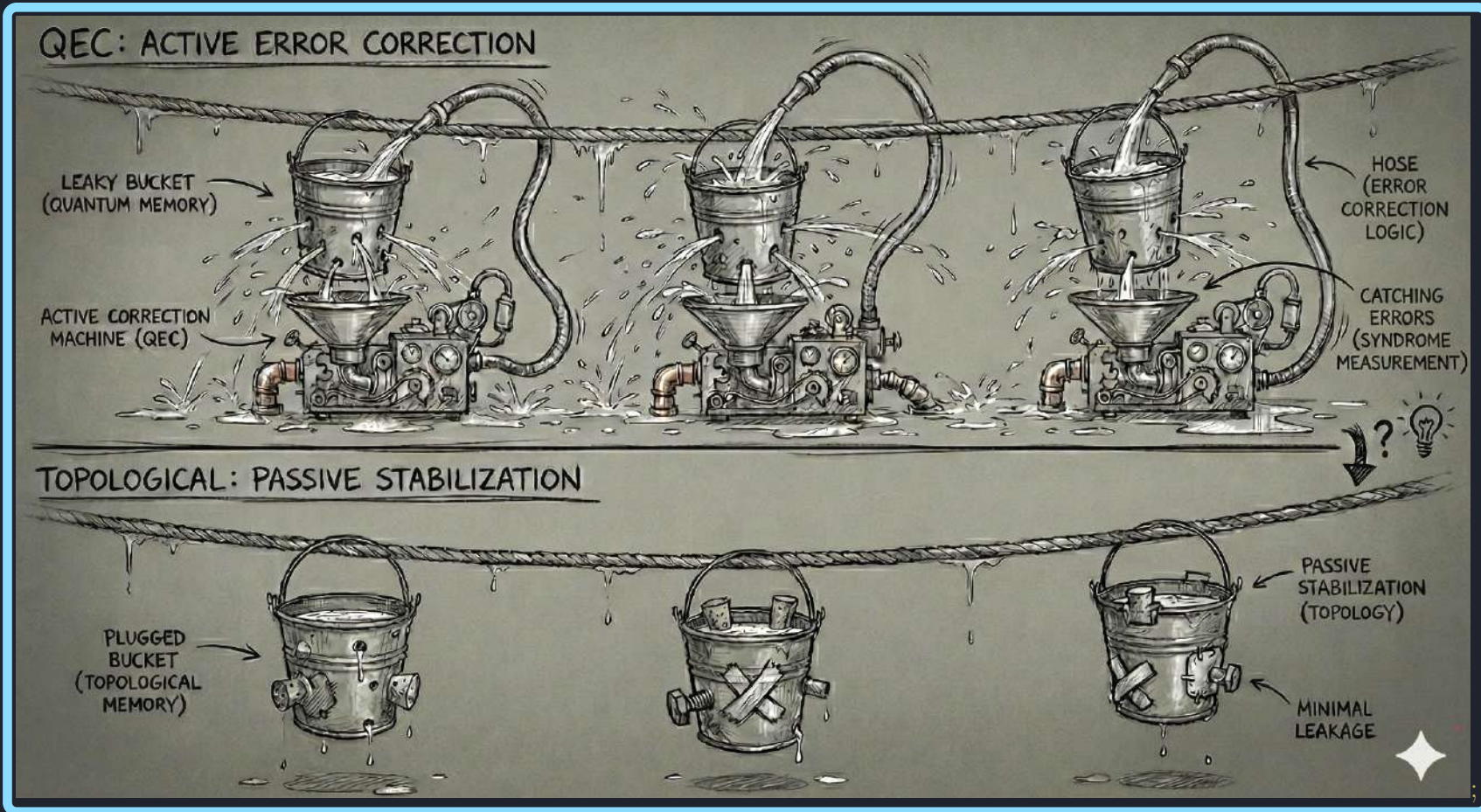
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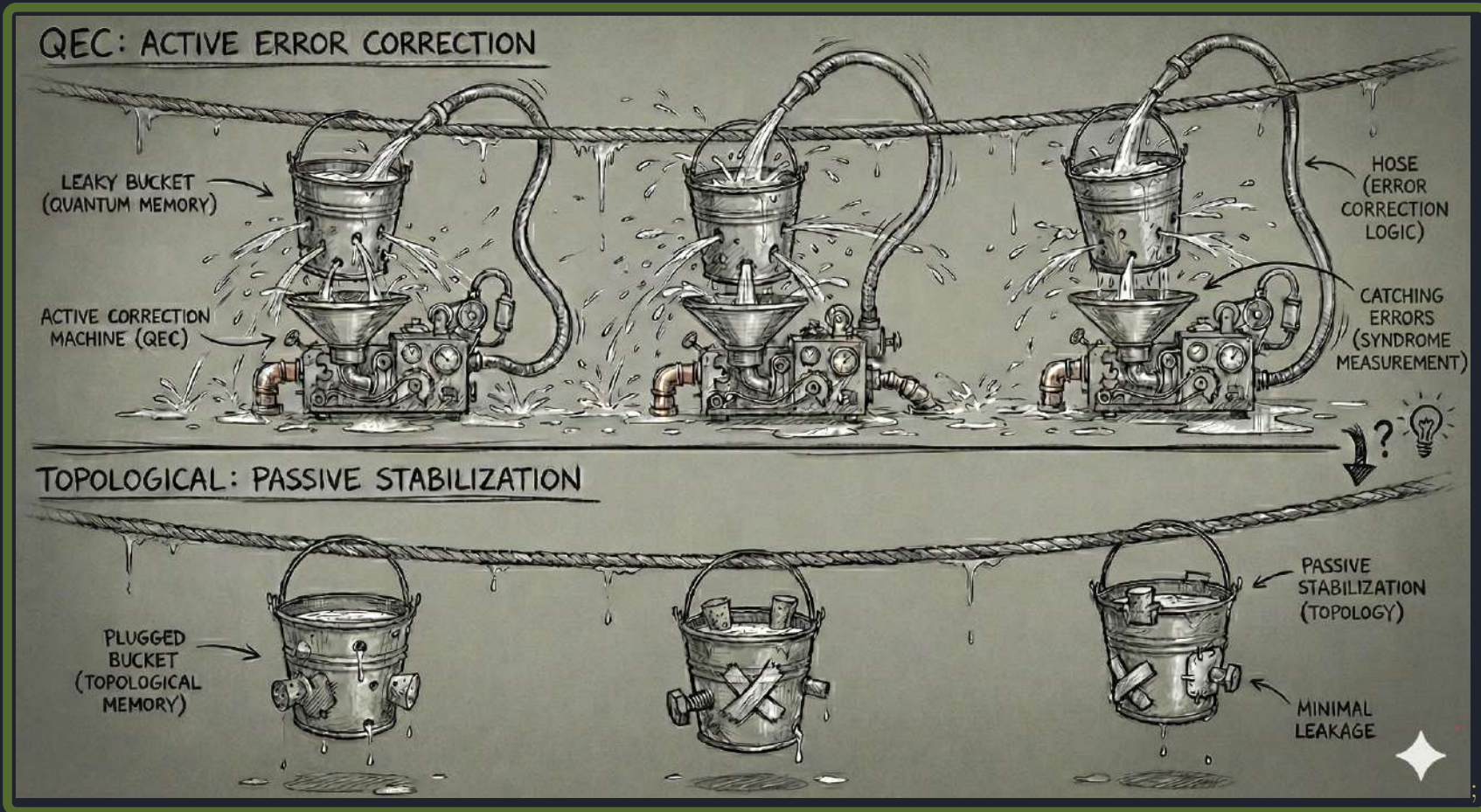
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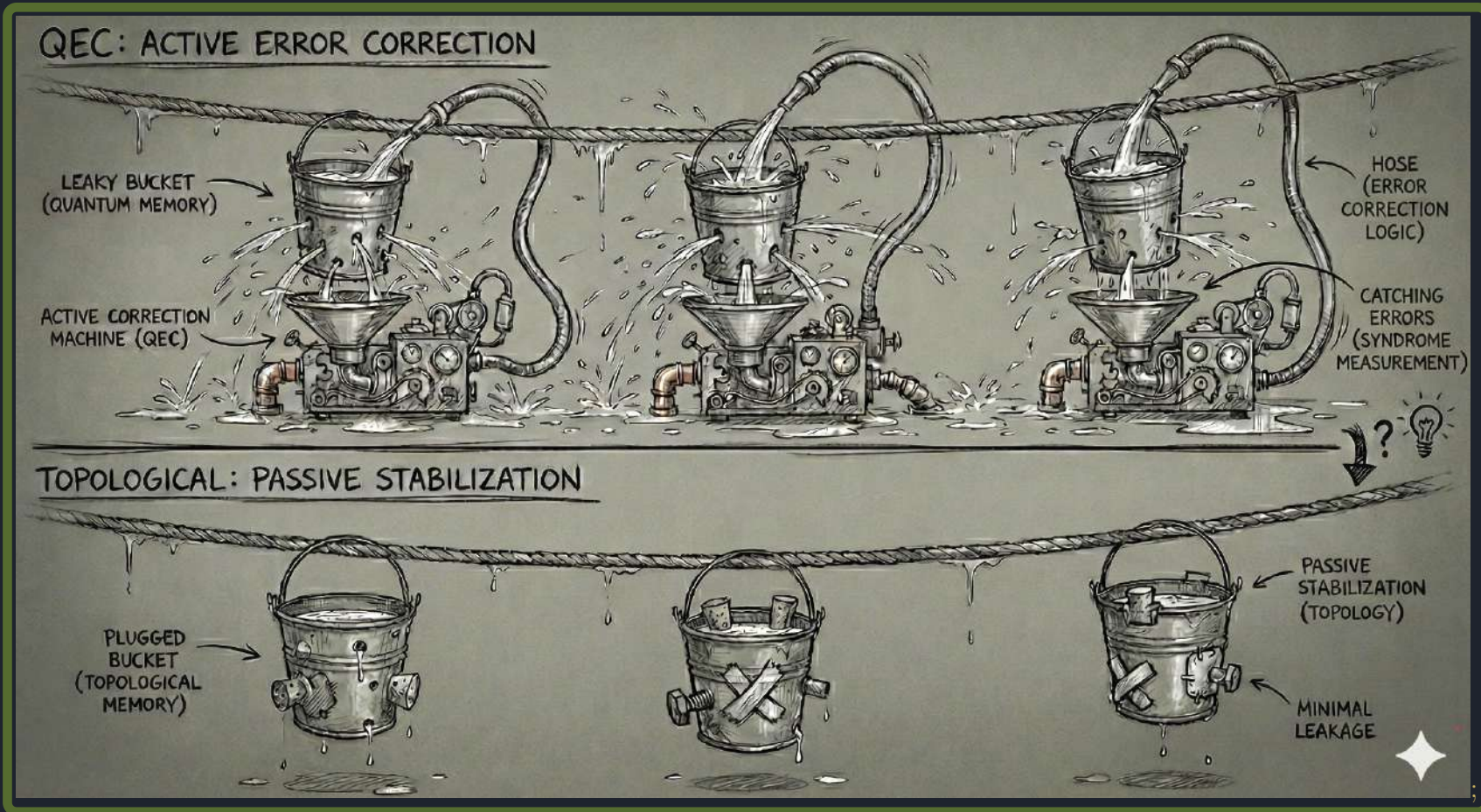


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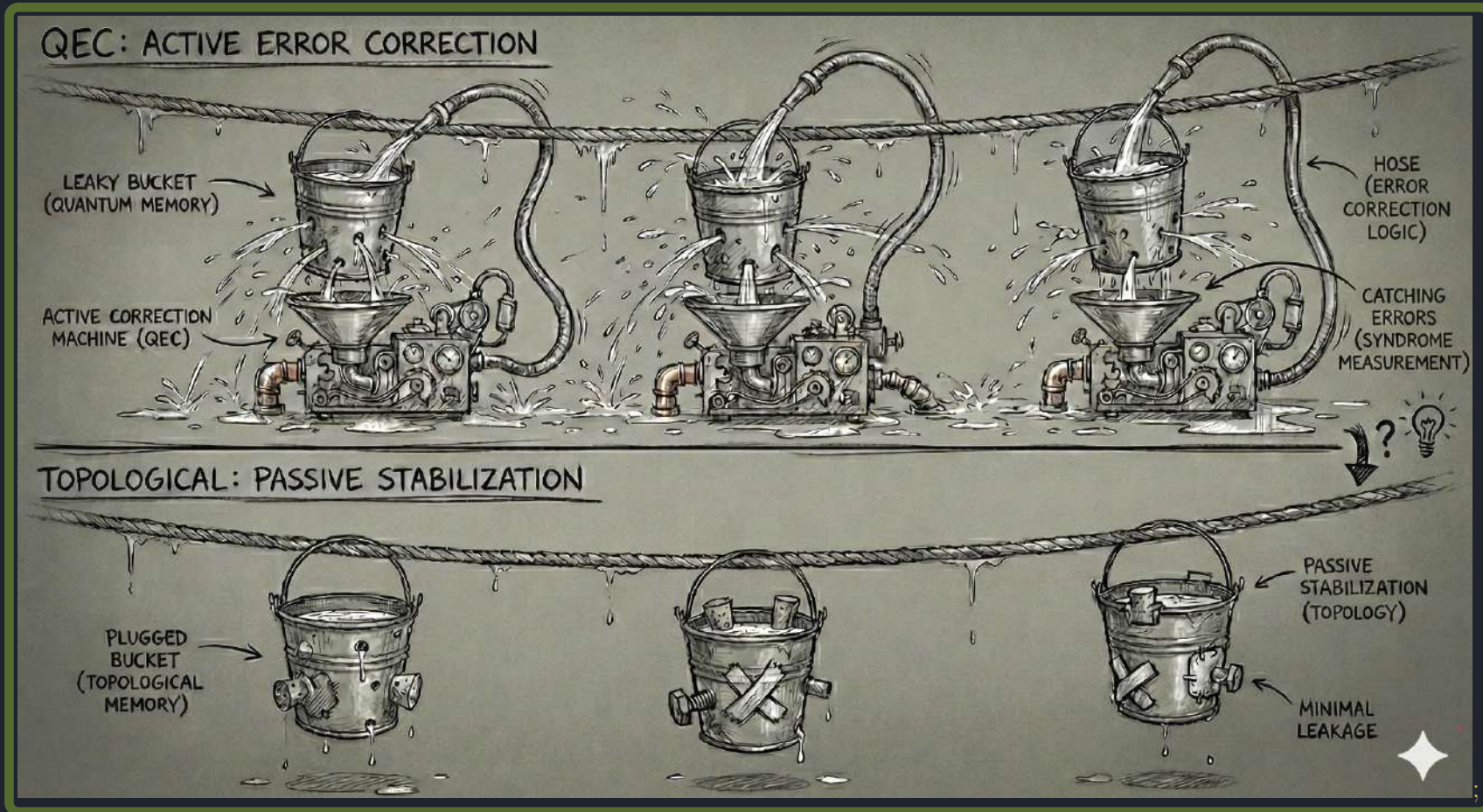
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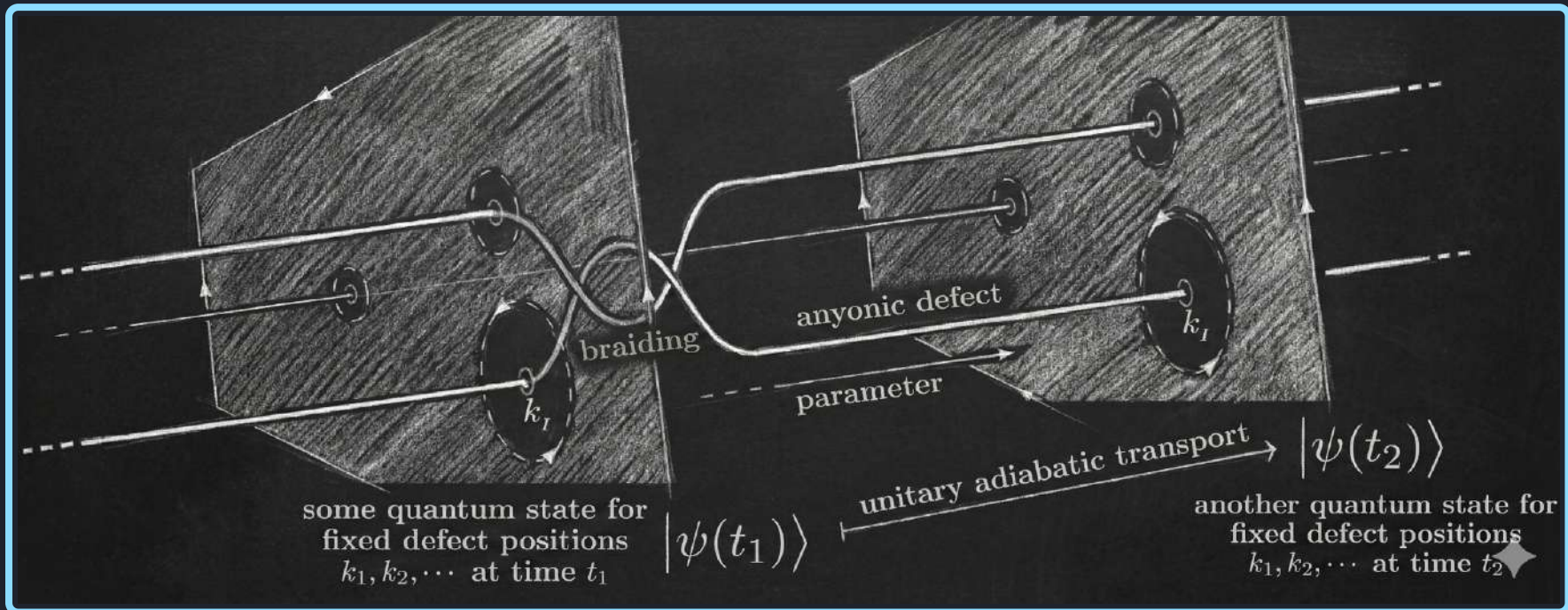


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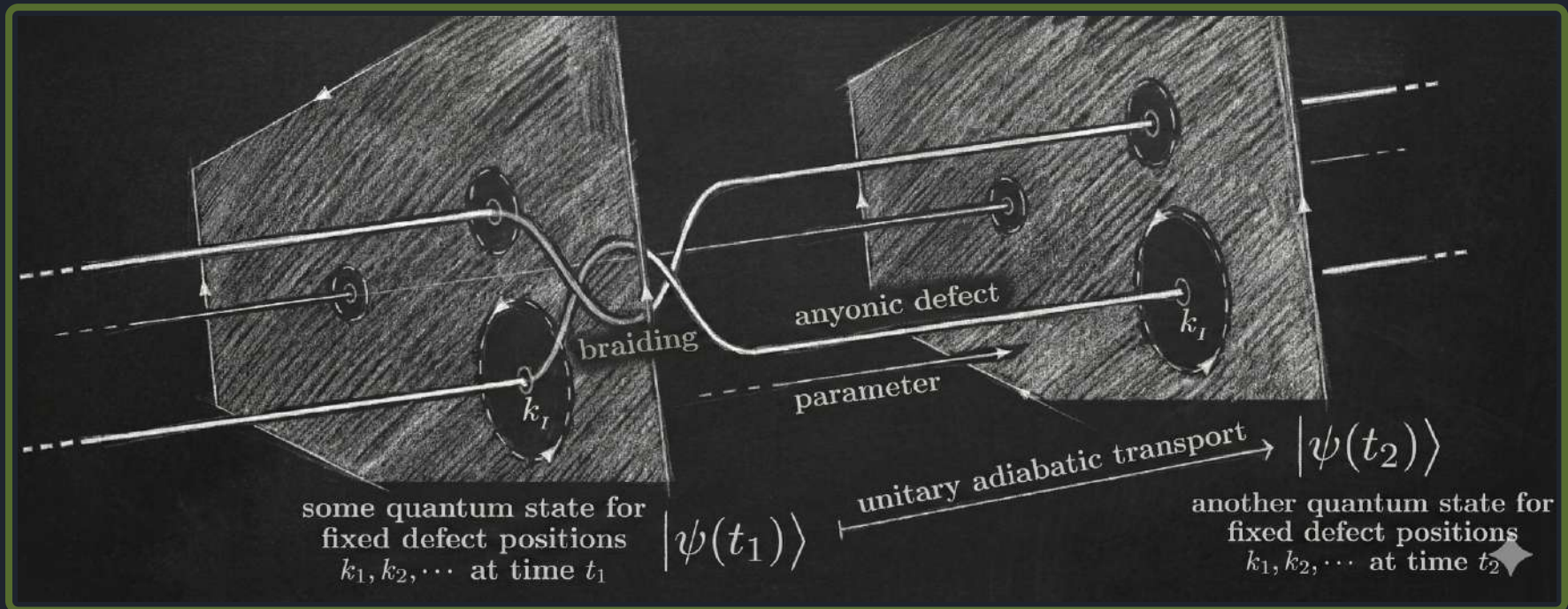
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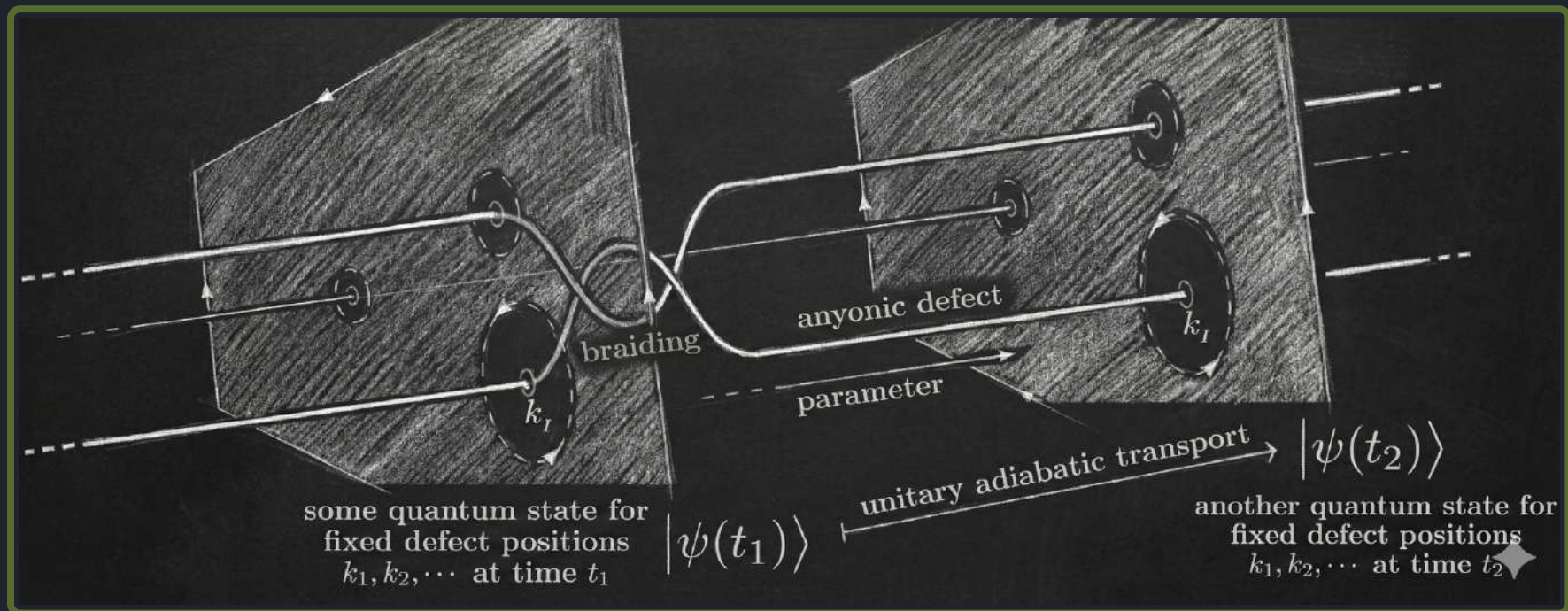


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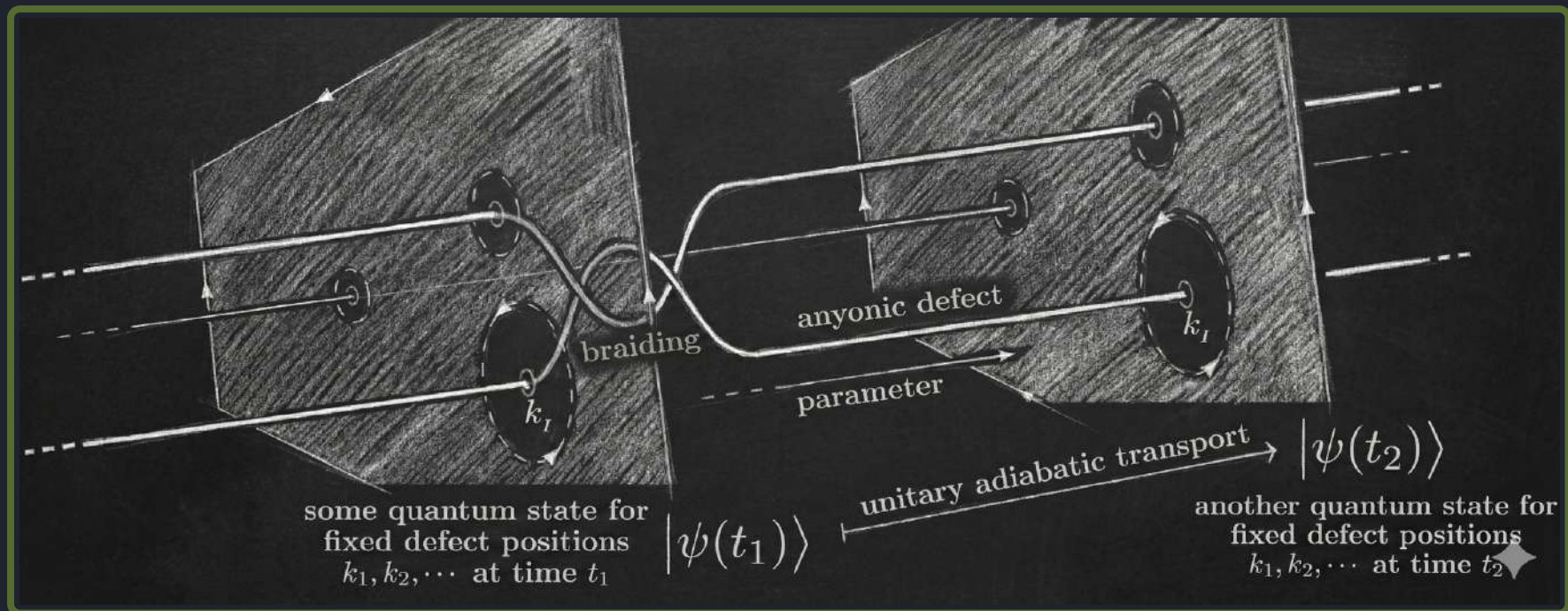
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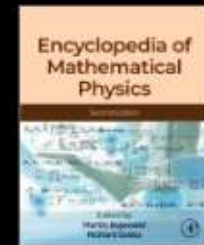
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Encyclopedia of Mathematical Physics (Second Edition)

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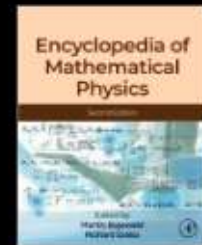
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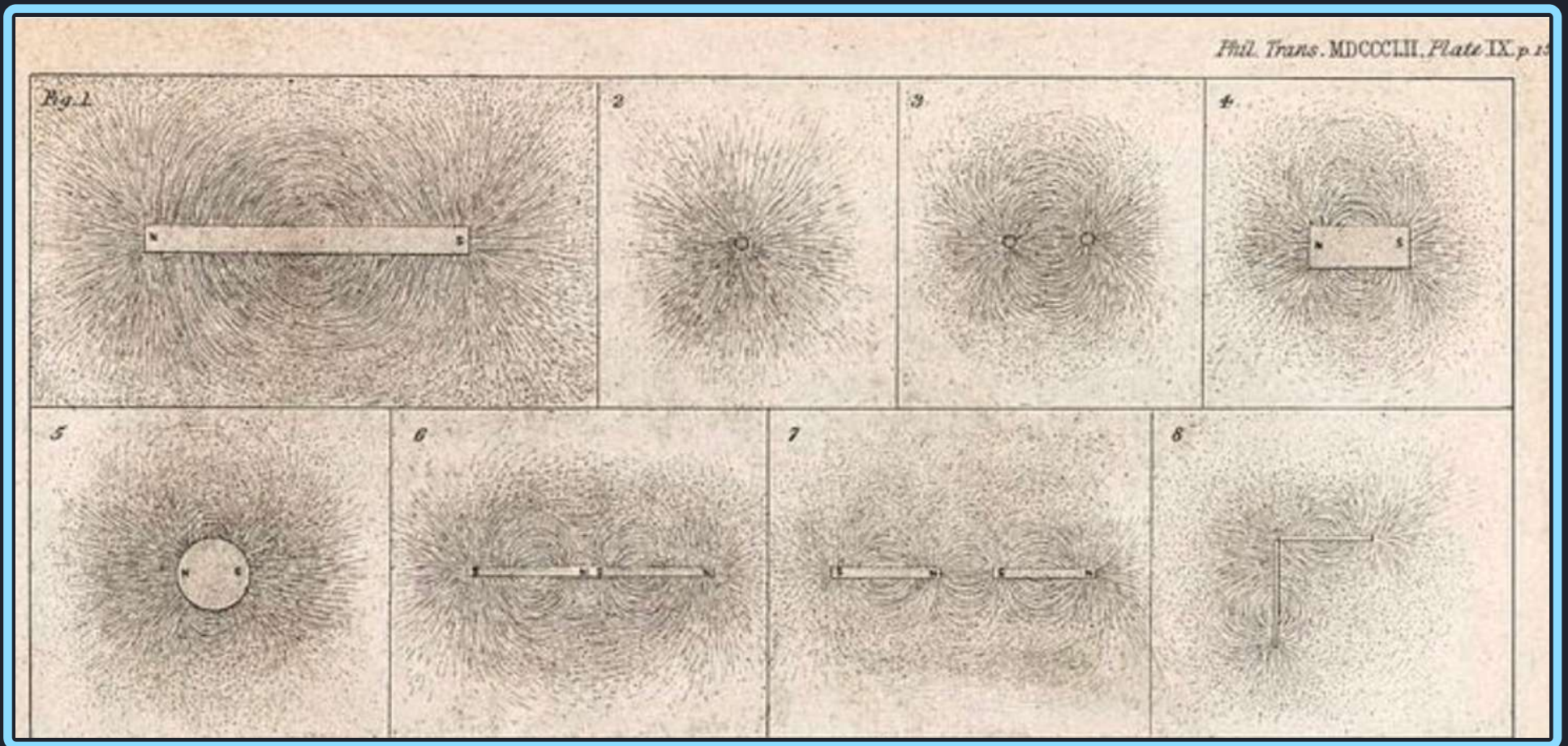


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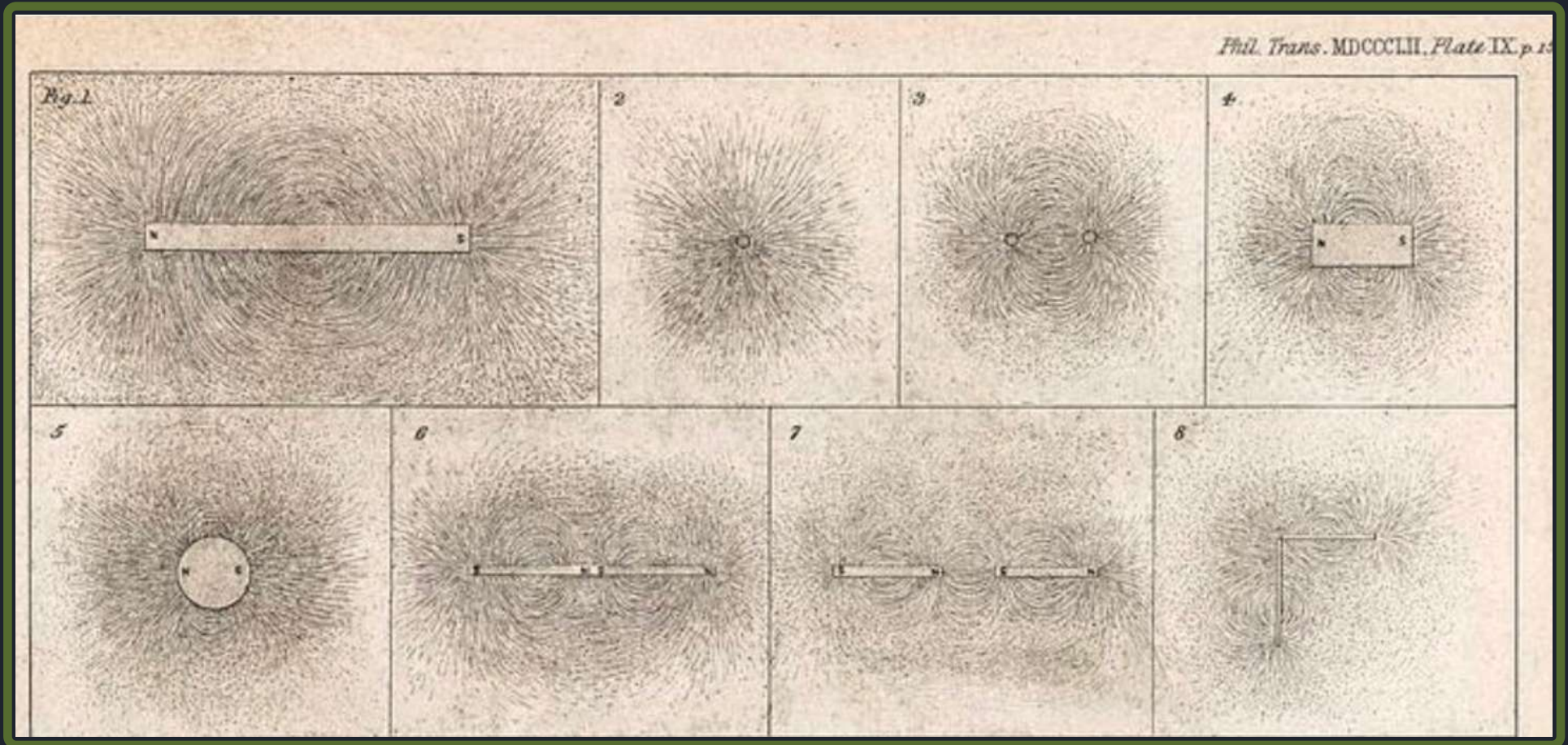
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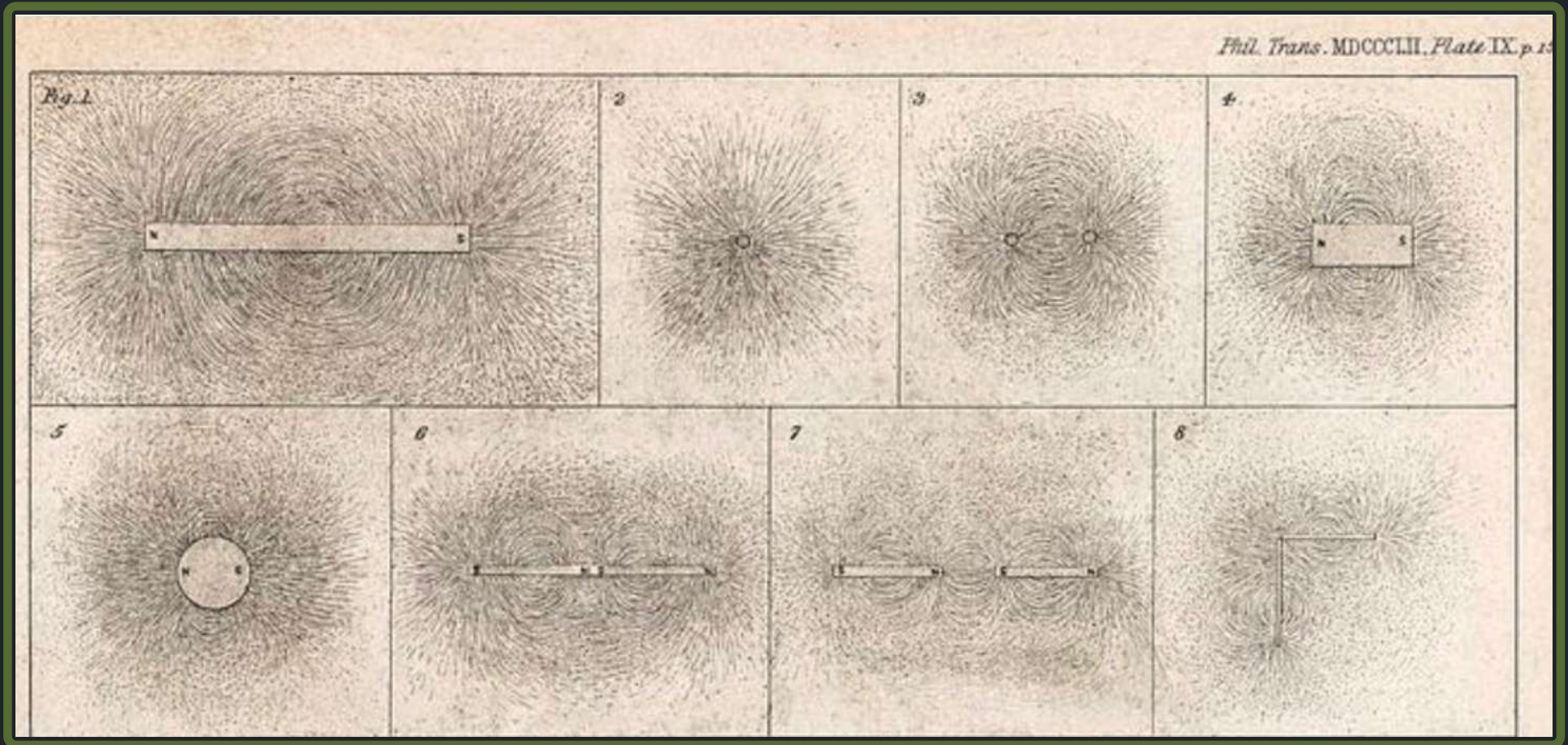


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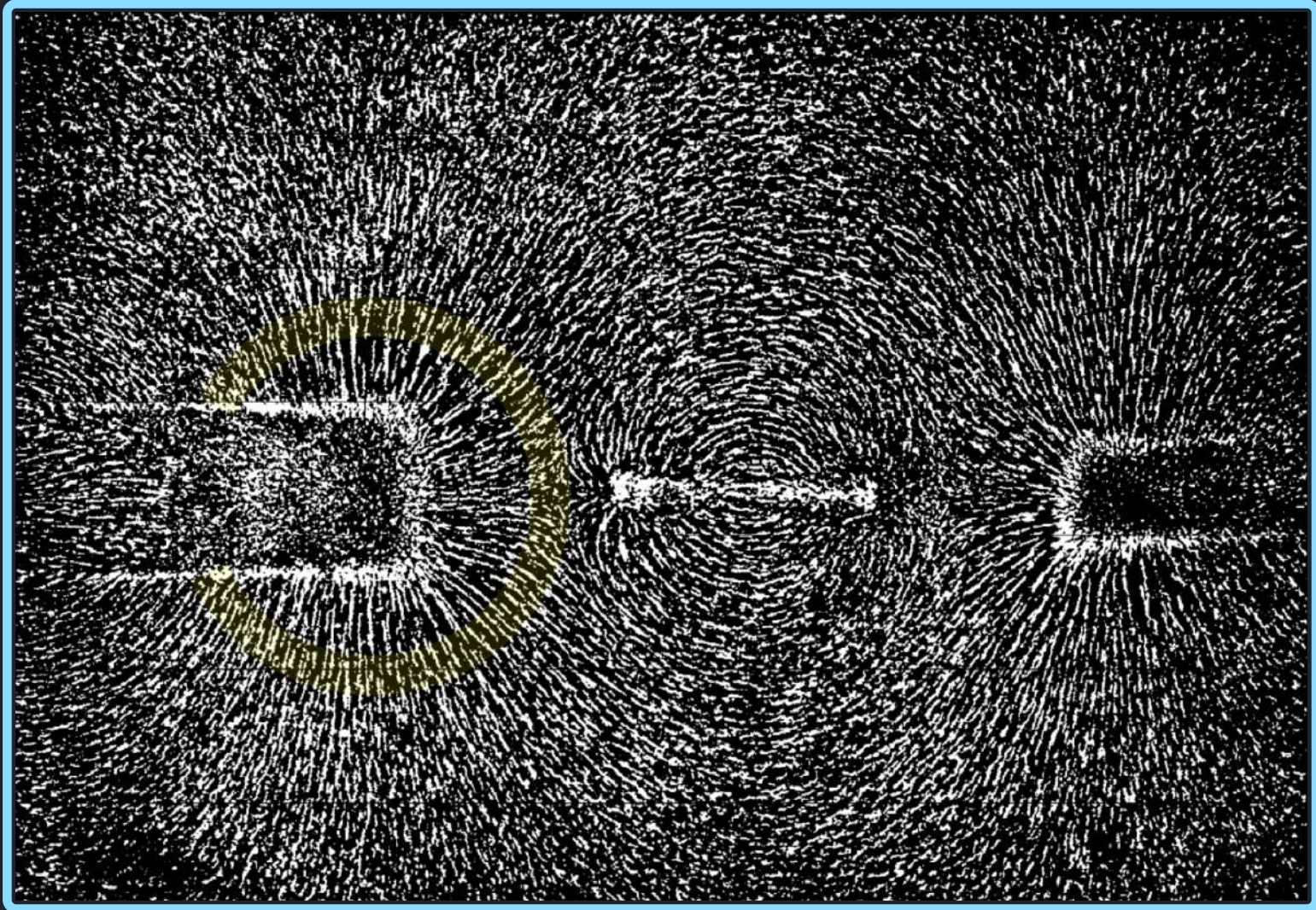
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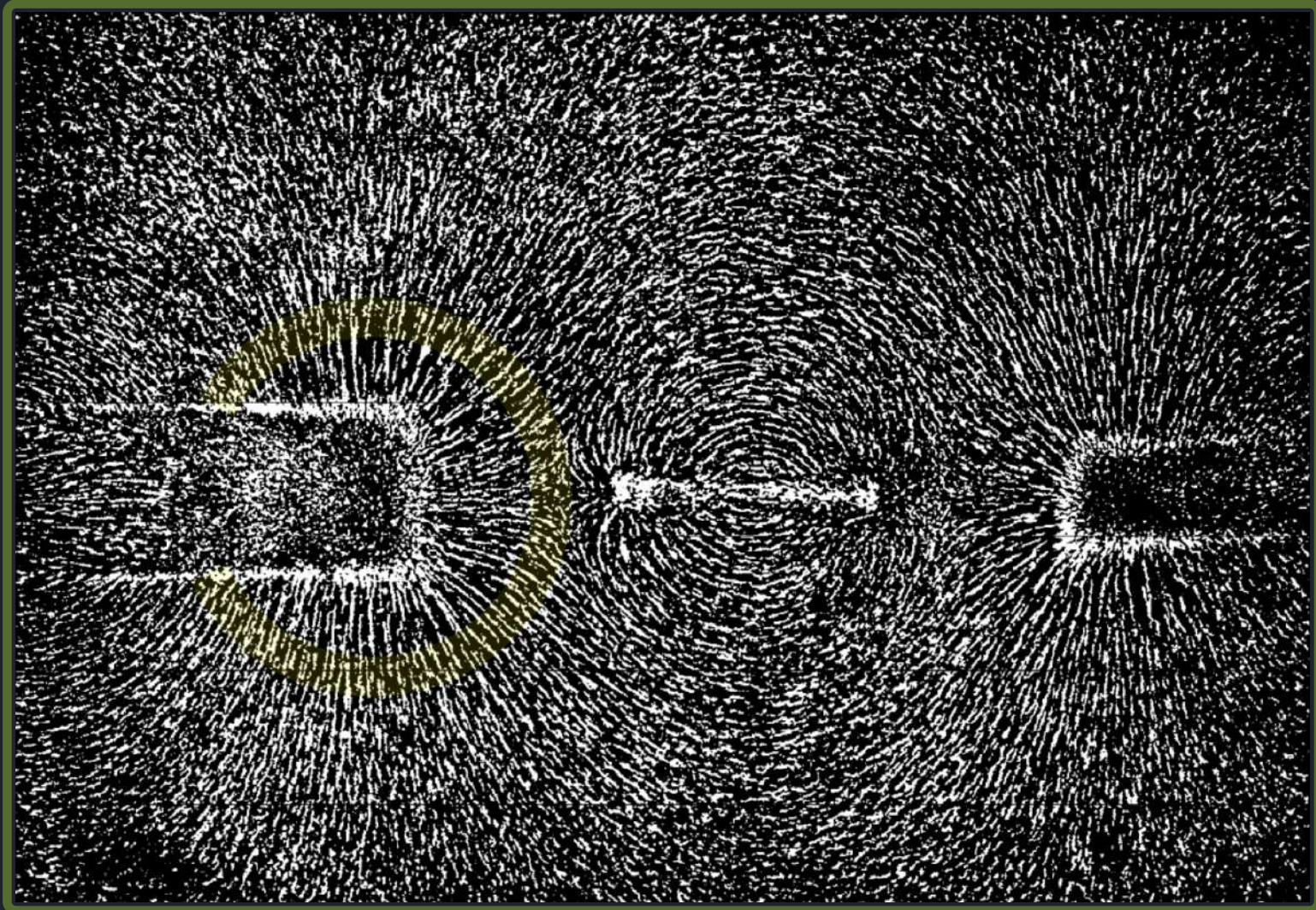
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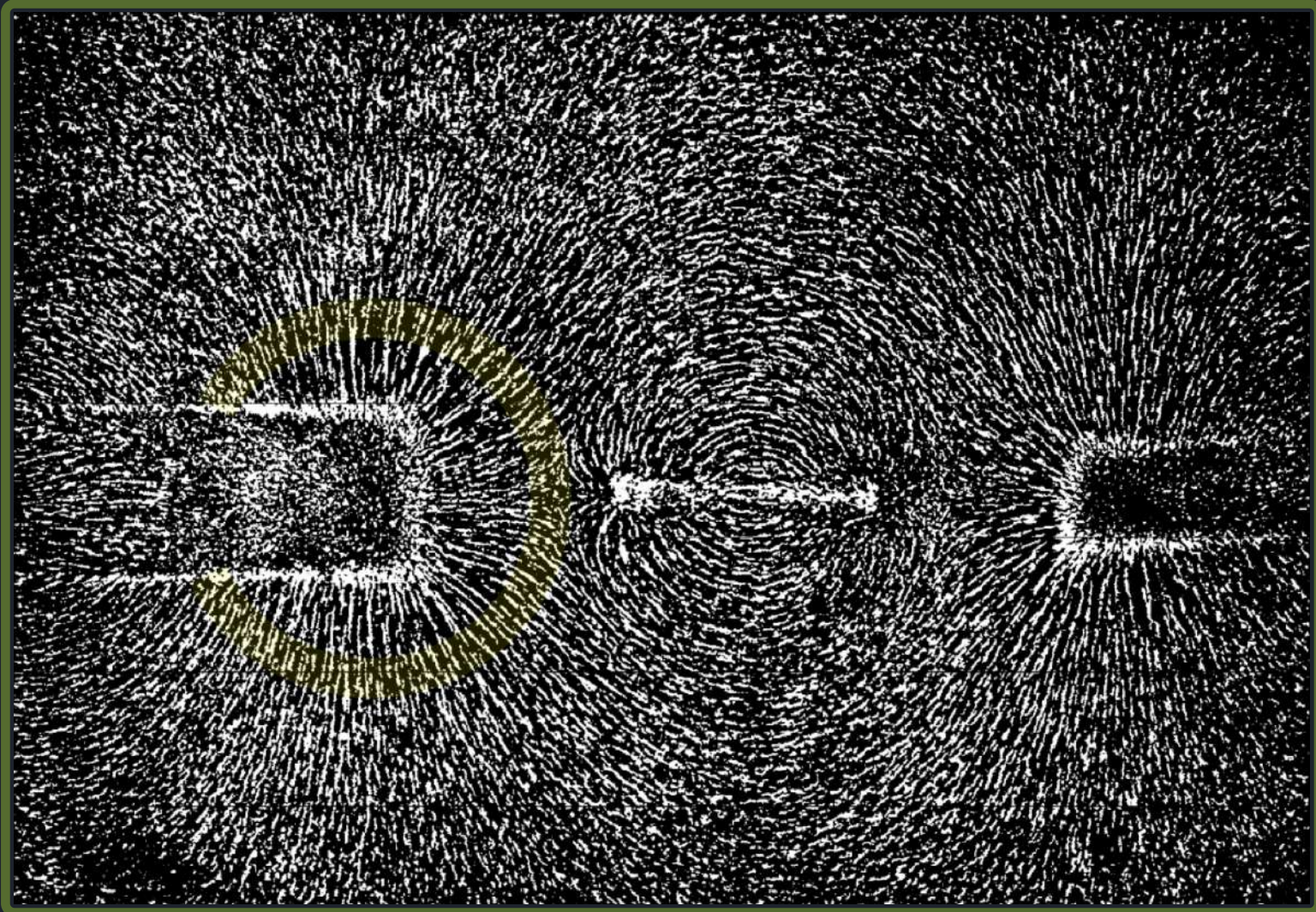
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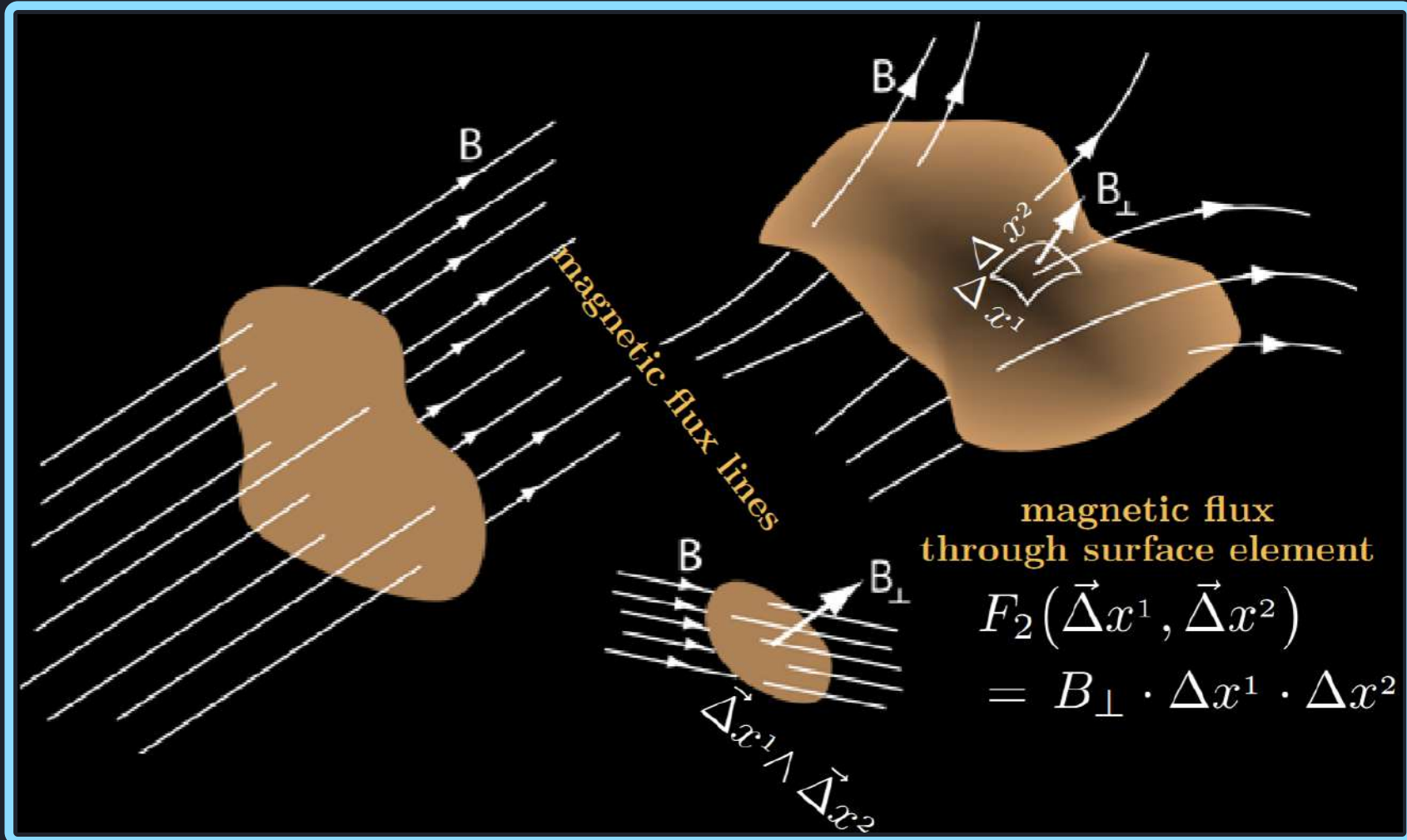


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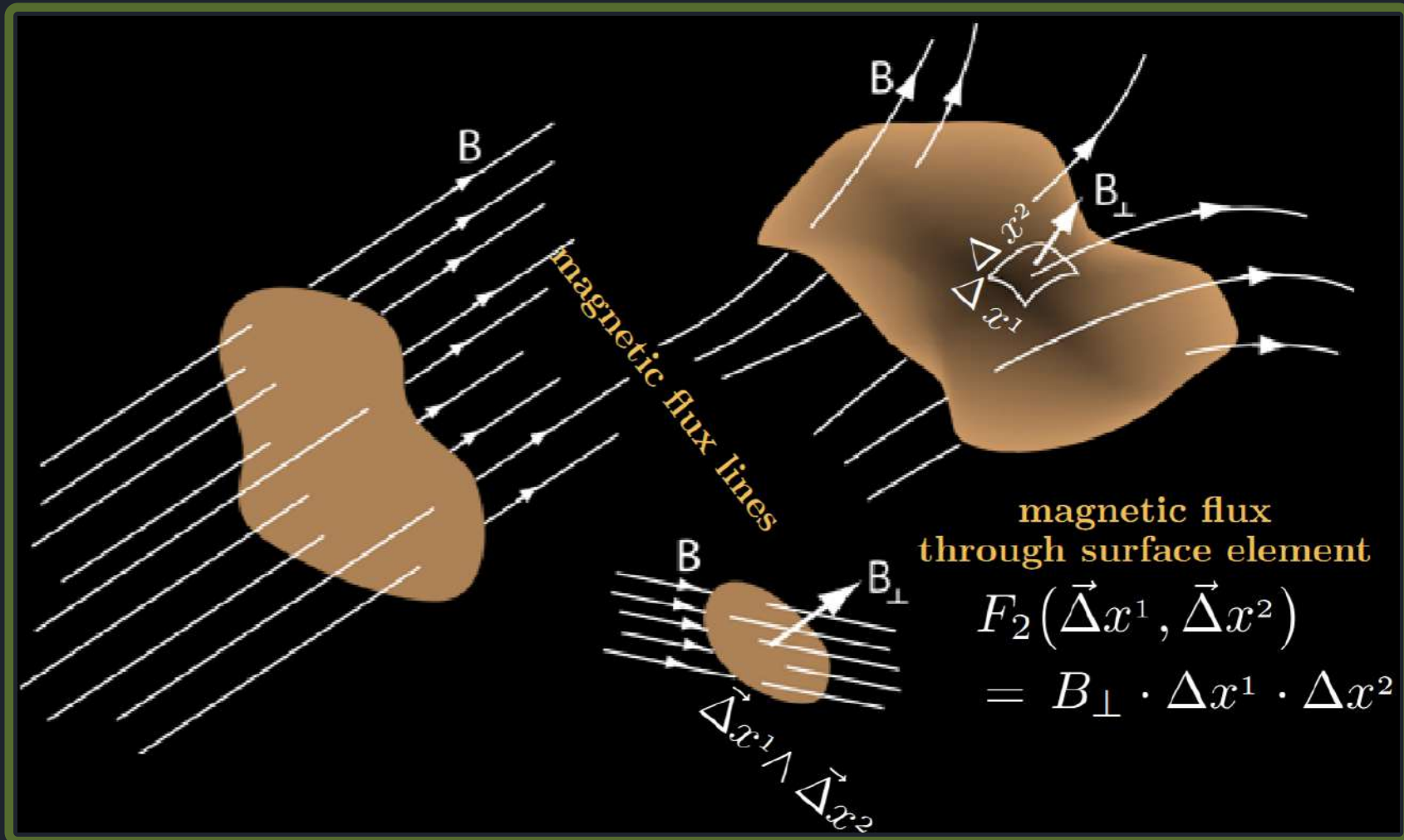
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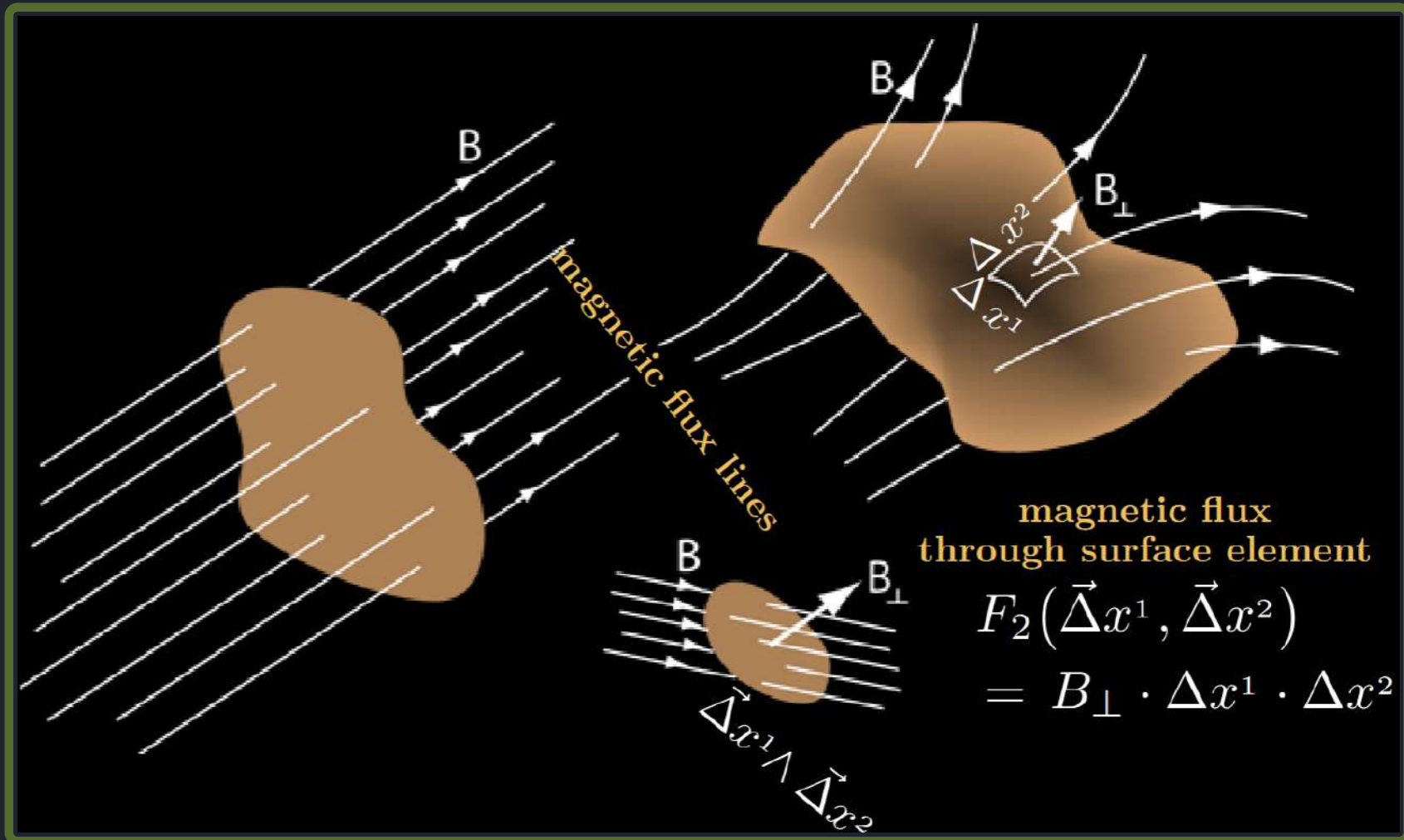


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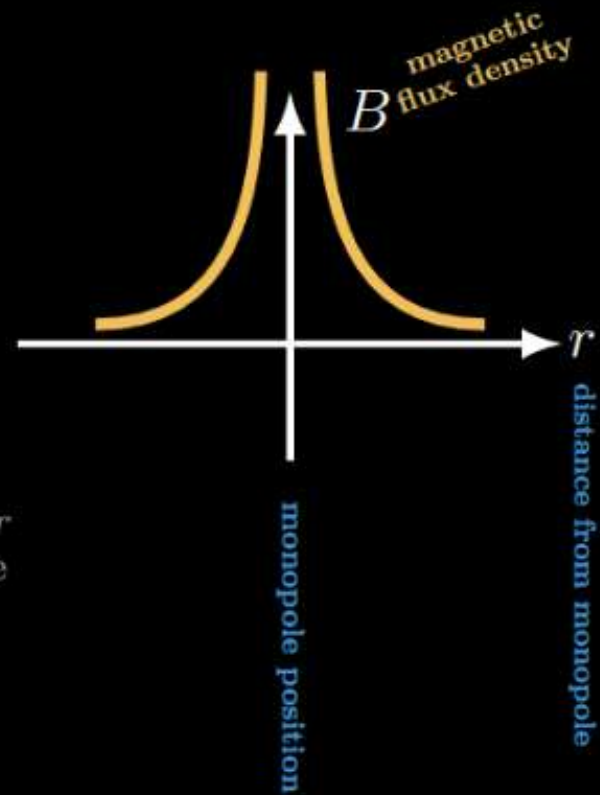
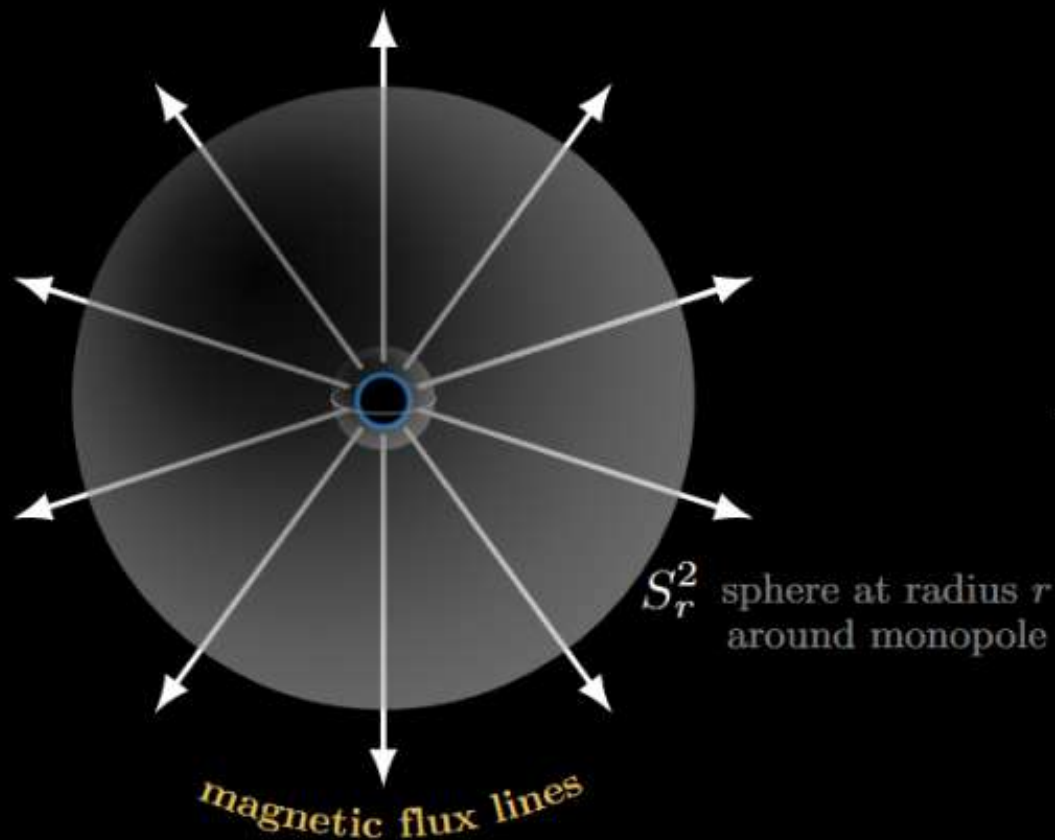
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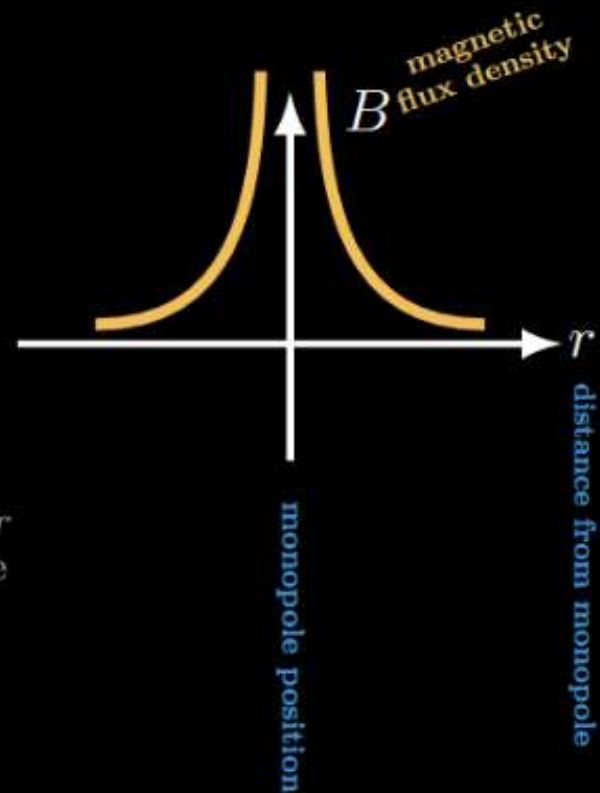
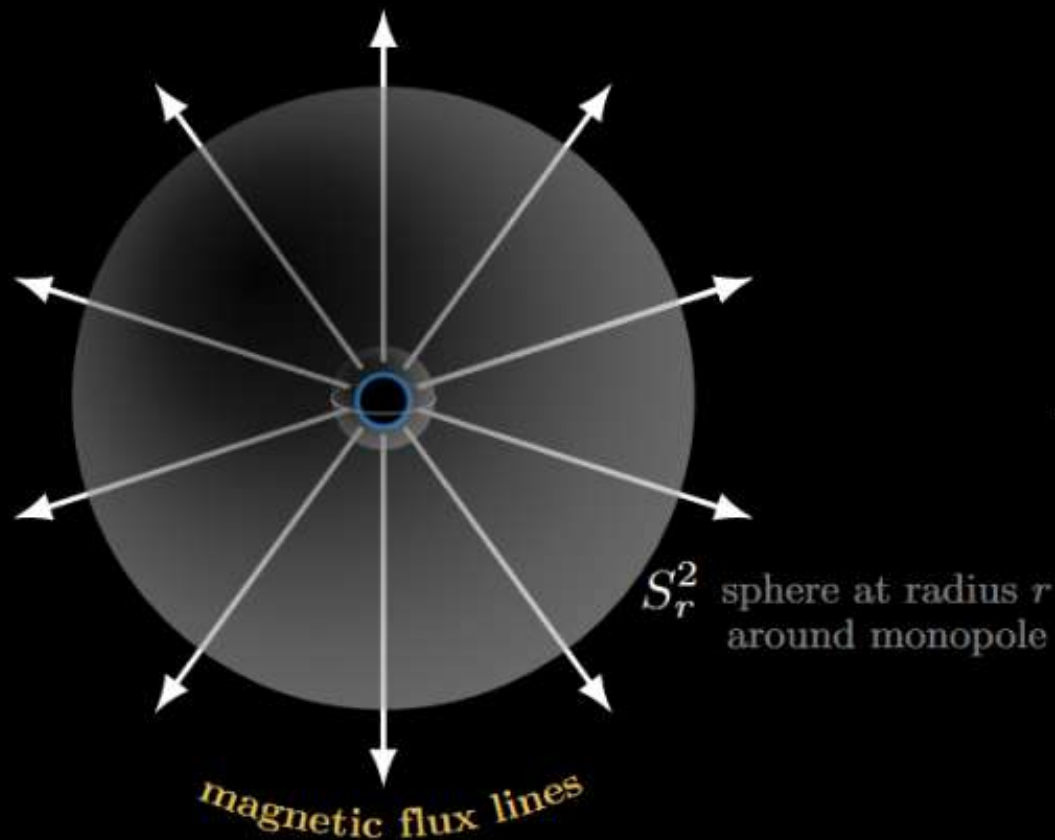
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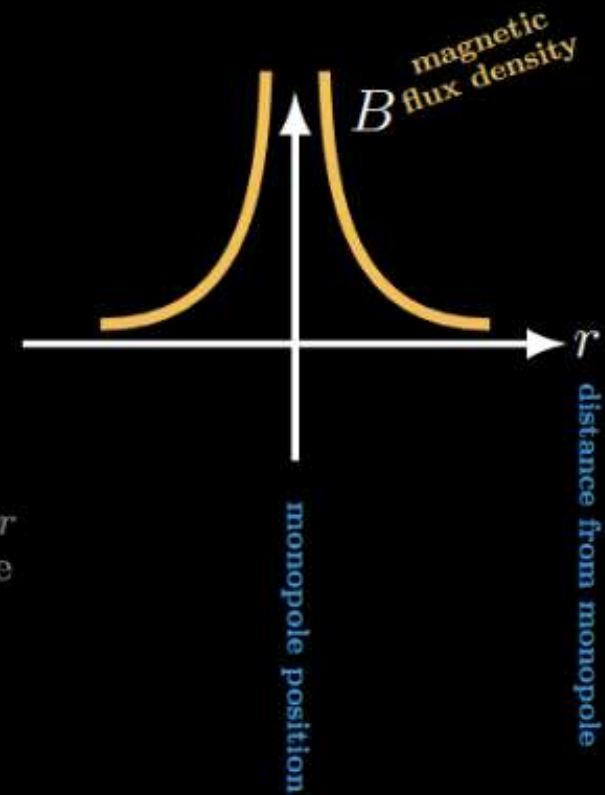
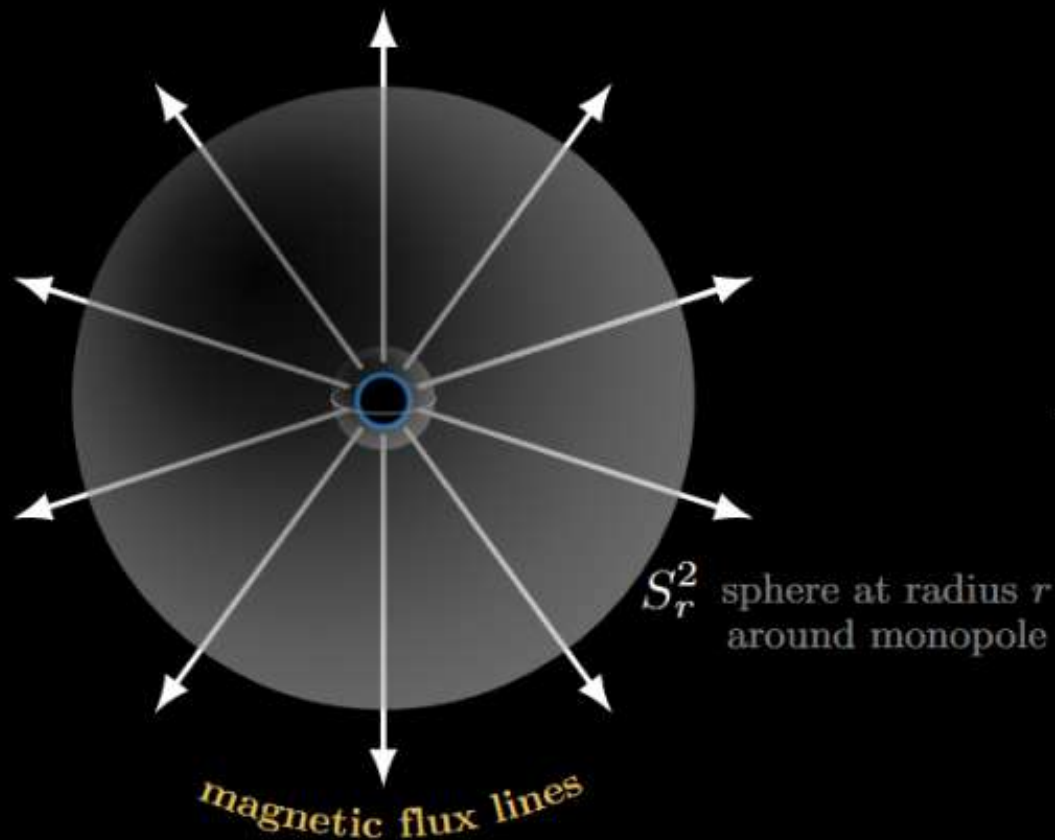
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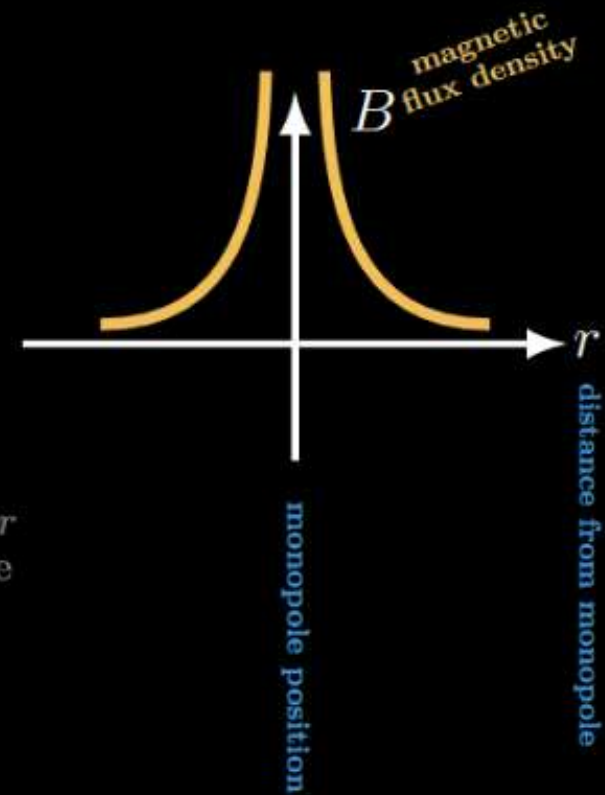
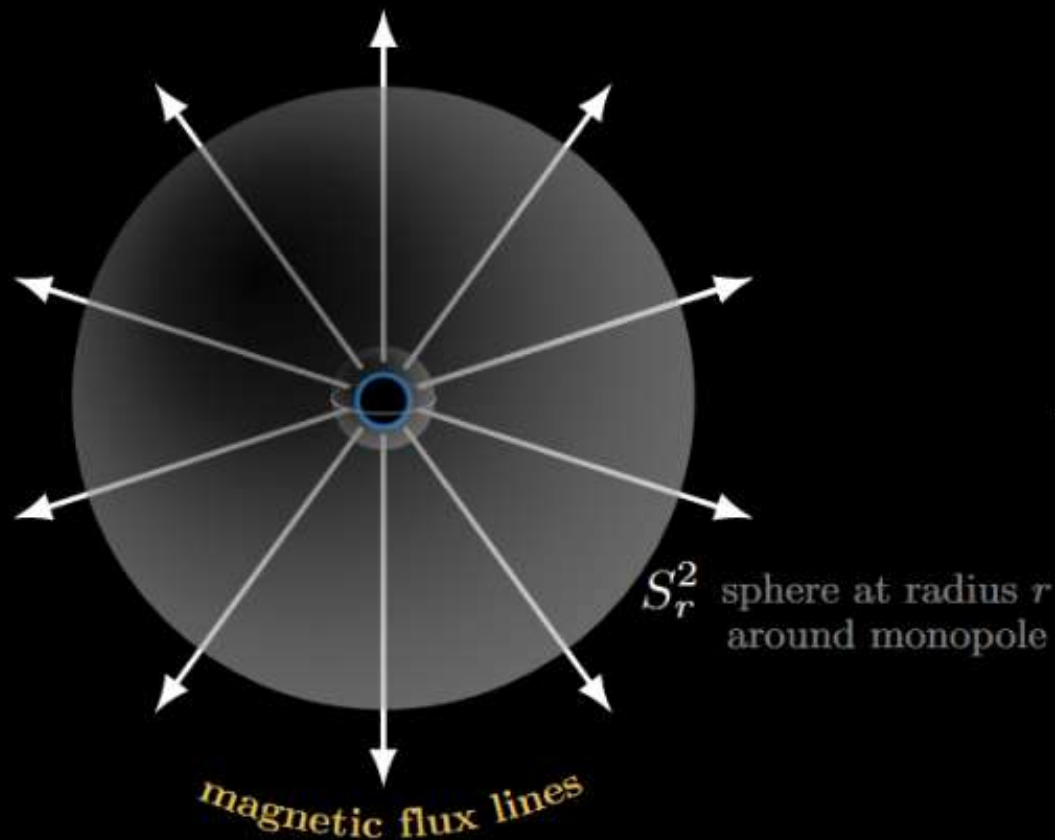
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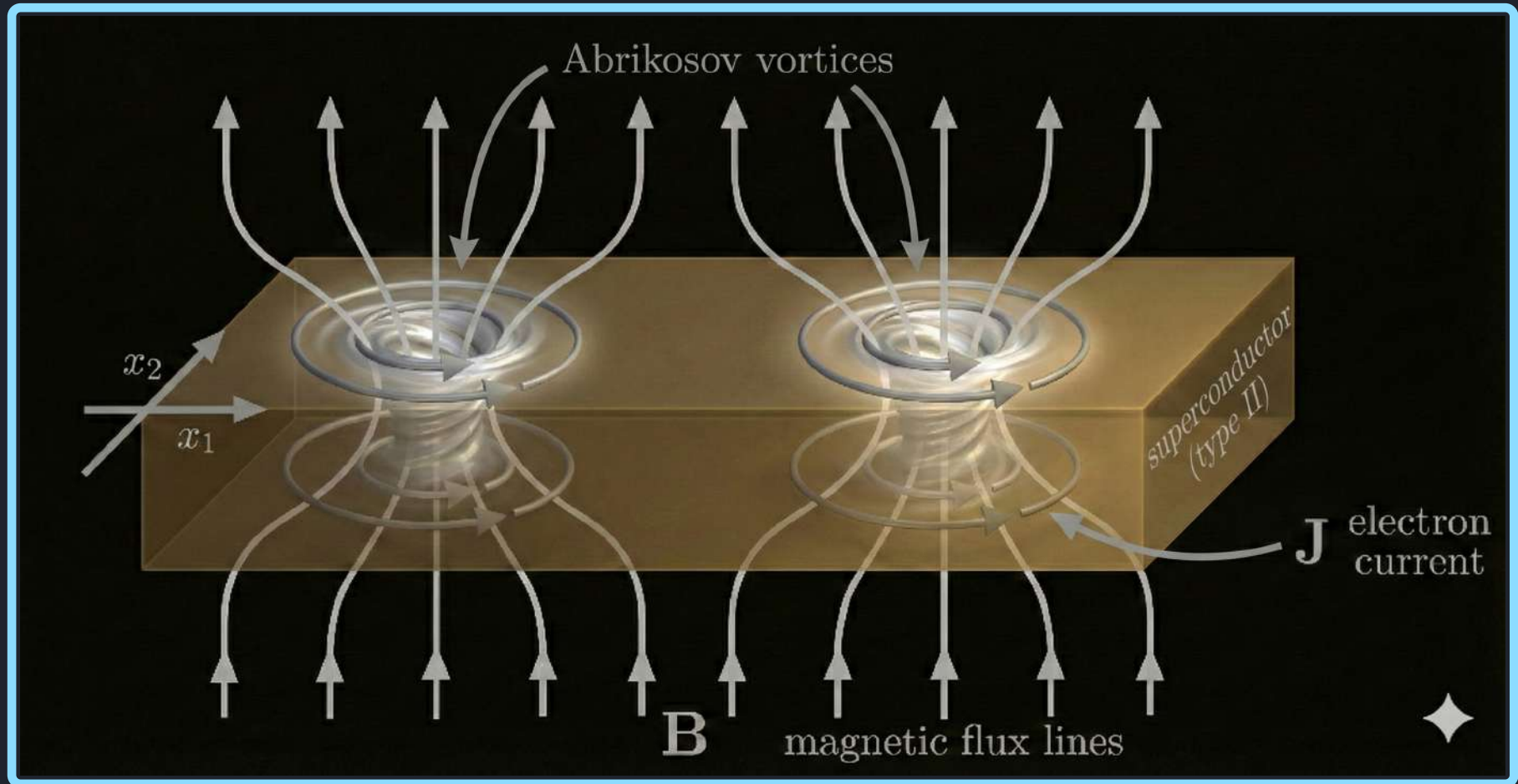
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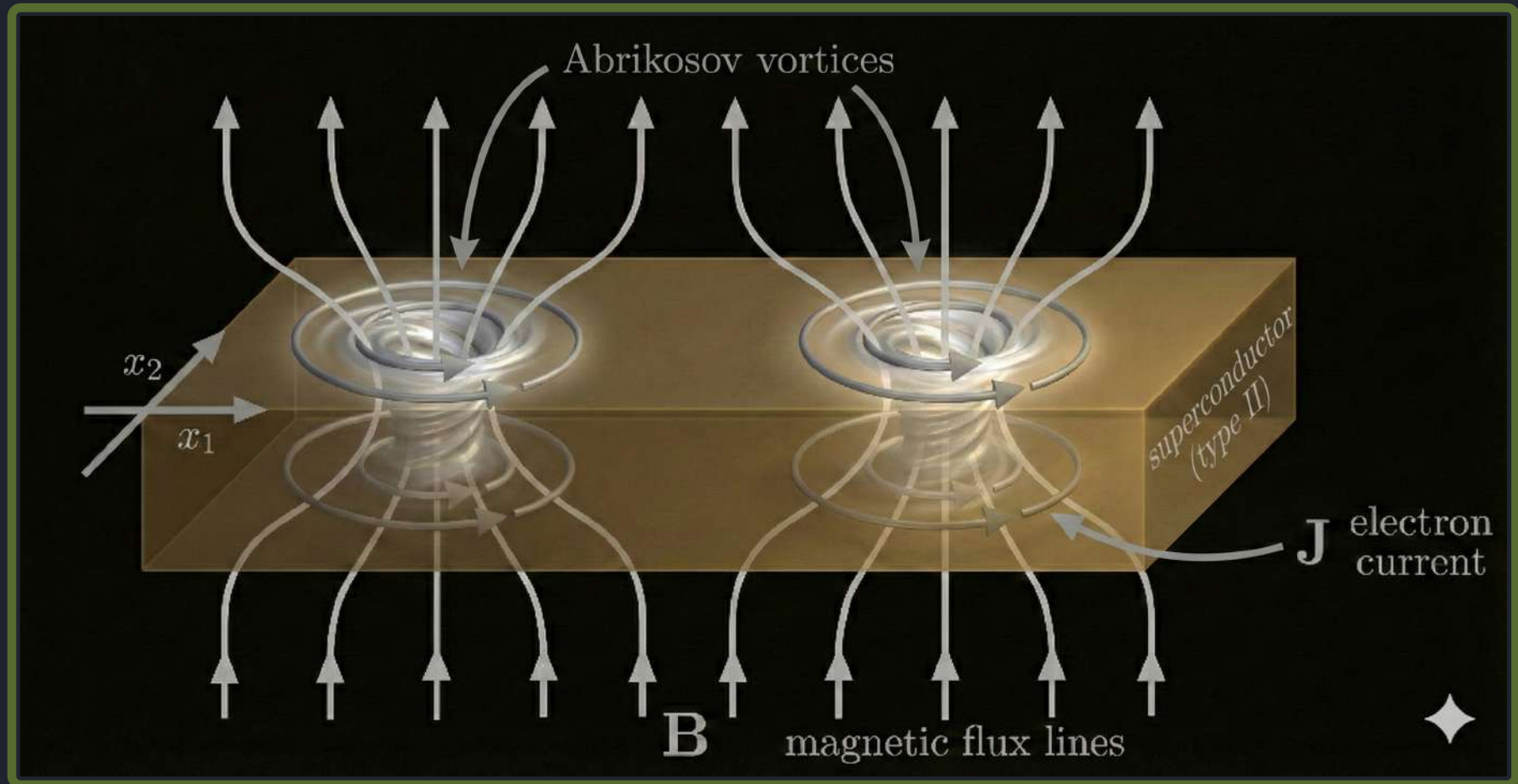
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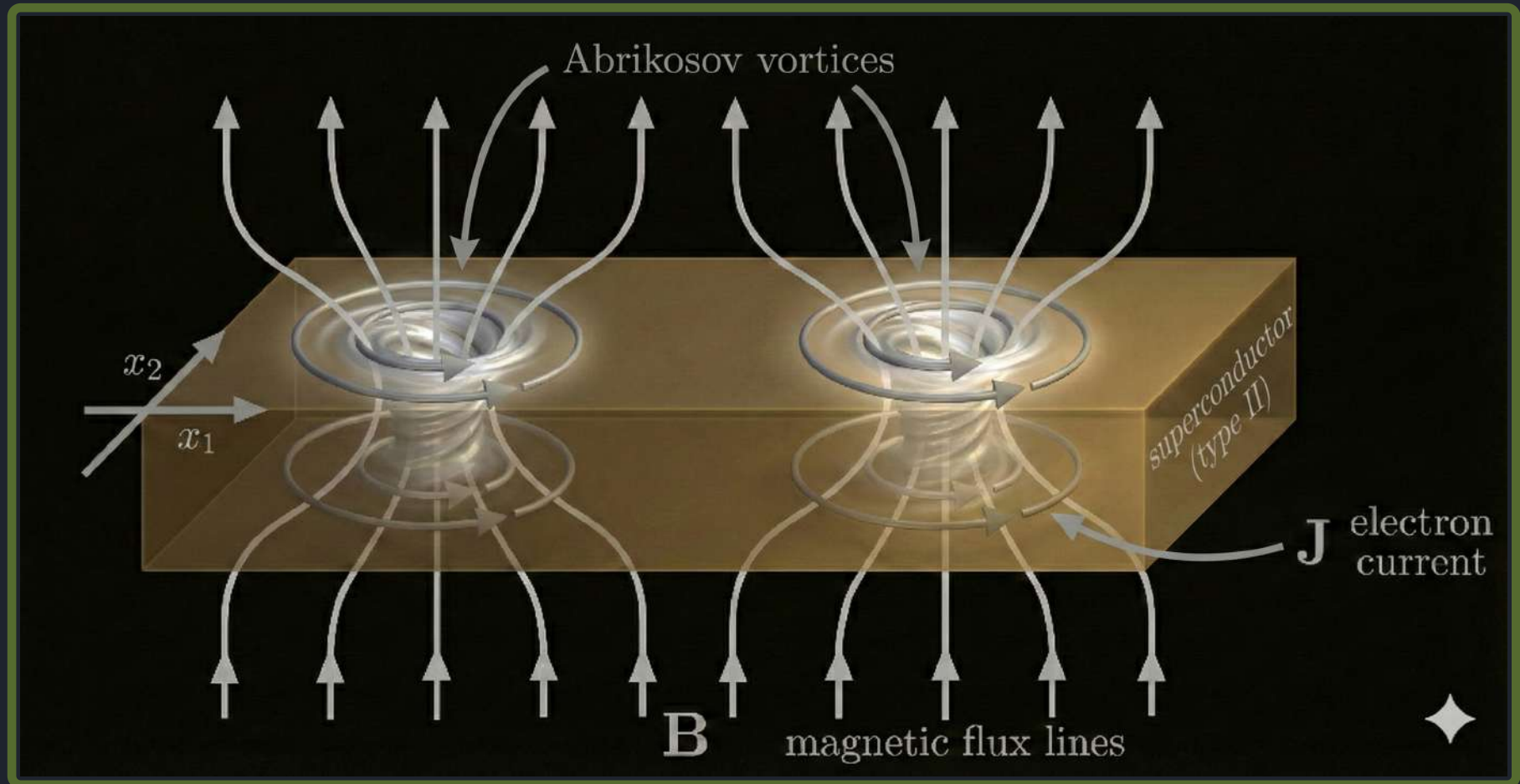
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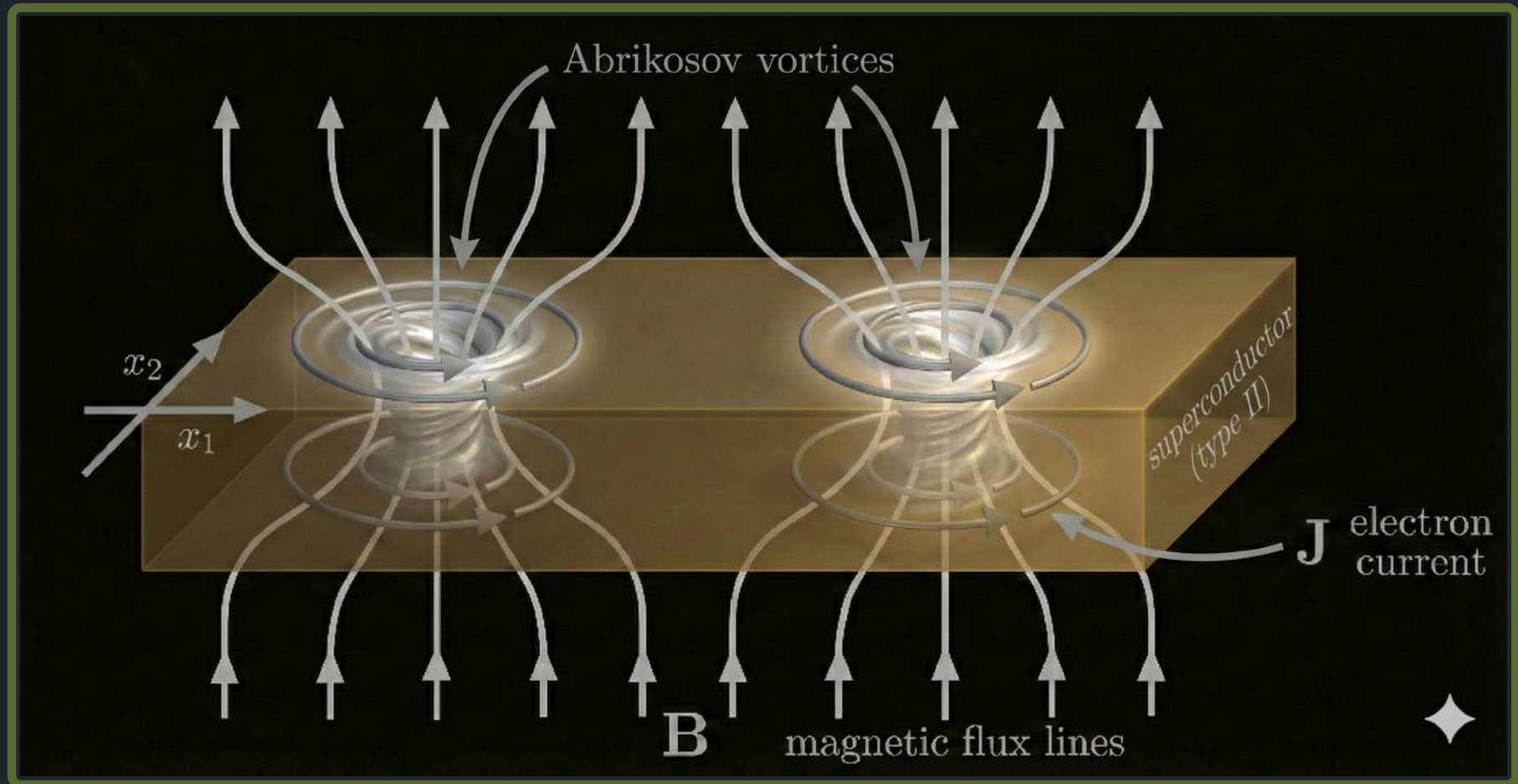


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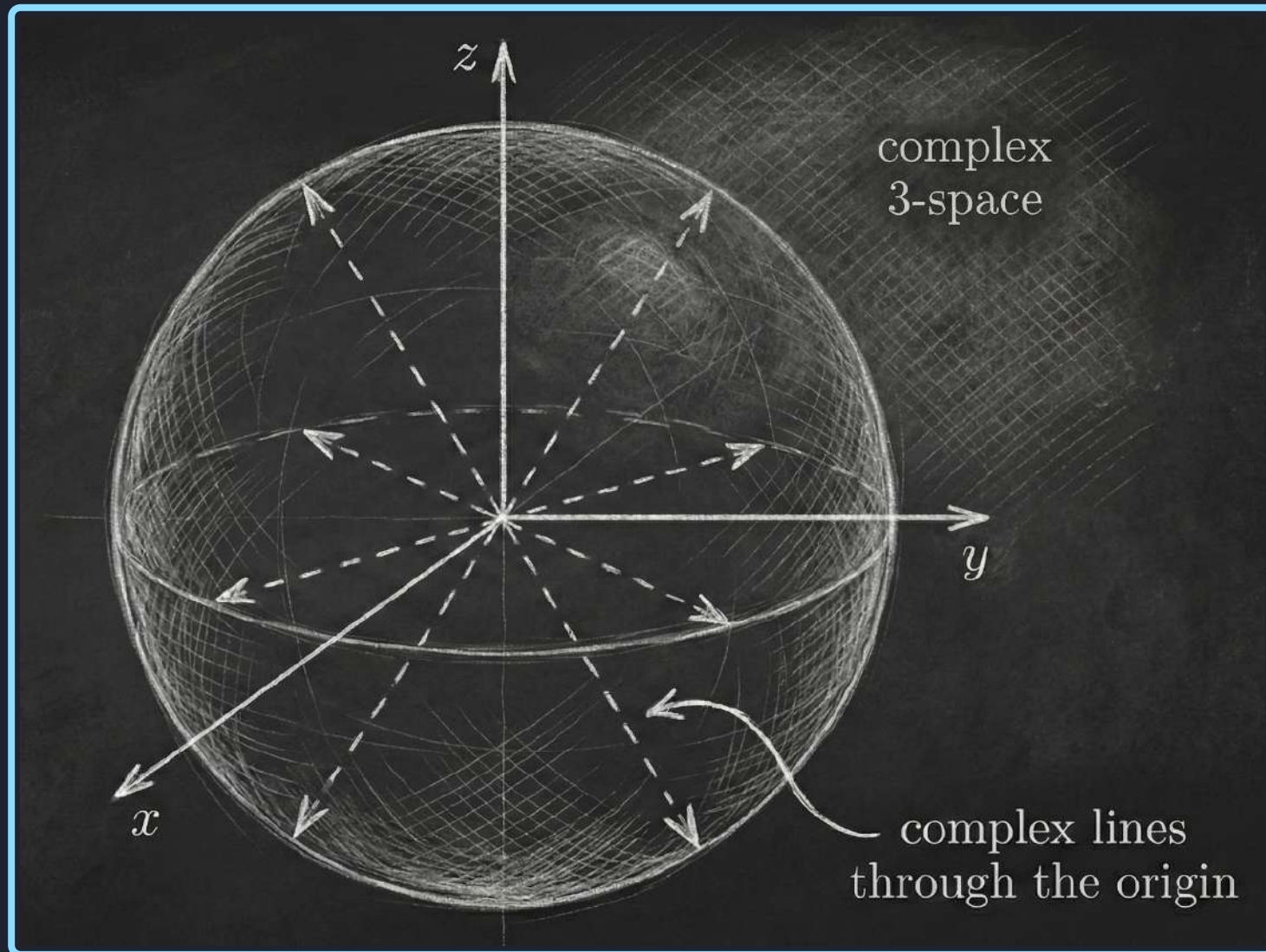
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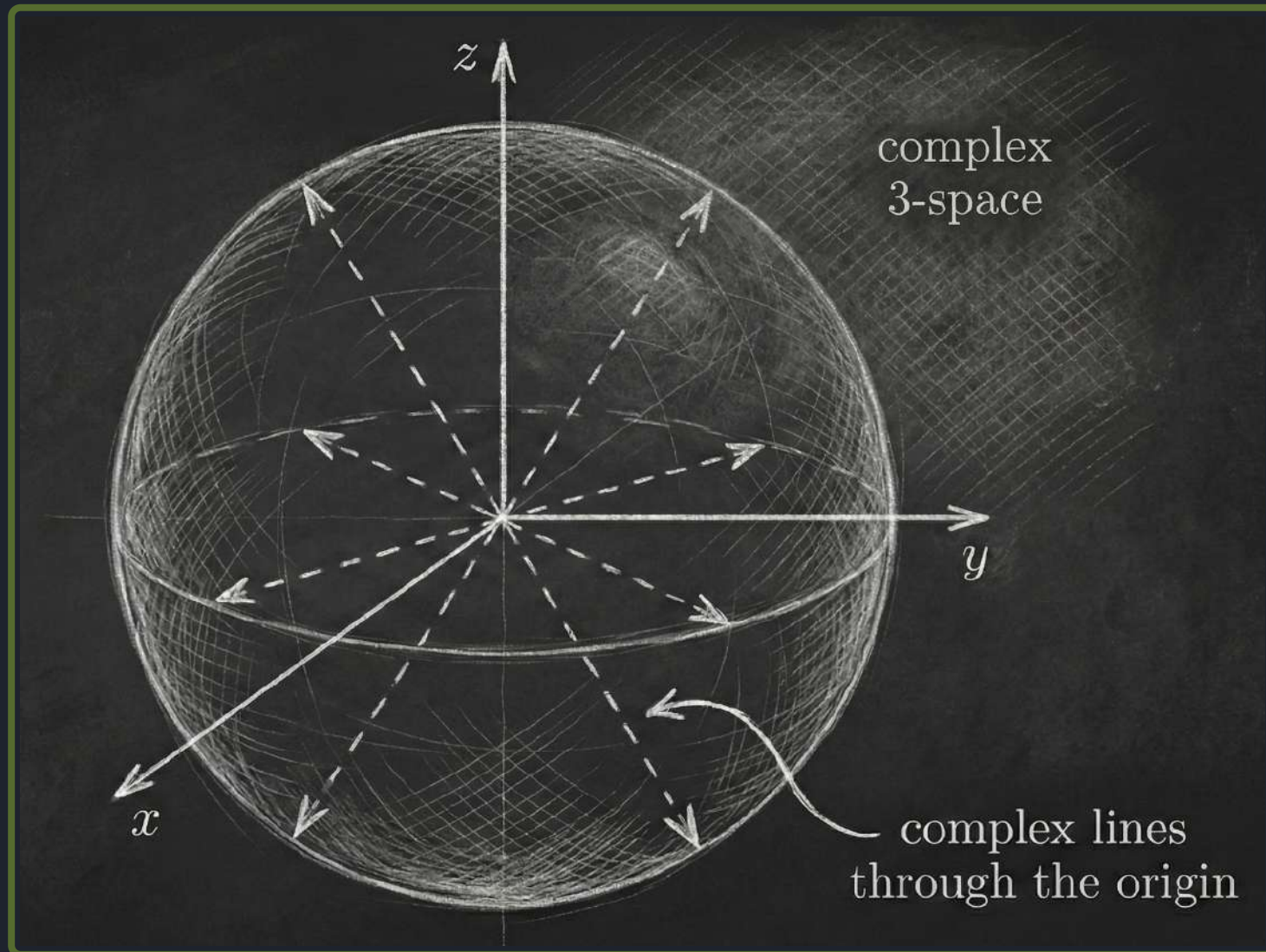
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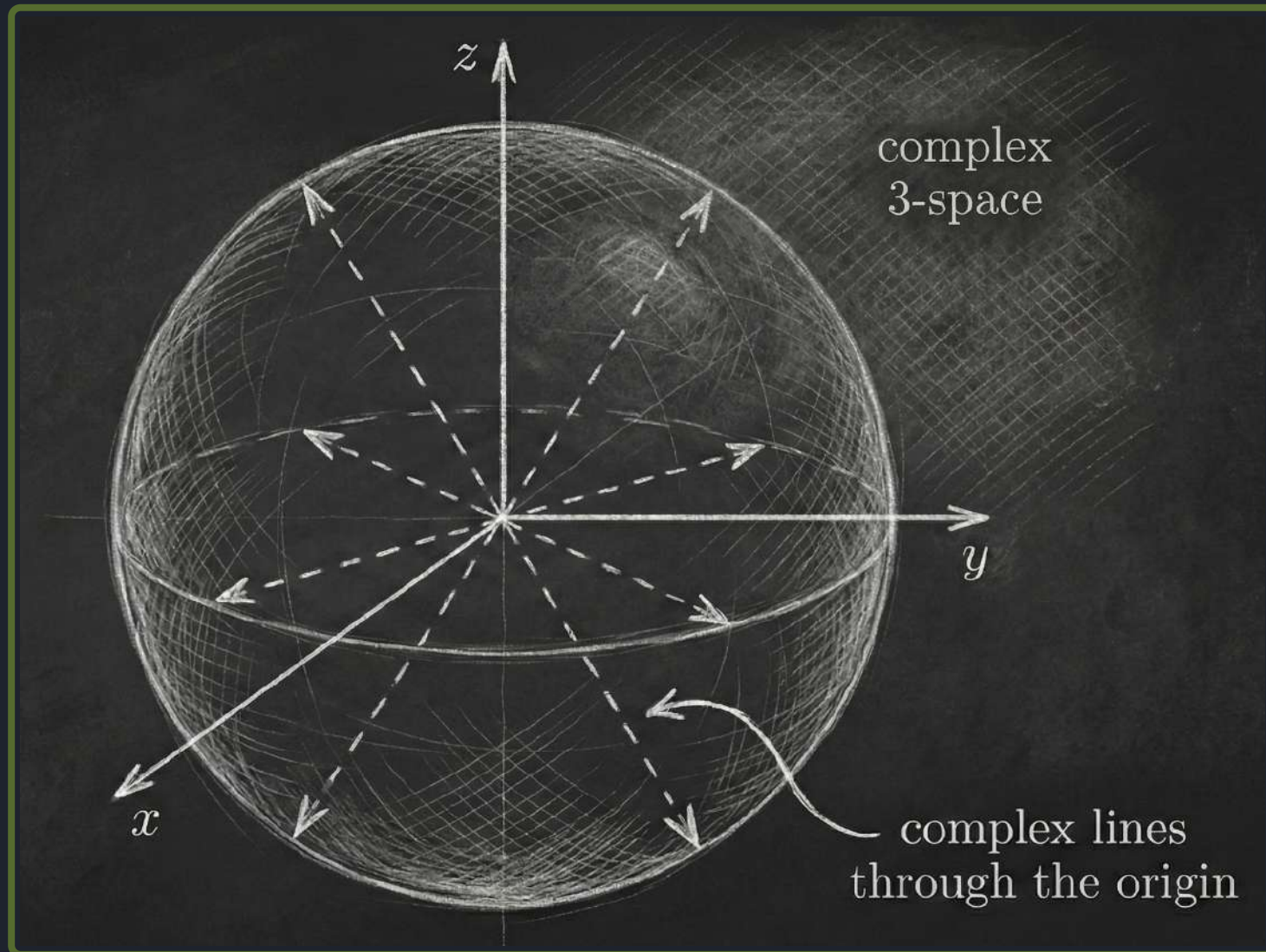
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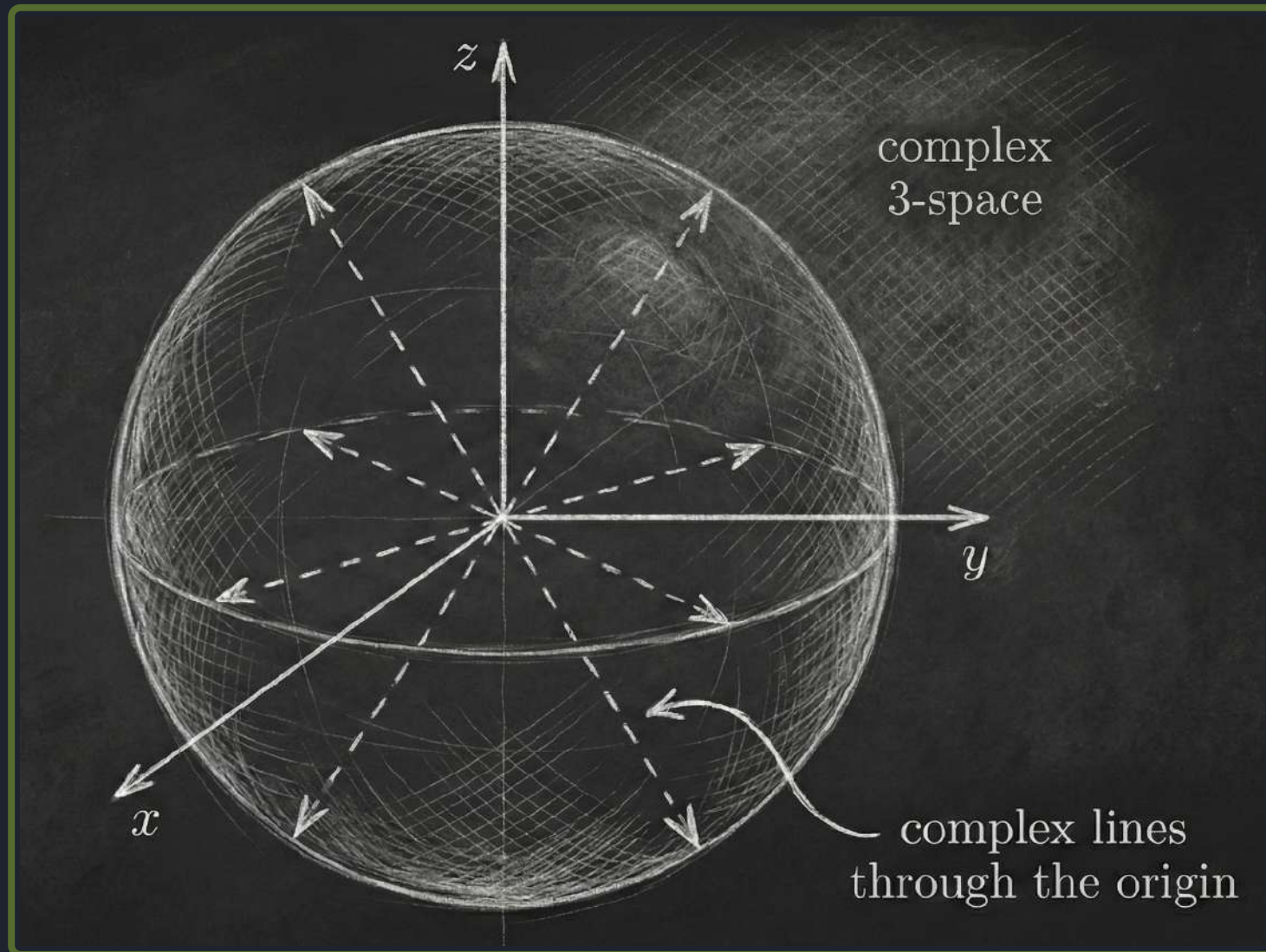
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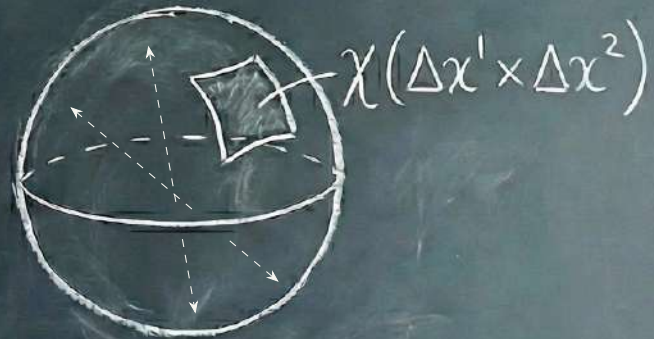
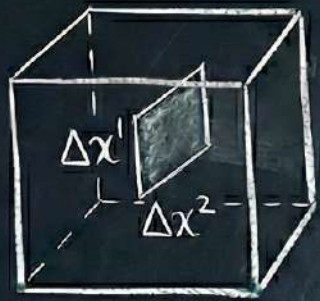


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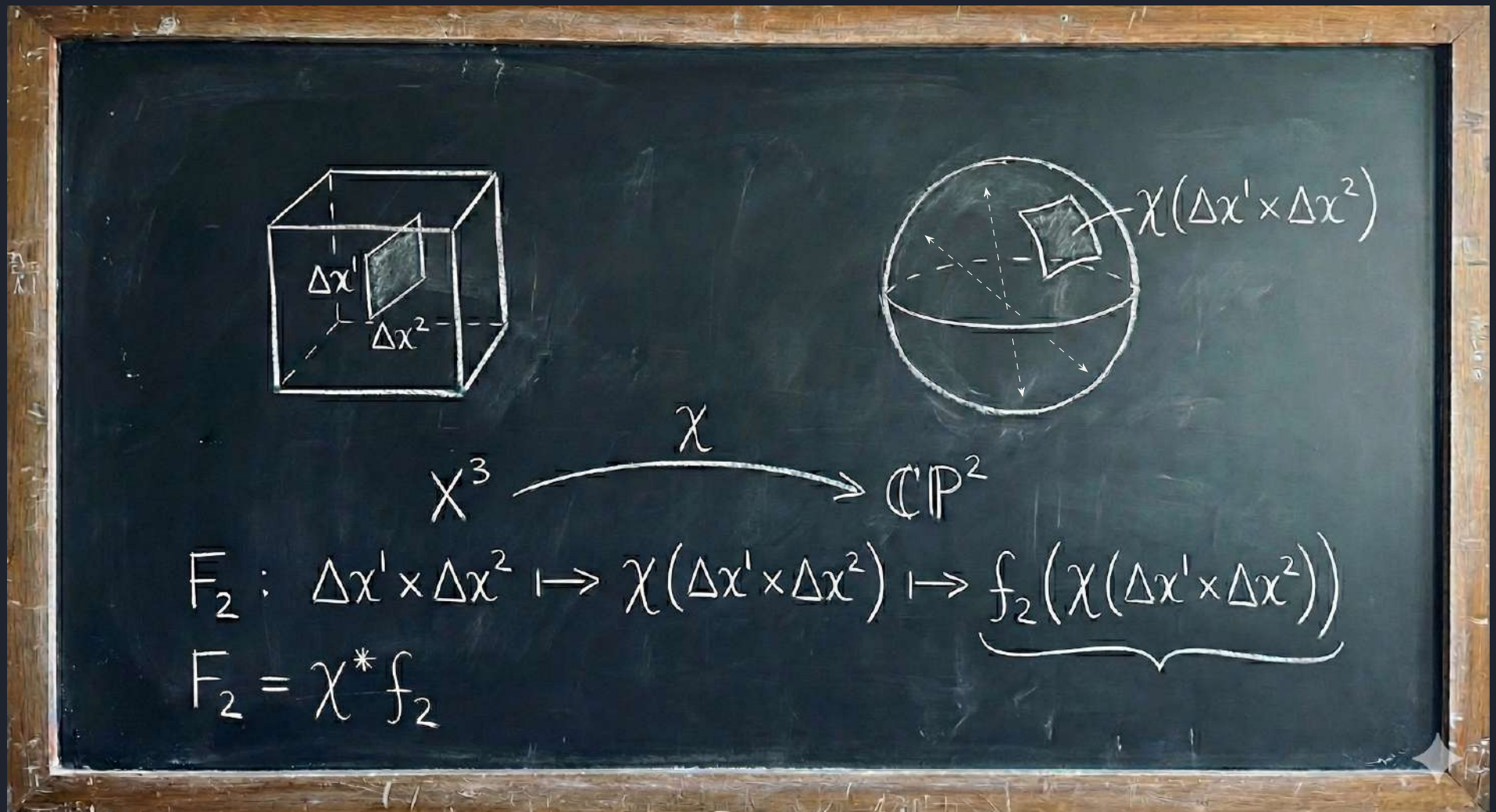


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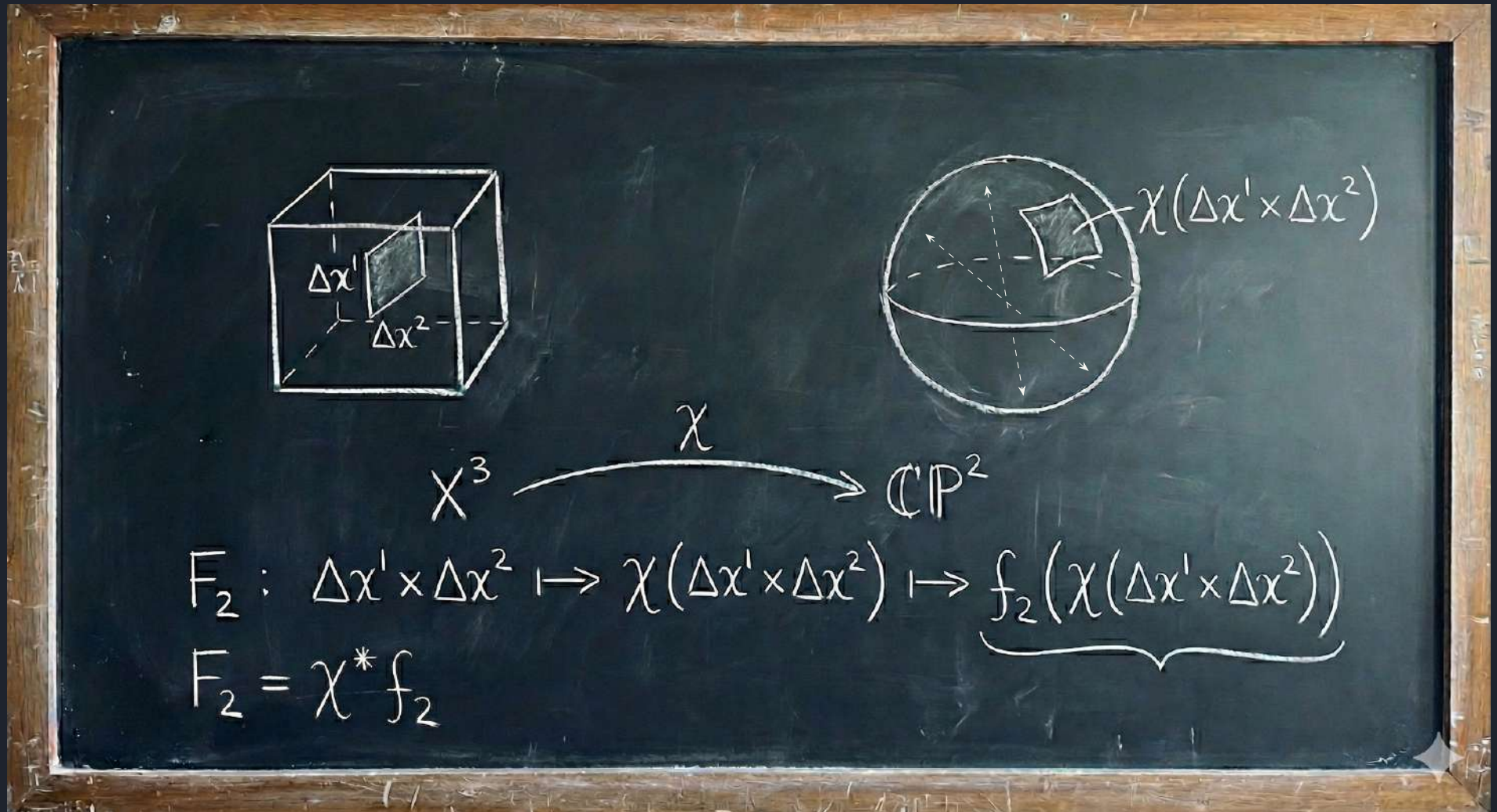
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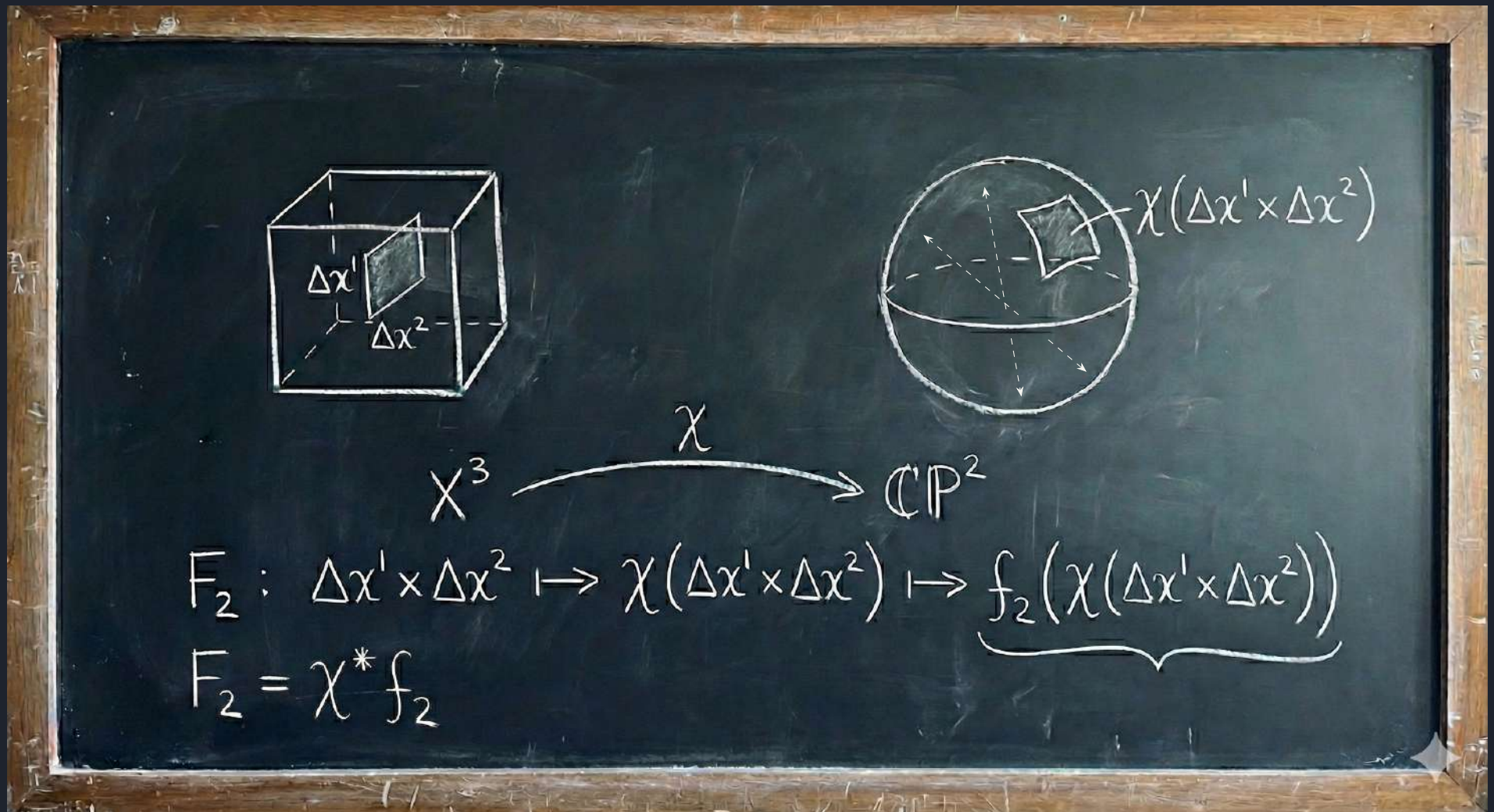
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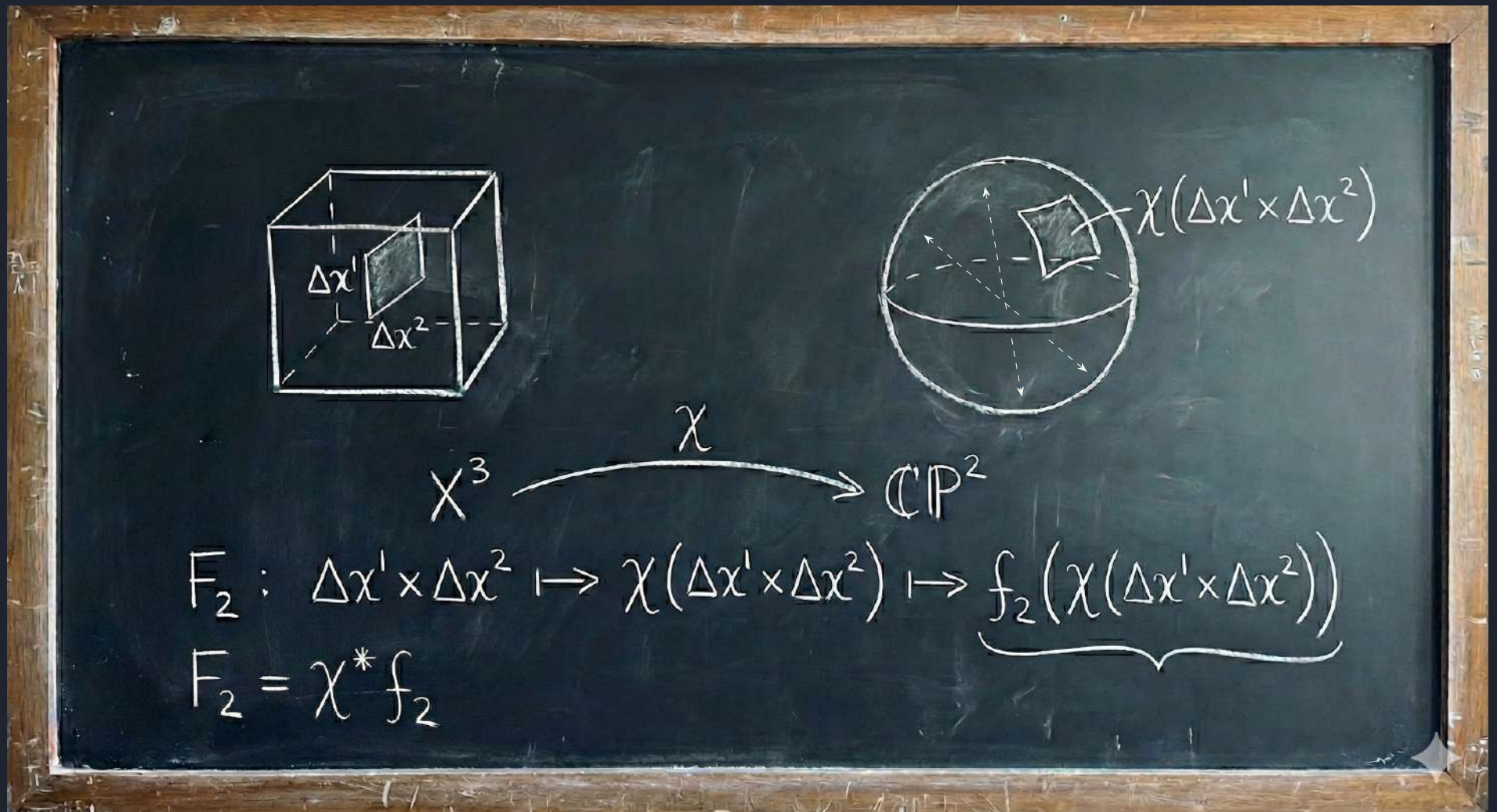
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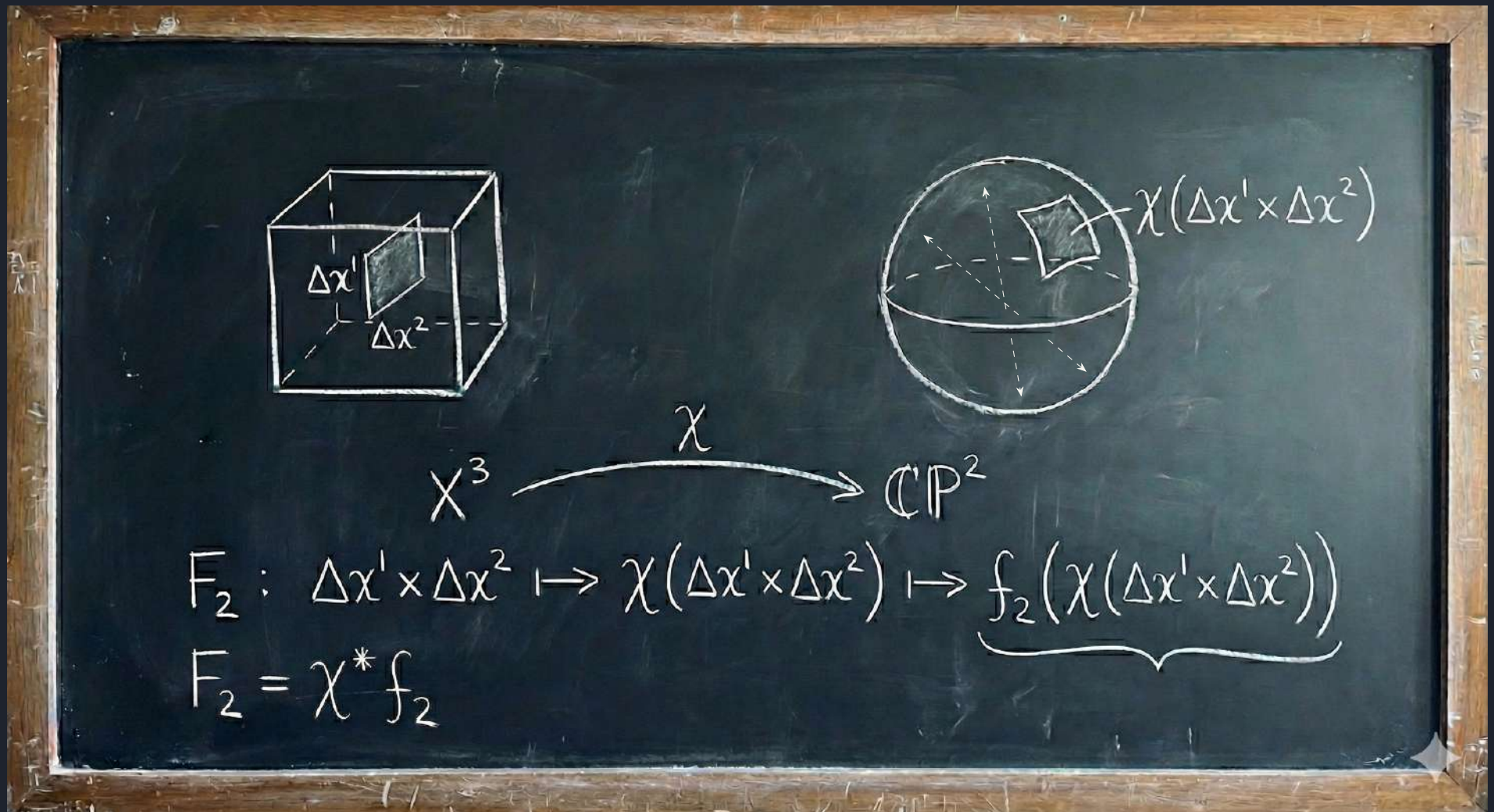
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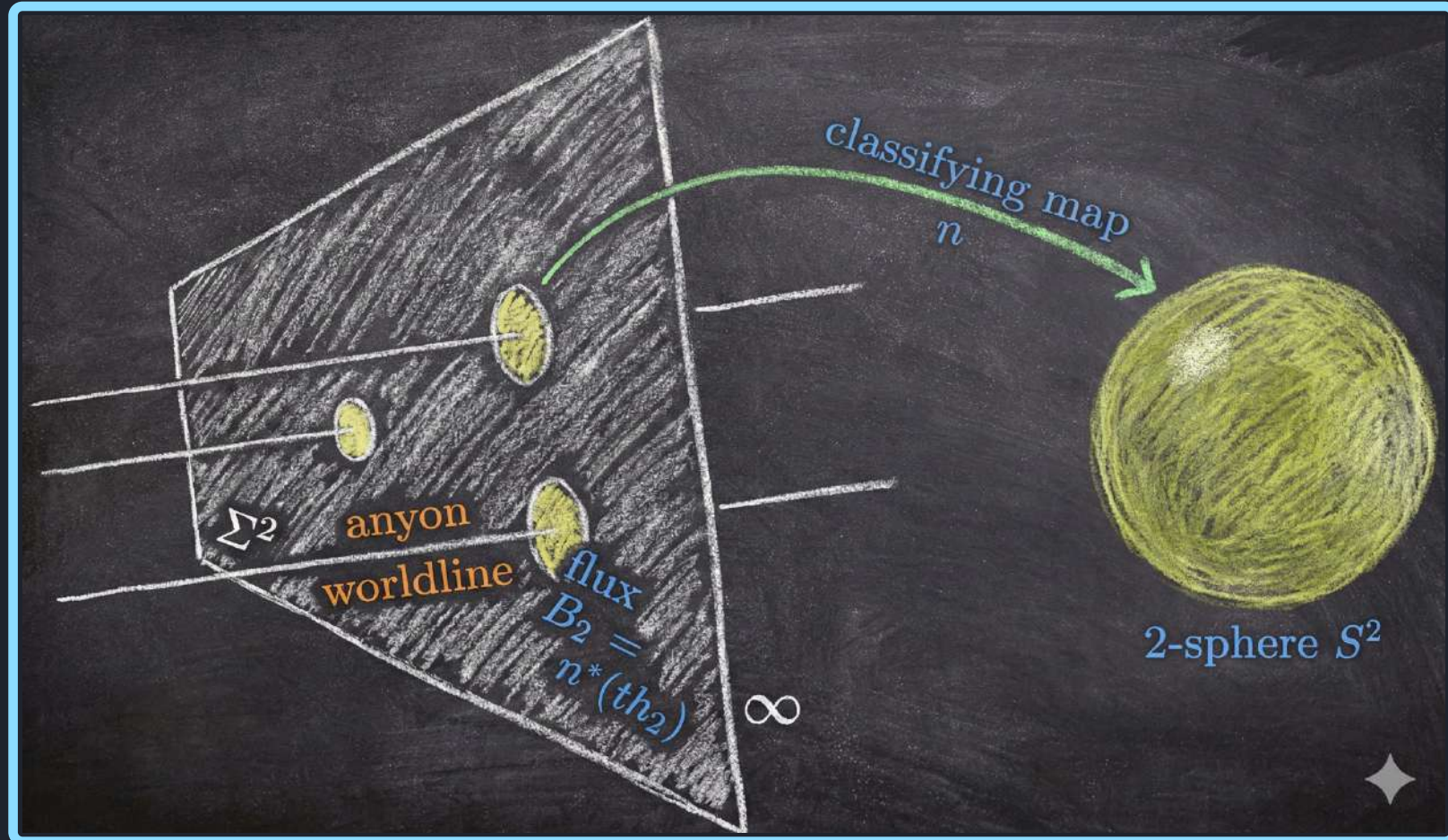
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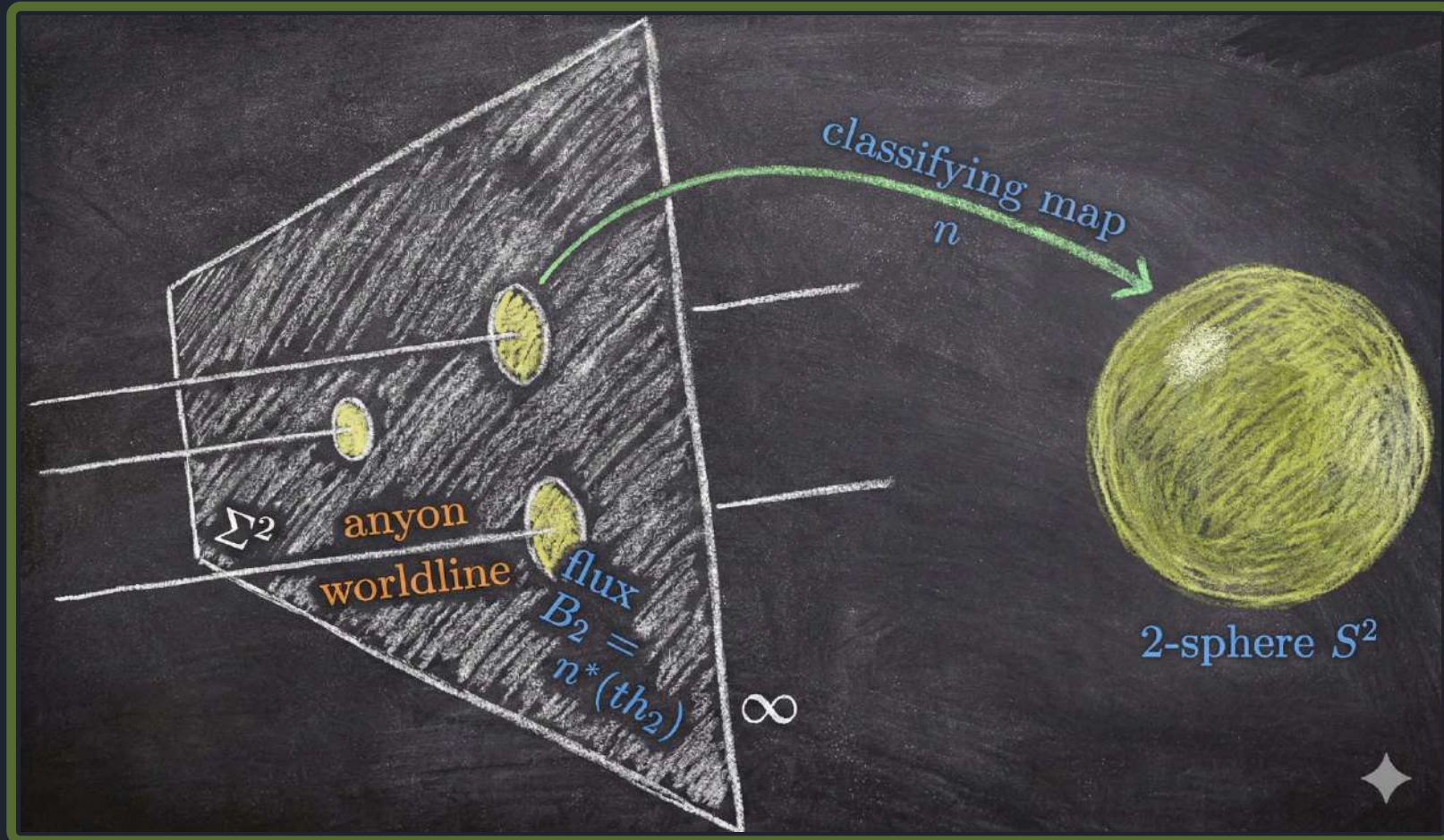
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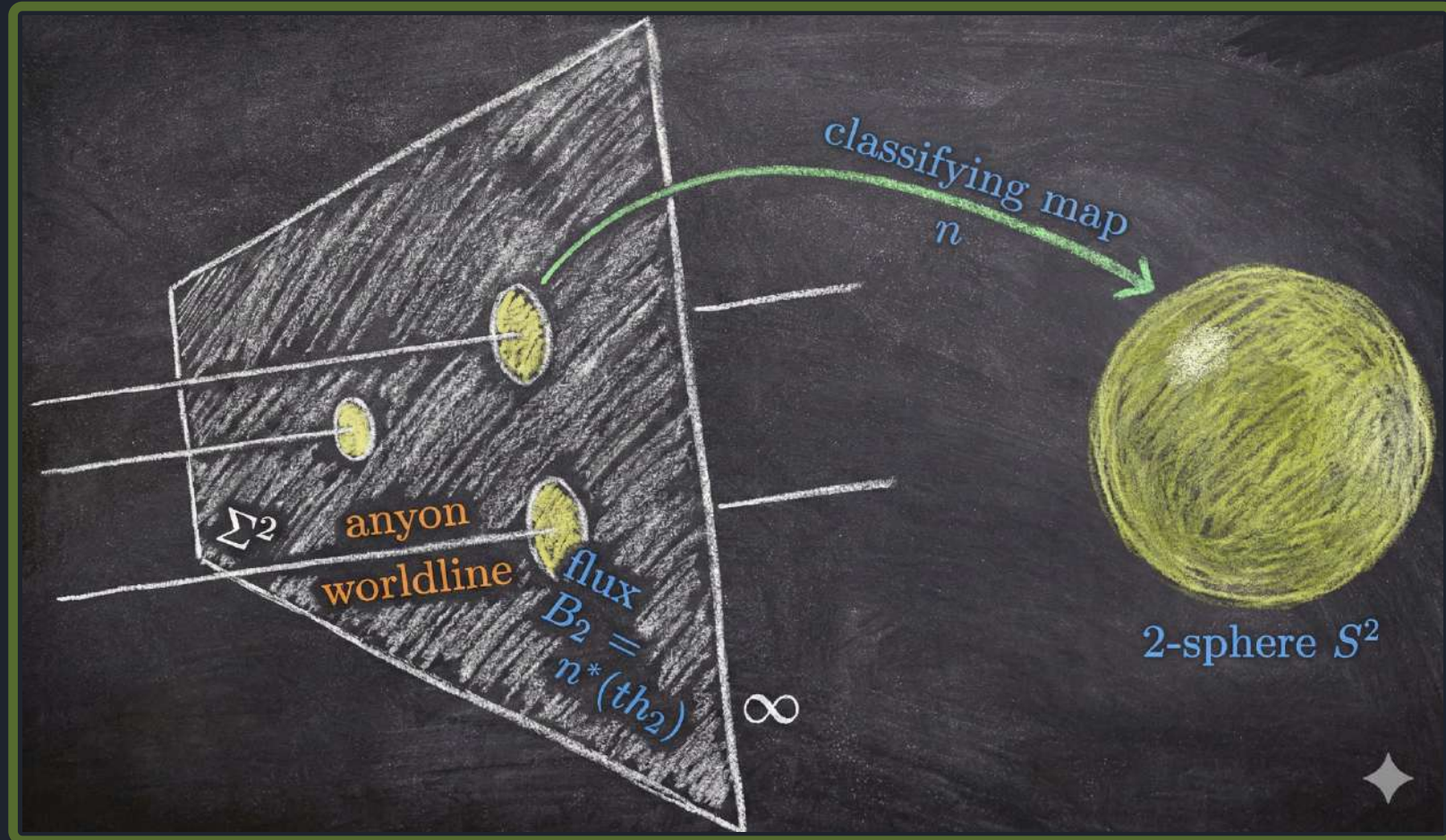


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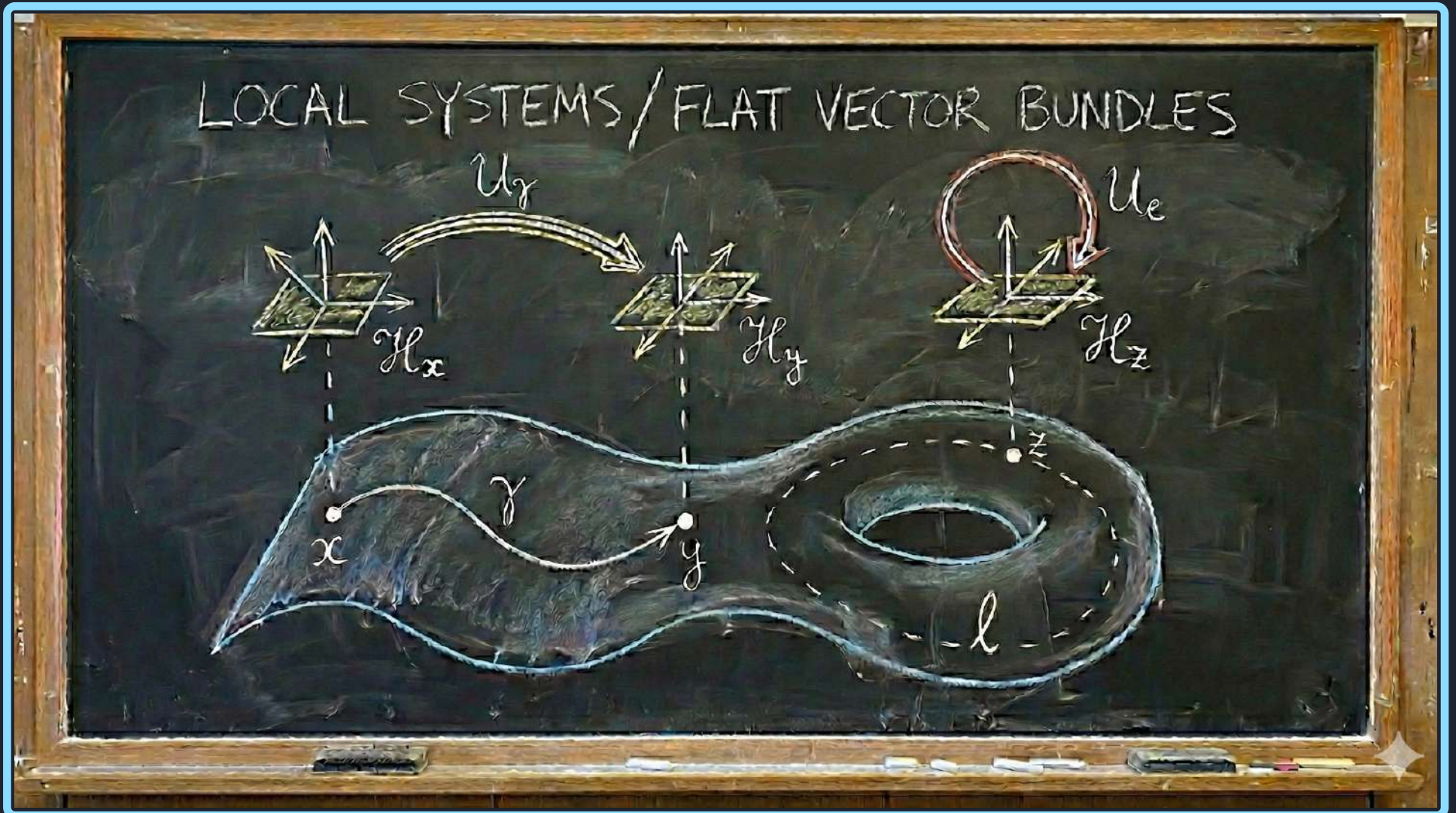
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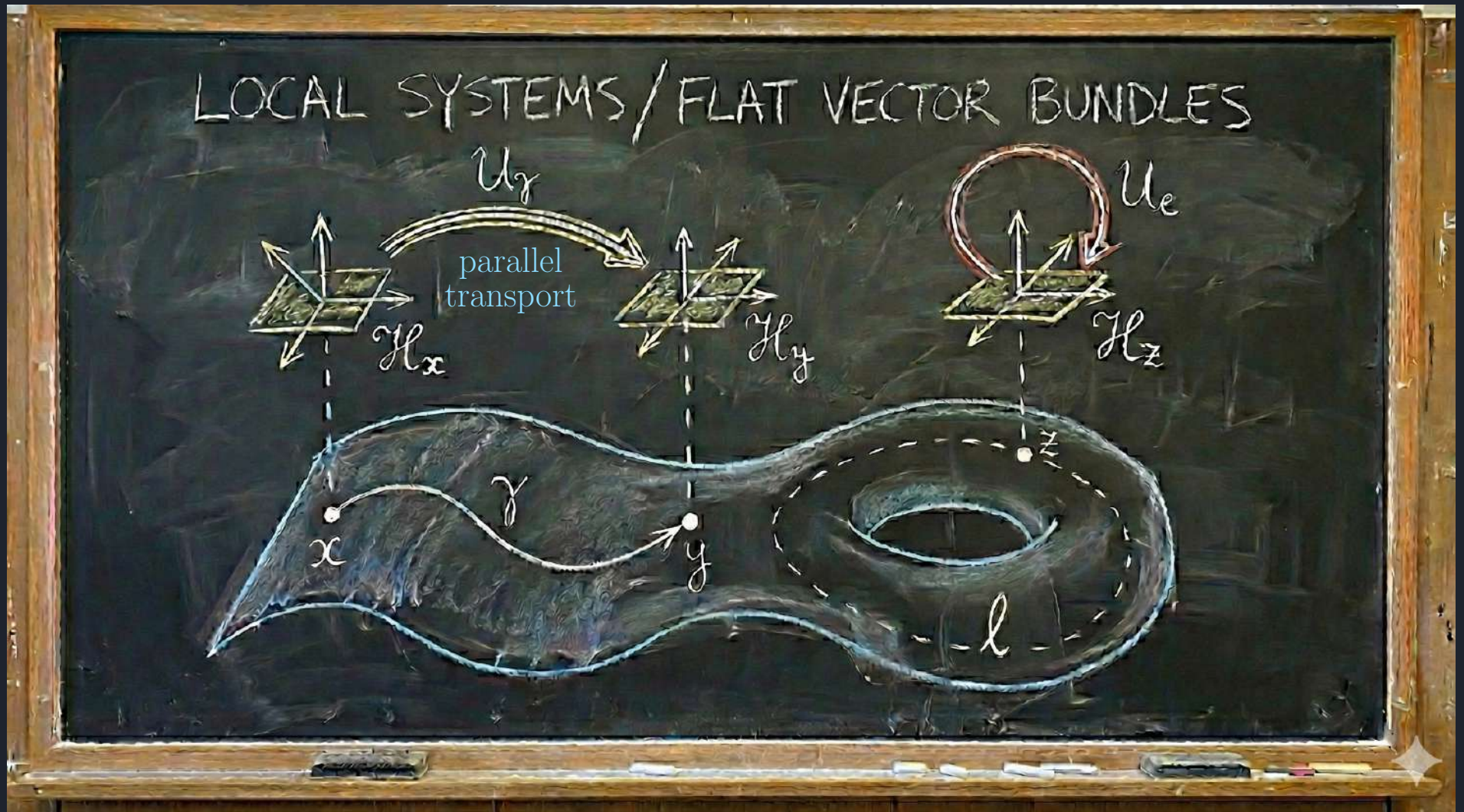
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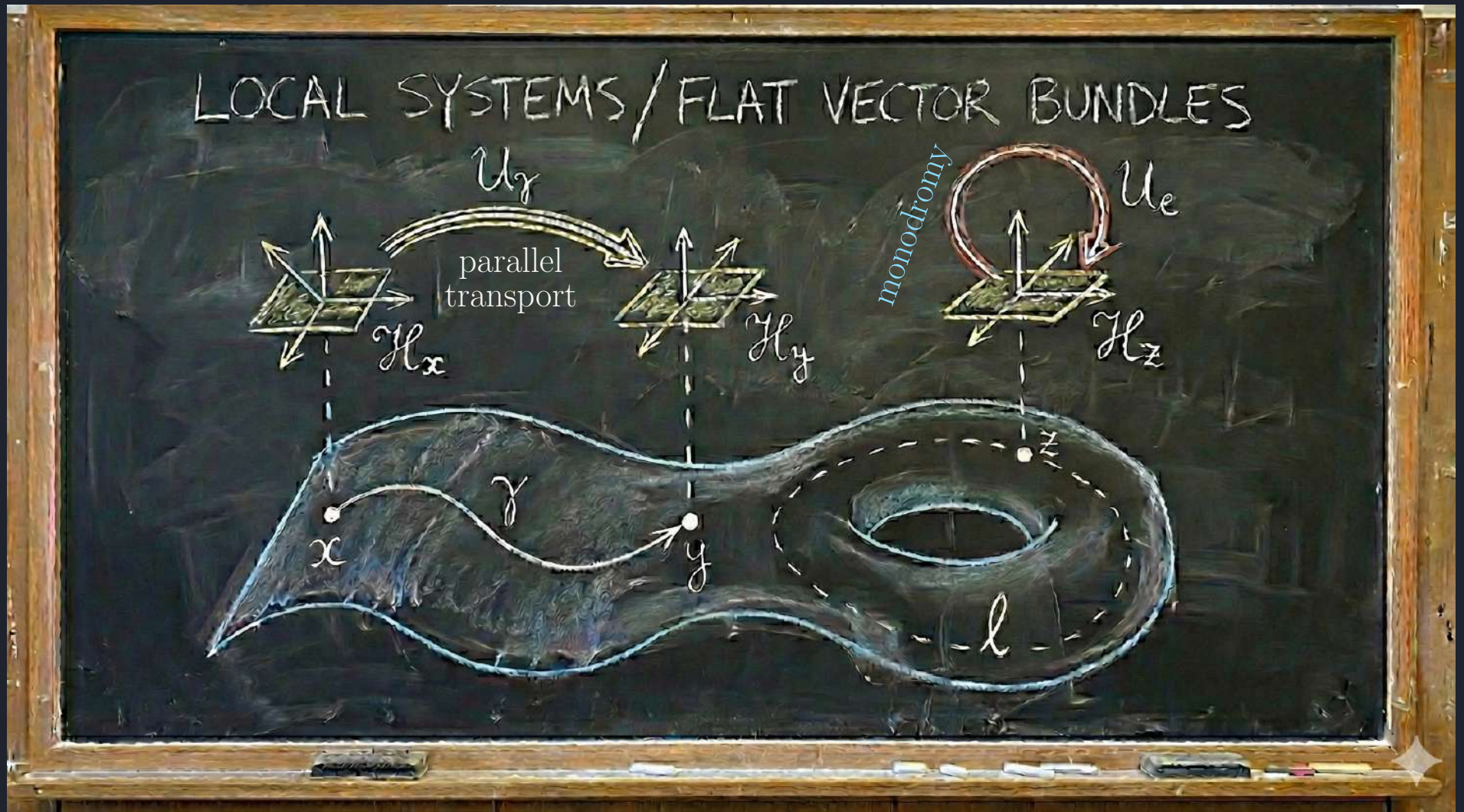
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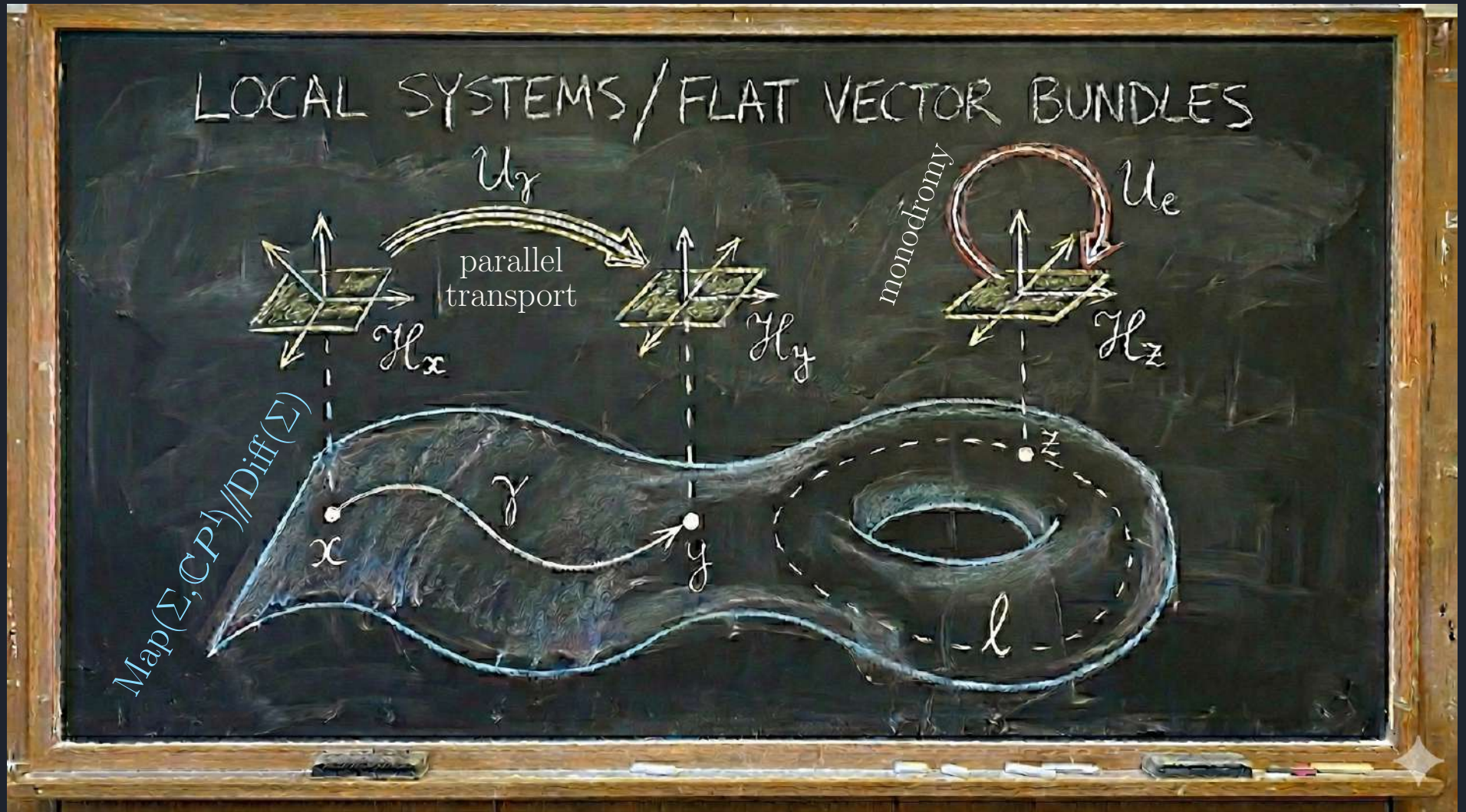
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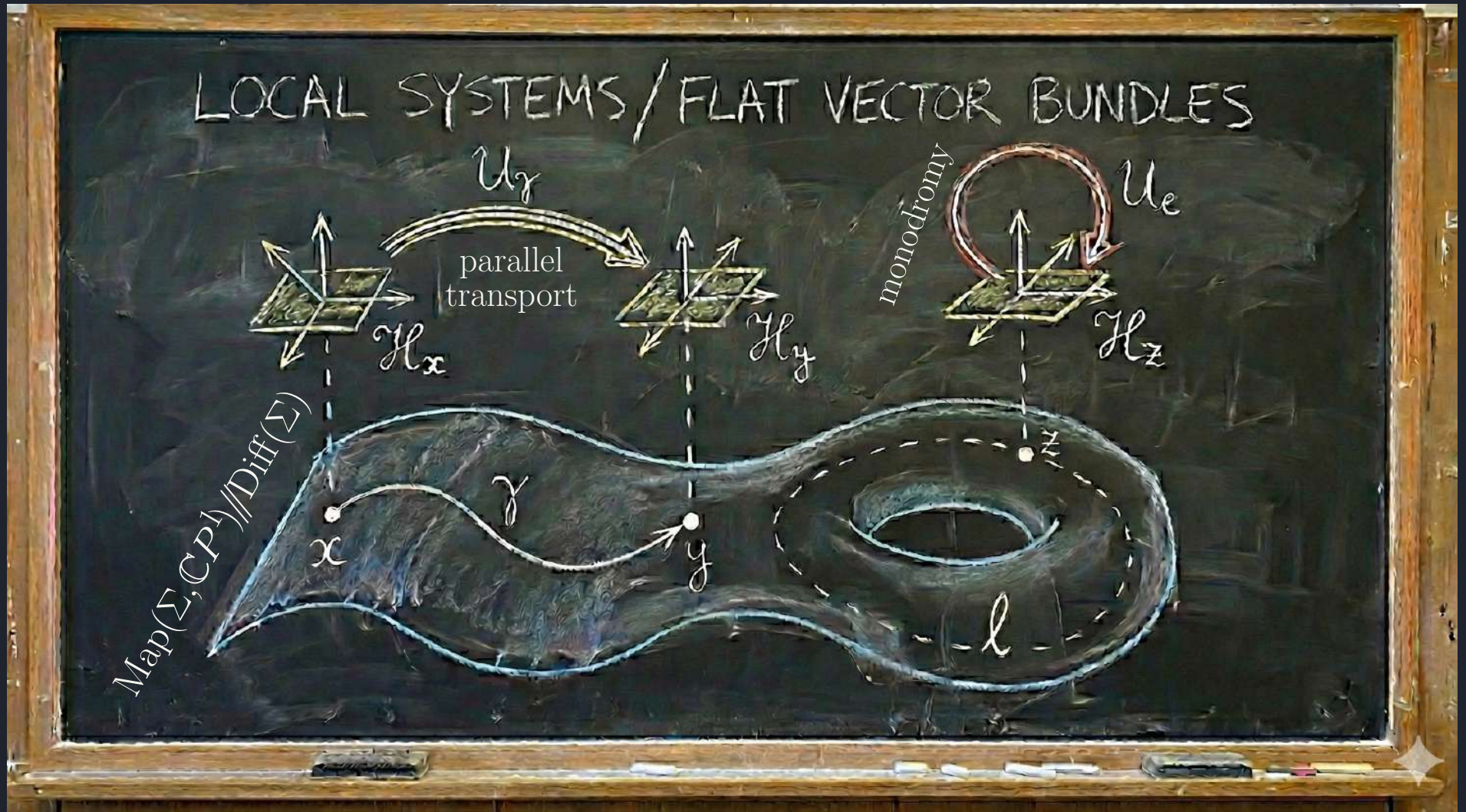
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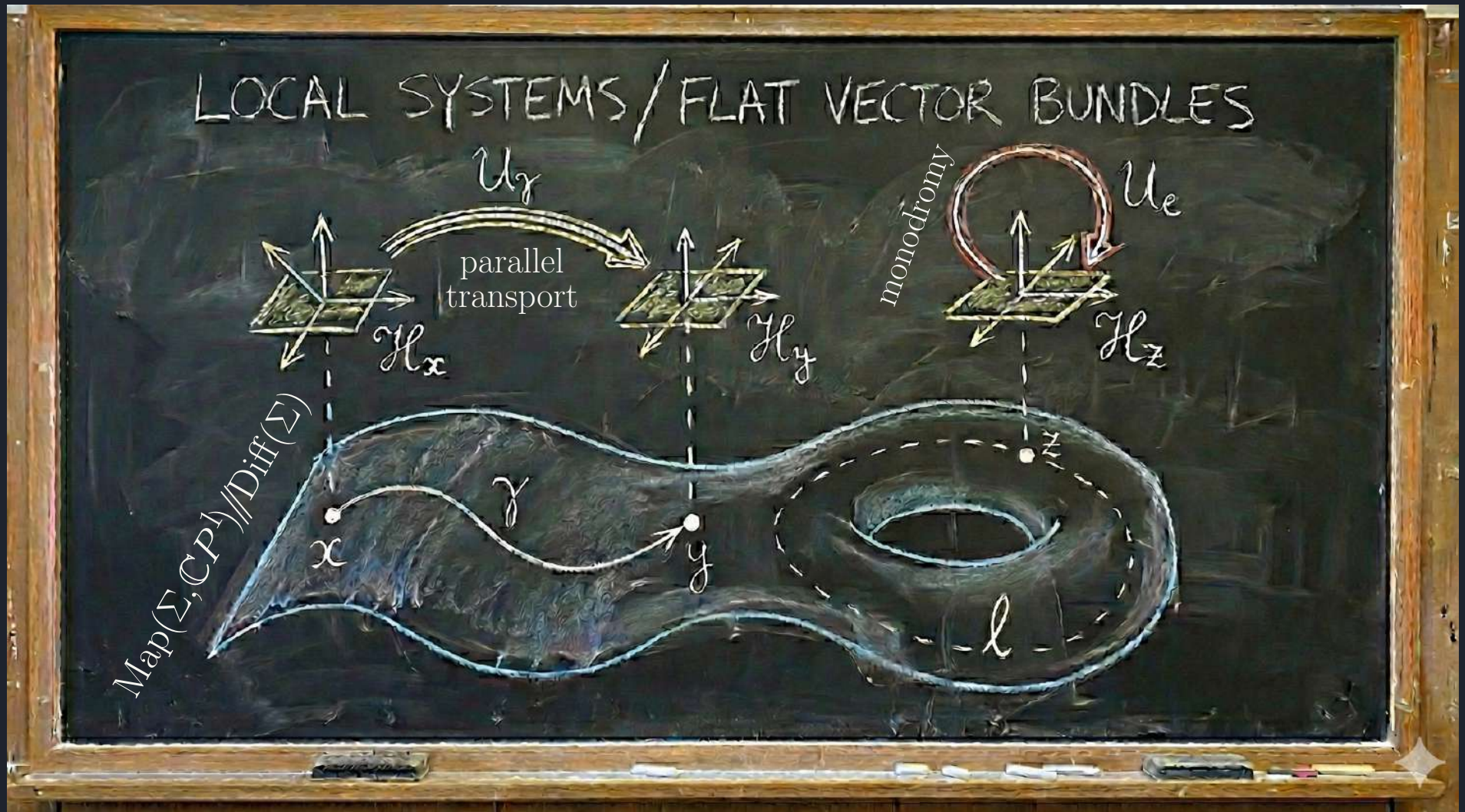
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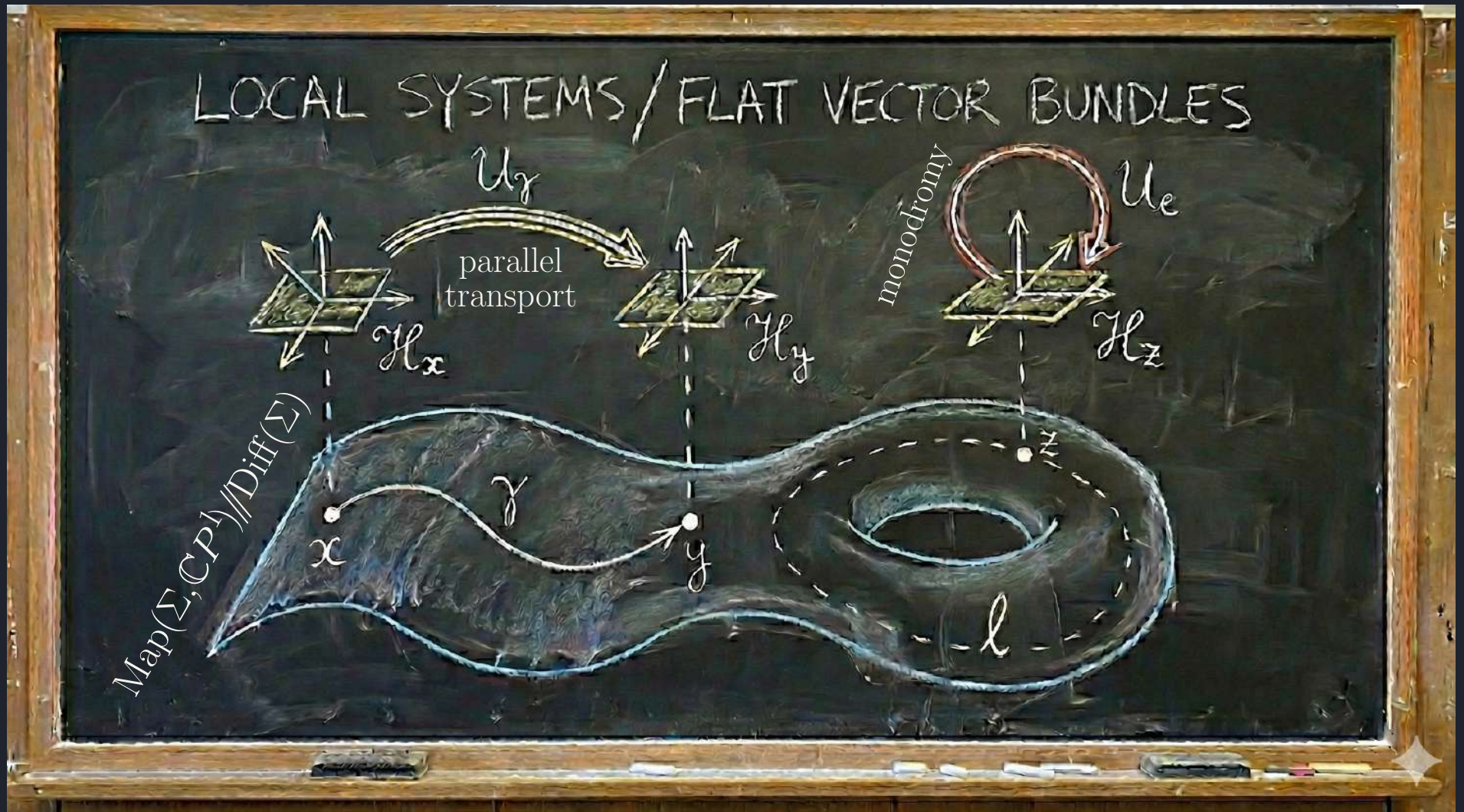
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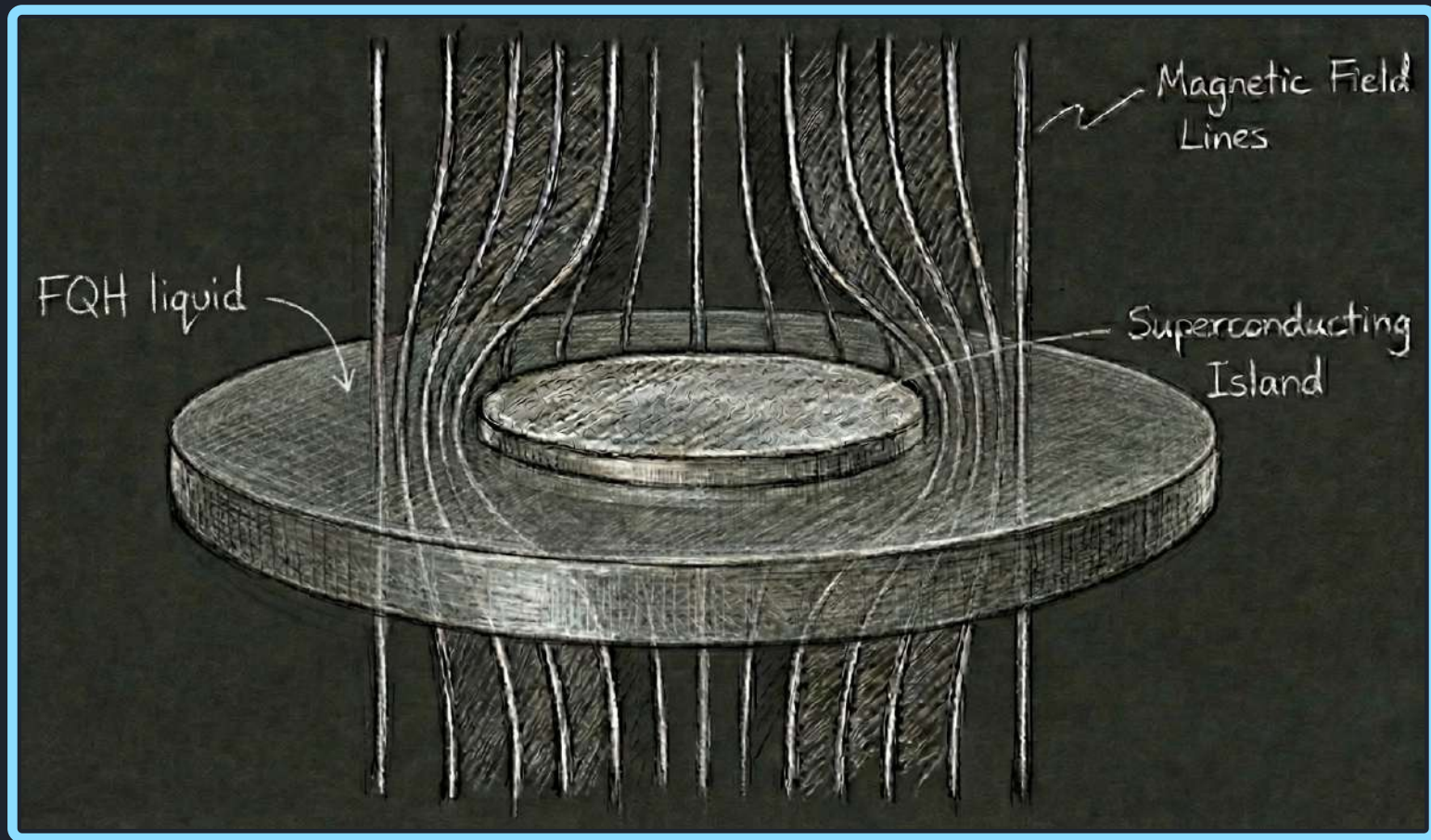
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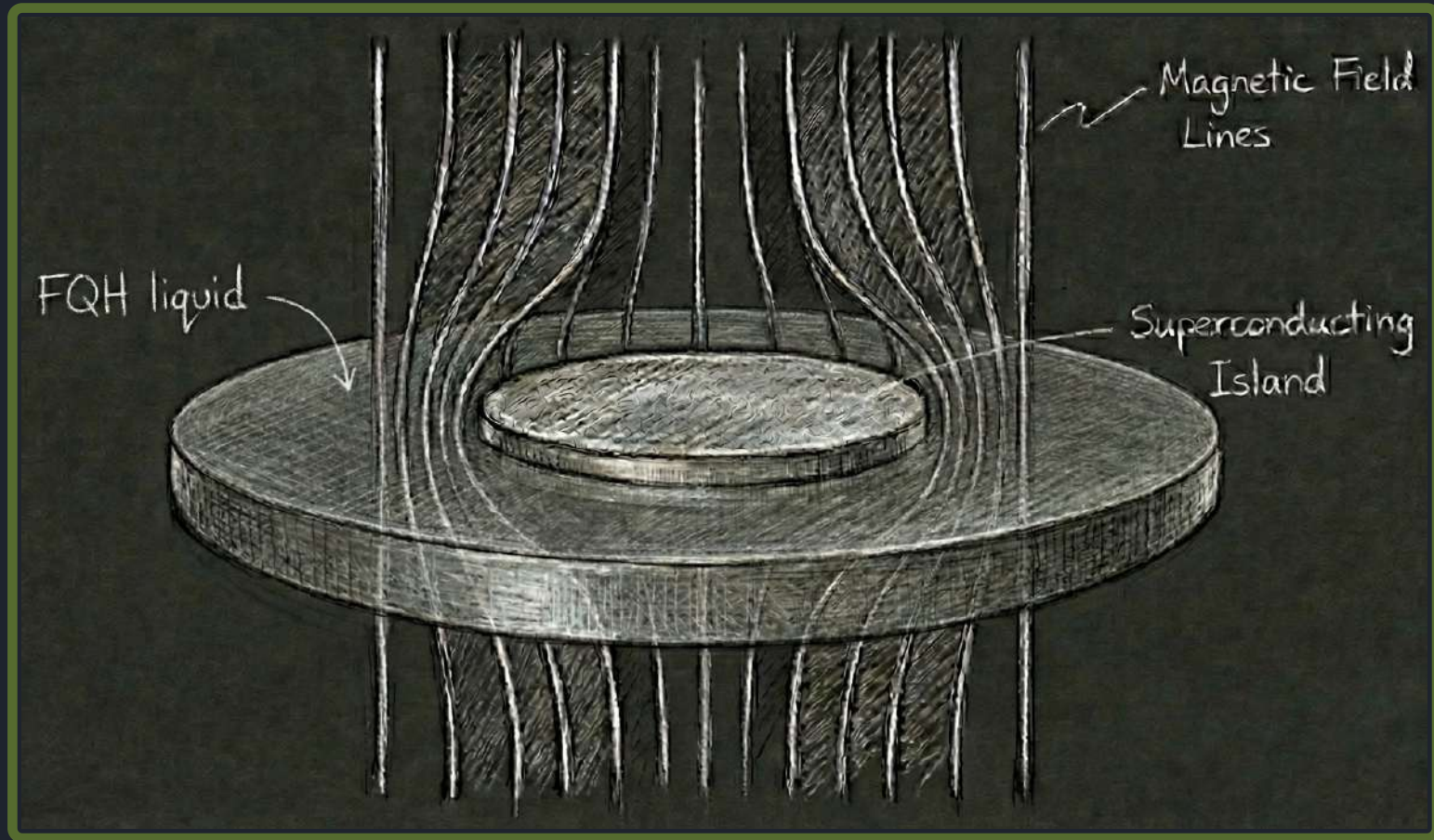
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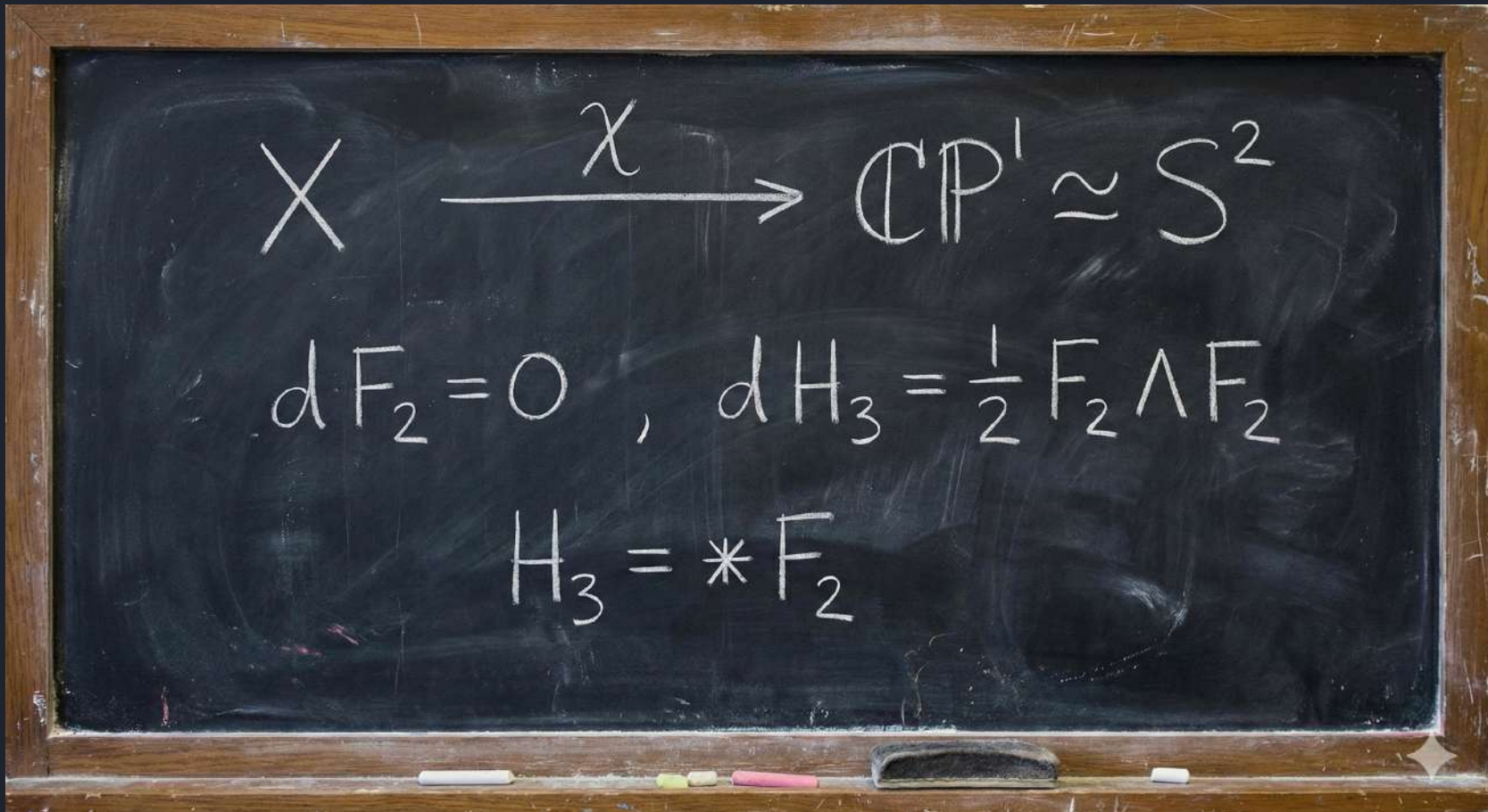
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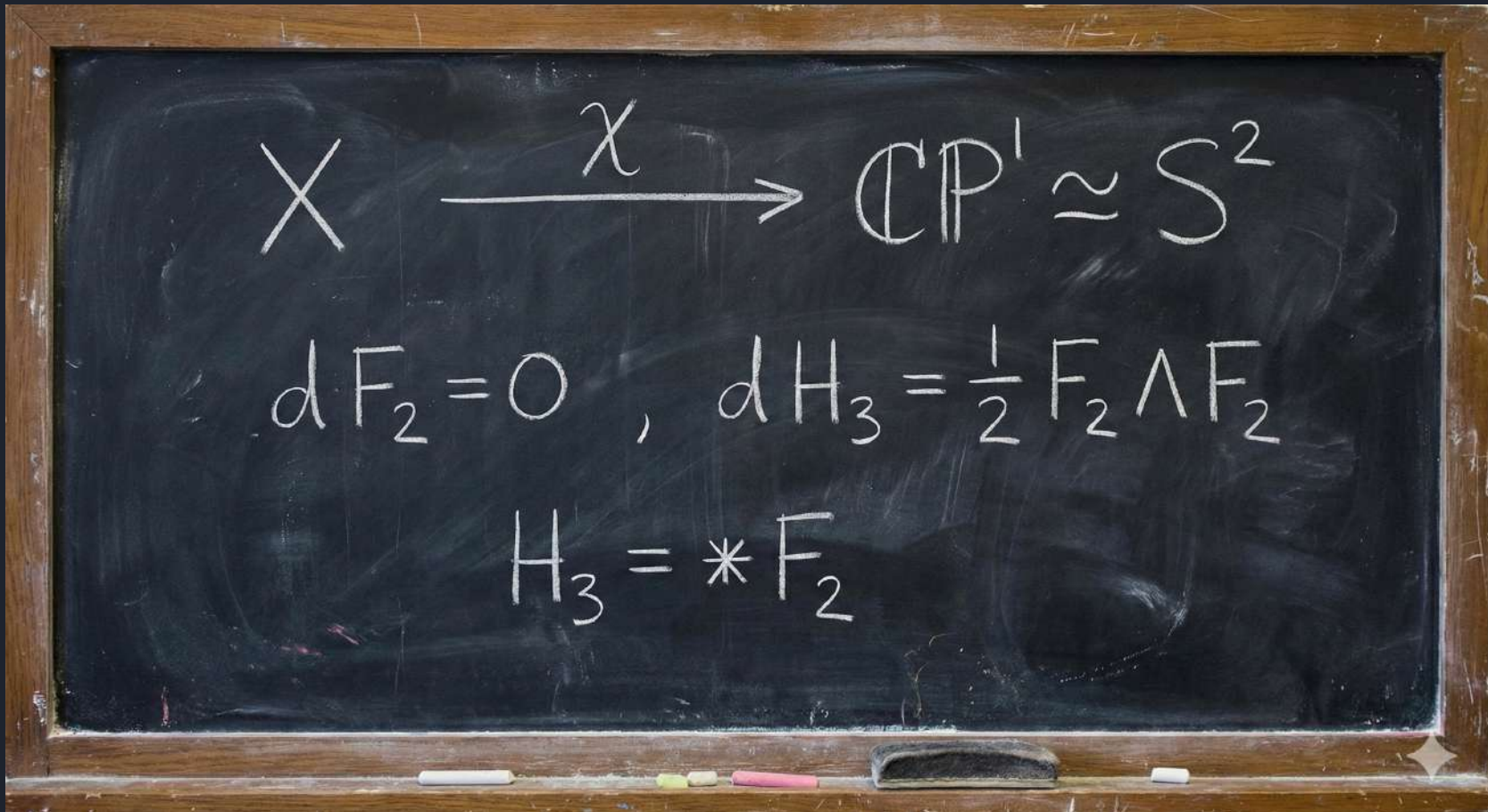
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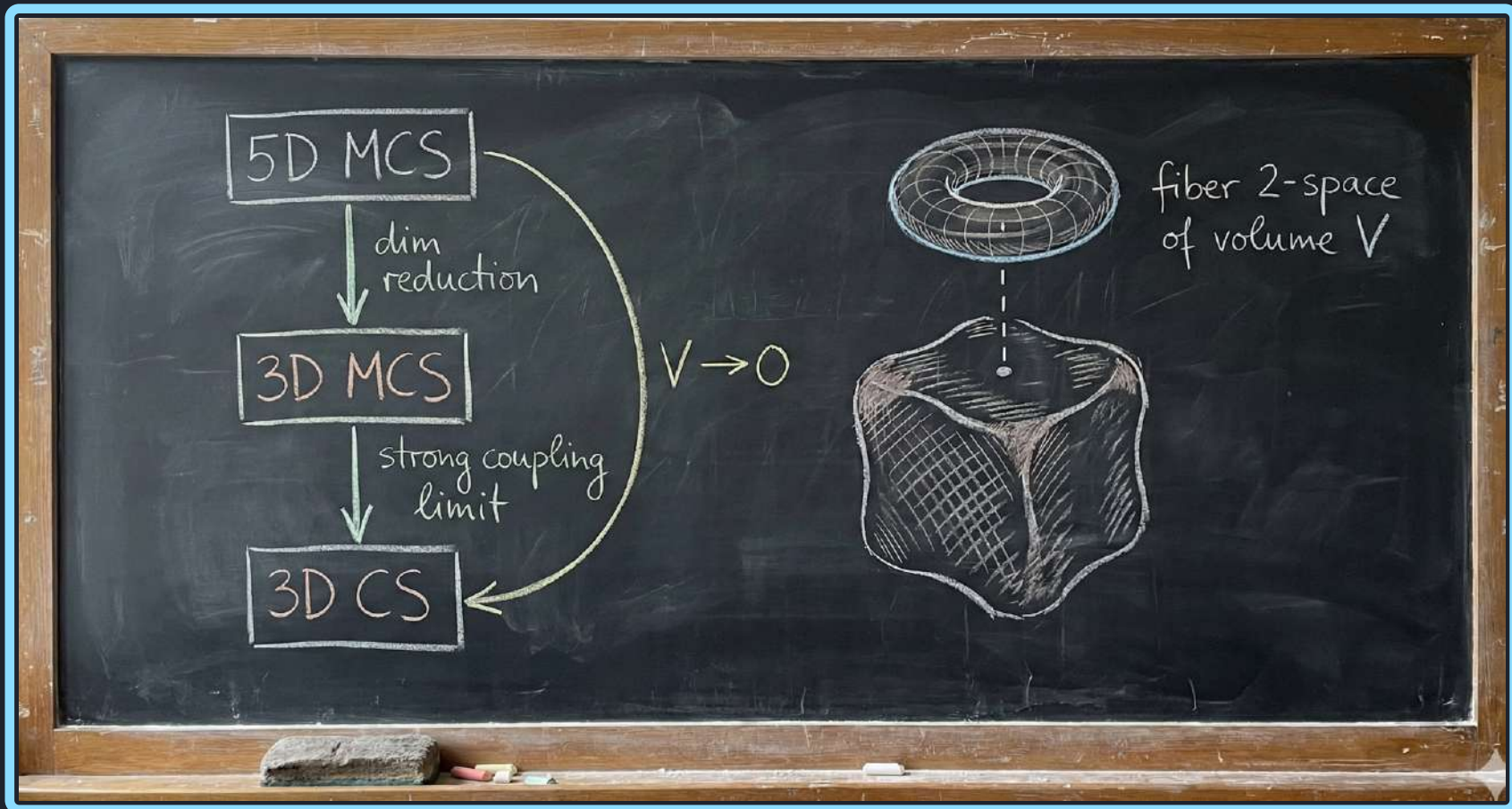
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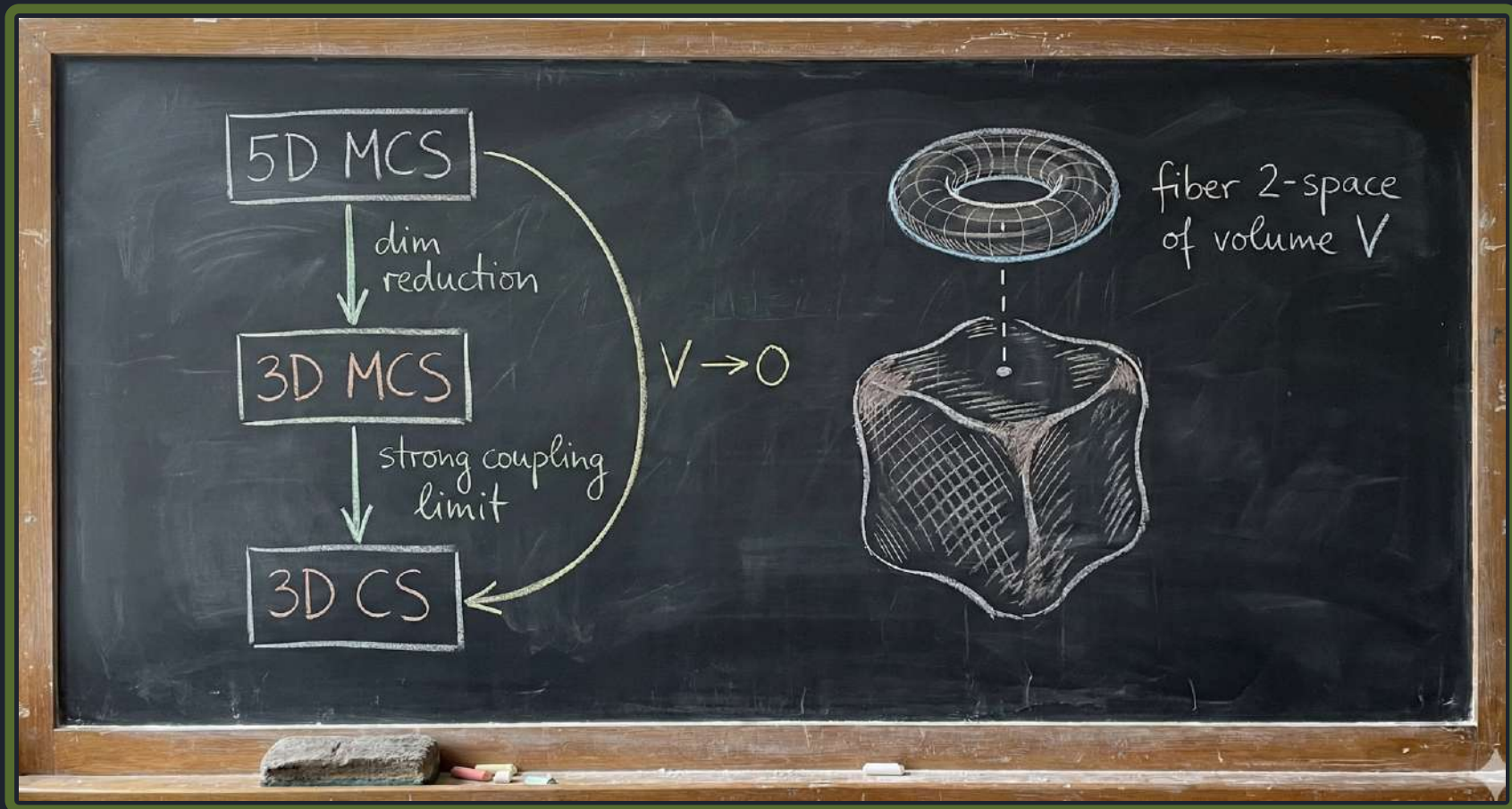
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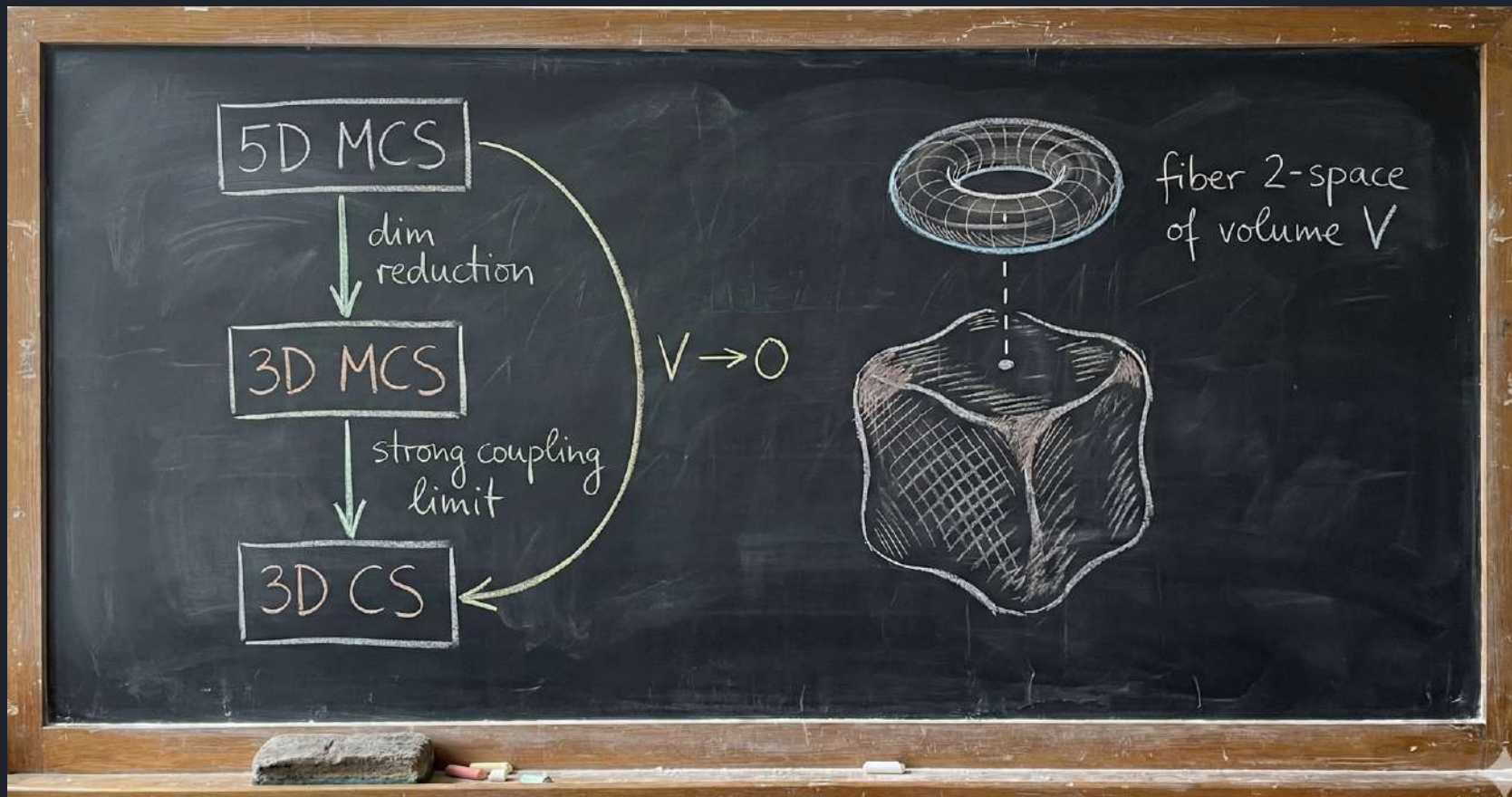
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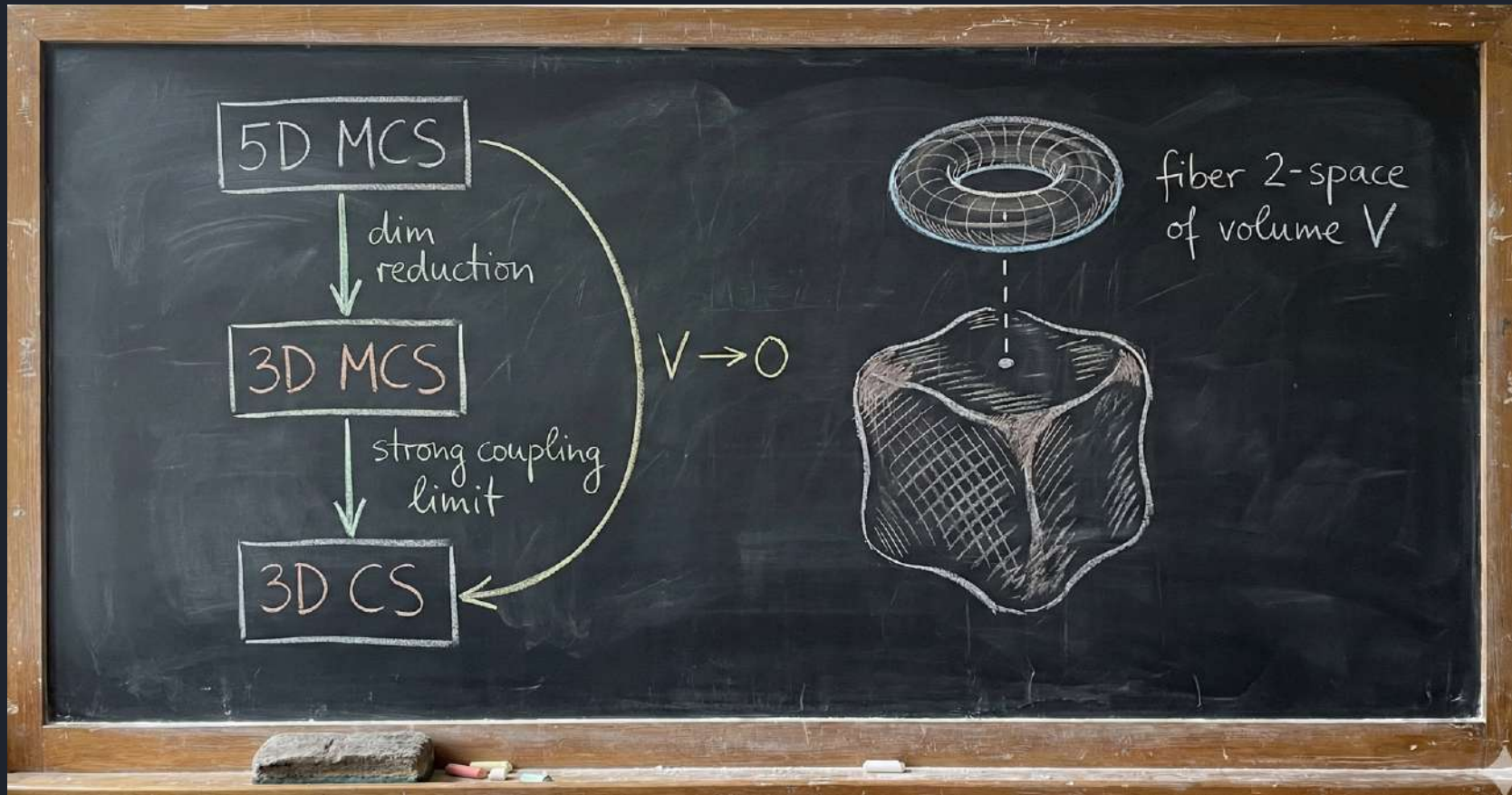
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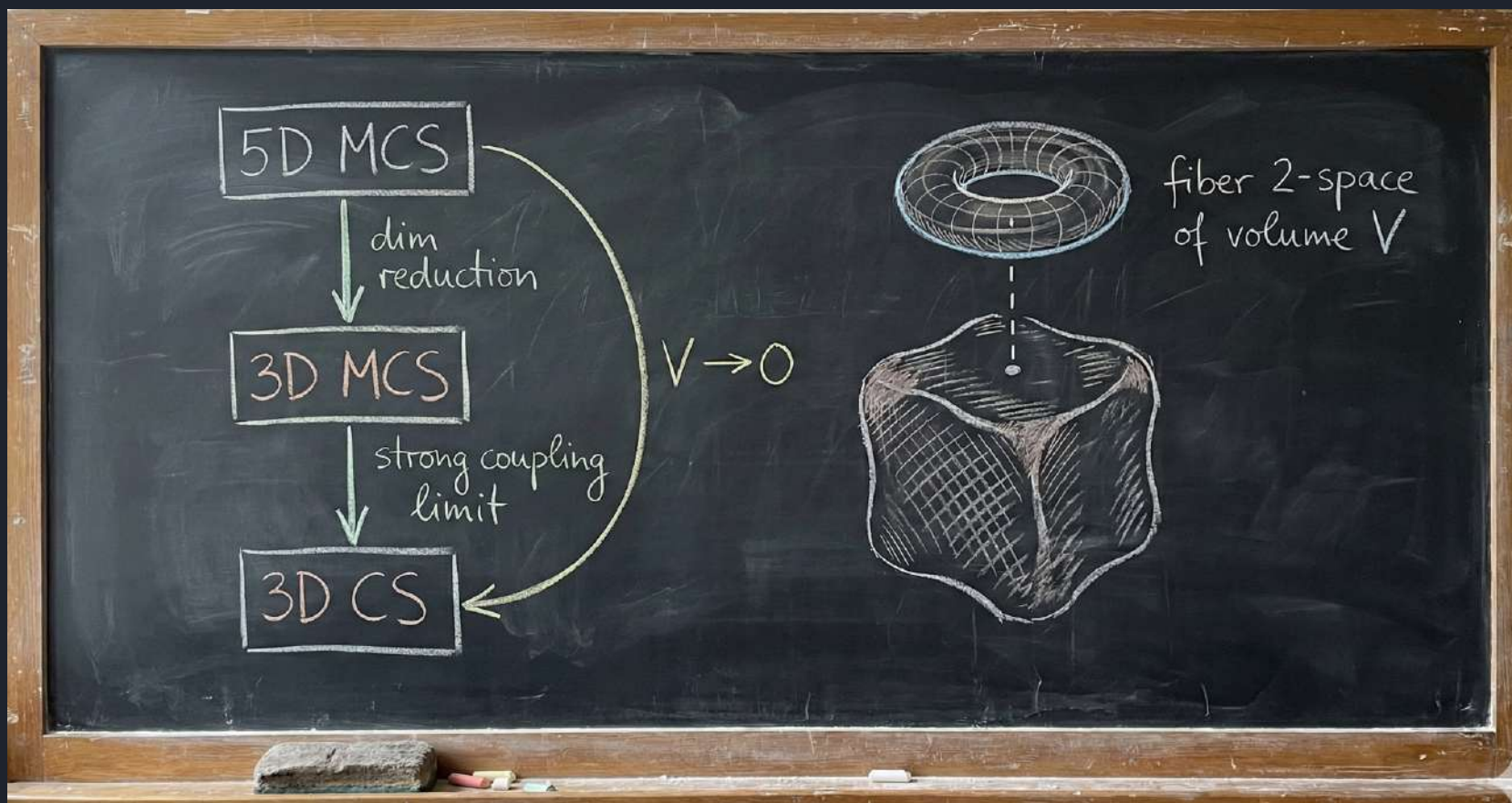
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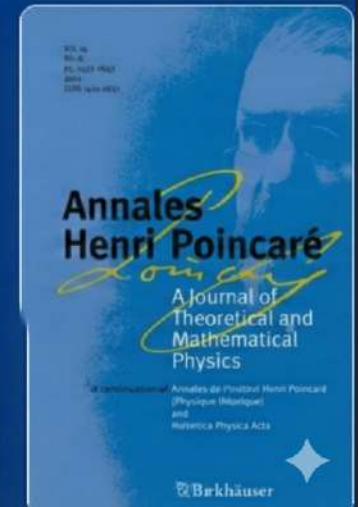
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Volume 26, pages 895–919, (2025)



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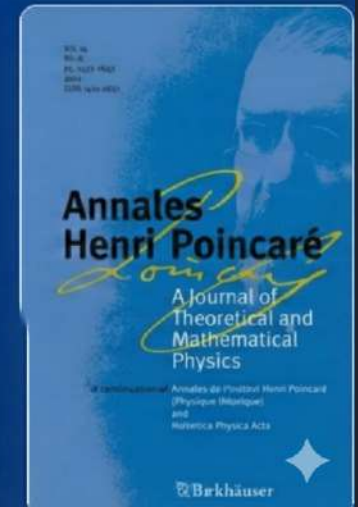
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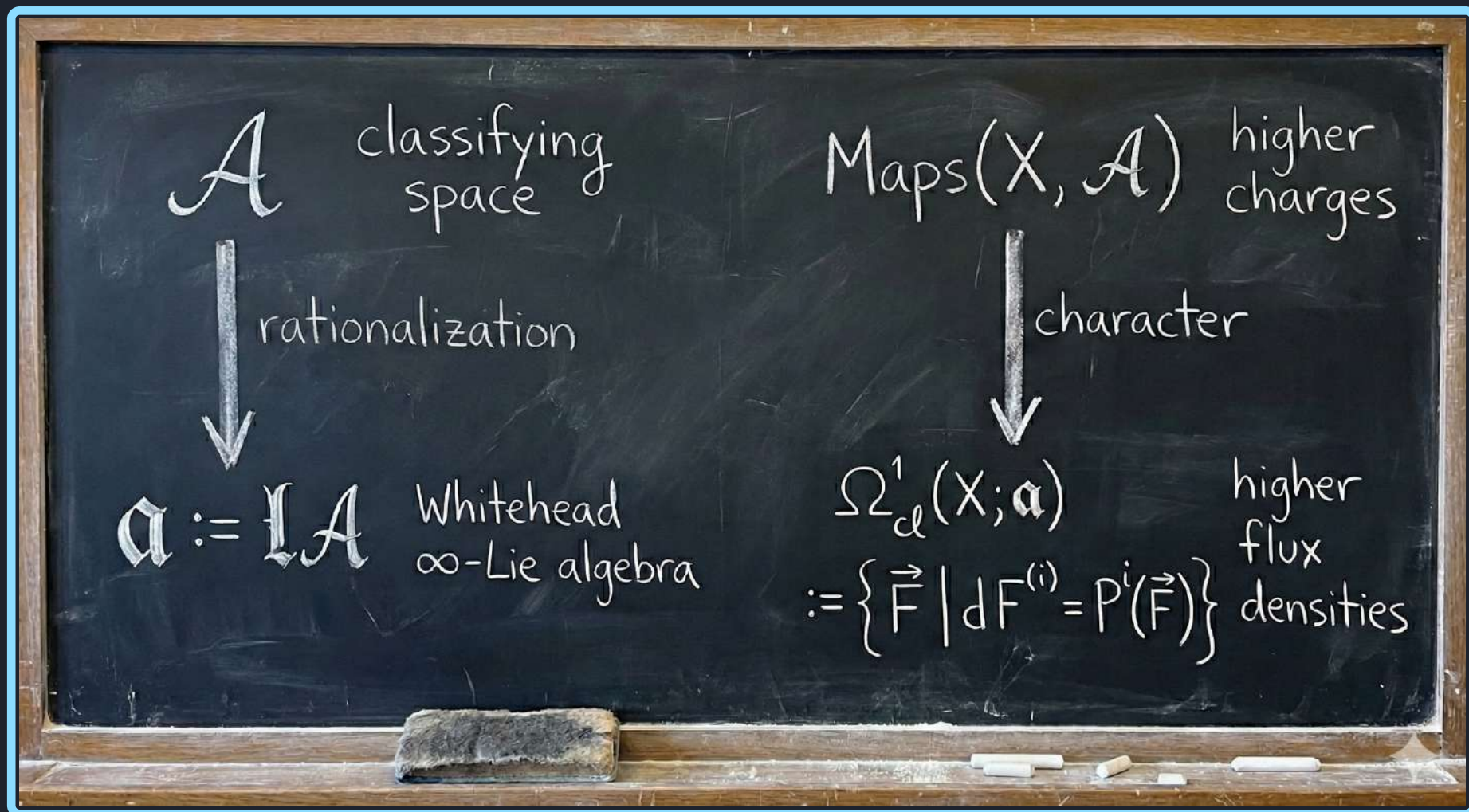
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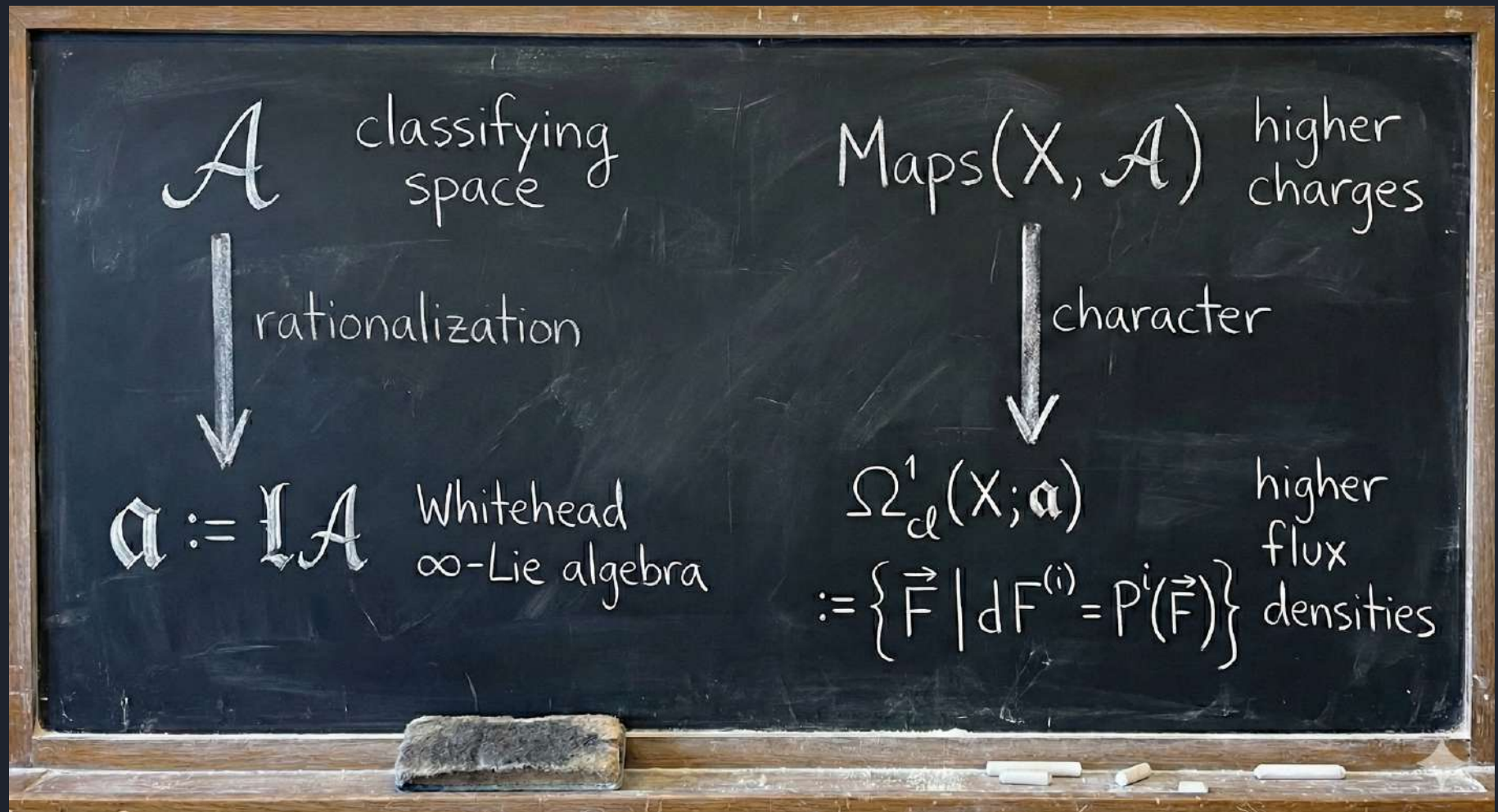
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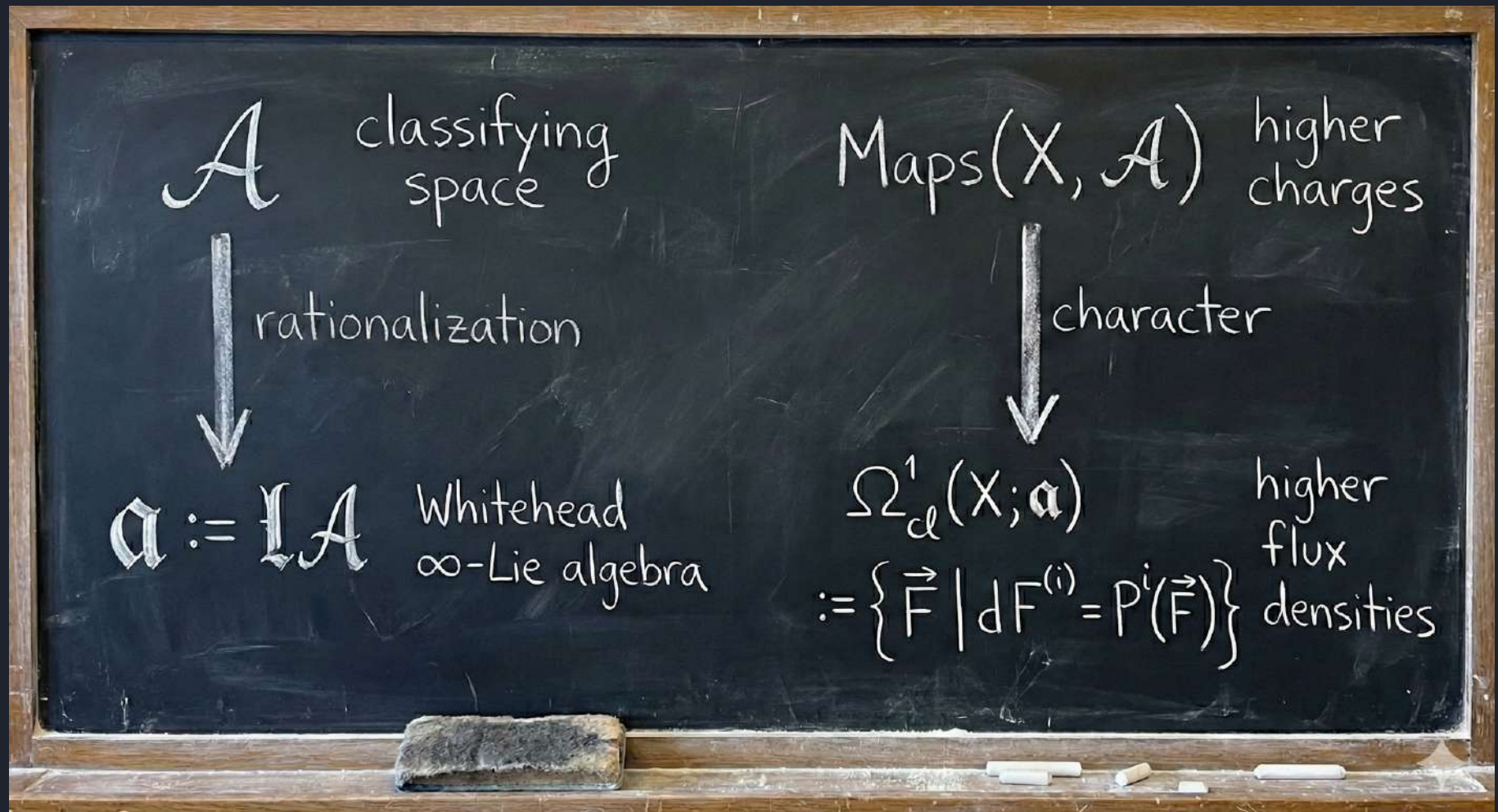


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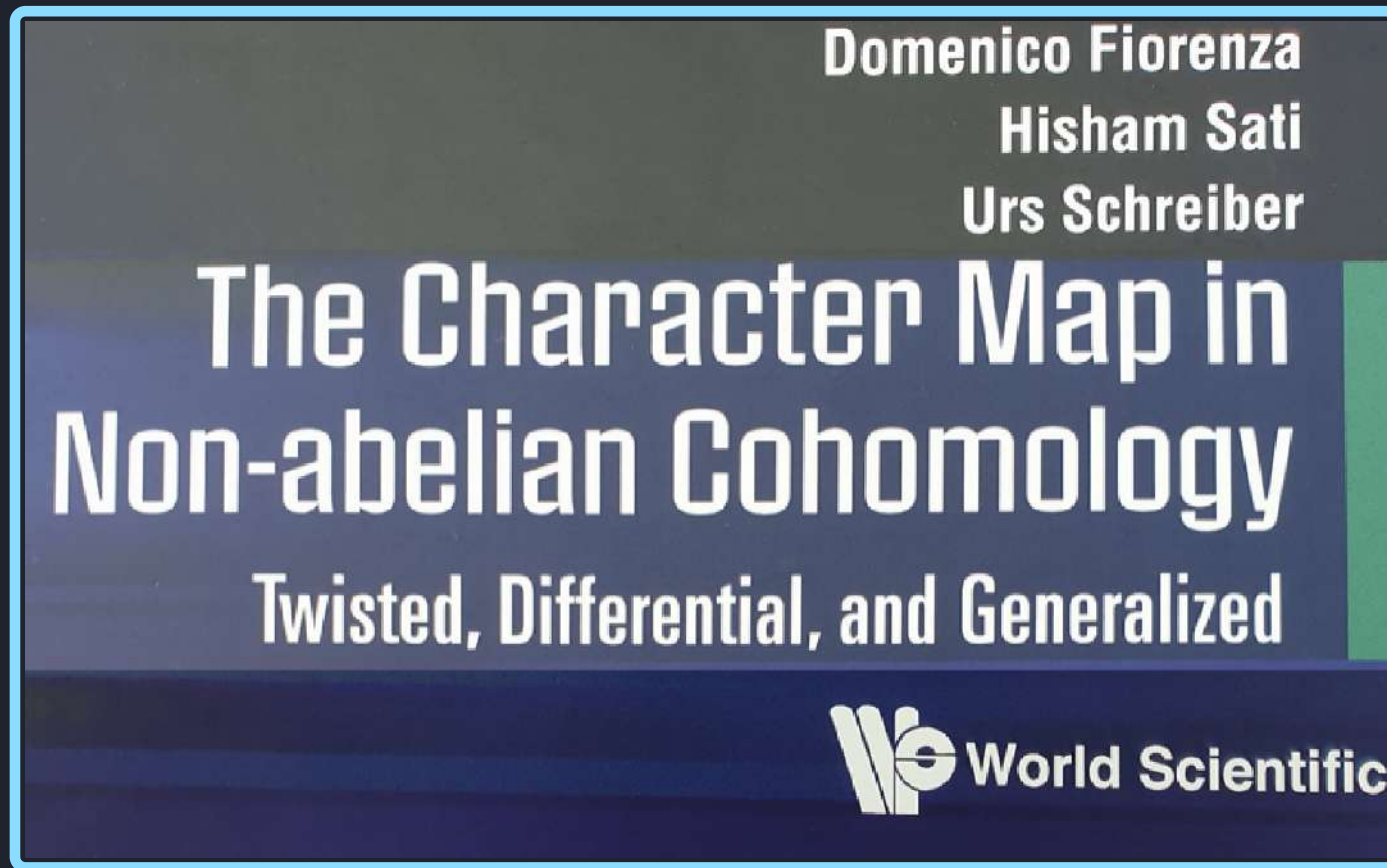
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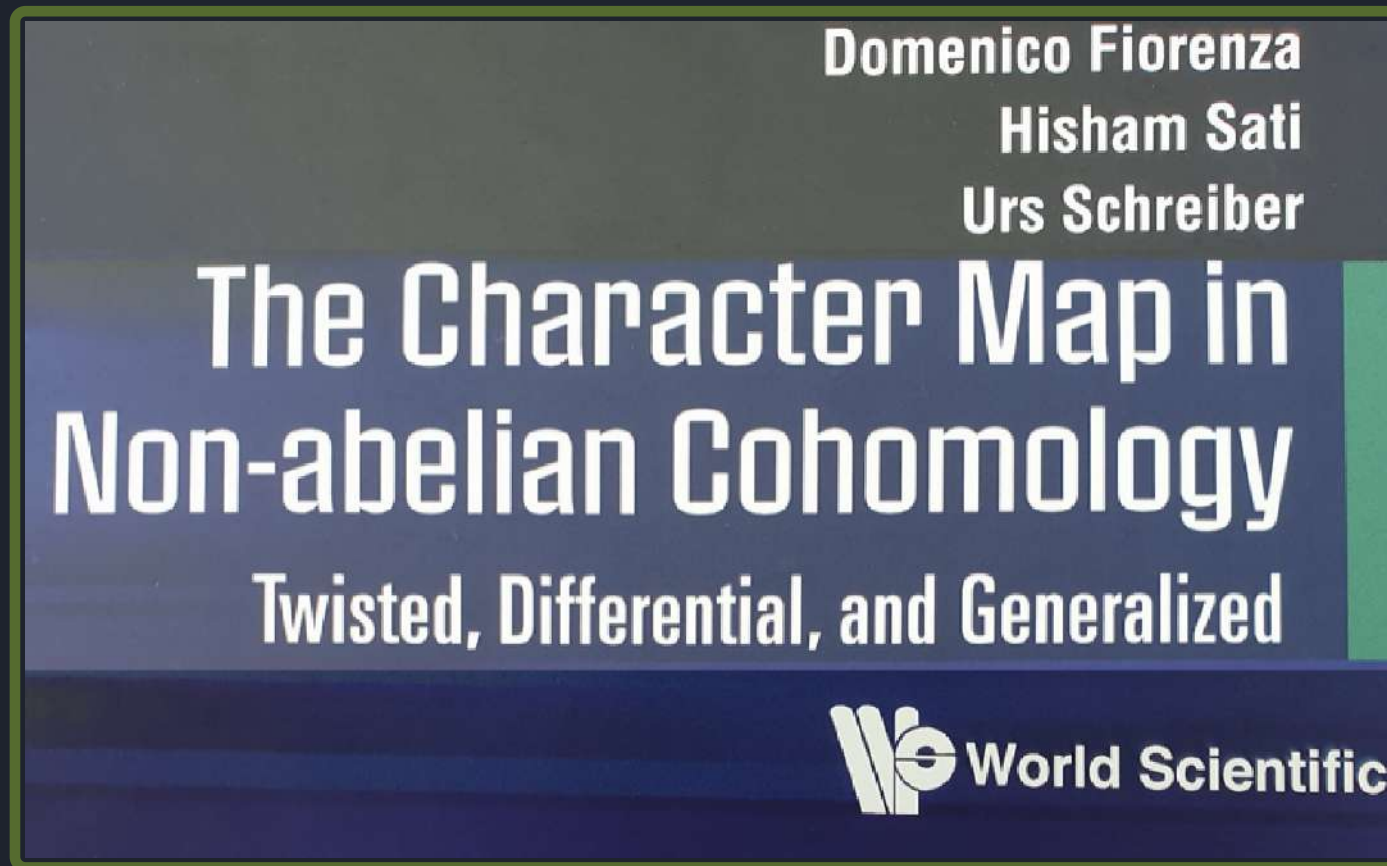
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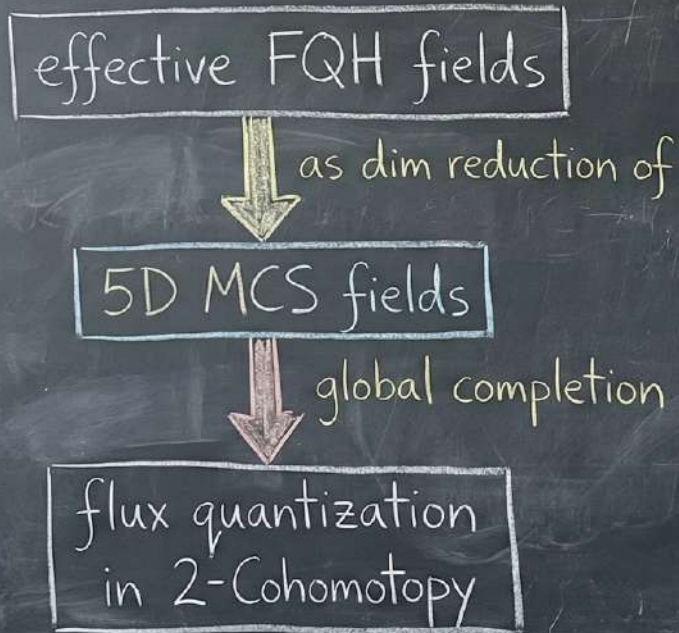


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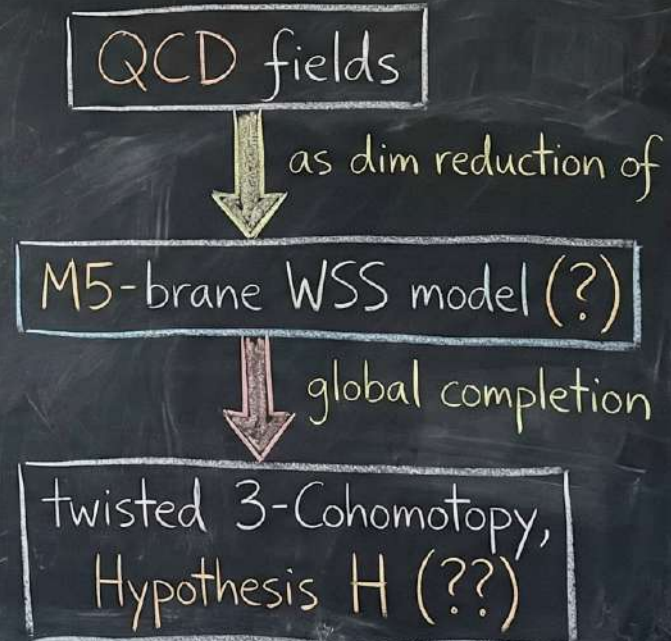
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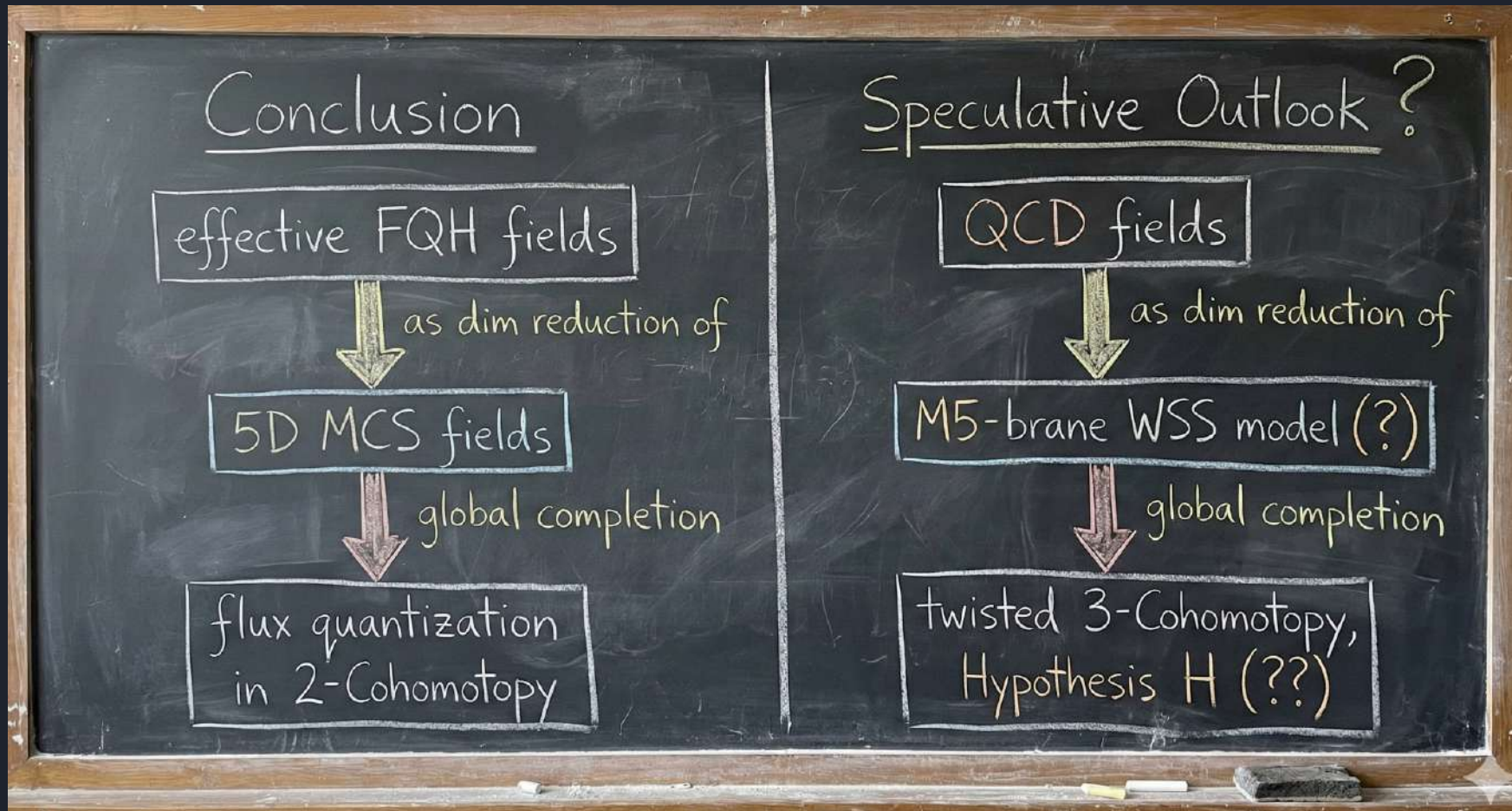
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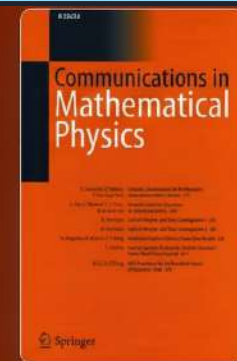


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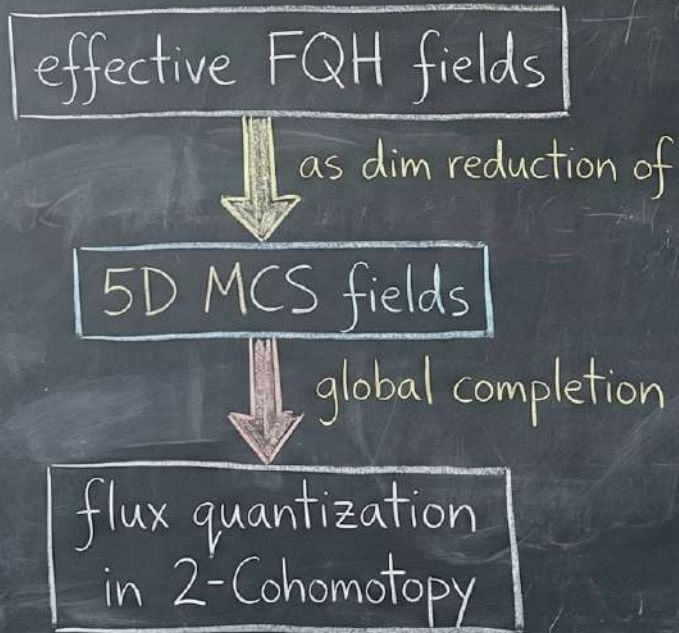
D. Fiorenza, H. Sati and U. Schreiber

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

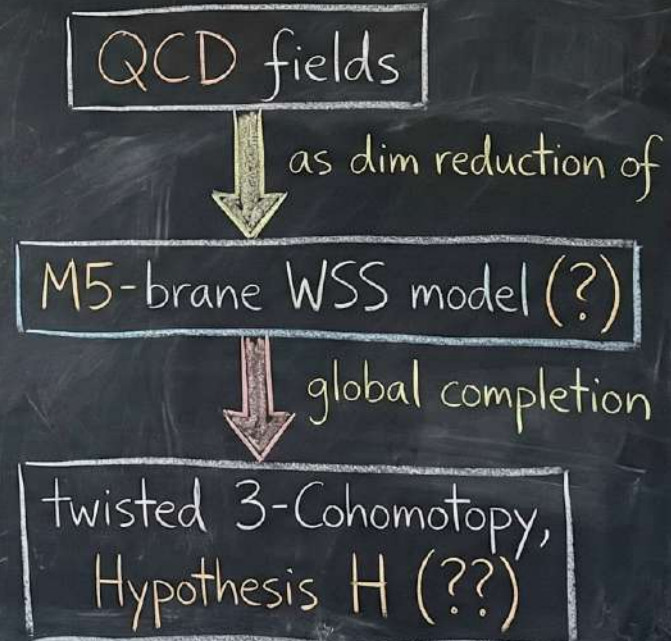


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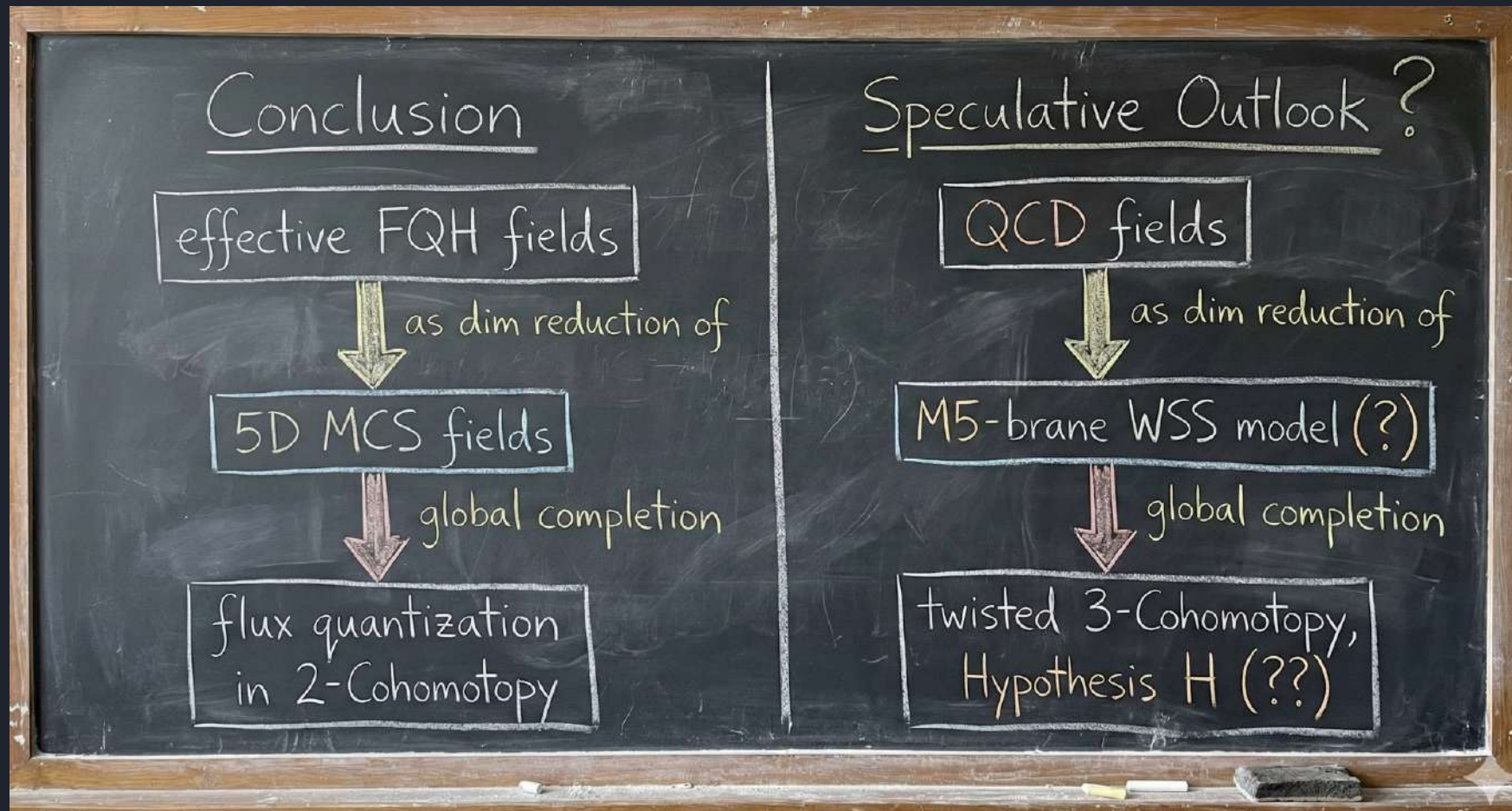
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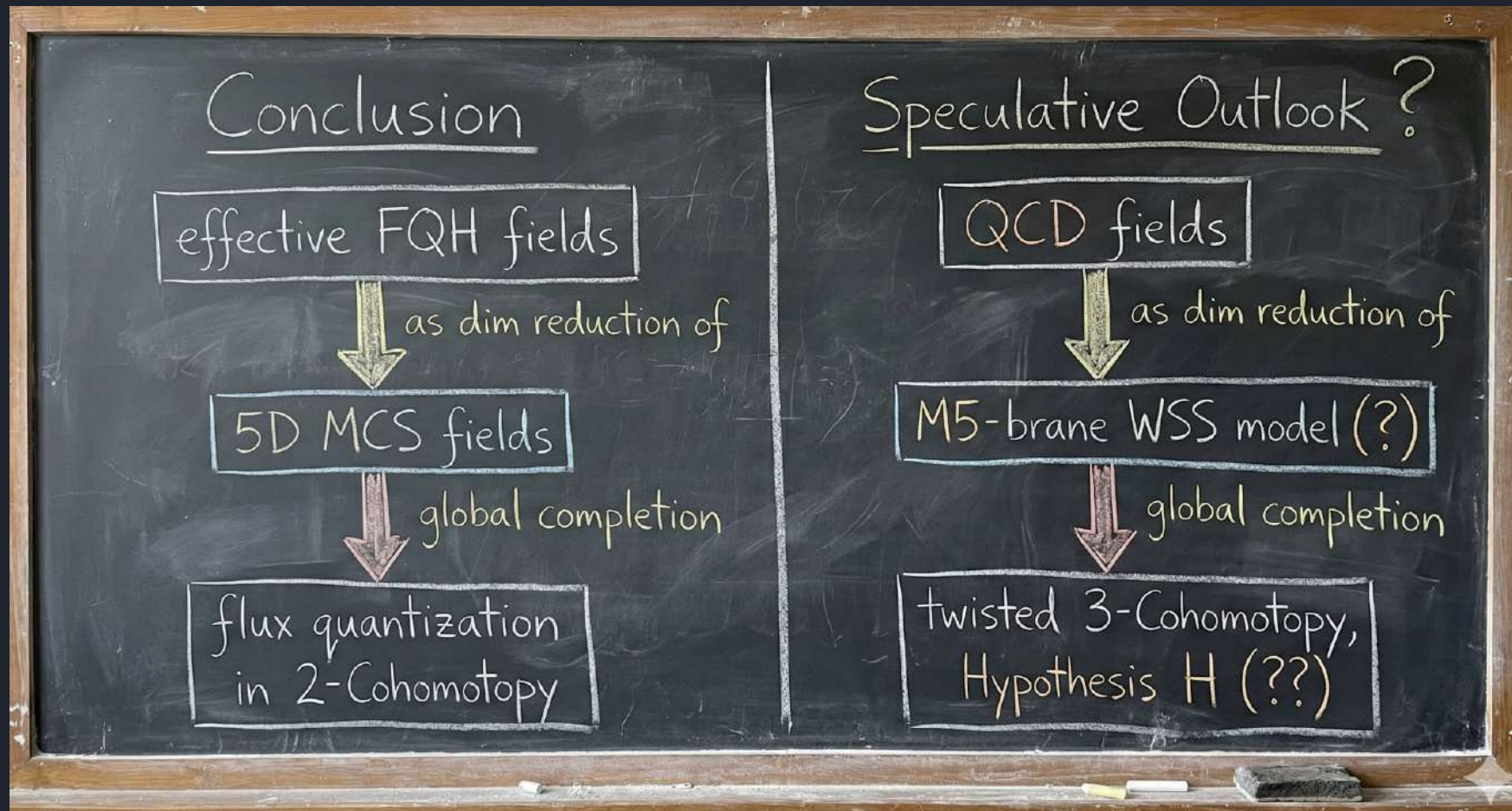


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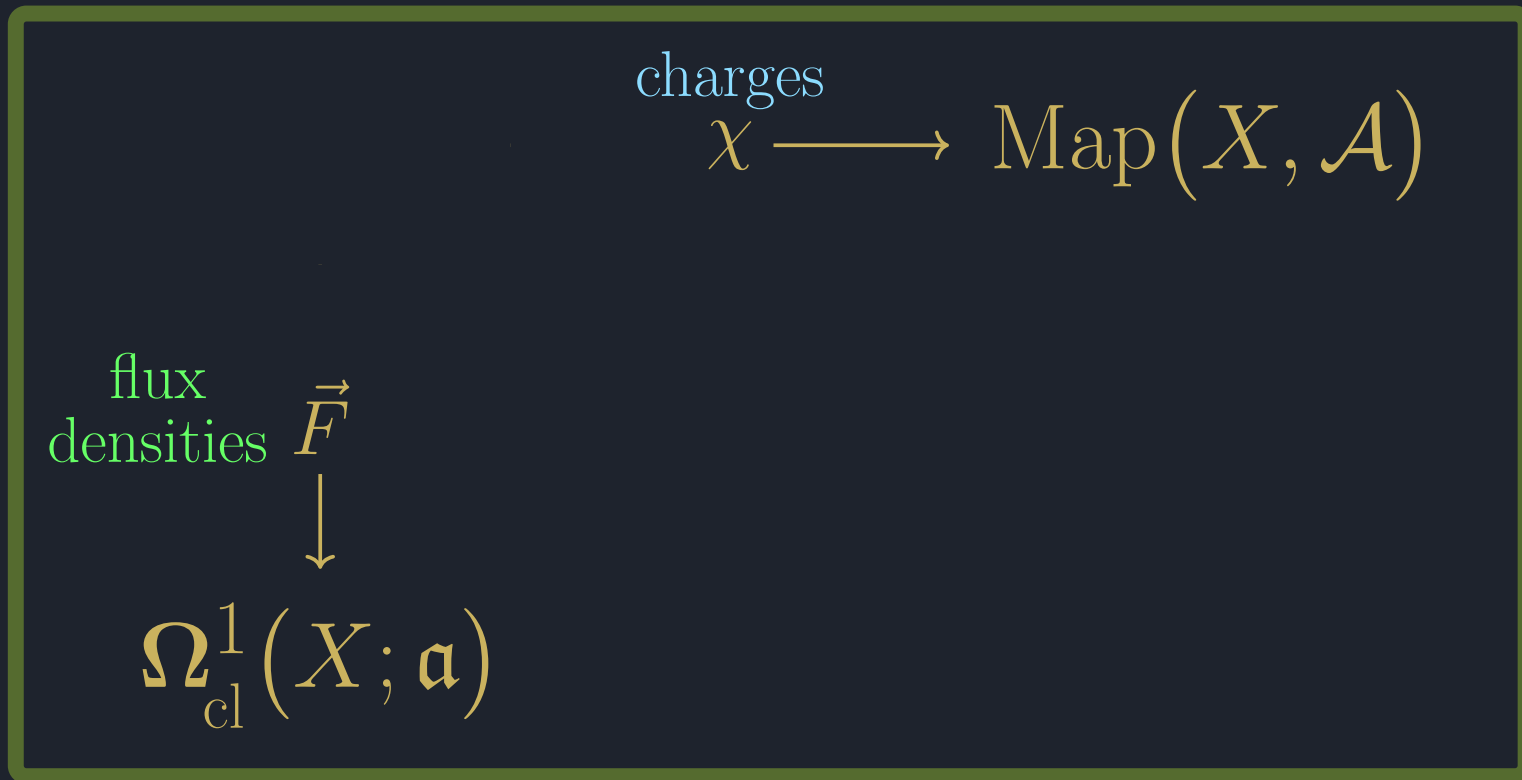
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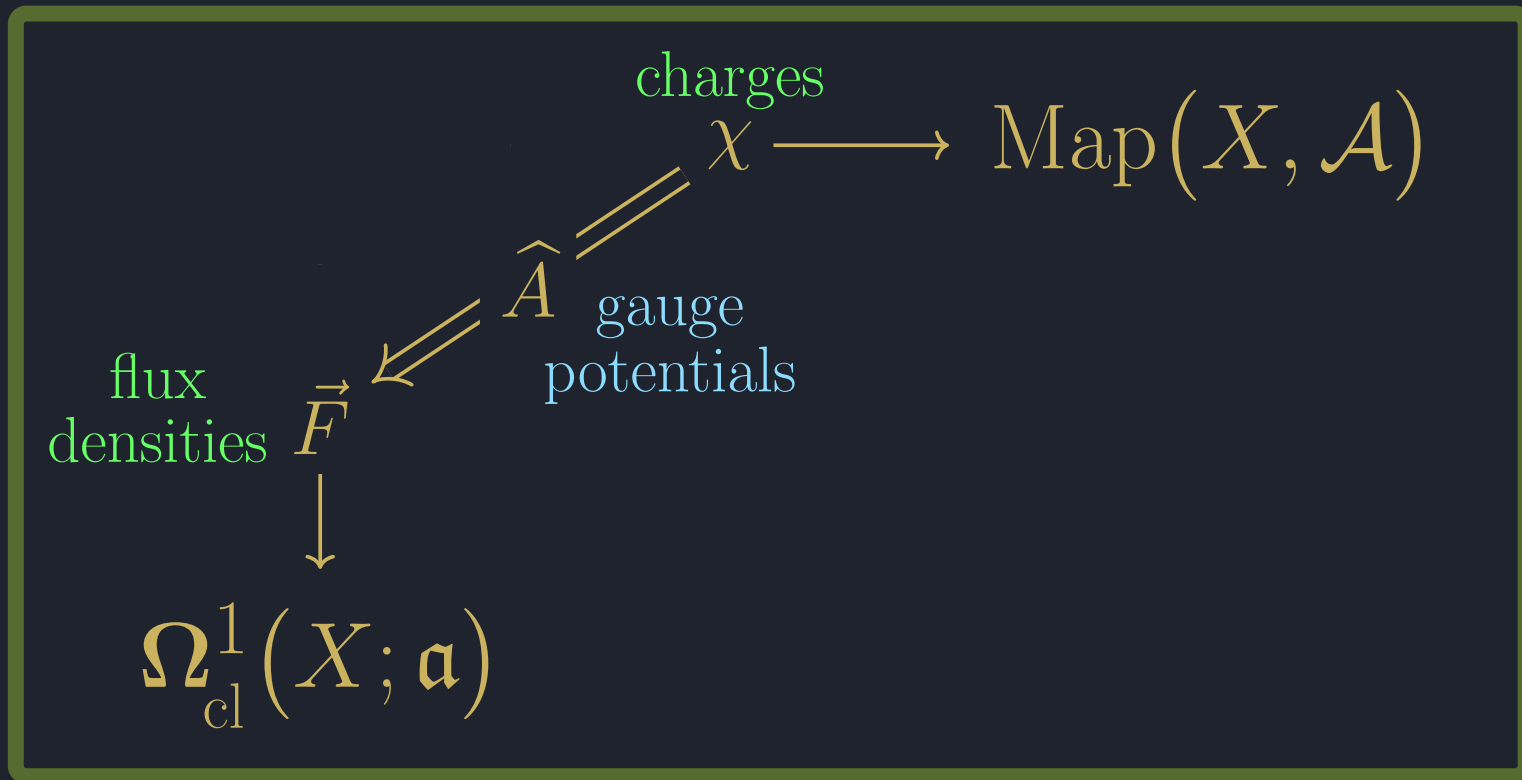
The nonperturbative field content must combine these.

$$\begin{array}{ccc} & \text{charges} & \\ & \chi \longrightarrow & \text{Map}(X, \mathcal{A}) \\ & & \\ \text{flux} & & \\ \text{densities} & \vec{F} & \\ & \downarrow & \\ & \Omega_{\text{cl}}^1(X; \mathfrak{a}) & \end{array}$$

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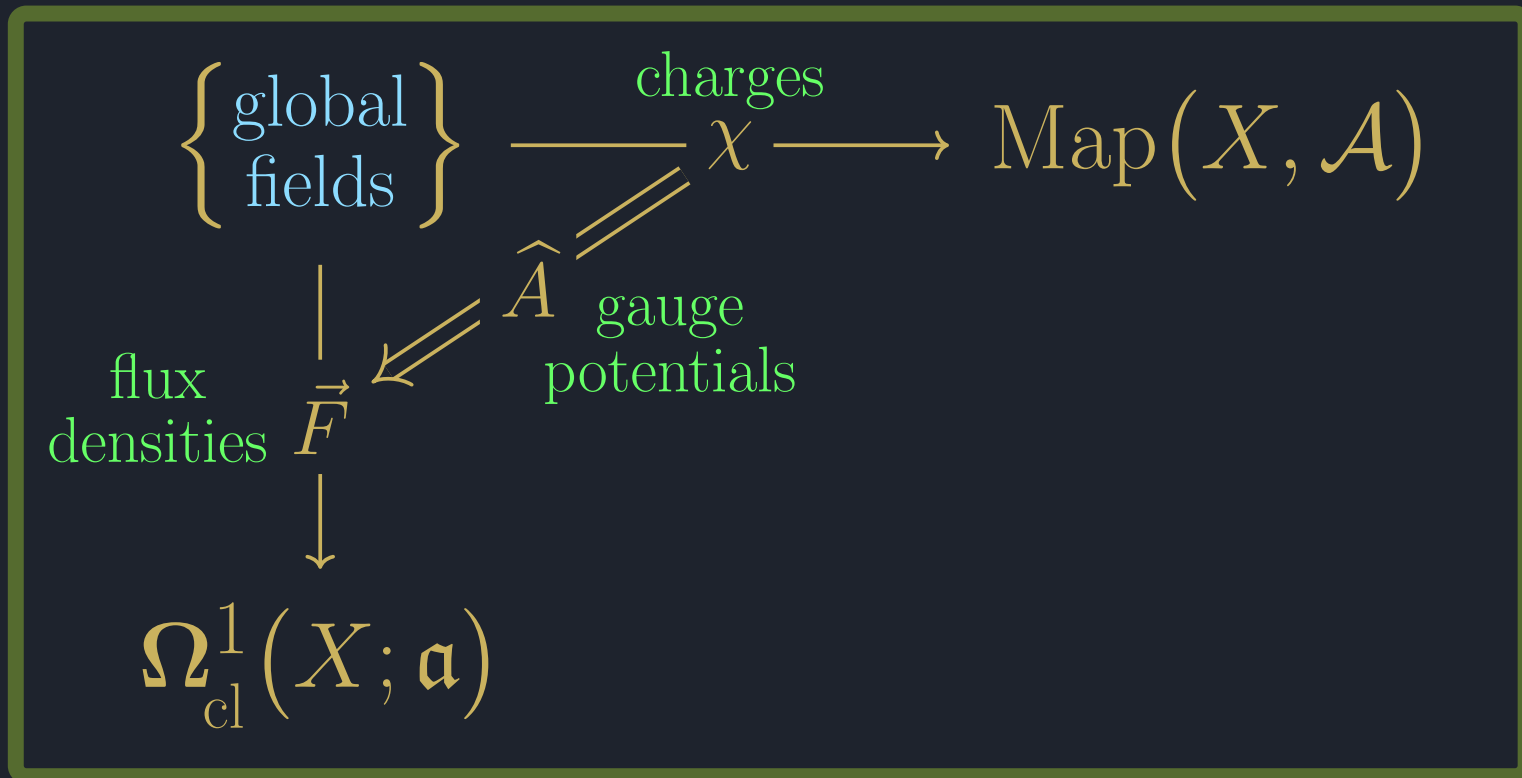
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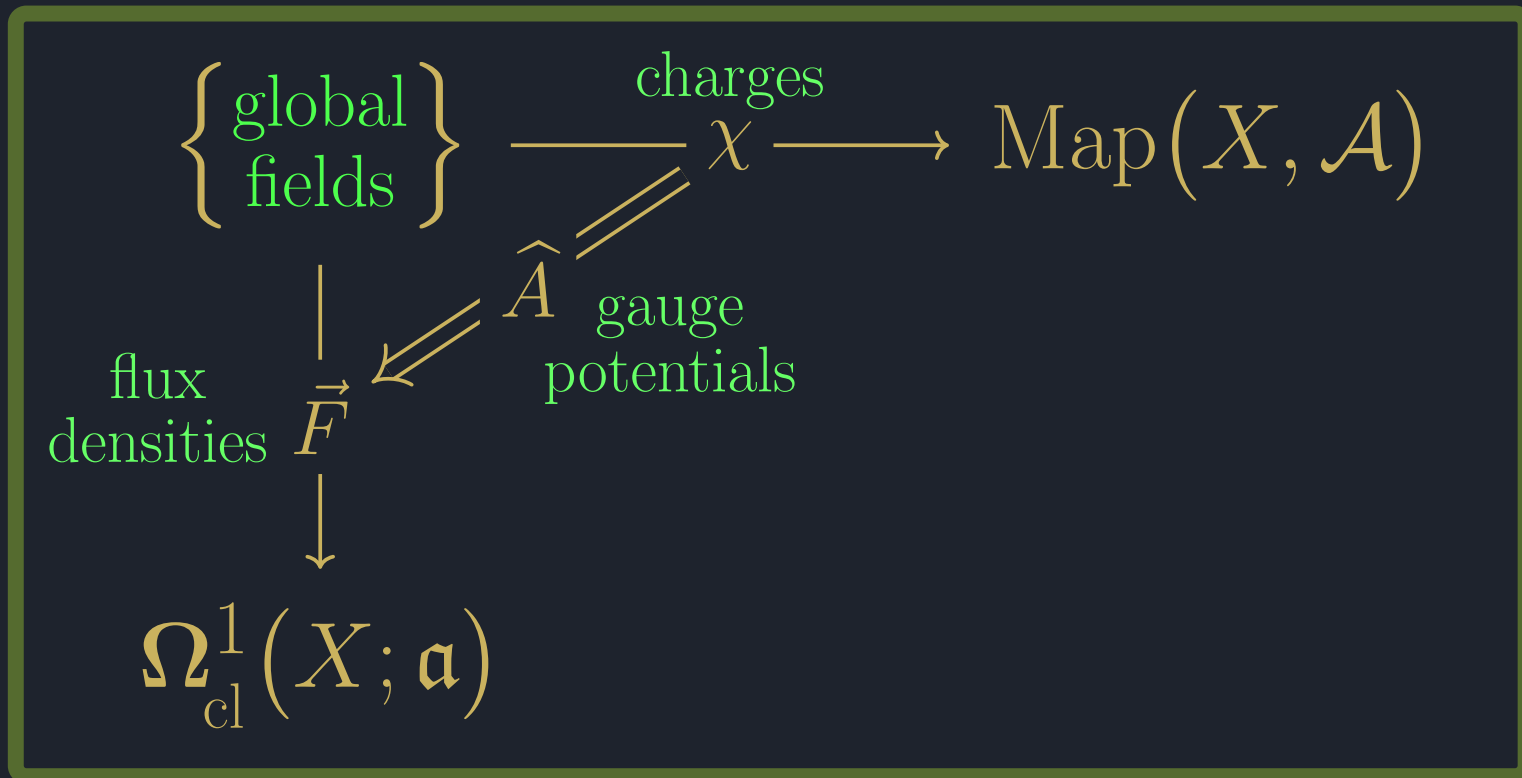
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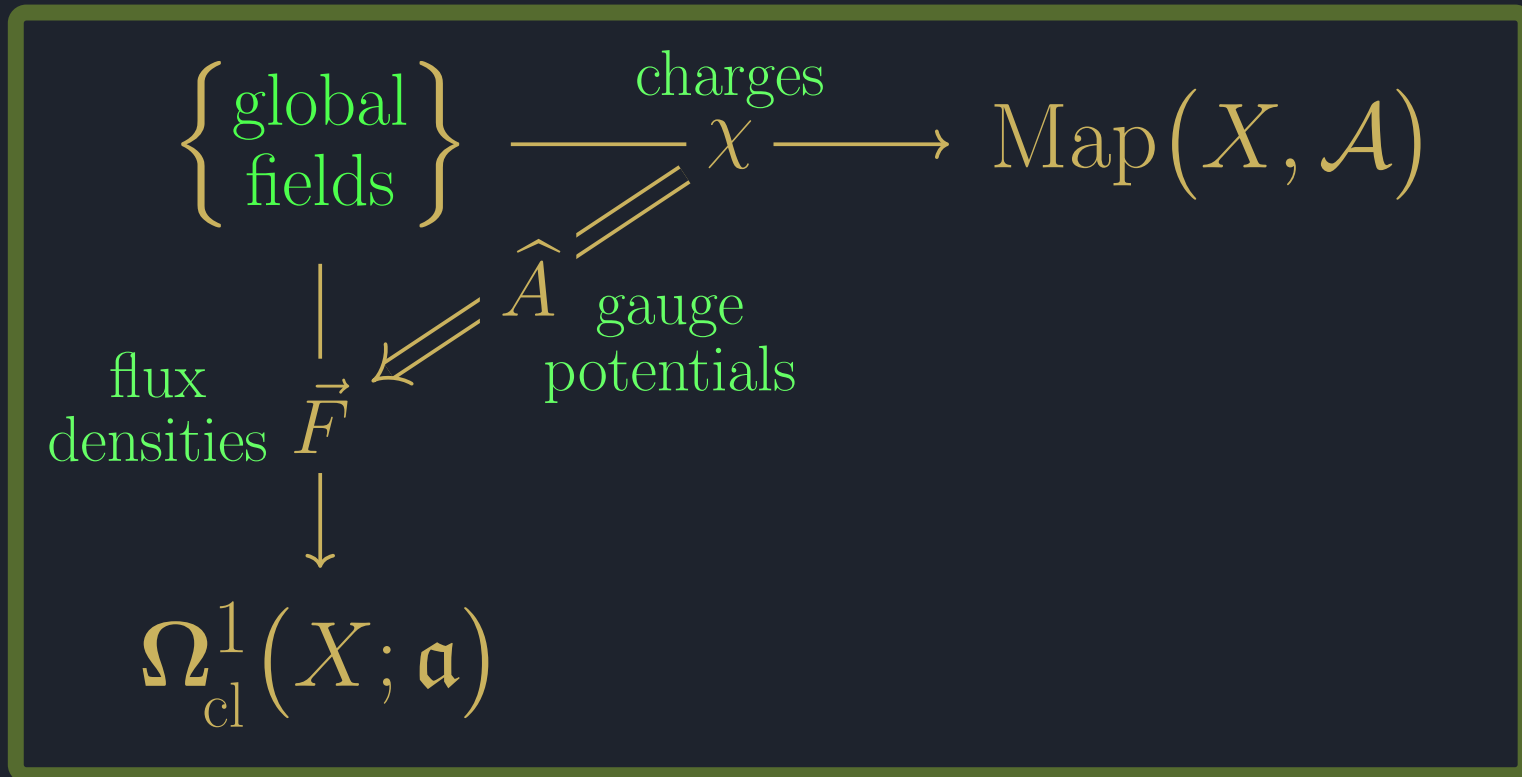


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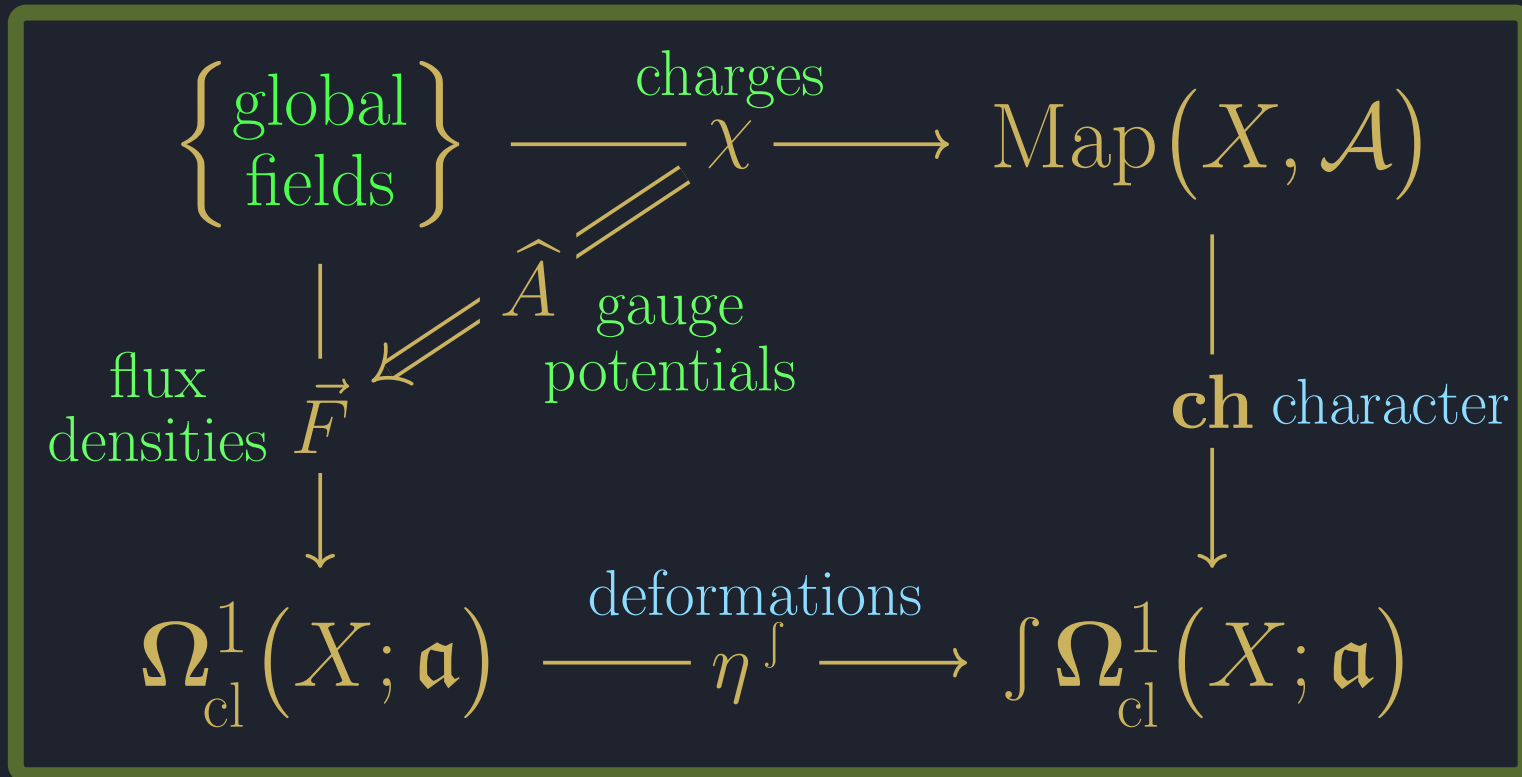


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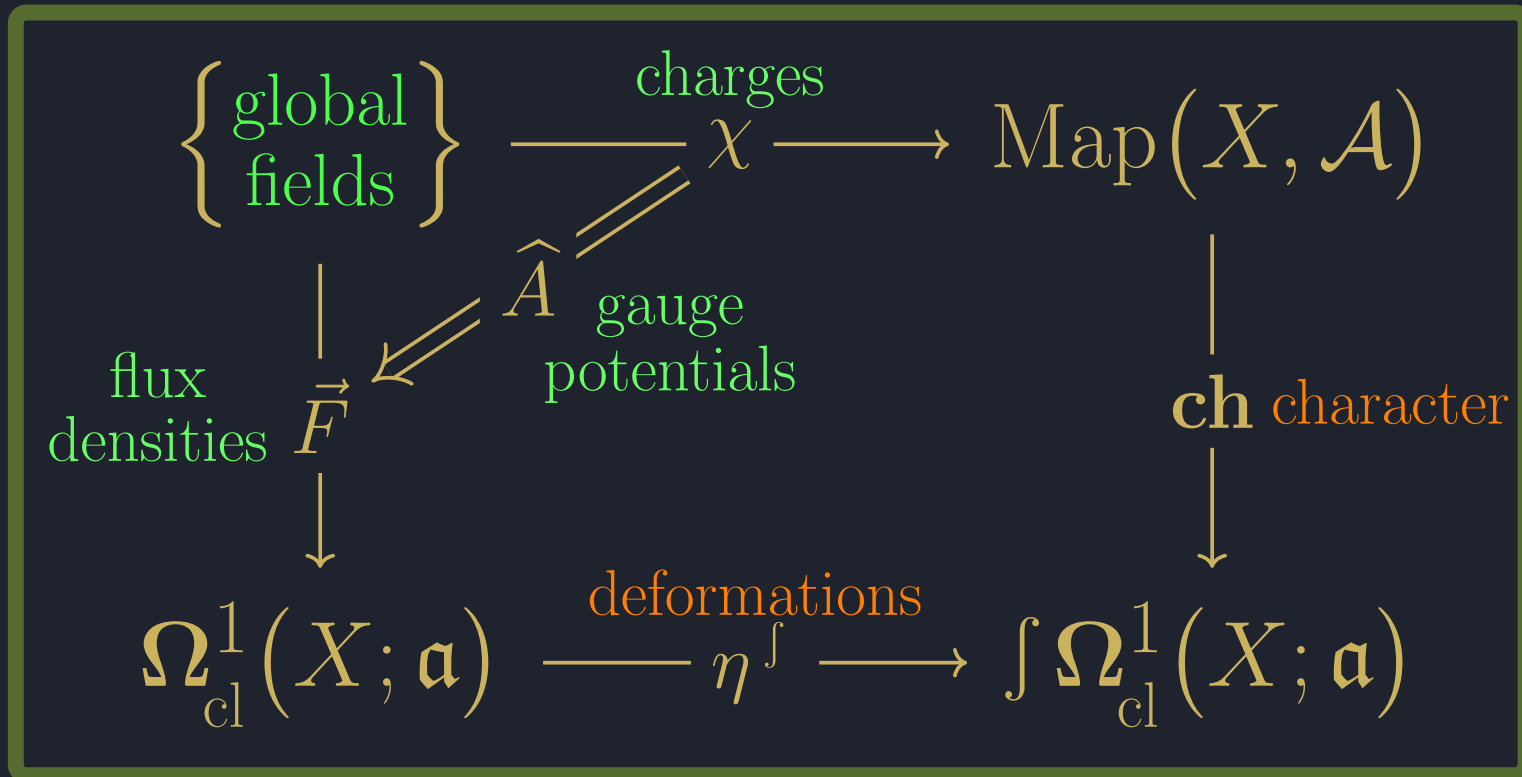


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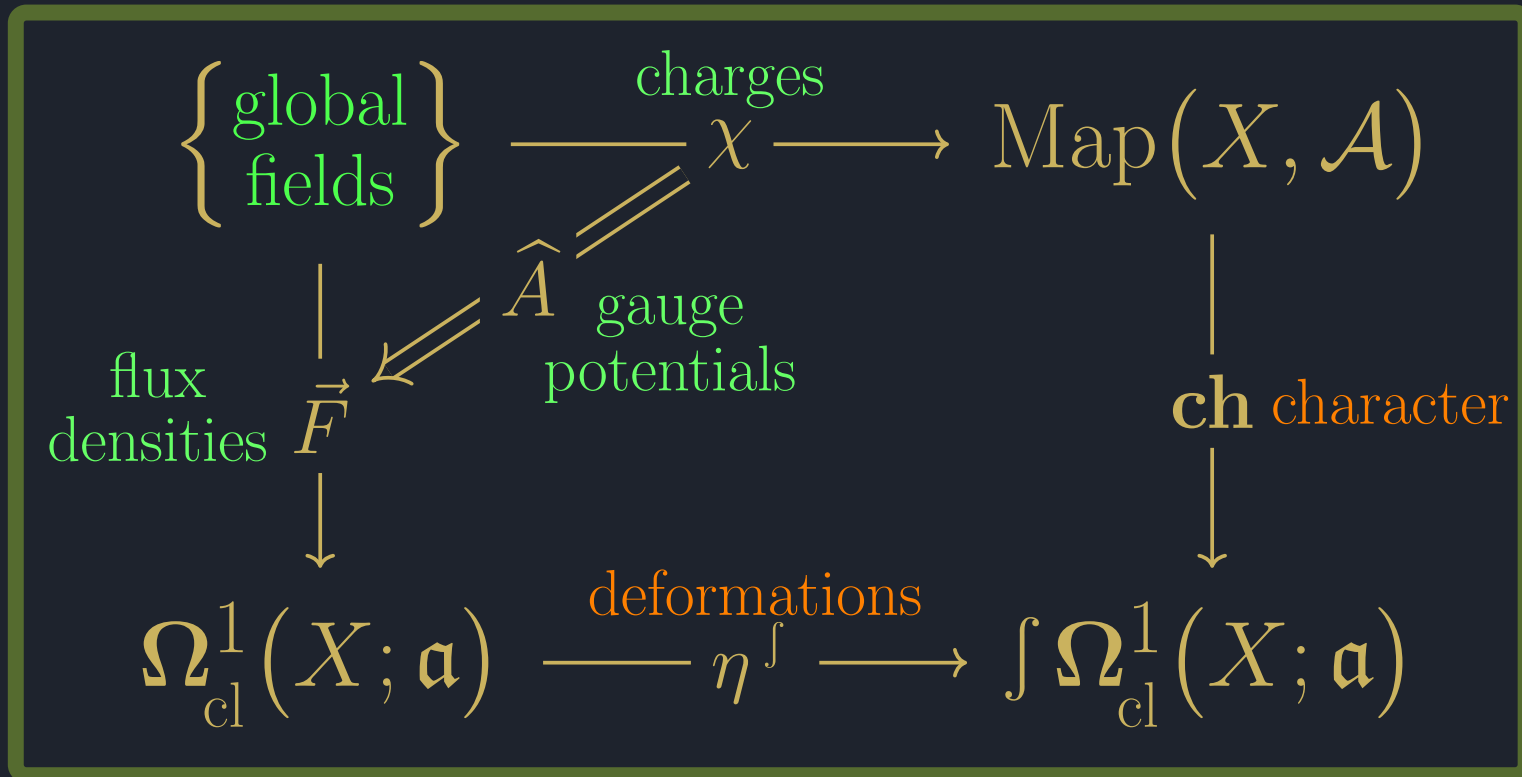


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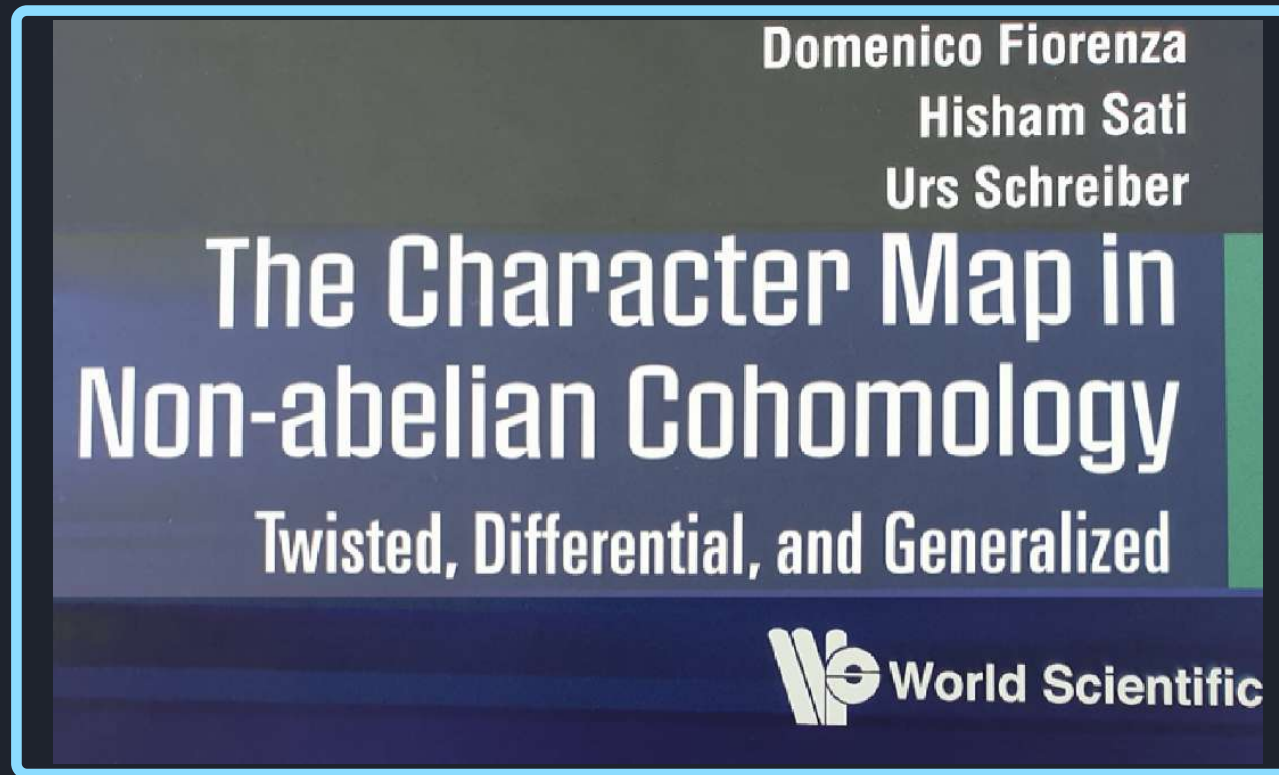


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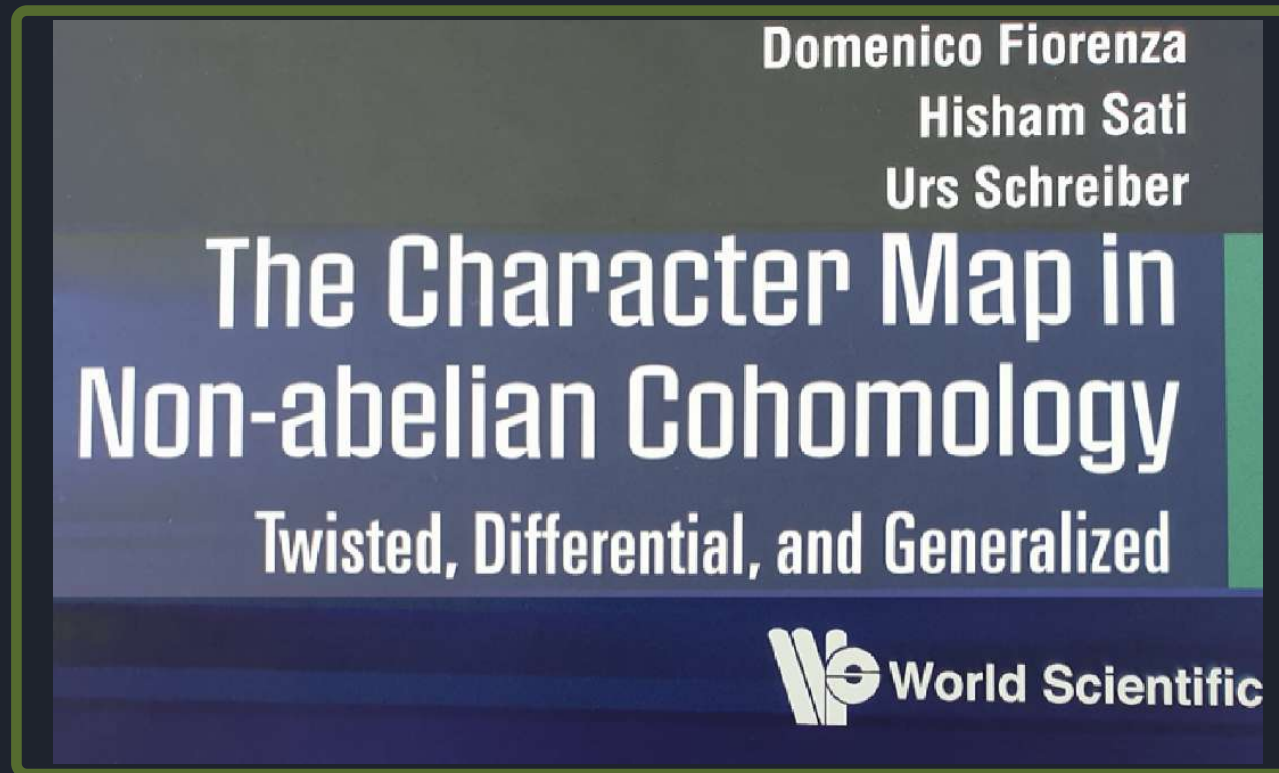


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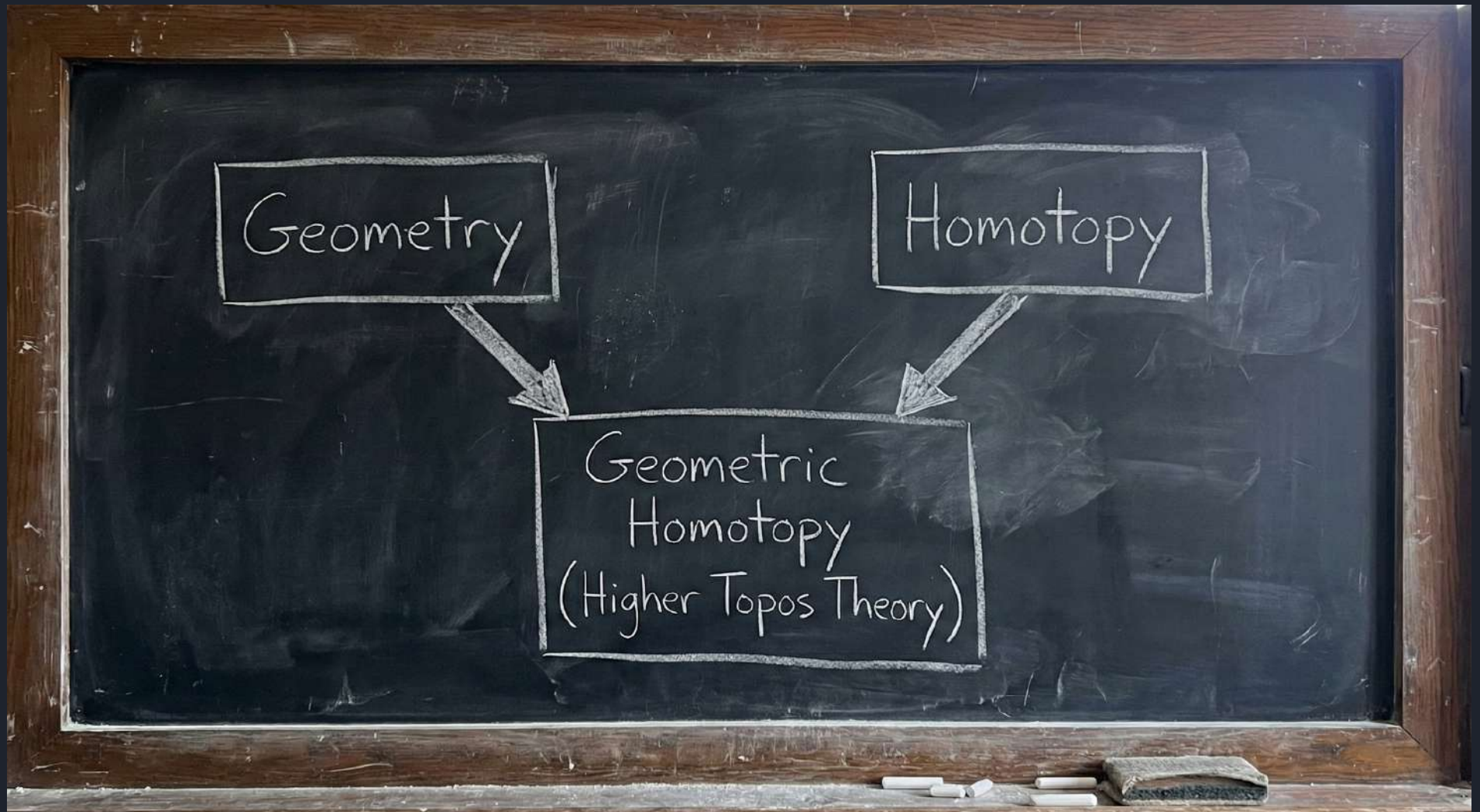
Geometry

Homotopy


Geometric
Homotopy
(Higher Topos Theory)



Thus to formulate nonperturbative physics in higher topoi



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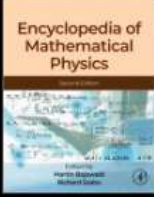


Encyclopedia of Mathematical
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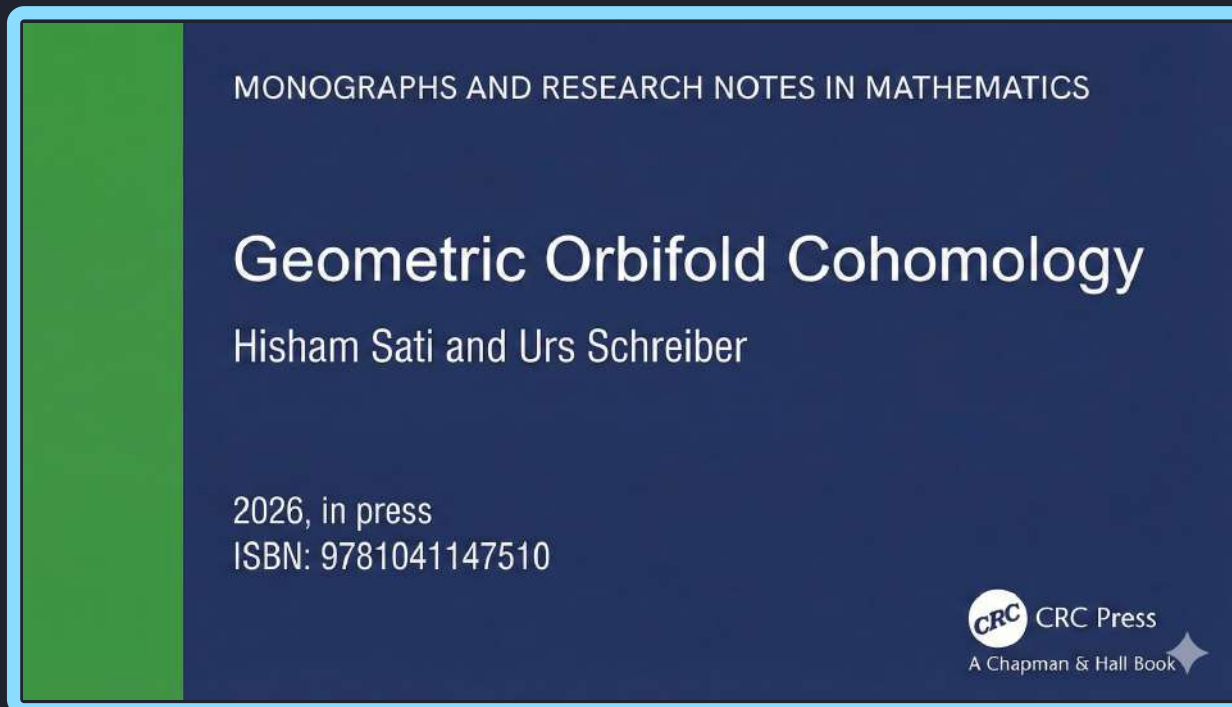
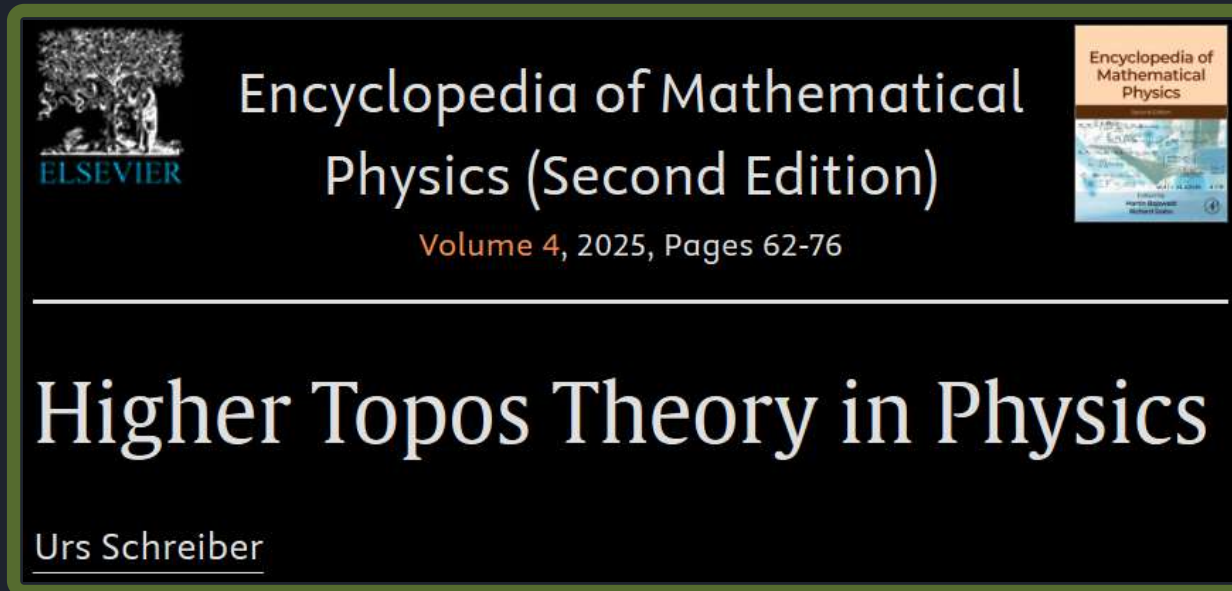
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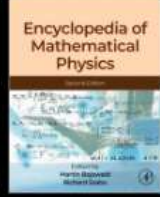
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Geometric Orbifold Cohomology

Hisham Sati and Urs Schreiber

2026, in press
ISBN: 9781041147510



CRC Press
A Chapman & Hall Book

Towards a programming language for topological physics

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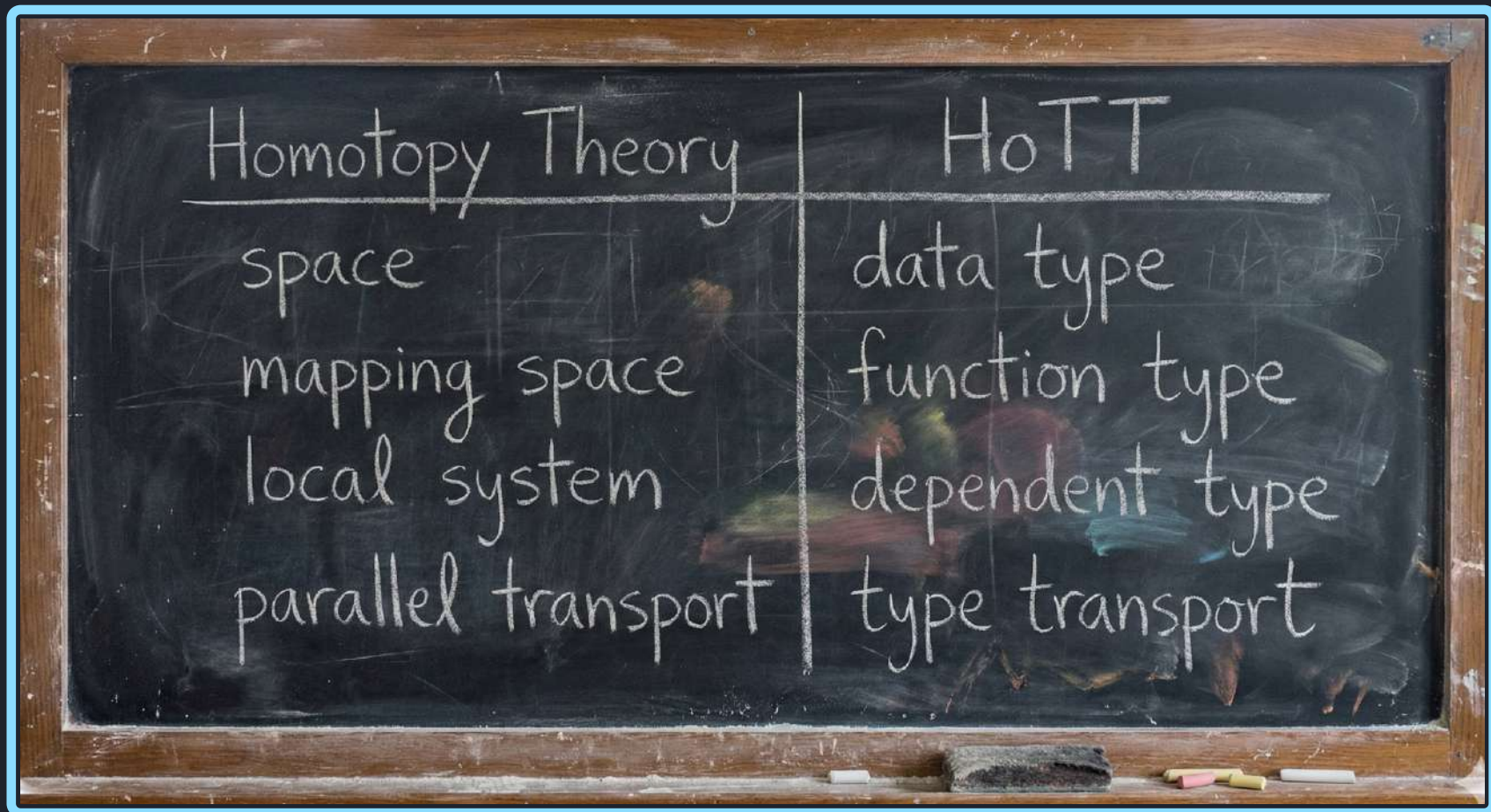
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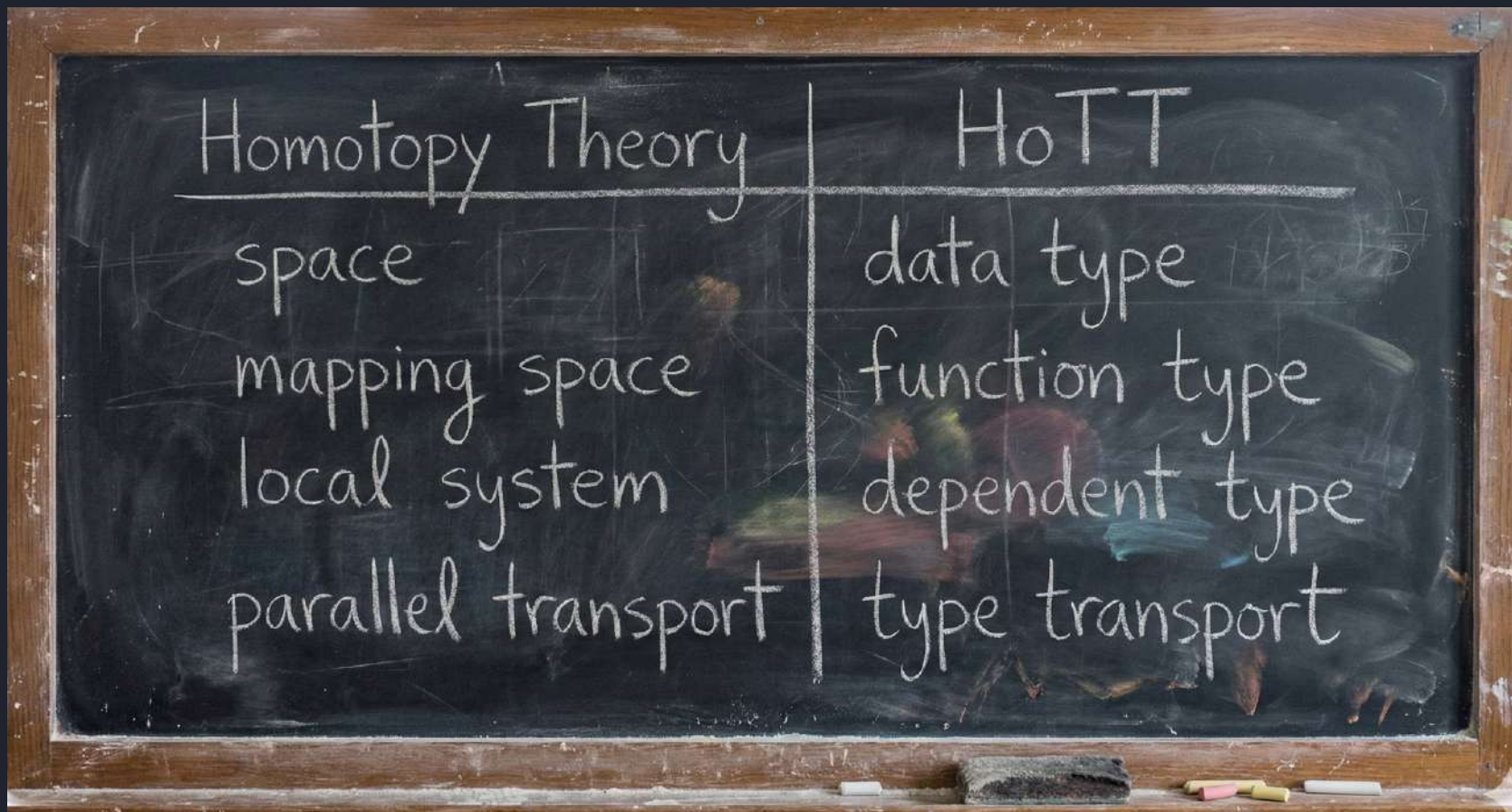
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Homotopy Theory	HoTT
space	data type
mapping space	function type
local system	dependent type
parallel transport	type transport

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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.

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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

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Summary and Outlook

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