Urs Schreiber:

Rethinking Topological Quantum

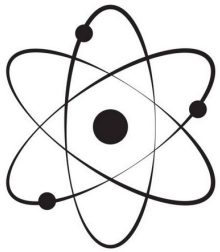
via Flux Quantization

Can we protect Quantum AI from Decoherence?

CENTER FOR QUANTUM & TOPOLOGICAL SYSTEMS @ جامعة نيويورك أبوظبي NYU ABU DHABI

May 2025 [ncatlab.org/schreiber/show/Rethinking+Topological+Quantum]

use peculiar physics at atomic scales



quantum computers are exponentially more powerful than classical computers
(for certain tasks)

in principle

possible dramatic enhancement
e.g. for machine learning algorithms

in principle

in principle

Quantum AI:
Real-time learning & querying!

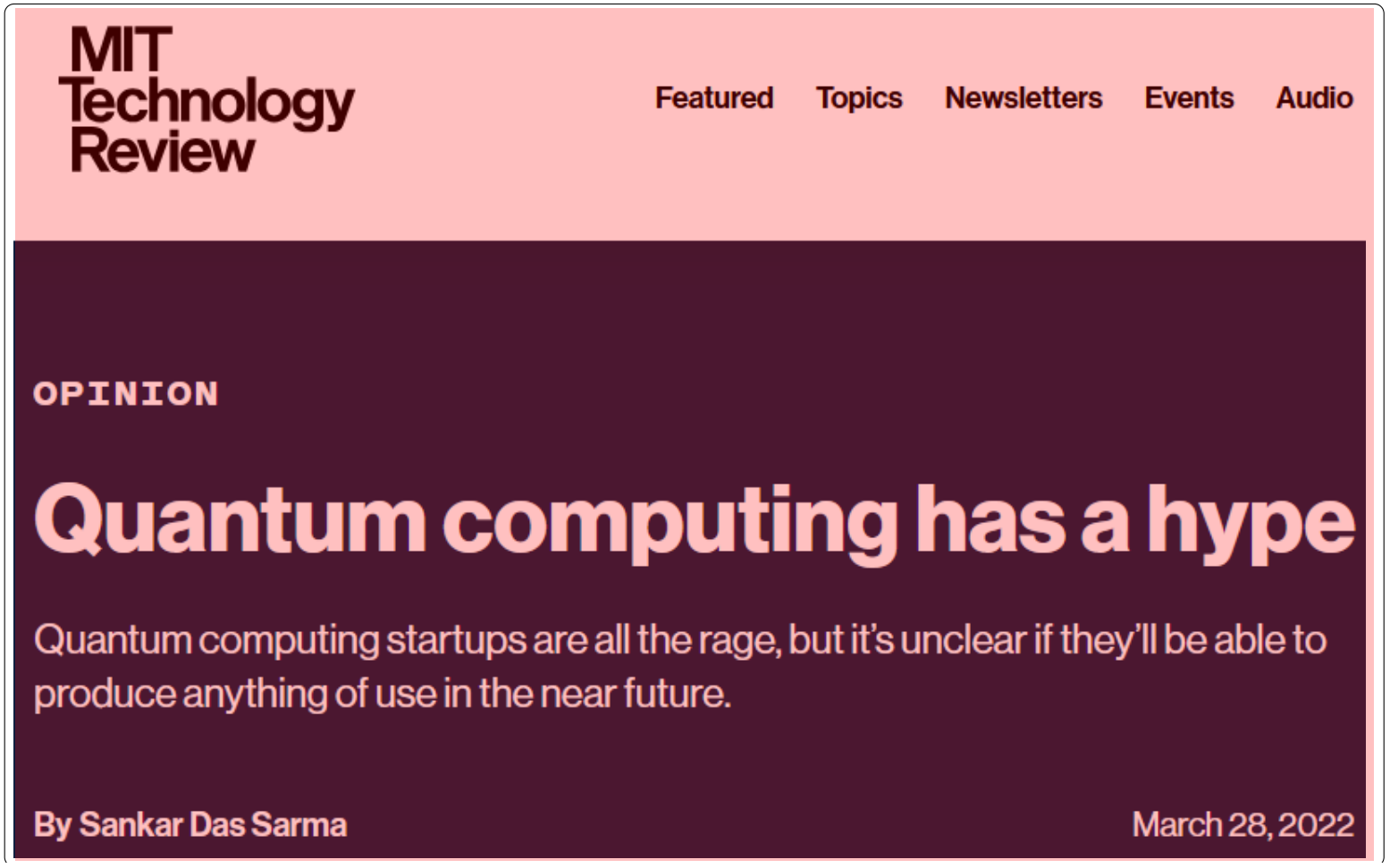
The practical Problem:

quantum is
immensely **noise intolerant**

Decoherence

$\Downarrow$

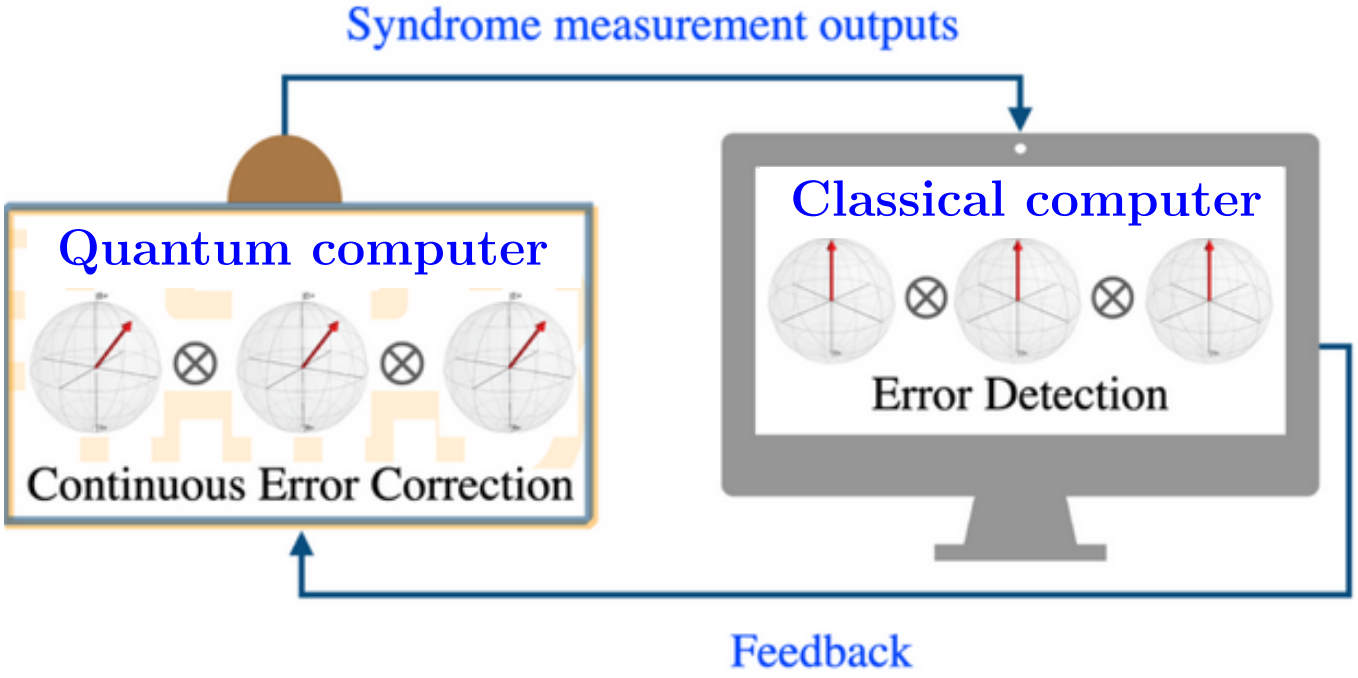
existing quantum computers are puny



popular hope:

live with the noise and
keep fighting it by software:

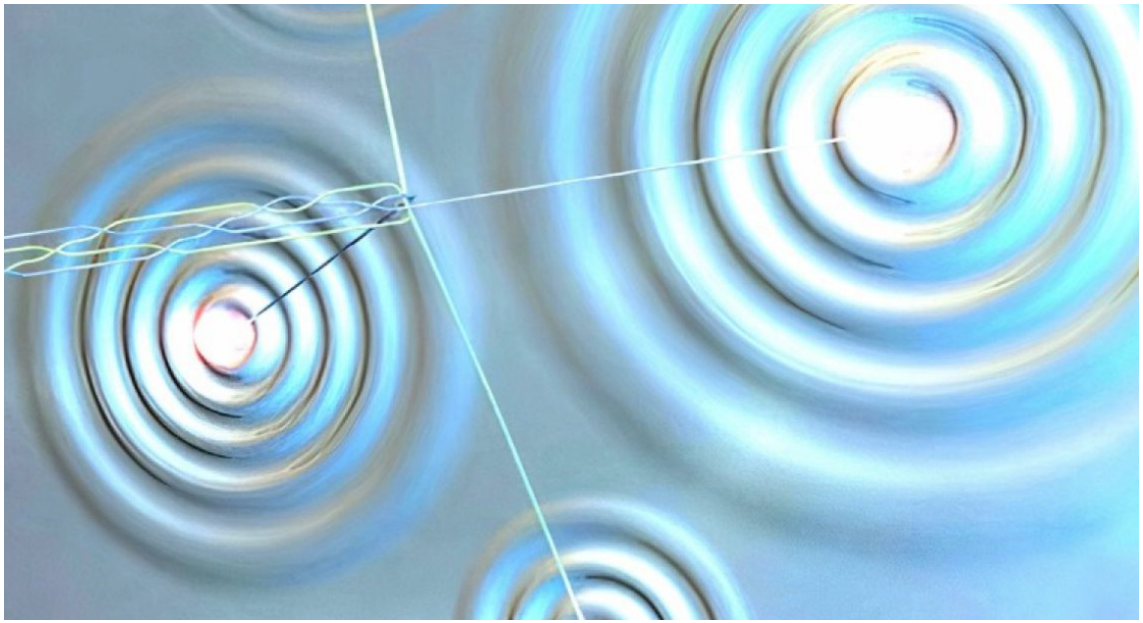
"Quantum Error Correction"



more profound approach:

prevent errors
already on hardware
by fundamental physical effects!

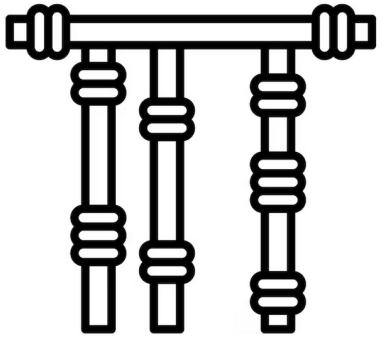
"Quantum Error *Protection*"



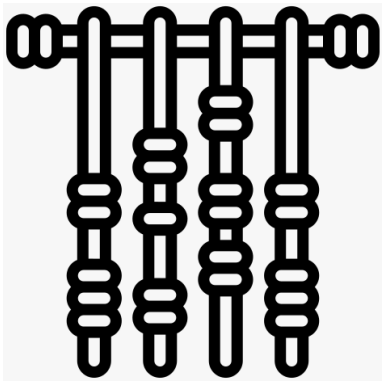
invariance under
gentle deformations

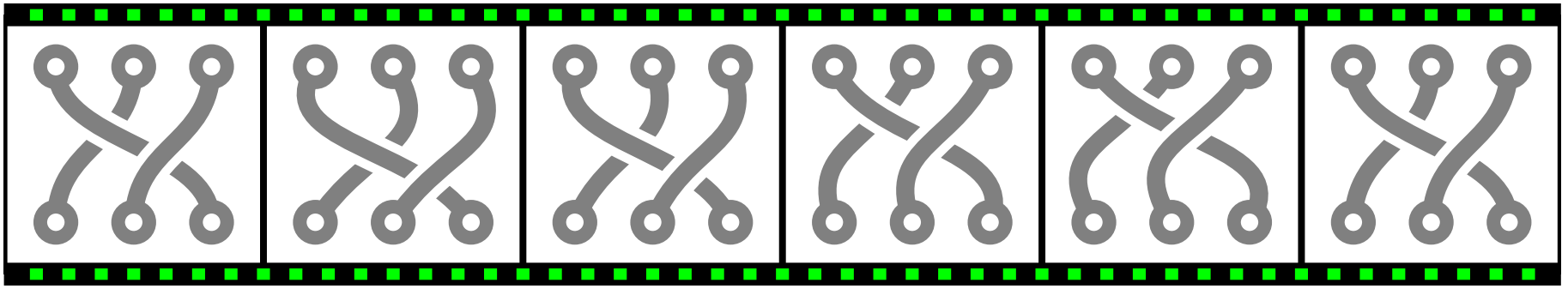
tantalizing candidate:

topological quantum effects



store information
like knots in a rope!

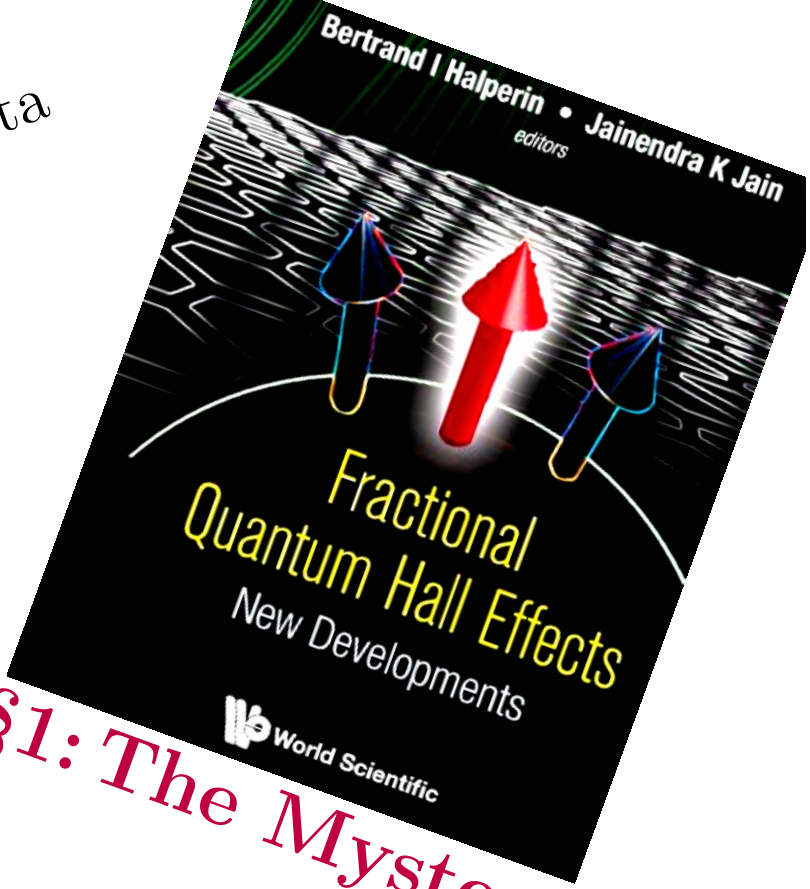




unit of quantum data

but for Topological Qubits:

theoretical understanding
remains superficial



§1: The Mystery

& experimental claims
remain dubious

because topological quantum

is "non-perturbative physics":

a \$1M "**Millennium Problem**"

(prize offered by *Clay Mathematics Institute*)

Novel attack at our CQTS @ NYU AD:

jargon: *geometric engineering of topological quantum on flux-quantized M-branes*

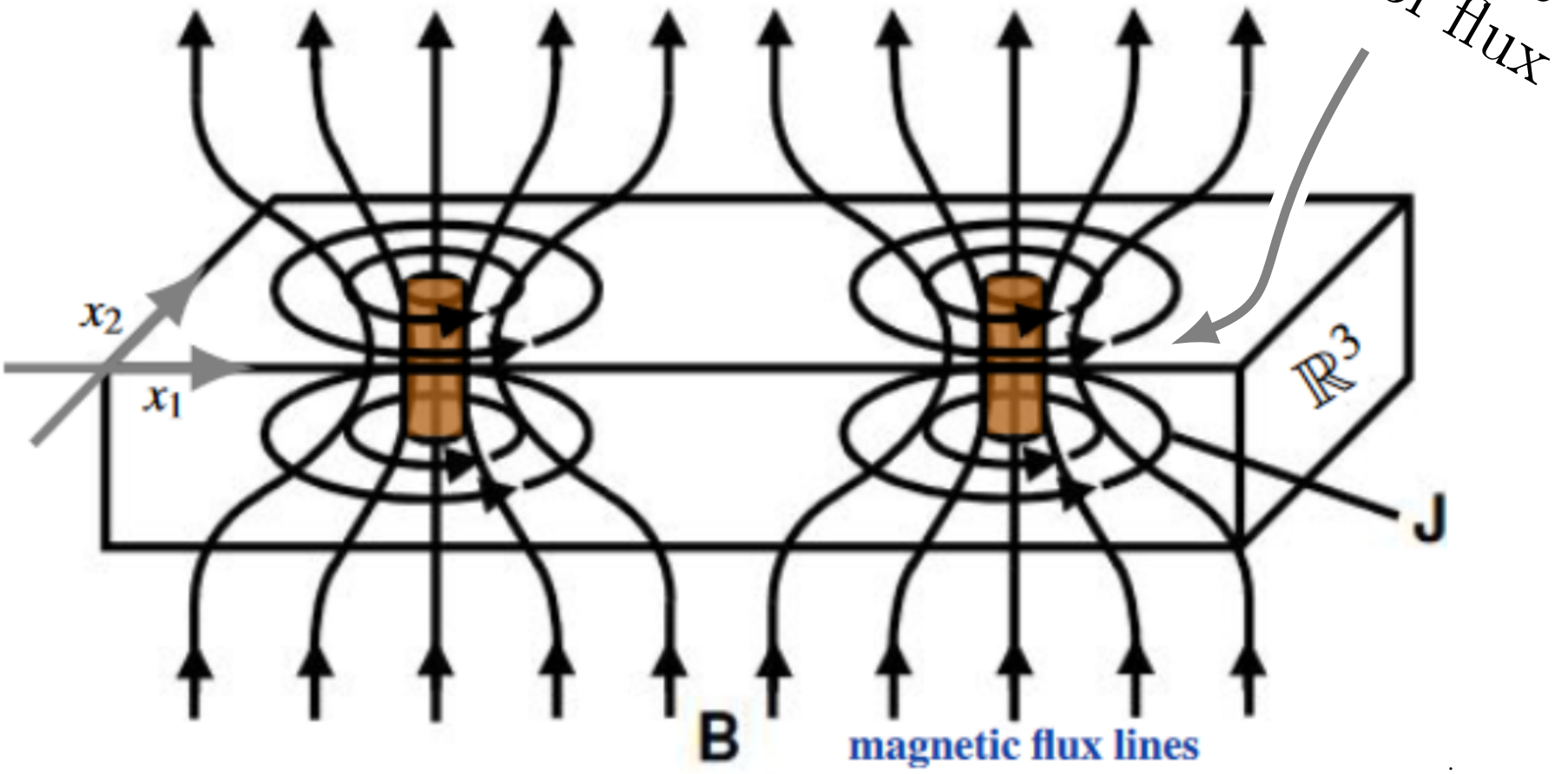
flux-quantized

new key method

in established experiments

["fractional Quantum Hall (FQH) systems"]

the topological objects are
magnetic **flux quanta**



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but state of the art of
magnetic flux quantization
was ~~is~~ century old:

Quantised Singularities in the Electromagnetic Field.

By P. A. M. Dirac, F.R.S., St. John's College, Cambridge.

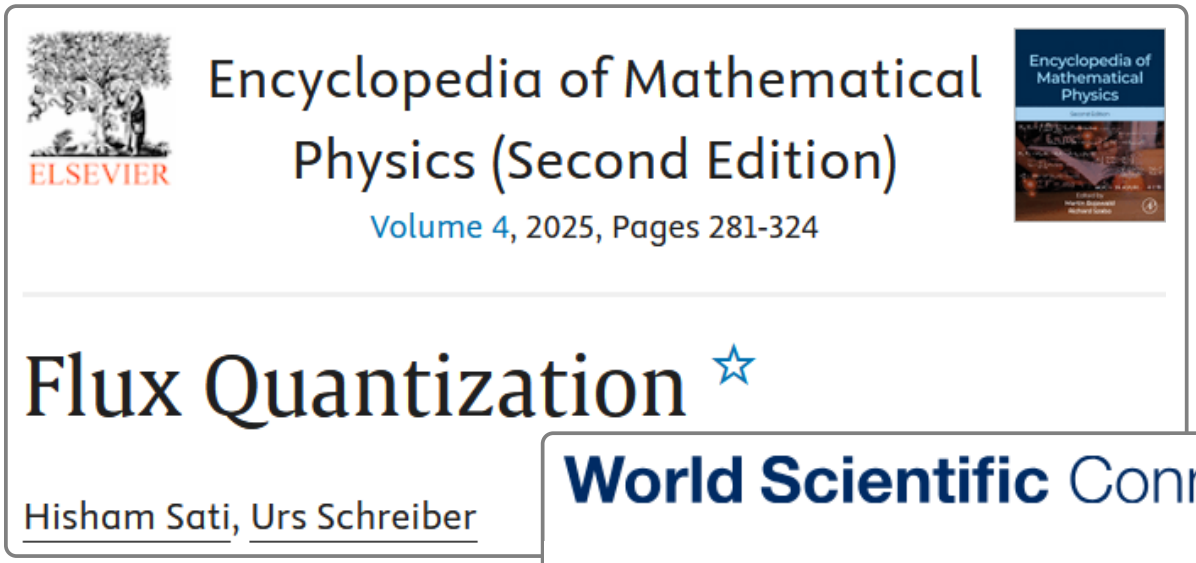
(Received May 29, 1931.)

& *incompatible* with
FQH phenomenology

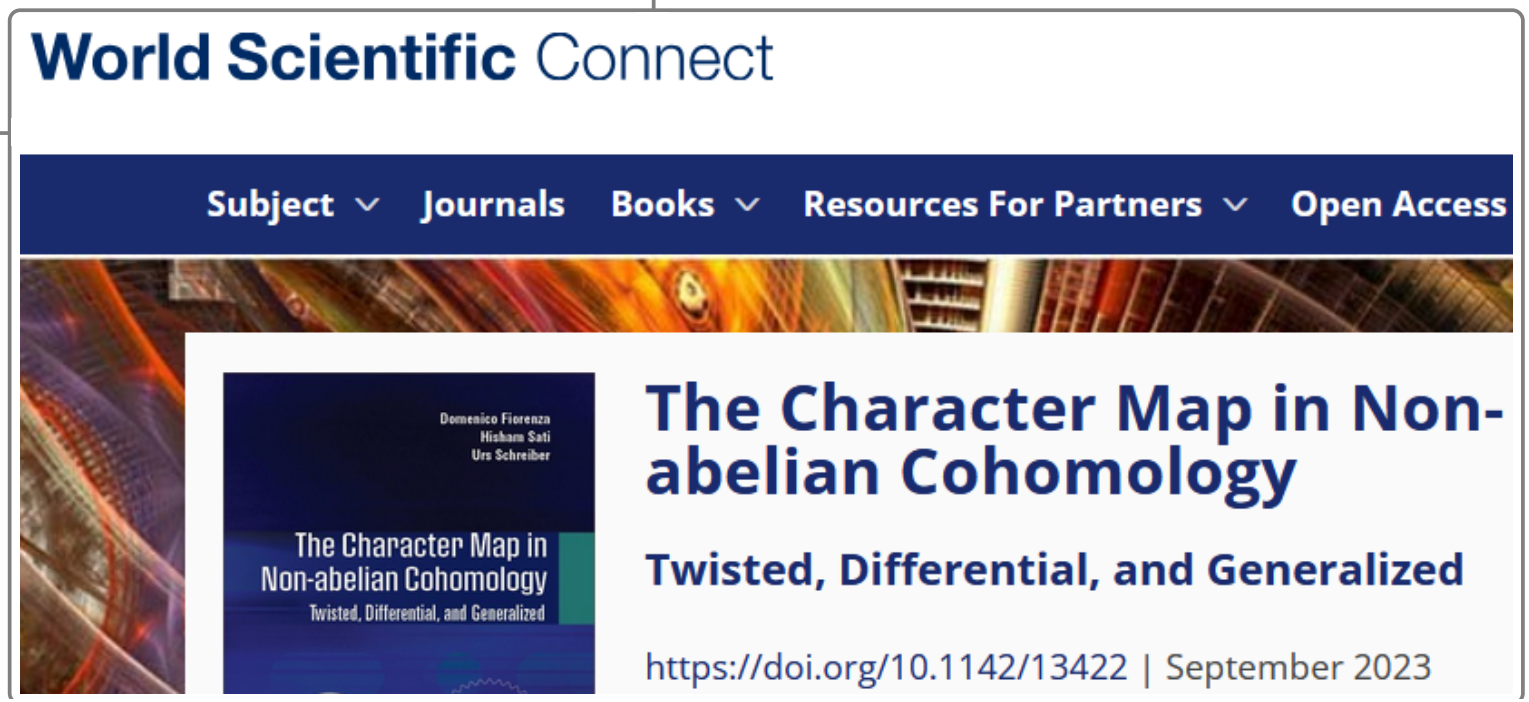
What gives?

New mathematics:

Theorem: ∃ **exotic flux** quantization laws for non-linear flux



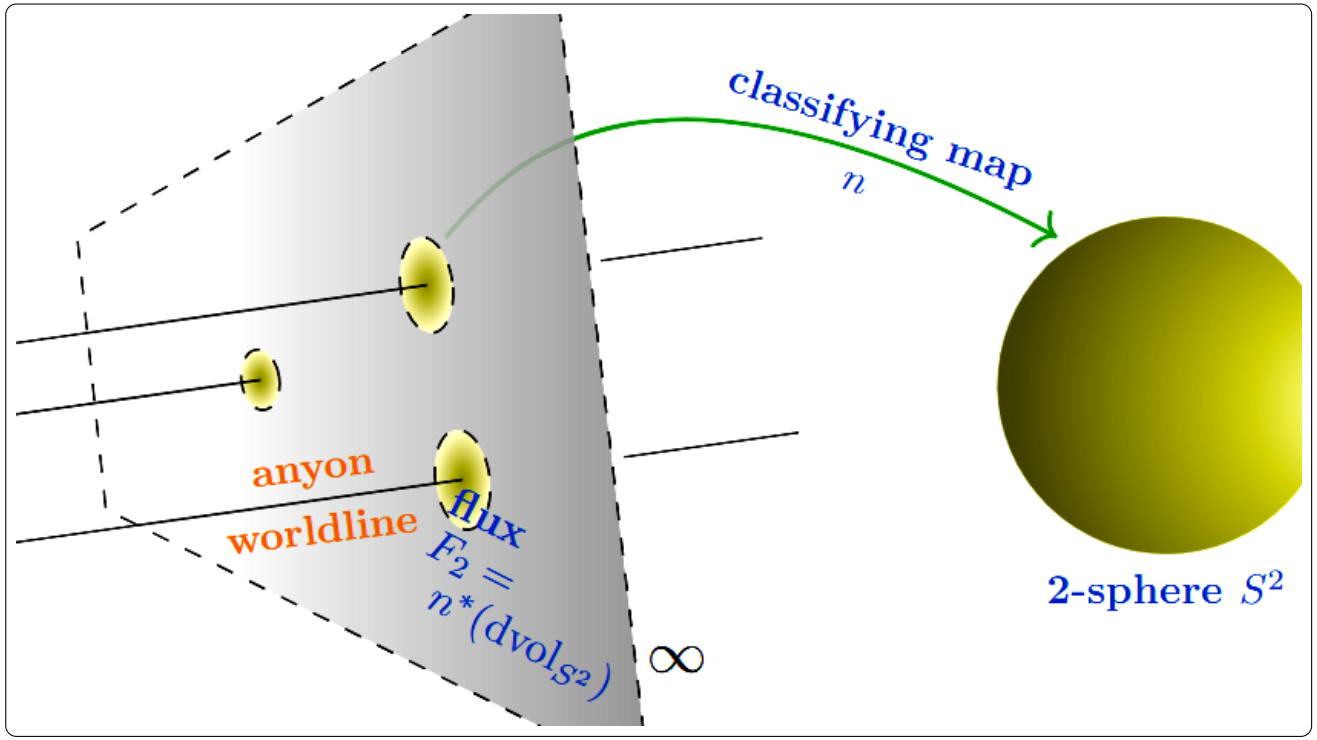
make flux quanta talk to topology!



$\Rightarrow$ New physics:

exotic flux quantization
classified by 2-sphere

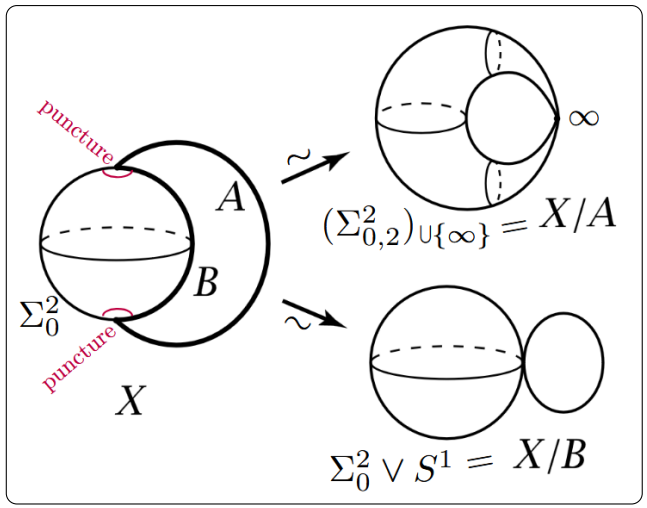
explains FQH topology!



Quantum

Topology

Flux Quantization



rigorous theory

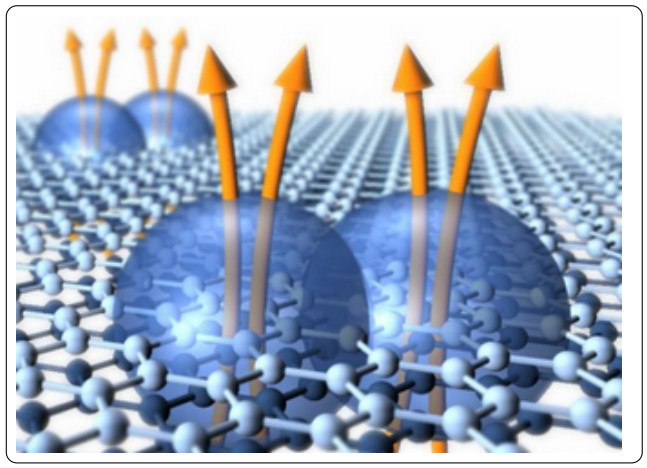
math

algebraic topology

flux quantization

topological quantum

physics



predicts **new pathways** to topological quantum **hardware**

non-perturbative FQH flux theory ⇒ FQH topological quantum hardware ⇒ error-protected quantum computers ⇒ Quantum AI

a potential new pathway?...

I [will have] just come directly from

discussing laboratory realizations

so please excuse my jet lag.

& Thanks for your attention!