Urs Schreiber:

# Rethinking Topological Quantum

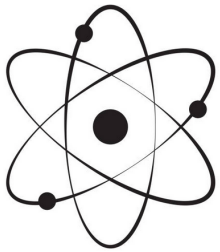
## via Flux Quantization

## Can we protect Quantum AI from Decoherence?

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

(May 2025) find these slides and more at: [ncatlab.org/schreiber/show/Rethinking+Topological+Quantum]

use peculiar physics
at atomic scales

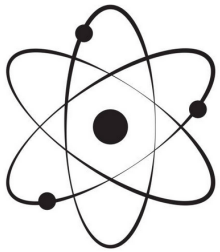


**quantum computers** are
excessively more powerful
than classical computers
(for certain tasks)

possible dramatic enhancement
e.g. for machine learning algorithms


**Quantum AI:**
Real-time learning
& querying!

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

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in principle


**Quantum AI:**
Real-time learning & querying!

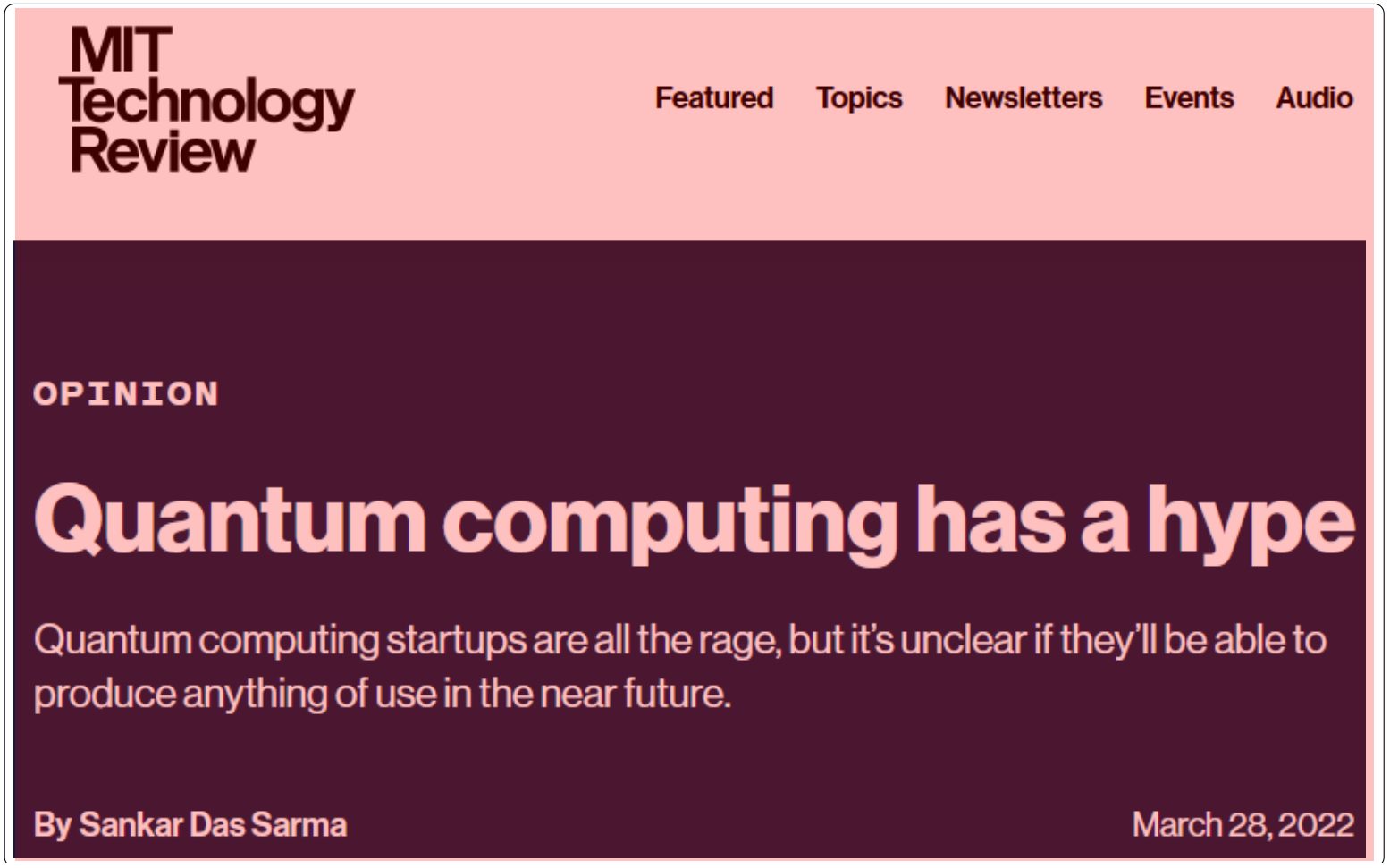
# The practical Problem:

quantum is
immensely **noise intolerant**

Decoherence

$\Downarrow$

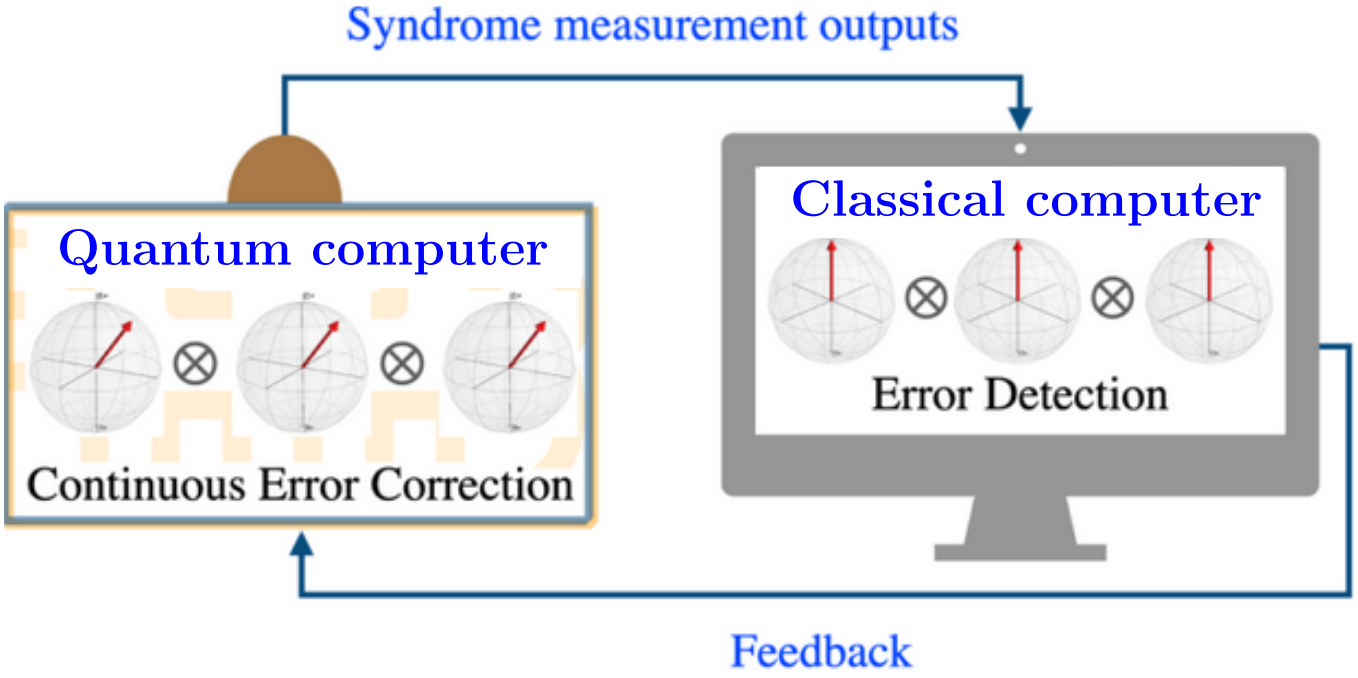
existing quantum computers are puny



popular hope:

live with the noise and
**keep fighting** it by software:

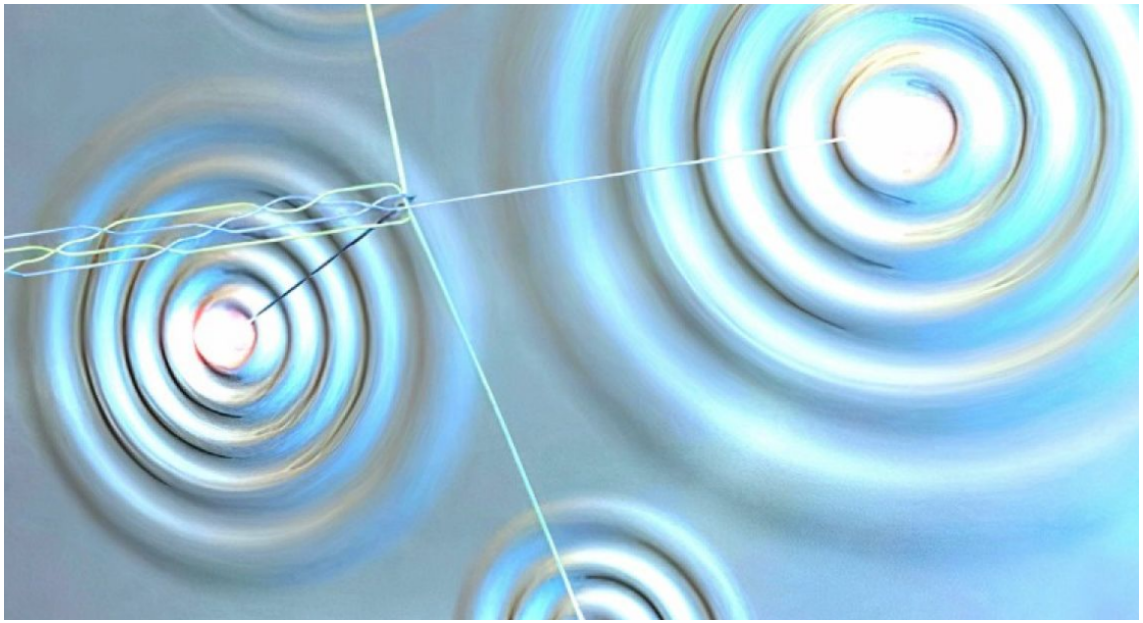
"Quantum Error Correction"



more profound approach:

**prevent** errors
already on hardware
by fundamental physical effects!

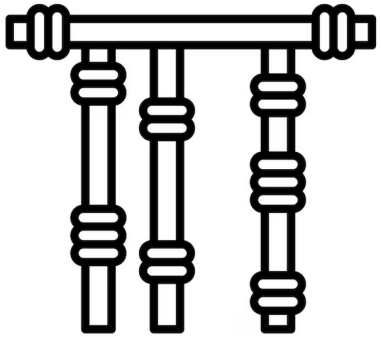
"Quantum Error *Protection*"



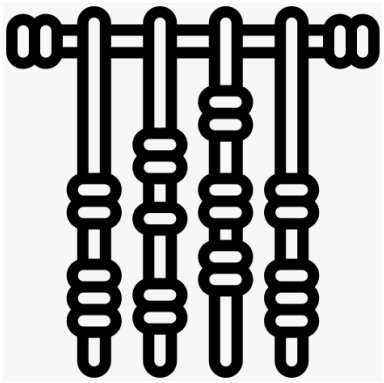
invariance under
gentle deformations

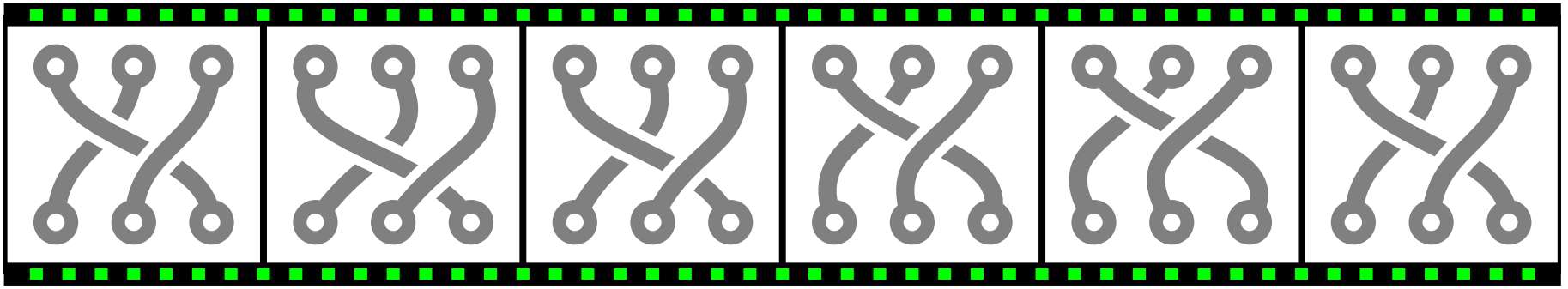
tantalizing candidate:

**topological** quantum effects



store information
like knots in a rope!

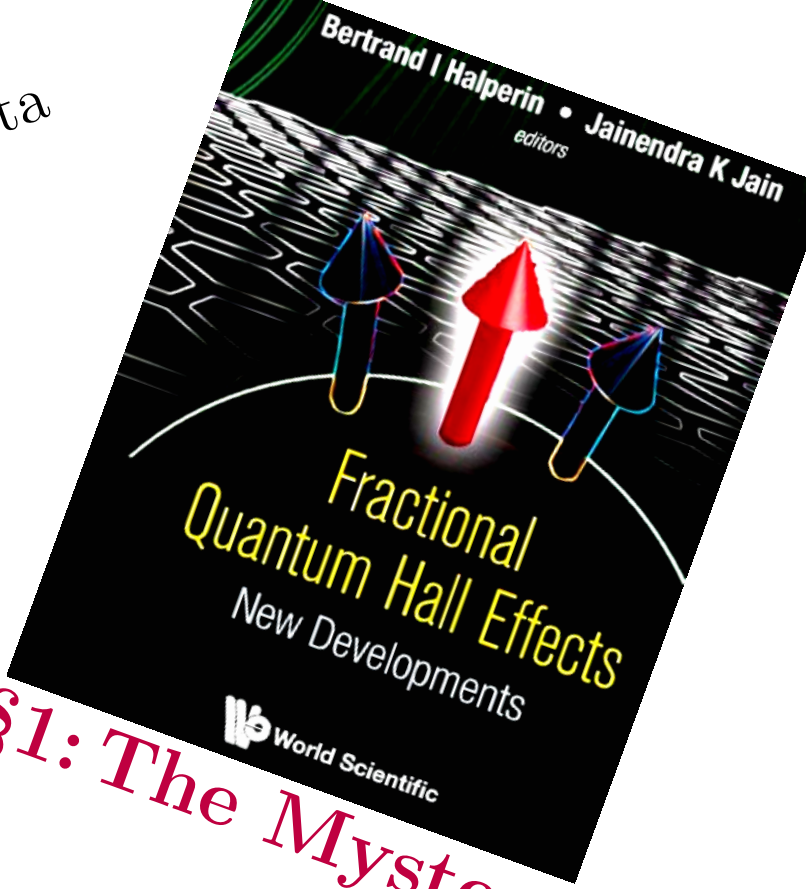




unit of quantum data

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*

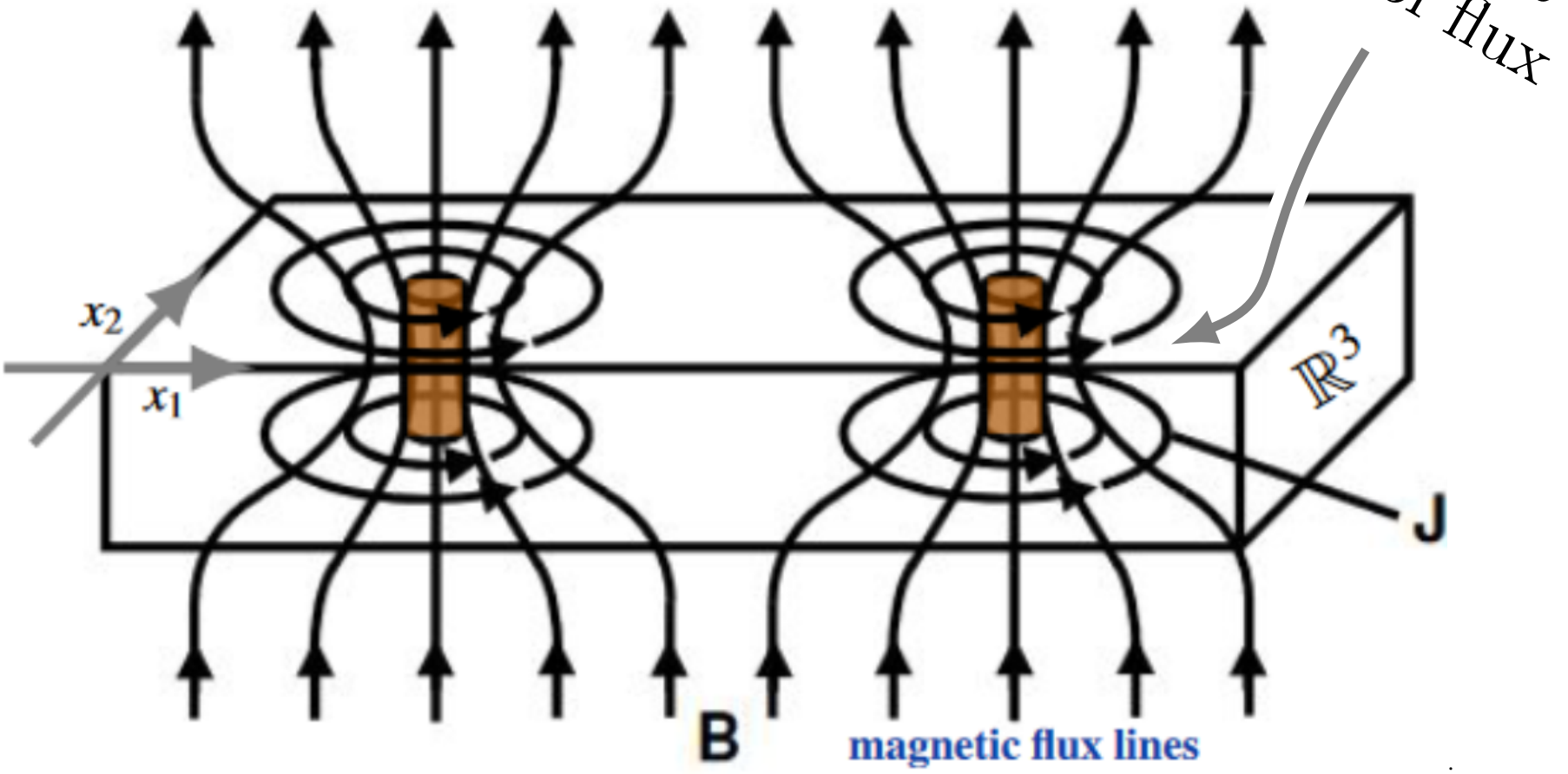
*flux-quantized*

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.

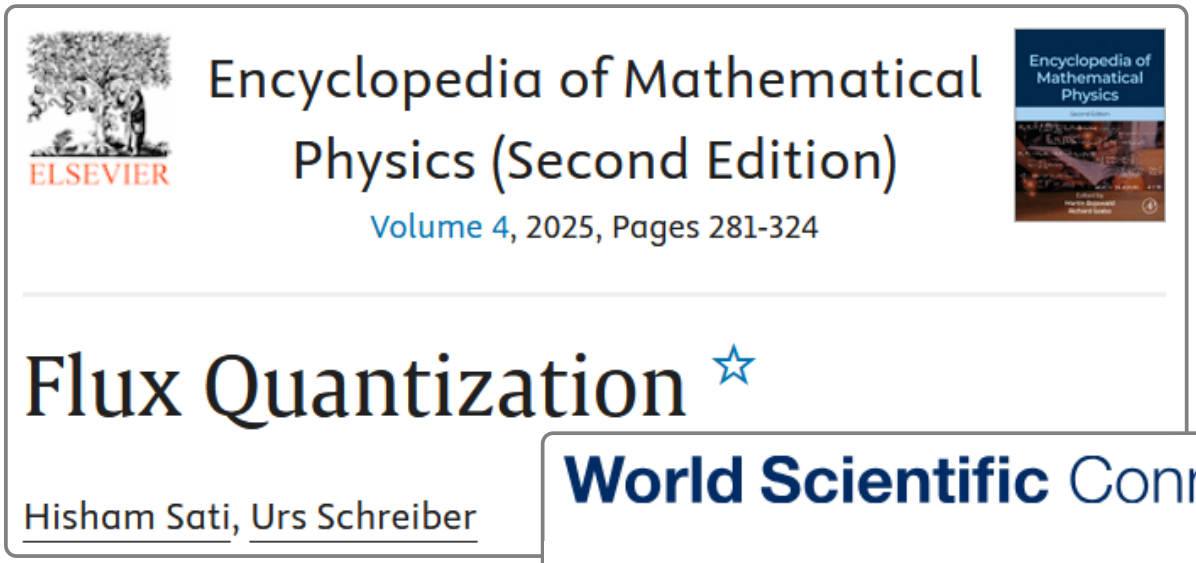
(Received May 29, 1931.)

& *incompatible* with
FQH phenomenology

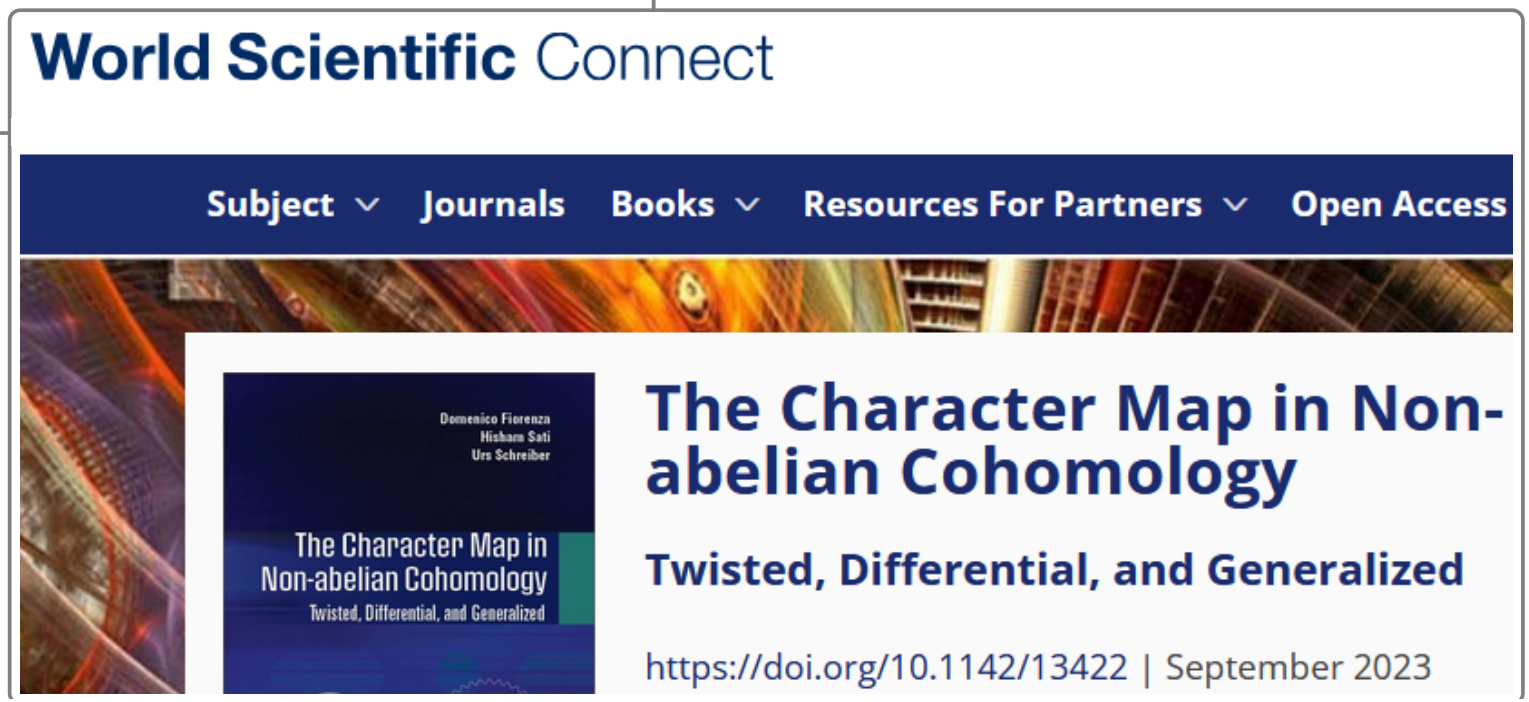
What gives?

# New mathematics:

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



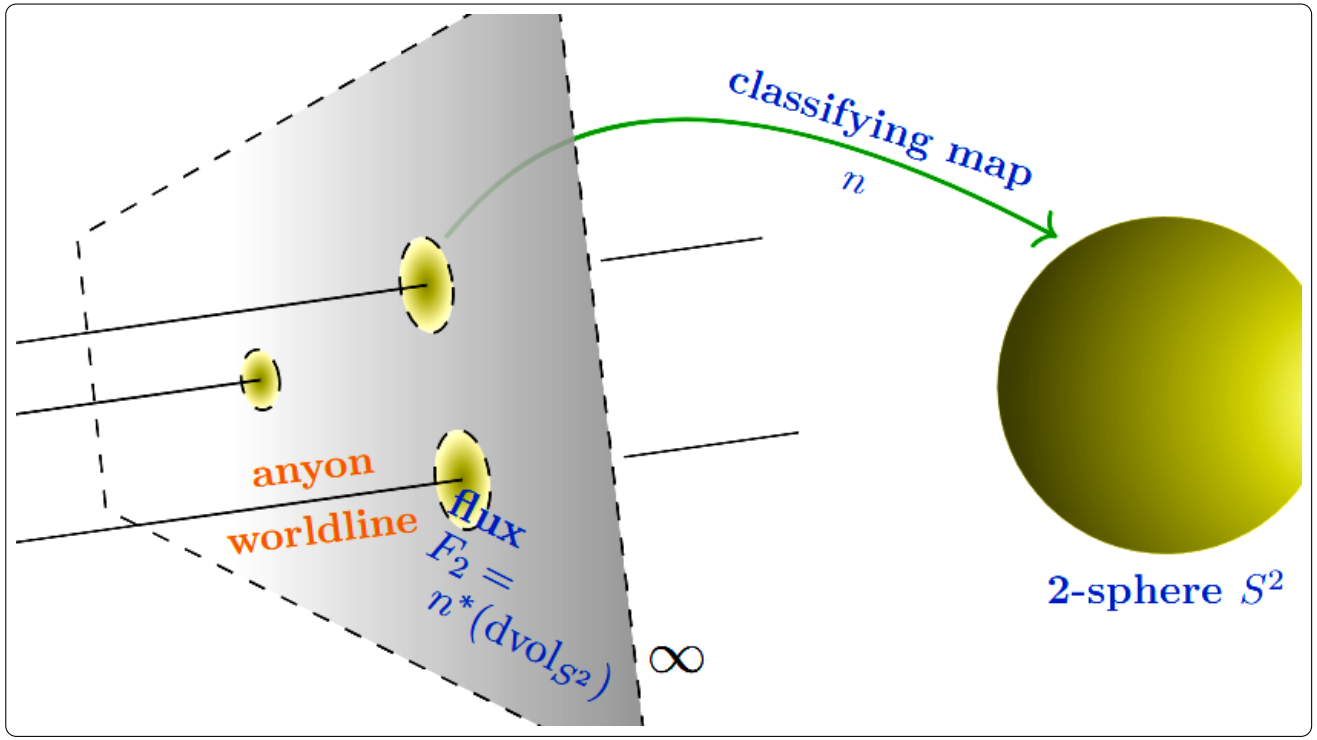

make flux quanta talk to topology!



$\Rightarrow$ New physics:

exotic flux quantization
classified by 2-sphere

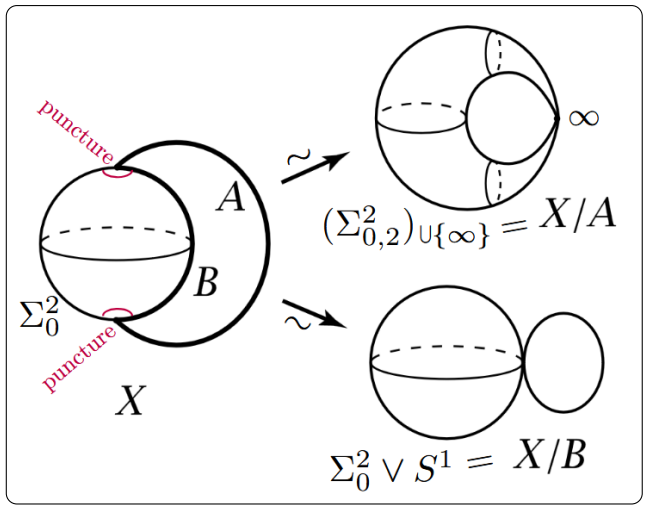
explains FQH topology!




Quantum

Topology

**Flux Quantization**




rigorous theory

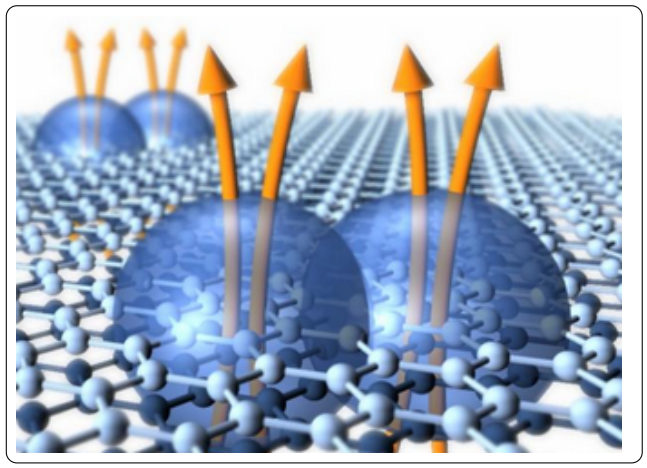
math

algebraic topology

flux quantization

topological quantum

physics



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

I just come directly from


discussing laboratory realizations

so please excuse my jet lag.

& Thanks for your attention!