

Urs Schreiber:

Rethinking Topological Quantum via Flux Quantization

Can we protect Quantum AI from Decoherence?

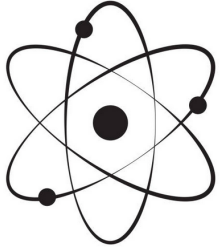


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(May 2025) find these slides and more at: [\[ncatlab.org/schreiber/show/Rethinking+Topological+Quantum\]](https://ncatlab.org/schreiber/show/Rethinking+Topological+Quantum)

use peculiar physics
at atomic scales



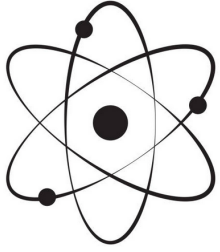
quantum computers are
excessively more powerful
than classical computers
(for certain tasks)

possible dramatic enhancement
e.g. for machine learning algorithms



Quantum AI:
Real-time learning
& querying!

use peculiar physics
at atomic scales



quantum computers are
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in principle

possible dramatic enhancement
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in principle



in principle

Quantum AI:
Real-time learning
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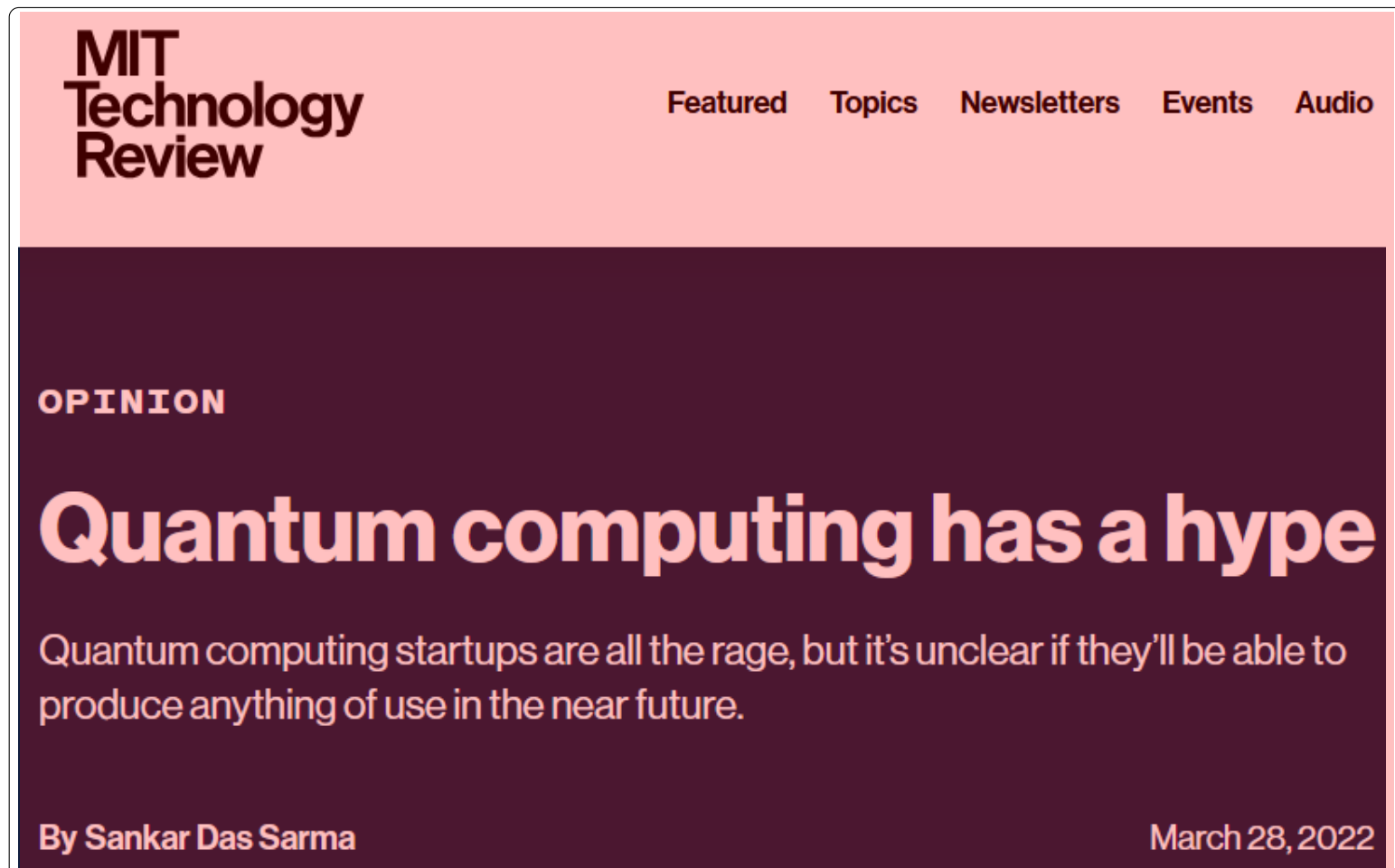
The practical Problem:

quantum is
immensely **noise intolerant**

Decoherence



existing quantum computers are puny



The image shows a screenshot of an article from MIT Technology Review. The header is light blue with the MIT Technology Review logo on the left and navigation links (Featured, Topics, Newsletters, Events, Audio) on the right. The main content area has a dark blue background. The word 'OPINION' is in white. The title 'Quantum computing has a hype' is in large white letters. Below the title is a white subtitle: 'Quantum computing startups are all the rage, but it's unclear if they'll be able to produce anything of use in the near future.' At the bottom, the author 'By Sankar Das Sarma' is on the left and the date 'March 28, 2022' is on the right.

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OPINION

Quantum computing has a hype

Quantum computing startups are all the rage, but it's unclear if they'll be able to produce anything of use in the near future.

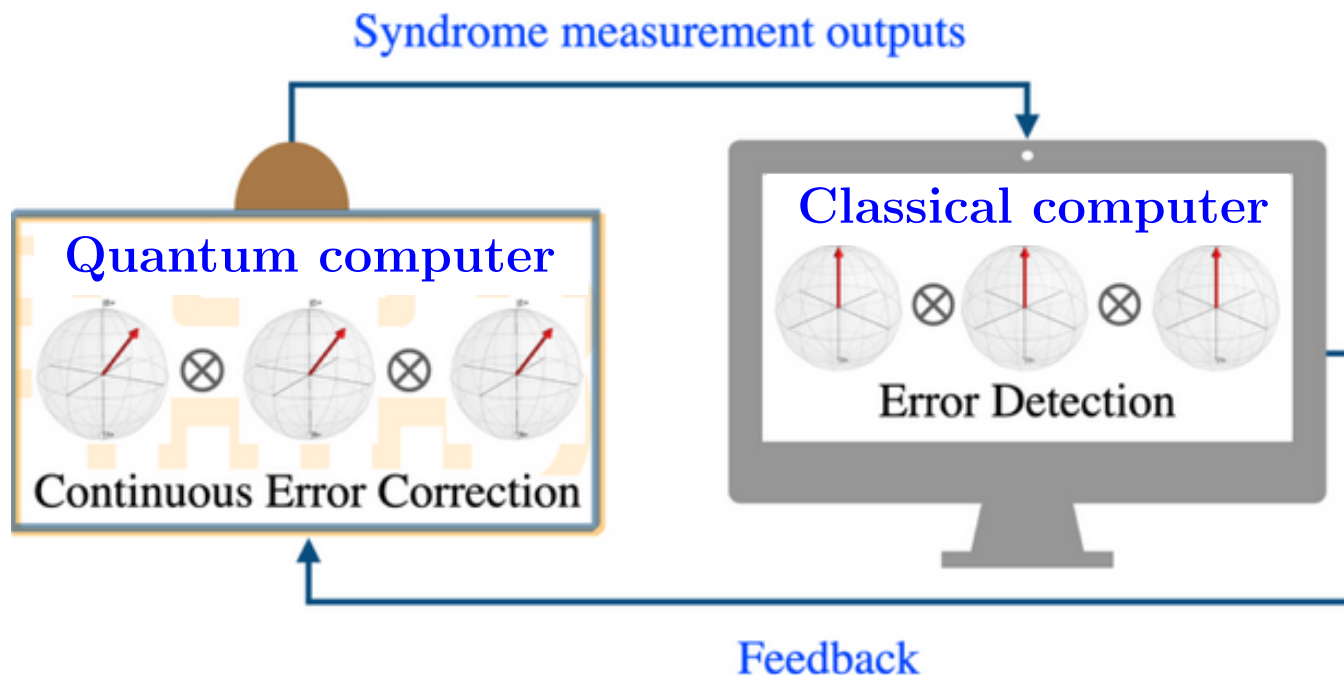
By Sankar Das Sarma

March 28, 2022

popular hope:

live with the noise and
keep fighting it by software:

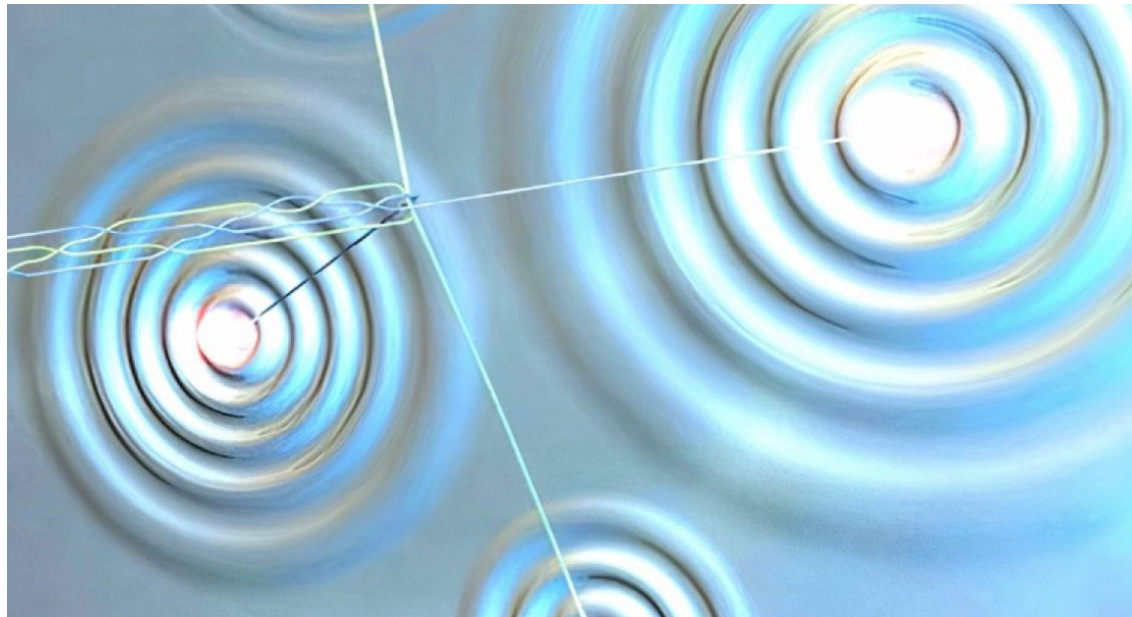
“Quantum Error Correction”



more profound approach:

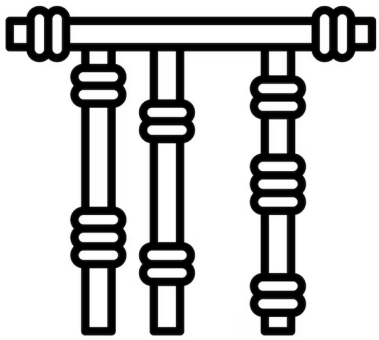
prevent errors
already on hardware
by fundamental physical effects!

“Quantum Error *Protection*”

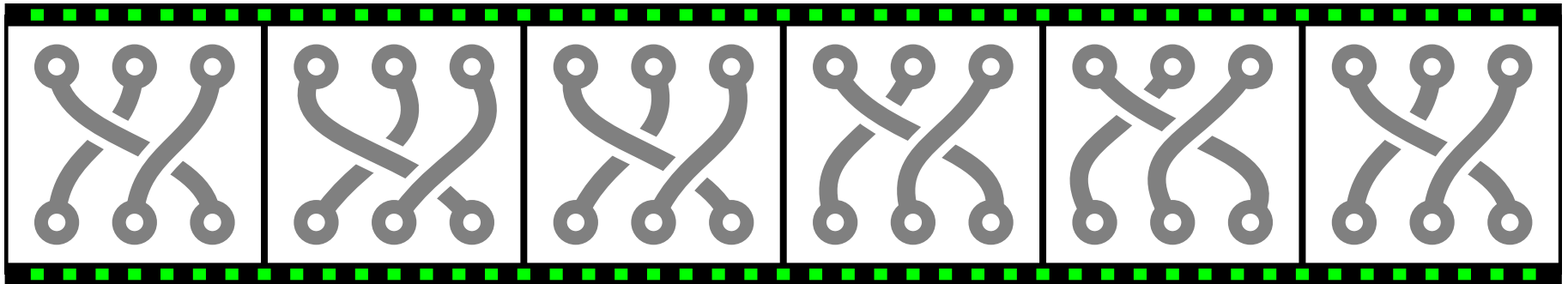
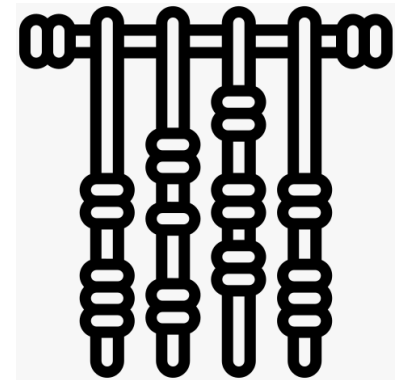


invariance under
gentle deformations

tantalizing candidate:
topological quantum effects



store information
like knots in a rope!

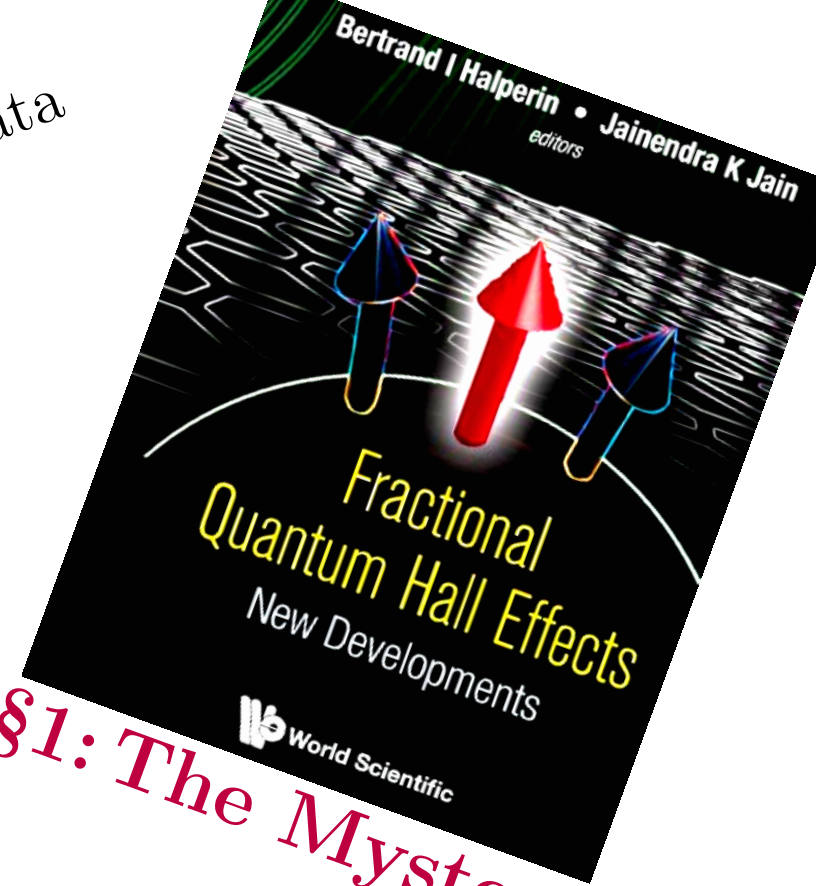


unit of
quantum data

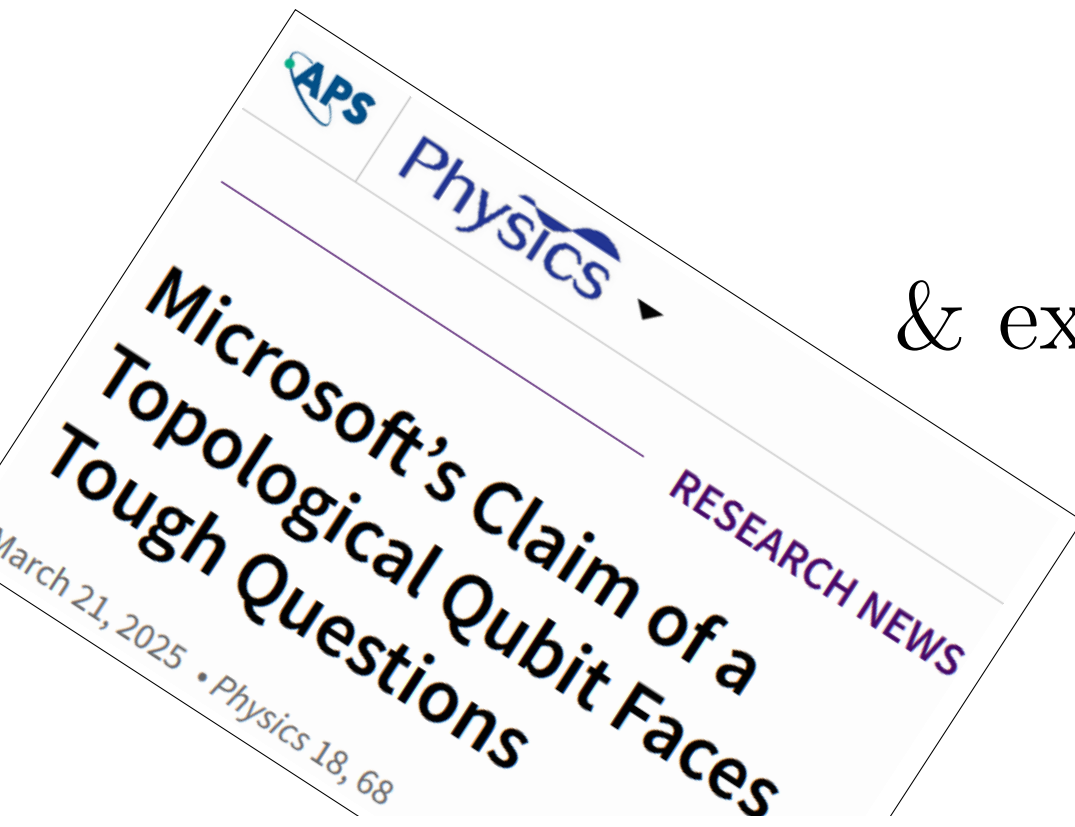
but for Topological Qubits:

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*



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?

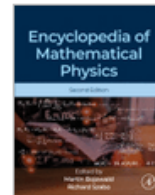
New mathematics:

Theorem: $\exists$ **exotic flux** quantization laws for non-linear flux



Encyclopedia of Mathematical
Physics (Second Edition)

Volume 4, 2025, Pages 281-324



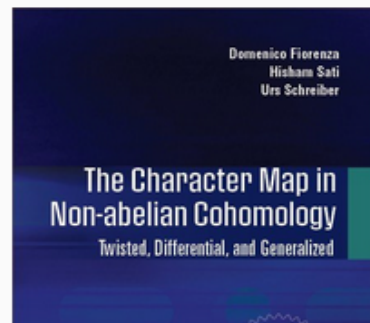
Flux Quantization

Hisham Sati, Urs Schreiber

*make flux quanta
talk to topology!*

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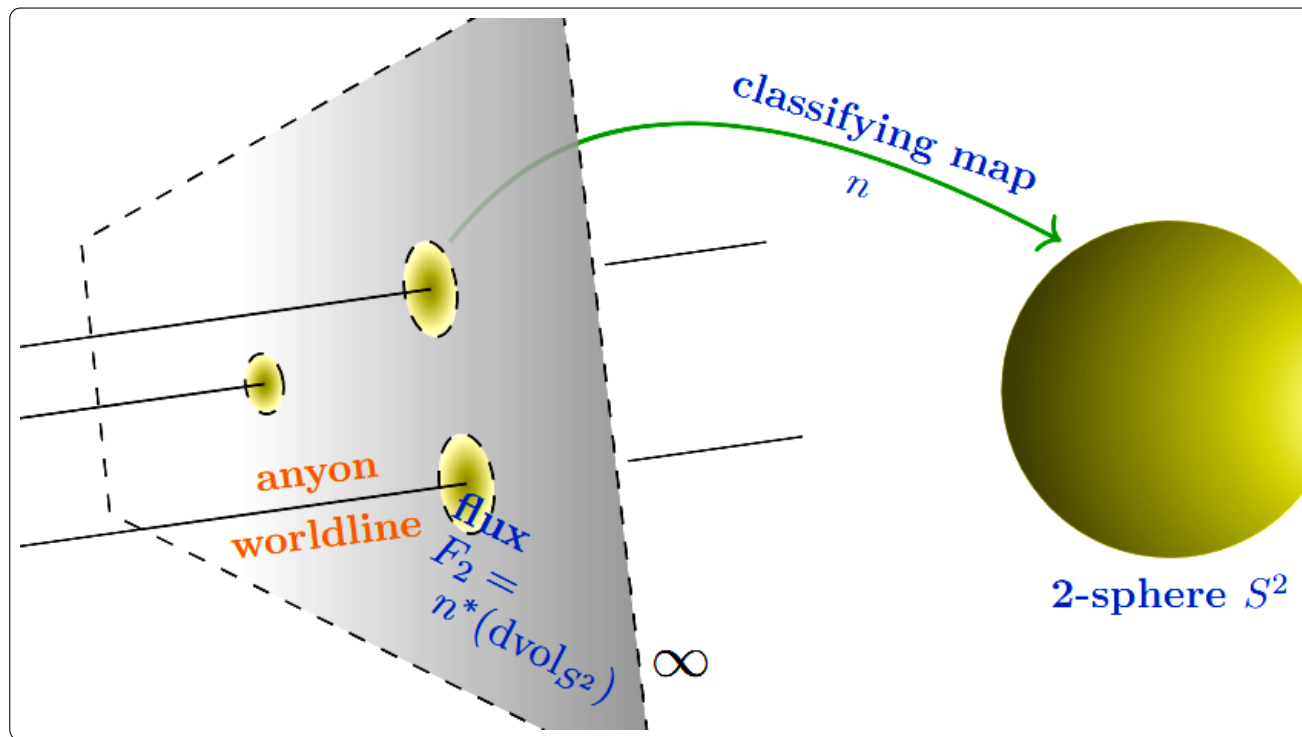
The Character Map in Non-abelian Cohomology

Twisted, Differential, and Generalized

<https://doi.org/10.1142/13422> | September 2023

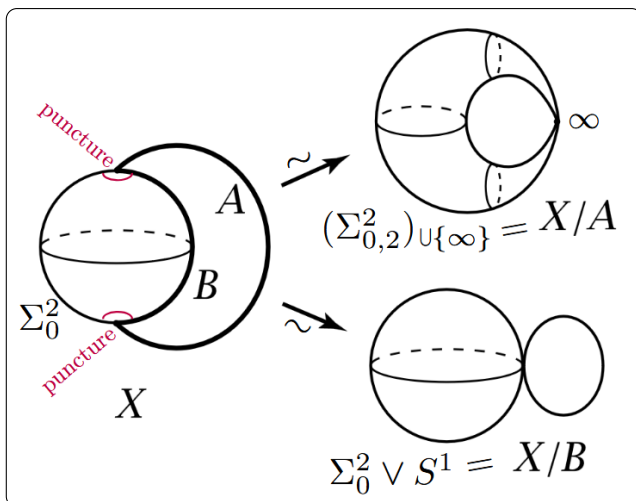
$\Rightarrow$ New physics:
exotic flux quantization
classified by 2-sphere
explains FQH topology!

Quantum



Topology

Flux Quantization



rigorous theory

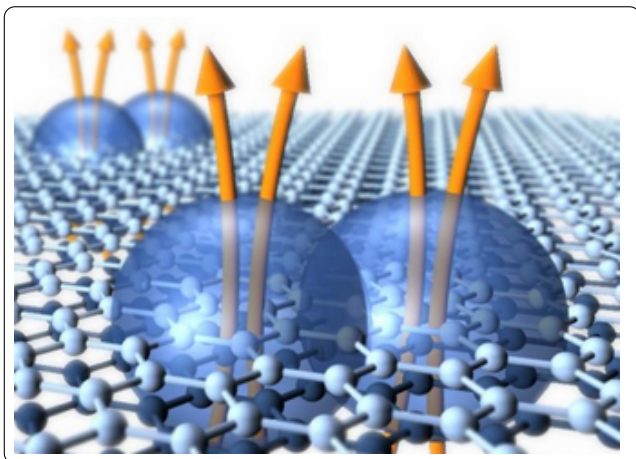
math

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
GAI

a potential new pathway?...

I just come directly from



SHABANI LAB

QUANTUM MATERIALS & DEVICES

discussing laboratory realizations

so please excuse my jet lag.

& Thanks for your attention!