JAPAN SOCIETY FOR THE PROMOTION OF SCIENCE
日本学術振興会

Higher Unitary Quantum Symmetries

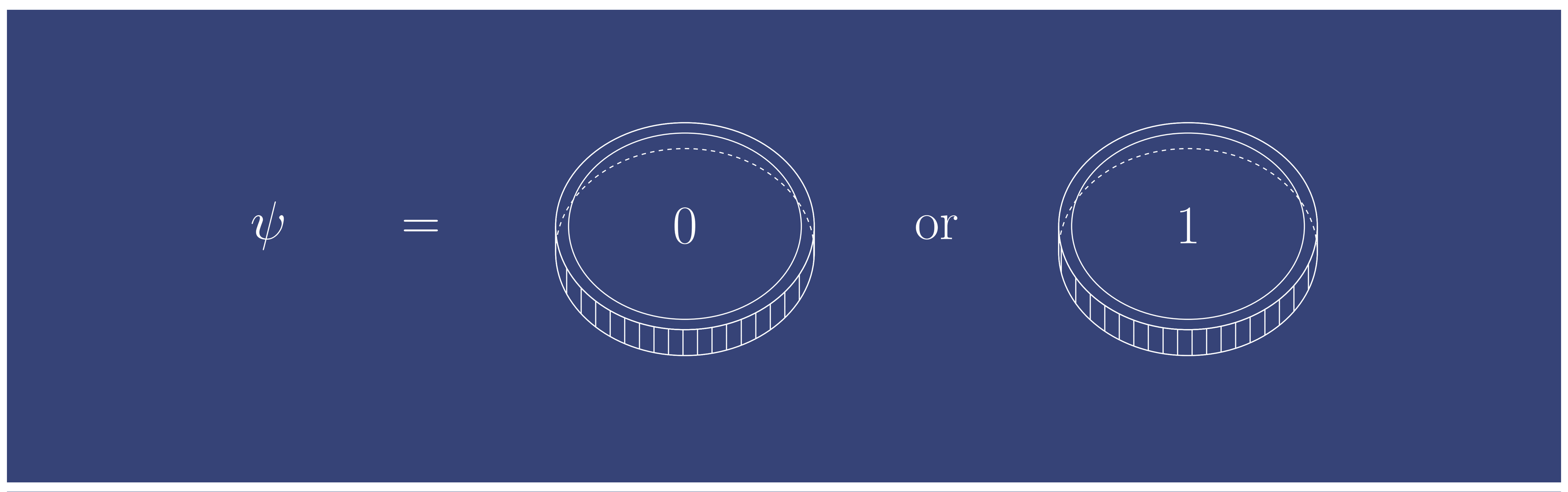
Giovanni Ernesto Ferrer Suárez[1]

[1]Department of Mathematics, The Ohio State University

Host Researcher: Dr. Yasuyuki Kawahigashi[2]

[2]Department of Mathematical Sciences, The University of Tokyo

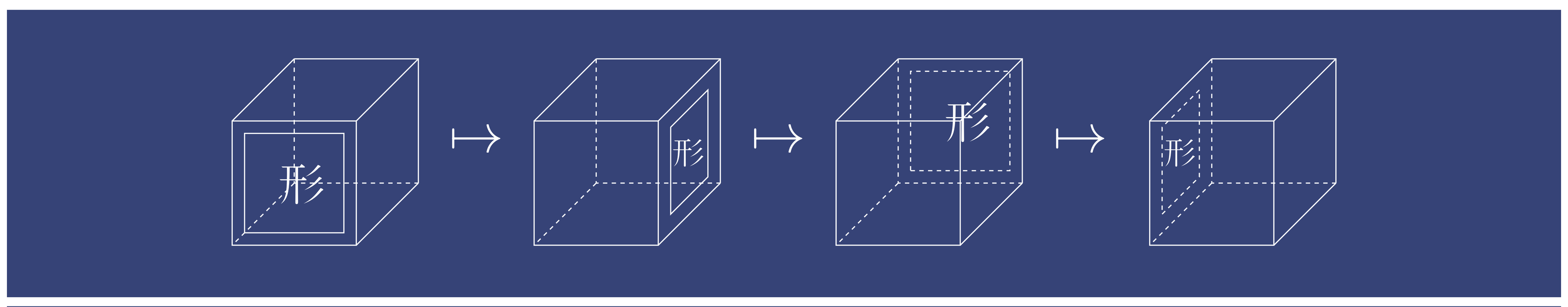
Classical Information



Classical Bits

- Classical computers store information in *bits*.
- The *state* ψ of a bit is binary: either 0 (up) or 1 (down).
- The *state space* of a single bit is a *set*: $\{0, 1\}$

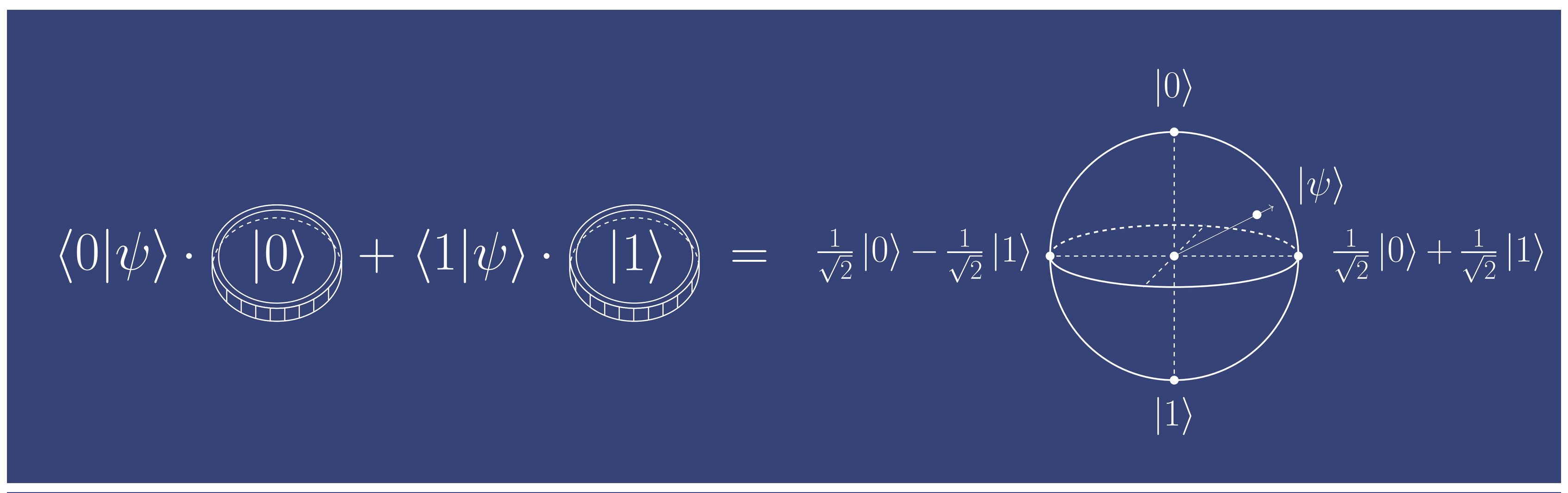
Classical Symmetries



Symmetry Groups

- A *symmetry* of an object is a "structure-preserving" move.
- These form mathematical structures known as *groups*.
- Groups were studied by mathematicians since the 19^{th} century. Significant progress was made throughout the 20^{th} century. These are now standard coursework in the 21^{st} century.

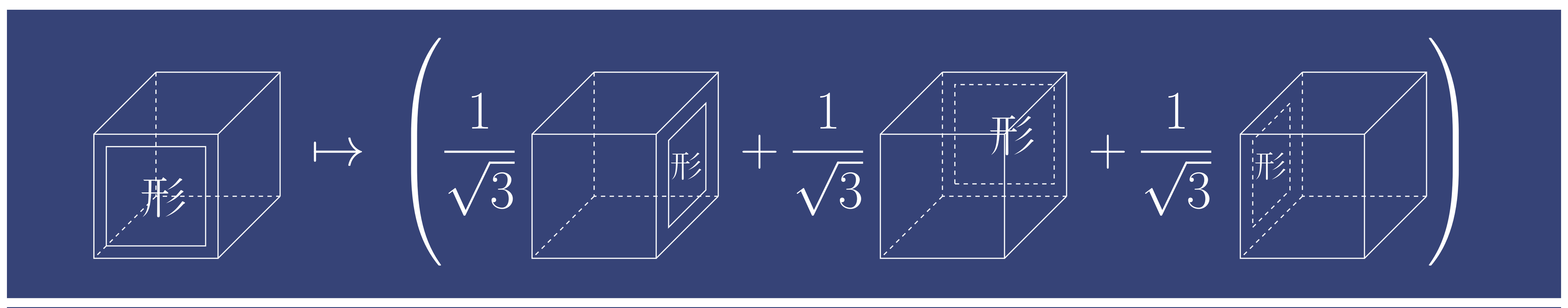
Quantum Information



Quantum Bits

- Quantum computers store information in *qubits*.
- The *state* $|\psi\rangle$ of a qubit is in a *superposition* of $|0\rangle$ and $|1\rangle$.
- The *state space* of a single qubit is a *Hilbert space*: $\mathbb{C}|0\rangle \oplus \mathbb{C}|1\rangle$

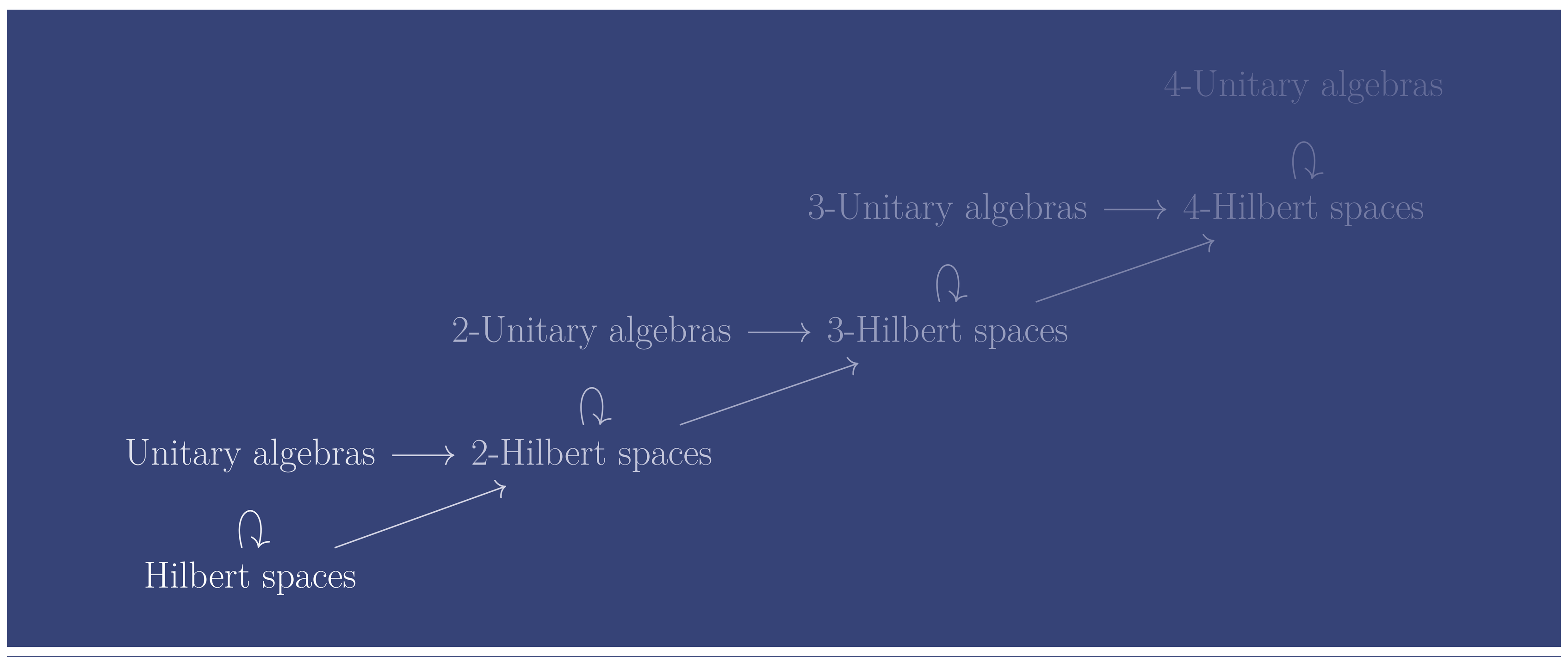
Quantum Symmetries



Unitary Algebras

- By superposition, quantum symmetries act *probabilistically*.
- Quantum symmetries assemble into richer structures, such as *unitary algebras*, *quantum groups*, and *tensor categories*.
- Such structures were first introduced in the 20^{th} century. Progress on their study continues in the 21^{st} century.

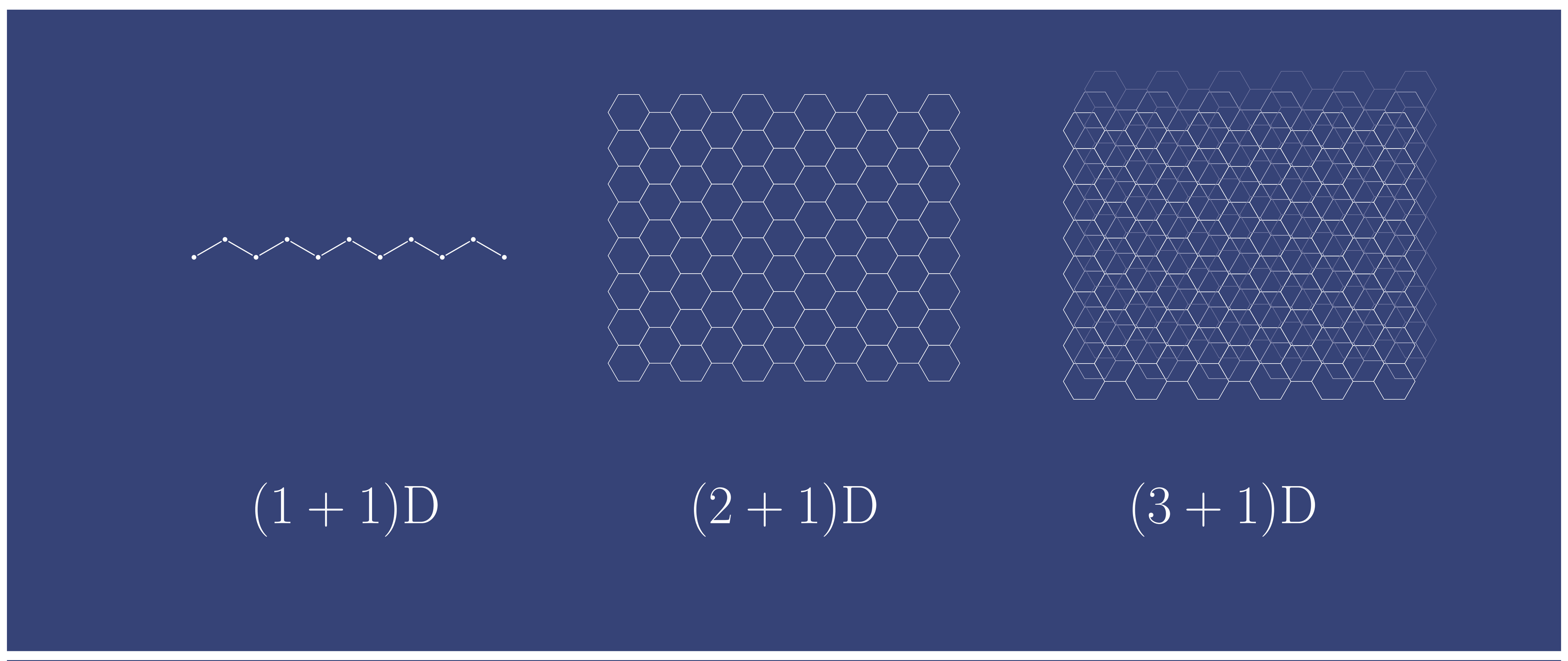
Research Programme



Select Recent Work

- Unitary quantum symmetries textbook (F, Kawagoe, Penneys)
- Theory of 3-Hilbert spaces (Chen, F, Hungar, Penneys, Sanford)
- Foundations for 3-unitary algebras (F)
- Groundwork for higher unitarity (F, et. al.)

Applications



Ethos

- Higher Hilbert spaces naturally describe topological order.
- $(N+1)$-Hilbert spaces correspond to $(N+1)$D phases of matter
- Studying higher unitary quantum symmetries yields results about topologically ordered phases of matter.

For Acknowledgments, References, Contact information
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