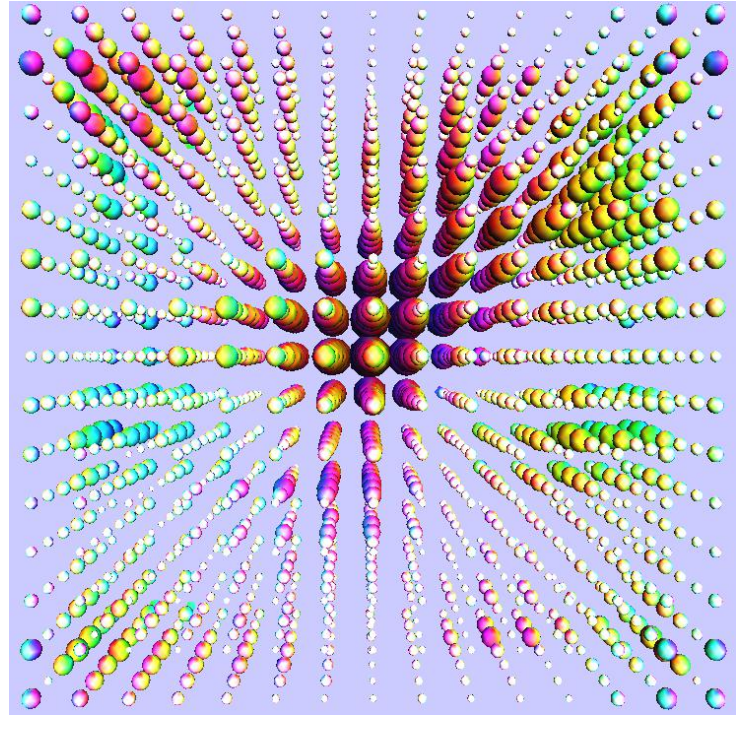




Research Context: Lattice field theory

www.davidschaich.net

Quantum field theory (QFT) { governs fundamental constituents of the universe and how they interact
combines quantum mechanics + special relativity



Replace continuous space & time $\longrightarrow$ discrete **lattice** of points

$\implies$ Formal mathematical definition

$\implies$ Numerical predictions from advanced computing

Crucial tool for **strongly interacting** systems

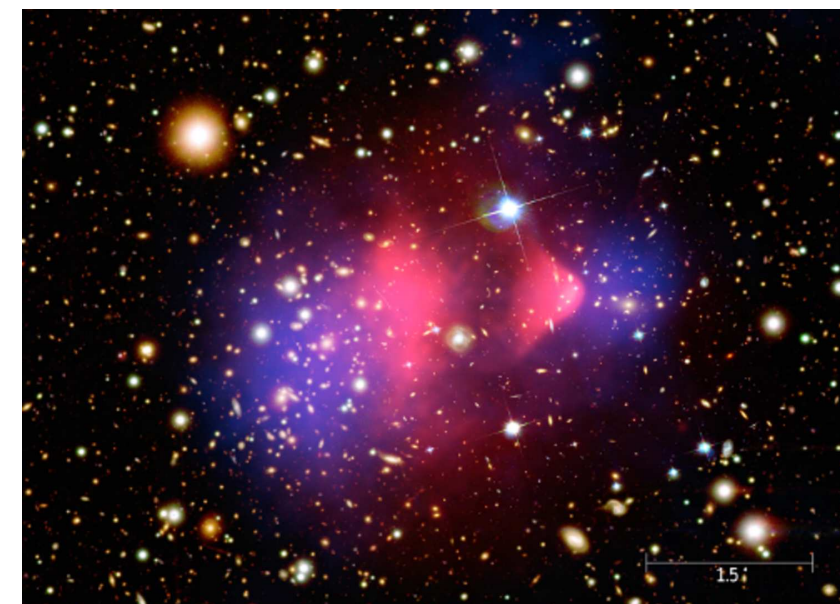


My UKRI FLF project applies lattice field theory to three inter-related new frontiers

Frontier: Composite Higgs and composite dark matter

Hypothesize Higgs boson or dark matter
arise from strongly interacting QFT

Can explain currently mysterious features of these particles



$\longrightarrow$ Predictions for collider experiments & gravitational waves

Collaboration for impact

UoL Quantum Tech Network

Connect researchers
& promote opportunities
across faculties



Lattice 2024 in Liverpool

International Symposium

[Chicago '23; Mumbai '25]

$\sim$ 500 presentations

throughout a week



Northern Quantum Meetings

Day-long in person

Once or twice annually

N8 and beyond



IBM Research & Hartree

Joint Study Agreement

Point of contact

for quantum computing



STFC 'DiRAC' HPC Facility

Science Case co-author

Innovation placements

in quantum computing



Nat'l Quantum Tech Progr.

Quantum Comp. Centre

Quantum Comp. Hub



Liv.Inno CDT

PGR in quantum comp.

Industrial placements

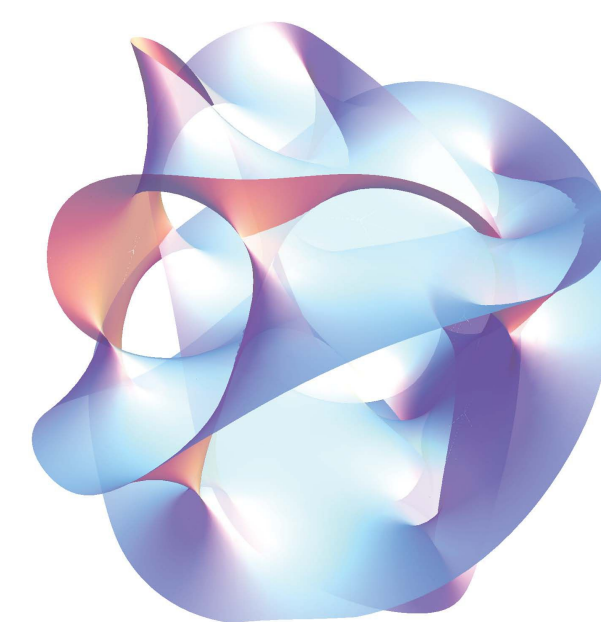


Frontier: Supersymmetry and holographic dualities

Holographic duality conjecture

Quantum gravity equivalent to supersymmetric QFT

$\longrightarrow$ non-perturbative definition from lattice field theory



Challenge: Discrete lattice space-time breaks supersymmetry

Developing and applying novel lattice methods

to test holographic duality and investigate quantum gravity

Frontier: Sign problems and quantum computing

Problem: Algorithms encounter negative (or complex) numbers
where they expect probabilities between 0% and 100%

$\implies$ Exponentially increasing computational costs

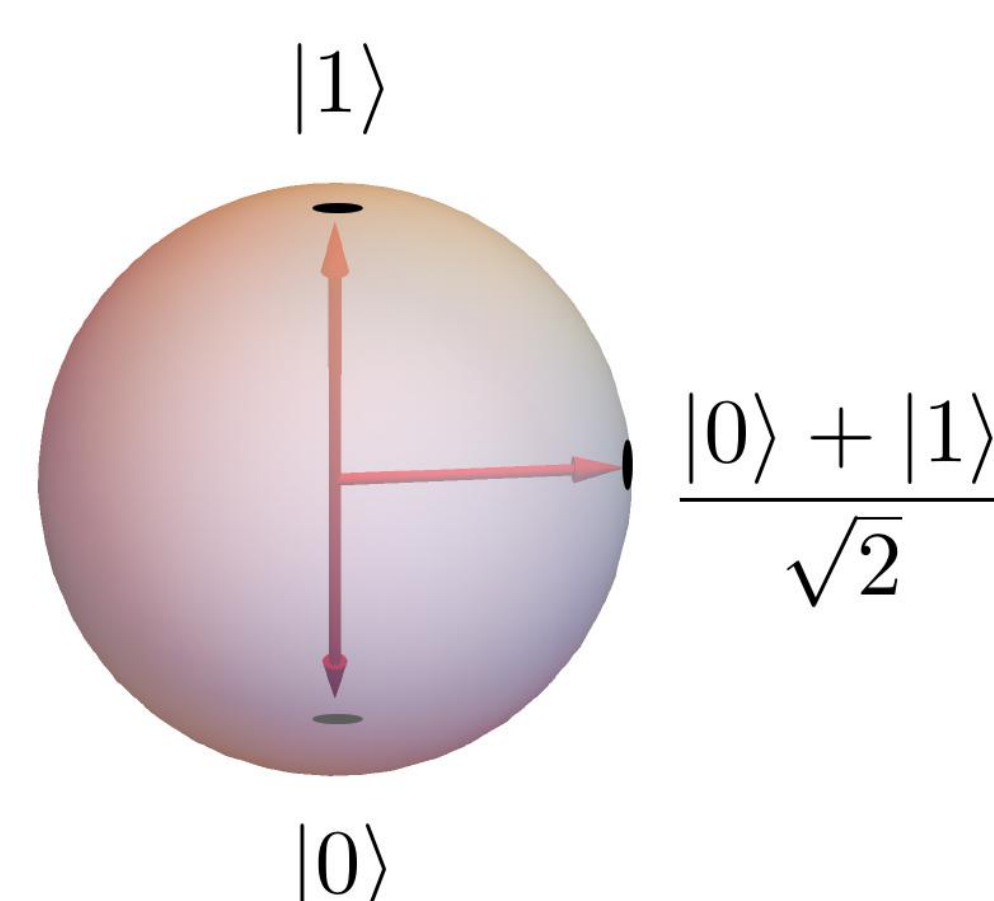
to analyse quantum systems with non-quantum methods

Developing and applying quantum methods

to investigate quantum systems

Requires complicated reformulation in terms of

entangled qubits / qudits / qumodes



Working with emerging UK quantum technologies industry

to build upon recent progress and advances