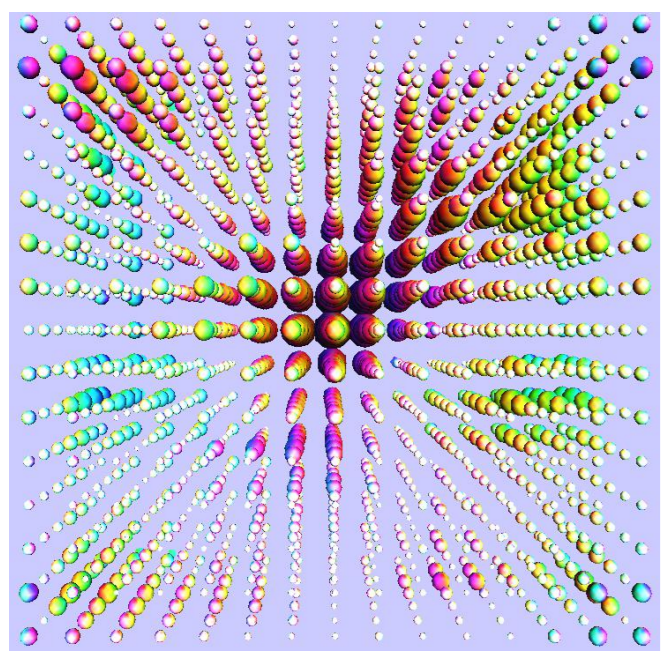




## Research Context: Lattice field theory

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



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

$\Rightarrow$  Formal mathematical definition

$\Rightarrow$  Numerical predictions from supercomputing

Crucial tool for **strongly interacting** systems



My project applies this approach to three inter-related new frontiers

## Frontier: Composite Higgs and composite dark matter

**Hypothesis:** Higgs boson or dark matter arise from as-yet unknown strongly interacting QFT

Can explain currently mysterious aspects of these particles

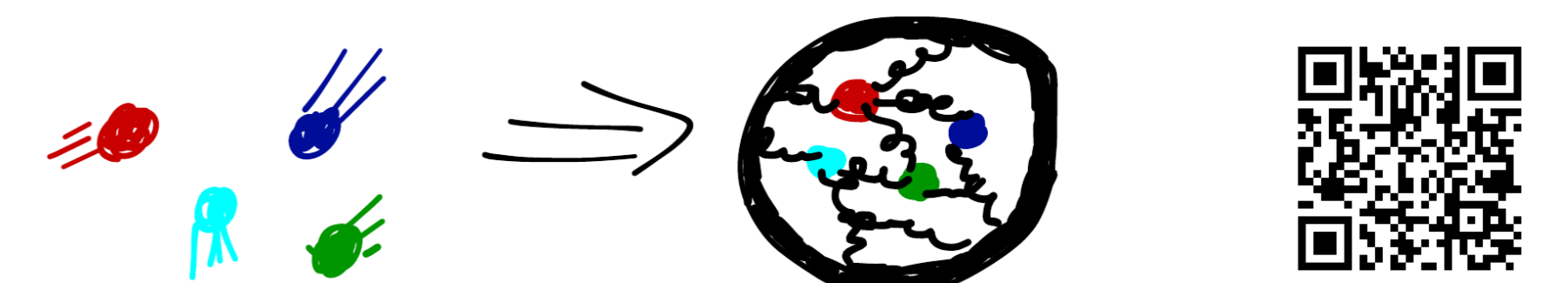


**Goal:** Predictions for future experiments, e.g., gravitational waves

## Recent achievements

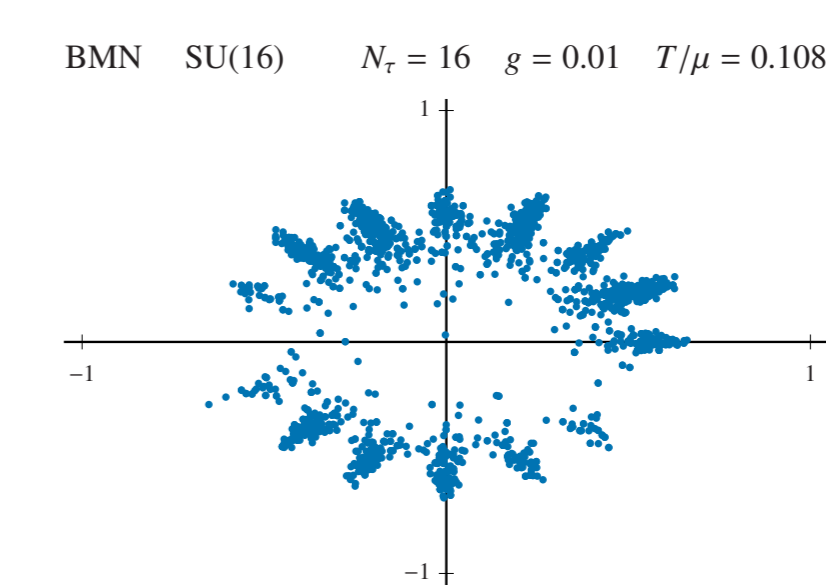
Stealth dark matter and gravitational waves

Preliminary results presented at annual *Lattice* conference in Wuhan, June



Supersymmetric lattice field theories: Classical simulations and quantum opportunities

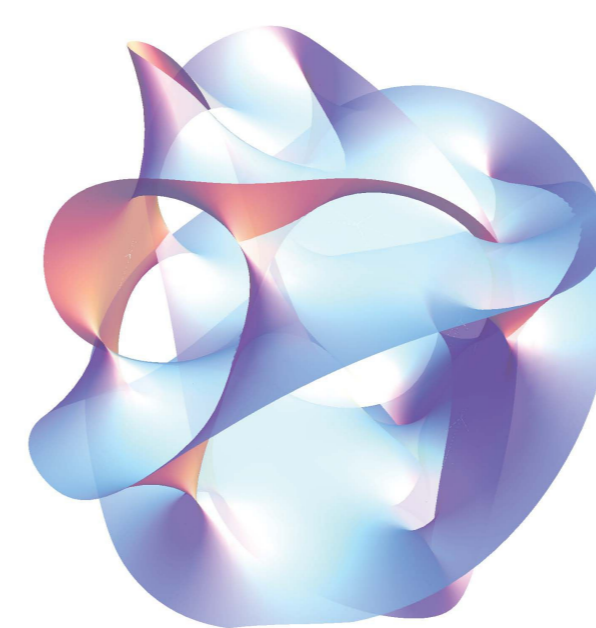
Invited presentation at ECT\* Trento workshop, June



## Frontier: Supersymmetry and holographic dualities

### Holographic duality conjecture

Quantum gravity equivalent to supersymmetric QFT  $\rightarrow$  non-perturbative definition from lattice field theory



**Challenge:** Discrete lattice space-time breaks supersymmetry

**Goal:** Develop and apply new lattice methods to test holographic duality and investigate quantum gravity

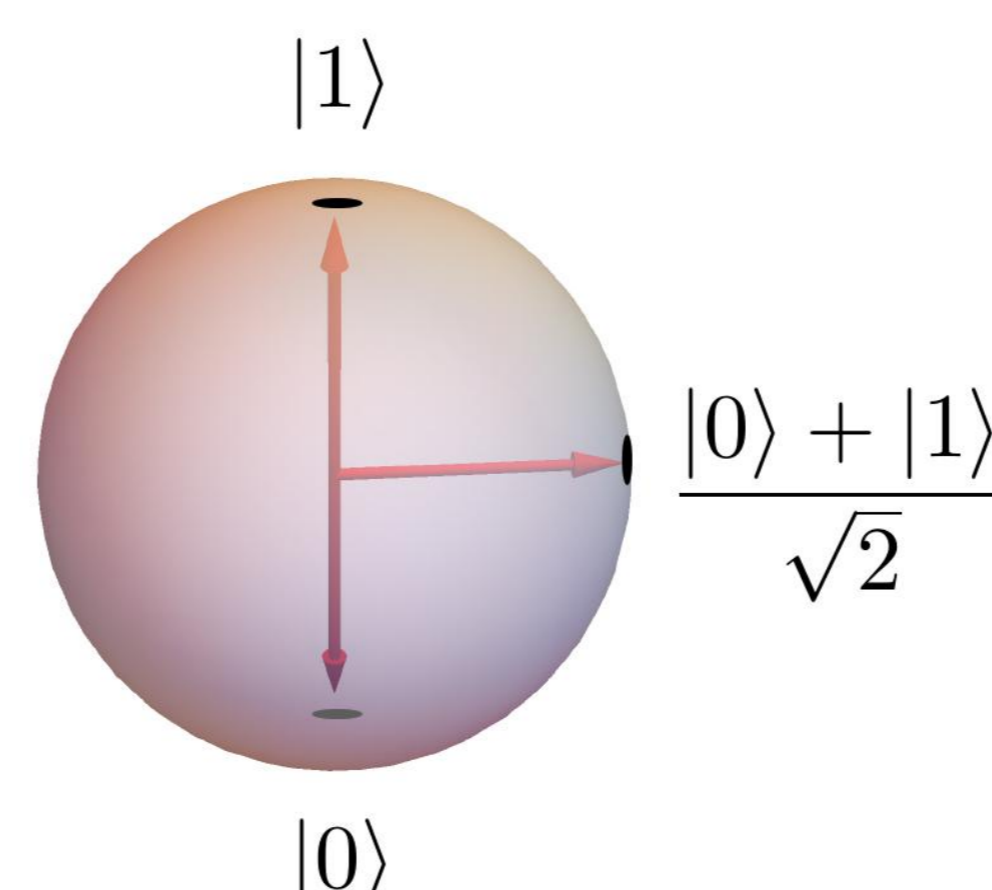
## Frontier: Sign problems and quantum computing

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

$\Rightarrow$  Exponentially increasing computational costs to study quantum systems with non-quantum methods

**Goal:** Develop and apply quantum methods to investigate quantum systems

Requires complicated reformulation in terms of entangled **qubits**



Will work with emerging UK Quantum Technologies **industry** to build upon dramatic recent advances

Forging quantum connections: —Networked Quantum Info. Technologies Hub

—National Quantum Computing Centre

—IBM Research



The Dark Side of the Universe Public engagement through *Ignite Liverpool*, August

