

QUANTERA CALL 2025

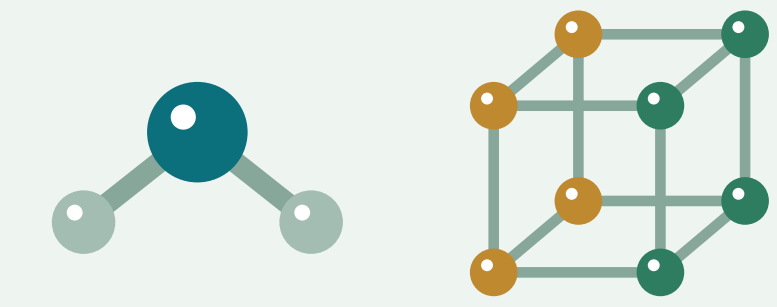
Digital methods in analog quantum simulation

Making quantum simulators more programmable and precise

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digianaqsim.eu

- **Goal:** Enable quantum simulation of real materials and molecules to advance materials discovery and drug design
- **Challenge:** Limited programmability and lack of fault tolerance in analog simulators
- **Platform:** Ultracold atoms in optical lattices with new local addressability
- **Solution:** Digital gates and algorithms for more general models, lower-temperature states and more flexible measurements



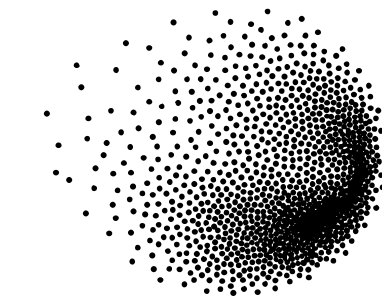
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Overcome limited size of digital simulators

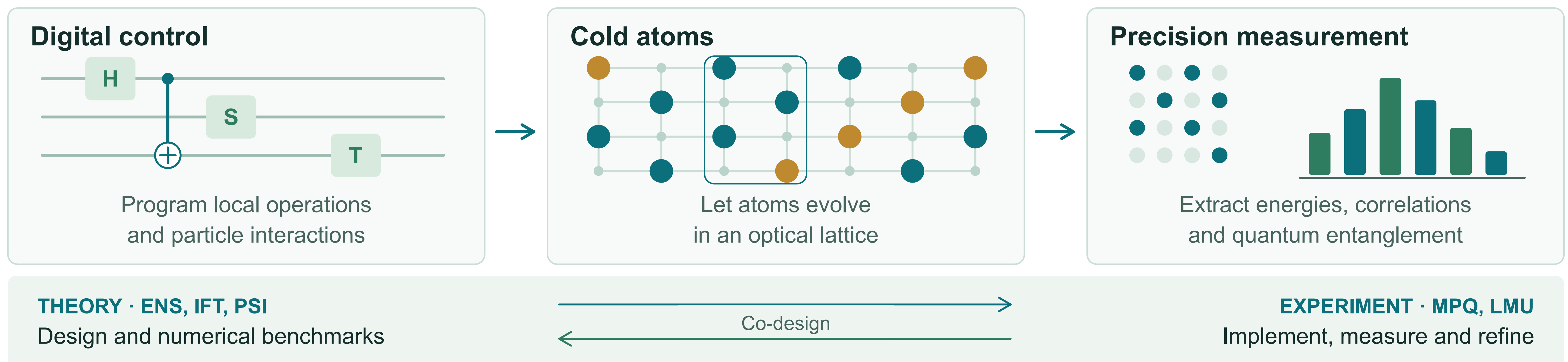
- Limited number of qubits restricts accessible system sizes
- Finite accessible simulation times limit the dynamics we can study

Overcome limited programmability in analog simulators

- Limited programmability has held back access to realistic models
- Limited readout capabilities restrict accessible observables

Digital gates. Analog time evolution.

We combine programmable (digital) operations with the natural (analog) dynamics of atoms.



1 Prepare quantum states

- Low-energy and finite-temperature states
- Faster, higher-fidelity preparation of strongly correlated matter

2 Engineer interactions

- Native gates for fermions and bosons
- Hybrid dynamics beyond standard Hubbard interactions

3 Probe with precision

- Energies, currents, pairing and entanglement
- Advanced protocols beyond standard measurement capabilities

Error mitigation across the toolbox

Characterise noise and reduce its effect on simulation results.

Partner expertise & selected publications

ENS · Algorithms & quantum simulation

A. Schuckert, ..., M. J. Gullans
arXiv:2411.08955 (2024; revised 2025)
A. Schuckert, ..., C. Monroe
Nature Physics 21, 374-379 (2025)

PSI · Randomized measurements

B. Vermersch, ..., A. Elben
PRX Quantum 5, 010352 (2024)
A. Elben, ..., P. Zoller
Nature Reviews Physics 5, 9-24 (2023)

IFT · Models & simulation protocols

D. González-Cuadra, ..., P. Zoller
PNAS 120, e2304294120 (2023)
C. Tabares, ..., D. González-Cuadra
arXiv:2511.04434 (2025)

LMU · Lattice control & quantum matter

A. Impertro, ..., M. Aidelsburger
Nature Physics 21, 895-901 (2025)
A. Impertro, ..., M. Aidelsburger
Phys. Rev. Lett. 133, 063401 (2024)

MPQ · Fermionic control & entanglement

N. Jain, ..., P. M. Preiss
Phys. Rev. Lett. 136, 223402 (2026)
F. Gkritsis, ..., P. M. Preiss
PRX Quantum 6, 010318 (2025)