Quantum simulation and information with trapped ultracold atoms

Francesco Scazza - Three-minute seminars 19 November 2021



ULTRACOLD ATOMS

Ultracold atoms are ideal building blocks for artificial quantum systems





Very controllable: manipulate internal and motional states, tune strength and nature of interactions, choose quantum statistics, precisely adjust the confinement potentials and dimensionality, ...







ULTRACOLD ATOMS

Ultracold atoms are ideal building blocks for artificial quantum systems





Very controllable: manipulate internal and motional states, tune strength and nature of interactions, choose quantum statistics, precisely adjust the confinement potentials and dimensionality, ...











ATOMIC SYSTEMS FOR FUNDAMENTAL SCIENCE







TRAPPED SINGLE ATOMS AS QUBITS



- Quantum information stored in **insensitive internal spin states** *





TRAPPED SINGLE ATOMS AS QUBITS



Optical tweezer micro-trap

Ebadi et al. *Nature* **595** (2021)

Quantum information stored in **insensitive internal spin states** *



G. Pagano, F. Scazza, and M. Foss-Feig. Adv. Quantum Tech. 2, 1800067 (2019)



Vol. 2 • No. 3–4 • April • 2019

WILEY-VCH

www.advquantumtech.com TECHN





ATOMIC ENSEMBLES AS QUANTUM SIMULATORS







Physical realisation







ATOMIC ENSEMBLES AS QUANTUM SIMULATORS







Physical realisation









ATOMIC ENSEMBLES AS QUANTUM SIMULATORS

Condensed matter phenomena



Model Hamiltonian

Physical realisation







Greif et al., *Science* **351** (2016)







- Repeated measurements → Evaluate correlation functions!
- Probe out-of-equilibrium physics at play!











Optical table at MPQ, Munich



ArQuS Lab: Ytterbium atoms in programmable micro-traps

Single-atom manipulation with metrological-grade control

Quantum simulation of localized spin impurities with optically trapped fermionic Yb atoms





UNIVERSITÀ DEGLI STUDI **DITRIESTE**



Multiplexed optical clocks and nuclear qubit registers Atomic ¹⁷¹Yb state manipulation on the clock transition





