Dual-type Dual-element Atom Array for Quantum Computation and Simulation

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Quantum science promises great potential to revolutionize our current technologies. The past few years have witnessed a rapid progress on using arrays of individually trapped atoms as a programmable quantum processor [1]. However, several predominant challenges remain, including reconfigurable individual addressability for qubit/spin operation and non-demolish selective detection, which lead to limited efficiency in implementing quantum algorithm, low experimental repetition rate, and preclude applications of many quantum error correction protocols. Here, we are building a novel architecture that sidesteps these challenges and enable experimental study on frontier topics in quantum information dynamics, with the long-term goal aiming for a fault-tolerant general-purpose quantum computer. This architecture combines an array of individually trapped ytterbium atoms and an array of rubidium atomic ensembles in a bilayer structure, with each layer has its own unique functionality and the interlayer interaction can be tuned with external electric field rapidly via Förster resonance. Spins/qubits are encoded with the electronic states of Yb atoms, while the Rb atomic ensembles perform ancillary operations on the nearby Yb atoms, including rapidly reconfigurable local qubit operation, and fast, non-demolish detection. With these newly developed techniques, this platform can implement previously inaccessible protocols on efficient generation of target quantum states, and is compatible with quantum error correction.

References

[1] Margado, M. & Whitlock, S. AVS Quantum Science, 3(2), 023501 (2021).

Figure

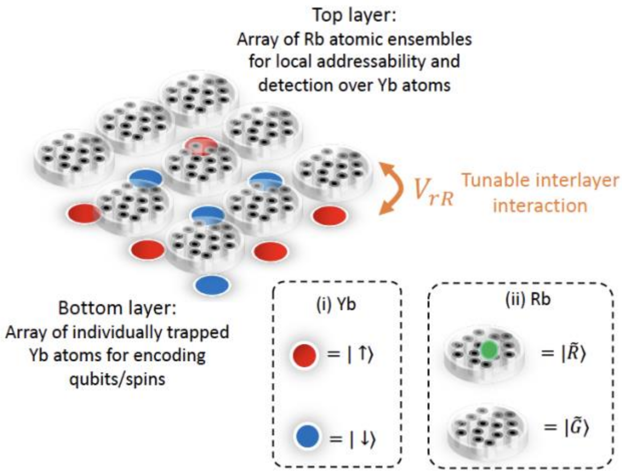

Figure: A sketch of the proposed dual-type dual-element atom array in a bilayer structure. The architecture consists of two types of arrays with different functionality: the bottom array is made with individually trapped atoms, in which the quantum information is encoded (inset (i)). The top layer is an array of small Rb atomic ensembles. Each ensemble has ~500 Rb atoms inside, with the radius of each atomic ensemble as 2um. These ensembles can facilitate local addressability over Yb atoms, and perform non-demolition, rapid readout via controllable interlayer interactions.