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Efficient Entanglement Purification and Distribution

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Entanglement Purification Circuit Design for dual-species atom arrays

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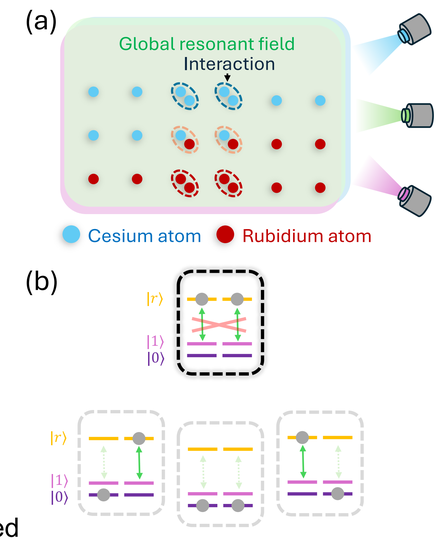
Project Goals:

- Design efficient quantum circuit for entanglement purification protocols with dual species atomic platform.
- Circuit compilation should follow certain physical constraints, which are given by the dual-species atom convenient operation set (DACOS) (DACOS).
- Only one operational zone is needed. No requirement of complication optical tweezer maneuver.

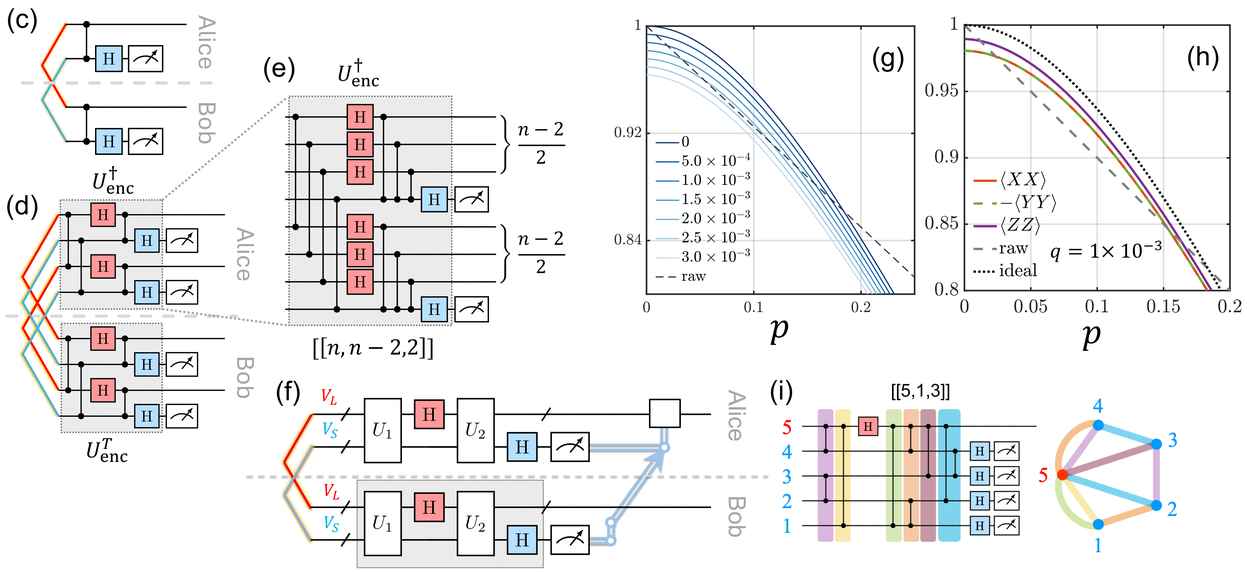
Dual-species atom convenient operation set (DACOS)

- $\mathcal{T}$: Relocation of atoms.
- $\mathcal{CZ}$: Inter/Intra- species atom Rydberg blockade – any CZ gates.
- $\mathcal{U}_\alpha$: Global control field – global single qubit gate.
- $\mathcal{M}_\alpha$: Global measurement – global single qubit gate.



Result:

- Any qubit stabilizer-code-based one-way EPP can be implemented efficiently under DACOS.
- We implement full density matrix circuit simulation for EPP.



(a) Dual species atom array platform (b) Rydberg blockade. (c) 2-to-1 protocol [Bennett,et al 1996]. (d,e) n-to-n-2 protocol. (f) General circuit compilation for any qubit stabilizer code. (g,h) Performance of the [[5,1,3]] EPP under noisy circuit. (i) Multigraph as a guide for compilation (Vizing's theorem).

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Generalized Quantum Repeater Graph States

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Project Goals:

•Improve the previous work on all photonic quantum repeater, based on the repeater graph state (RGS) [Azuma, et al. 2015]:

i. Establish multiple Bell pairs simultaneously
ii. Efficiently suppress the effective erasure error from probabilistic of Bell state measurement (BSM)

Challenge:

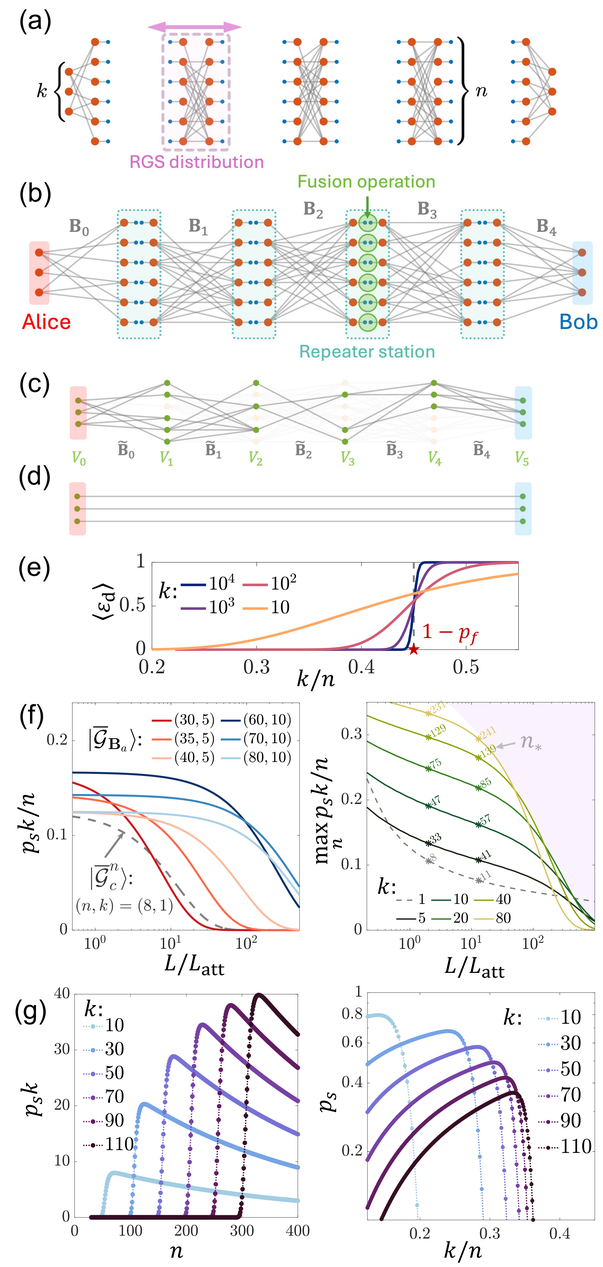
- The previous scheme uses a complete bi-partite graph, with limited bandwidth of at most 1 ebit per attempt.

New Idea:

- Use generalized bi-partite graph (characterized by bi-adjacency matrices)
- Associate with error correcting code (ECC) for erasure error. Such that higher rate can be achieved without sacrificing error rate.

Results:

- The new scheme can efficiently establish more ebits under arbitrary BSM loss rate.
- The successful BSM, if erroneous, can be handled by any good erasure ECC which also handles bit flip channel.
- Only single Pauli measurement is required in the protocol (besides BSM).
- Discussion about the resource state generation overhead
- Our paper has been posted on PRL.



(a) RGS distribution. (b) Repeater stations perform fusion operations. (c-d) Decoding based on single photon measurements. (e,f,g) The QKD performance.