We apply a series of projection techniques on top of tensor networks to compute energies of ground state wave functions with higher accuracy than tensor networks alone with minimal additional cost. We consider both matrix product states as well as tree tensor networks in this work. Building on top of these approaches, we apply fixed-node quantum Monte Carlo, Lanczos steps, and exact projection. We demonstrate these improvements for the triangular lattice Heisenberg model, where we capture up to 57% of the remaining energy not captured by the tensor network alone. We conclude by discussing further ways to improve our approach.

**References**

5. The ITensor library is a freely available code developed and maintained on http://itensor.org/index.html.

**Abstract**

We apply a series of projection techniques on top of tensor networks to compute energies of ground state wave functions with higher accuracy than tensor networks alone with minimal additional cost. We consider both matrix product states as well as tree tensor networks in this work. Building on top of these approaches, we apply fixed-node quantum Monte Carlo, Lanczos steps, and exact projection. We demonstrate these improvements for the triangular lattice Heisenberg model, where we capture up to 57% of the remaining energy not captured by the tensor network alone. We conclude by discussing further ways to improve our approach.

**Methods**

- **Matrix product states (MPS)**: These are a way of representing quantum states as matrices, which allows for efficient computation of Hamiltonian matrix elements.
- **Tree tensor networks (TTN)**: These have physical indices at the nodes of the tree, which can capture significant local entanglement structure missed by MPS. In our tests, TTN capture 30-40% of the energy missed by MPS for the same bond dimension.

**Conclusions**

These 4 approaches allow us to push beyond what is possible with tensor networks alone. We believe future applications using PEPS and other tensor networks will show even more significant gains.

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