CAFQA: Clifford Ansatz For Quantum Accuracy

**Quantum Computing**

**Why:** Cryptography, chemistry, optimization, and machine learning.

**How:** Qubits redefine computation with interference, superposition, and entanglement.

**When:** Larger QCs + higher-fidelity qubits must emerge for quantum computing to be disruptive.

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**Classical Support for Quantum**

Advancing NISQ frontiers with error mitigation and classical support.

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**CAFQA Philosophy**

- NISQ machines are noisy, so VQA is inaccurate and slow to converge.
- Well-chosen ansatz initialization can help VQA.
- Clifford initialization is promising because its simulation and search are classically efficient.
- Result: CAFQA achieves 99% mean accuracy across VQE tasks.
- Recovers up to 99.99% of correlation energy over Hartree-Fock.
- Scalability tackles large complex systems like Chromium Dimer.
- 2.5x faster convergence post initialization.

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**Design Overview**

**Classical**

- Classical discrete search:
  - Ideal evaluation
  - Fast evaluation each iteration
  - Scalable only in the Clifford space
  - Efficient discrete search (Bayesian Optimization)

**Quantum**

- Quantum continuous search:
  - Noisy evaluation
  - Fast evaluation each iteration
  - Scalable across the full parameter space
  - Efficient continuous search (e.g., SPSA)

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**CAFQA at work**

- BO Search / H2O
- Chemical Accuracy

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**Overall accuracy benefits**

<table>
<thead>
<tr>
<th>Year</th>
<th>Exponential Compute</th>
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<tbody>
<tr>
<td>2000</td>
<td>~</td>
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<tr>
<td>2010</td>
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<td>2030</td>
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**H2 Initialization: Accuracy!**

**Post-CAFQA tuning: Fast!**

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**Ask me more**

1. Extensions to CAFQA.
2. Error mitigation for variational quantum algorithms.
3. Leveraging diversity to improve NISQ-era fidelity.
4. Quantum resource management in the cloud.

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1: UChicago, 2: Super.tech, 3: MIT, 4: Tufts, 5: Duke