Financial Services
Challenge Provider

JPMorganChase

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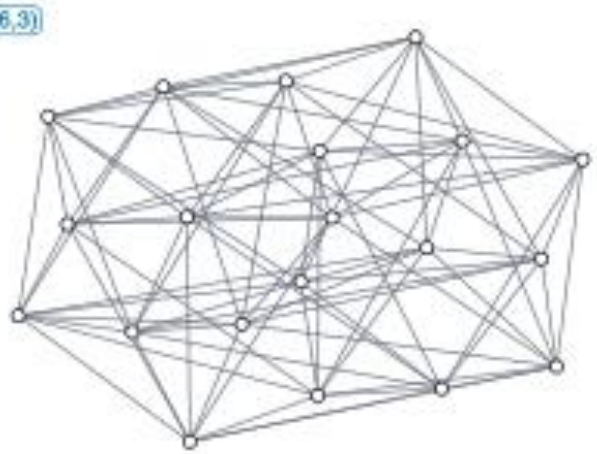
INTERNATIONAL YEAR OF QUANTUM
GLOBAL INDUSTRY CHALLENGE

the challenge

Develop solutions (scaling strategies, initial states, mixers, etc.) to improve performance of Portfolio Optimization (PO) capabilities.



Global Industry Challenge

- Improve QOKit performance on portfolio optimization

Constraint

- Hamming-weight-K, choosing exactly K assets

Conventional path

- all-to-all XY mixer → Trotter steps → grows with depth, p

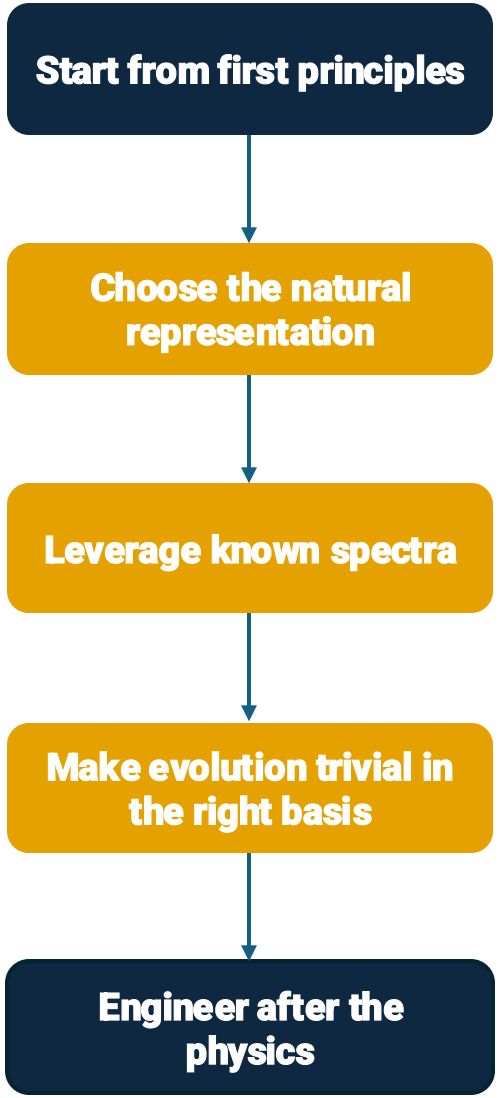
Observed pain point

- mixer is the performance-critical step

Goal

- exact one-shot mixer update, no Trotter error

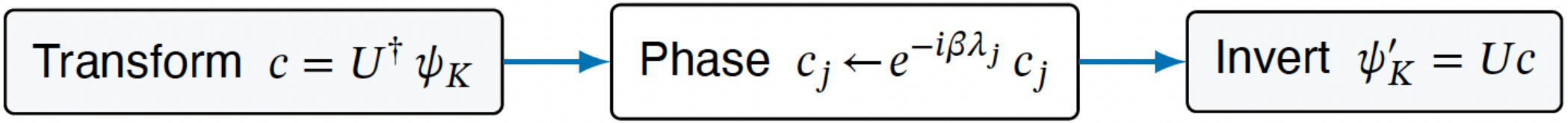
From bottleneck to spectral mixer



qBraid accelerated exploration, identification of bottle neck and verification on CPUs/GPUs

- **Before locking the idea**: Used qBraid Lab CPU/GPU instances to profile QOKit, stress the XY mixer, and probe GPU parallelism for spectral transforms.
- **Breadth over depth**: On qBraid, ran benchmark variants (penalty vs. constrained mixers), quick ML-assisted circuit-design experiments

XY on weight-K ≡ Johnson graph adjacency

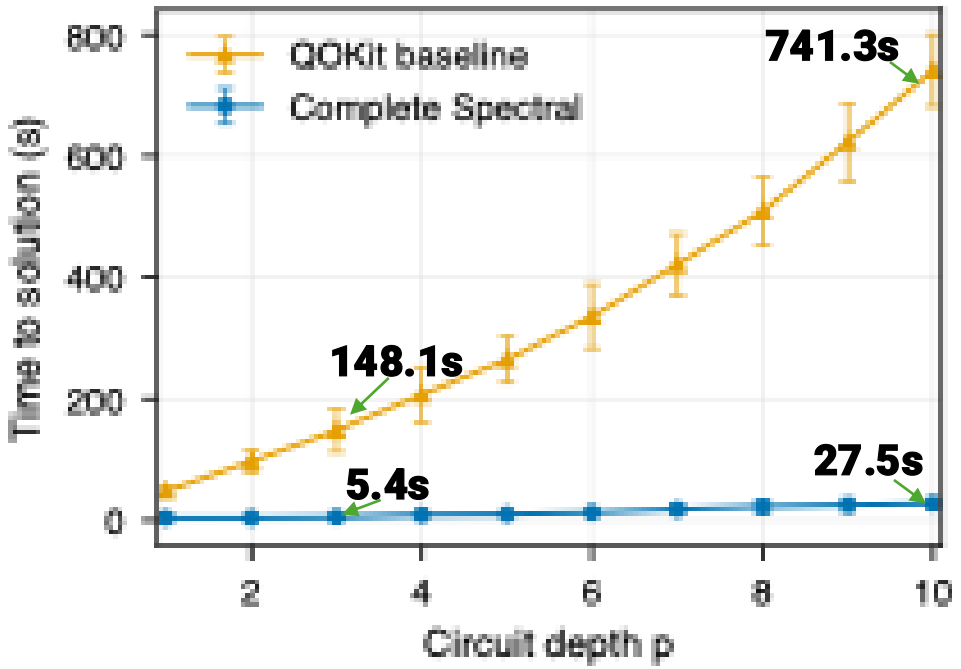


$$\psi'_K = U e^{-i\beta\Lambda} U^\dagger \psi_K$$

No trotter error

- Weight-K subspace forms vertices of **Johnson graph** $J(n, K)$
- XY mixer $\propto$ adjacency of $J(n, K)$
- Eigenvalues known in closed form: $\lambda_j = (K - j)(n - K - j) - j$
- Align initial state with mixer can improve performance

Complete Spectral Mixer in QOKit:
speed without accuracy loss



(~27×) speed up for every circuit depths

- **One-shot** $Ue^{-i\beta\Lambda}U^{\dagger}$ → no Trotter error
- slowly and linearly increase vs p on CPU, deeper sweeps now feasible
- Matches best-available accuracy and preserve ideal dynamics
- **Risk & limits**:
  - speedups are classical; hardware-routing non-trivial

Impact for PO today & What's next

Business Impact

- Faster classical simulation → **more scenarios** within the same CI window
- With deeper schedules & wider sweeps you surface lower-energy portfolios **with lower** compute budget
- No trotter error mixing helps **separate hardware noise** from algorithm effects when moving tuned schedules to QPUs

Technical Impact

- QOKit reduces QAOA cost by precomputing problem-diagonal structure and spanning CPU ↔ GPU↔cluster backends
  - **Add spectral precomputation for the mixer in weight-K sectors**
- Enable **clean gap-dependent studies** and **initial-mixer alignment** experiments in PO.

Future Works

- **Collaboration and Productization**:
  - Propose "mixer backends" interface and hybrid workflows for tuning QPUs.
  - Explore more for validations and use cases including finance and other more optimization problem with polished algorithm for paper and product.
  - **KEEP BE INNOVATIVE & CREATIVE!**