Quantum Computing for Heavy Quark Fragmentation (QC4HQ)

FY26 Q1 report

Funded participants: David Richards
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Marco Zaccheddu
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Collaborators:
Jack Araz (Saint George's, London -> UCLA)
Jianwei Qiu (JLab)
Raghav Jha (NCSU)
Zhongbo Kang (UCLA)
* *Yamil Cahuana Medran* (WM)
* *Peter Nguyen* (UCLA -> Duke)

* Graduate students

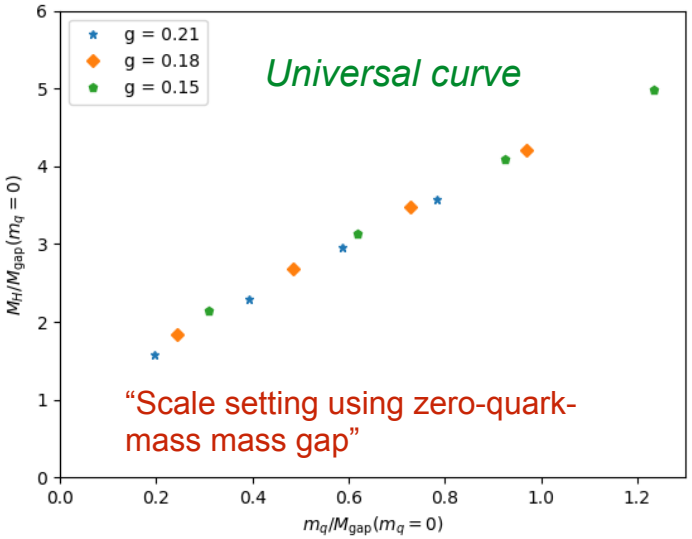
Tensor Network Calculations

Two-flavor NJL model with Tensor Networks

Qualitatively different to widely-studied one-flavor theory - now *asymptotically free.*

→ *Continuum limit/scale dependence*

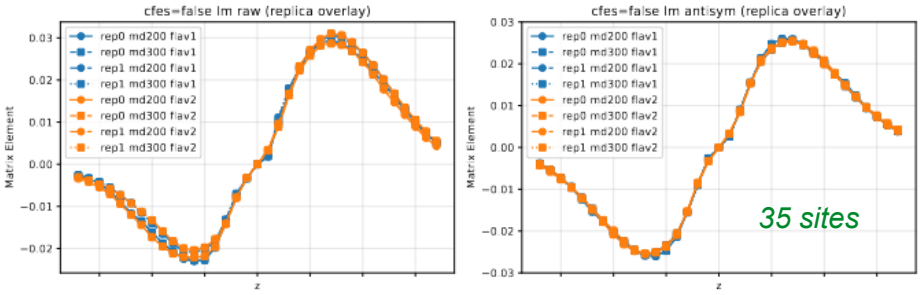
→ *Express as dimensionless mass ratios*



PDF is dimensionless - *so would expect universal curve if in the asymptotic regime.*

Challenges and solutions

- TN calculations using *Density-Matrix Renormalization Group (DMRG)* are "exact" - but need to investigate bond dimensions, but need sufficiently tight SVD.
- TN calculations *of PDF* are computationally and memory demanding
  - *Awarded Class-B Allocation on USQCD Cluster*
- Tuning of bond dimensions, and of singular values
  - OpenAI Codex on JLab farm



*Consistency in **spatial matrix elements** with bond dimension and flavor interchange.*

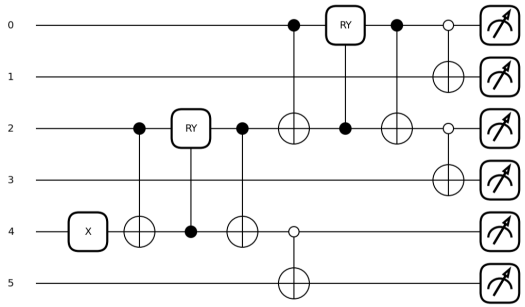
For paper

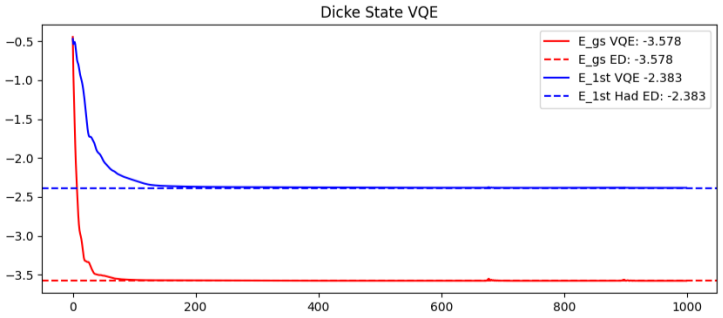
- Coordinate space to x space presents inverse problem
  - Exploring novel methods developed for LQCD (GP)
- Exhibit scaling for PDF analogous to energies

Quantum Calculations

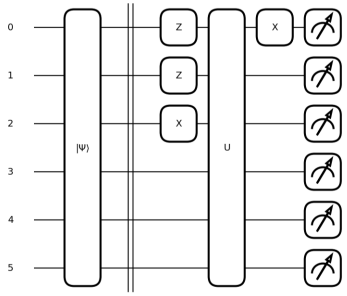
Calculations within PennyLane and on IBM Quantum

1-flavor on 6 qubits





Circuits for PDF and FF developed

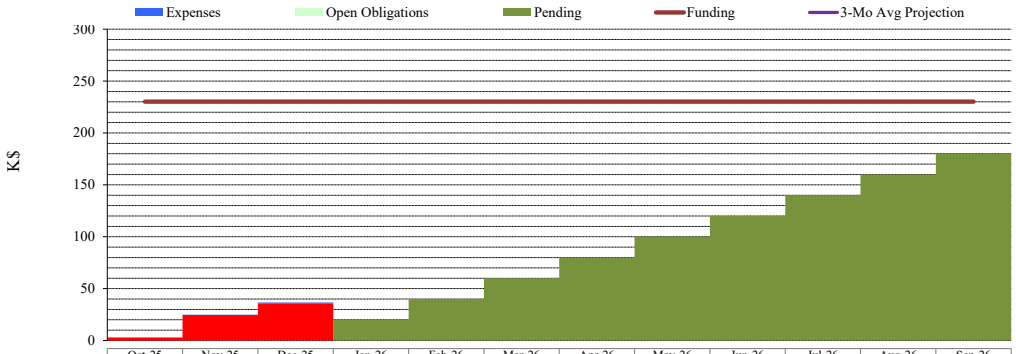


Circuit for PDF

- J-Y Zhang, M. Zaccheddu and DGR have accounts on IBM Quantum
- Need to update code to be compatible with supported version of PennyLane. 0.38 ⟶ 0.44
- Have not yet implemented Hadamard test needed for full implementation.

Funding

Quantum Computing for Heavy-Quark Fragmentation
D. Richards (LD2608)
WBS 1.02.LD.012 (Loaded $k)

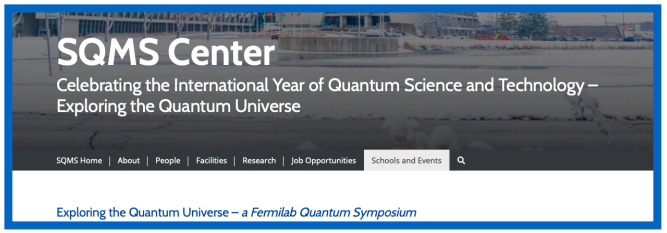


	Oct-25	Nov-25	Dec-25	Jan-26	Feb-26	Mar-26	Apr-26	May-26	Jun-26	Jul-26	Aug-26	Sep-26
YTD Spending	3	25	37	20	40	60	80	100	120	140	160	180
Pending	0	0	0	20	40	60	80	100	120	140	160	180
Open Obligations	0	0	0	0	0	0	0	0	0	0	0	0
Expenses	0	0	1	0	0	0	0	0	0	0	0	0
Labor	3	25	35	0	0	0	0	0	0	0	0	0
Funding	230	230	230	230	230	230	230	230	230	230	230	230
3-Mo Avg Projection												

Changes to Labour

- Marco Zaccheddu moving to 25% (AmSC)
- Jia-Yue Zhang now 75%

Jia-Yue



Collaboration meeting at JLab in Spring