UNIVERSITY OF LIVERPOOL

QUANTUM COMPUTER FOR NEUTRINO SCATTERING

SUBTITLE HERE

First Year Report

Marina Maneyro, MSc.

Postgraduate Research Student
School of Physical Sciences
University of Liverpool

May 2024

Supervisors:

Prof. Costas Andreopoulos

Dr. Gabriel Perdue

Dr. Doğa Kürkçüoğlu

ANII AGENCIA NACIONAL DE INVESTIGACIÓN E INNOVACIÓN

LIV.INNO

Abstract

Keywords:

Contents

List of Figures

List of Tables

Introduction

1 Quantum Computing

1.1| Fundamentals

Qubits, NISQ overview: [1] [2] [3] [4] [5]
Different hardware approaches: [6] [7] [8]
Bosonic systems: [7] [9]

1.2| Quantum Error Correction

General [9] [10] [11] [12] [13]
Specific Implementations [14] [15] [16]
Bosonic [17] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27]

2 Neutrino Physics

3 Project Outlook

4 Summary

Bibliography

[1] M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum Information (2010).

[2] J. Preskill, Quantum **2** (2018).

[3] What is quantum computing? | ibm.

[4] P. Kaye, R. Laflamme, and M. Mosca, page 274 (2007).

[5] R. Cleve, (2021).

[6] What is quantum annealing? — d-wave system documentation documentation.

[7] Superconducting bosonic qubits | zurich instruments.

[8] Ibm quantum computing | technology.

[9] S. M. Girvin, SciPost Physics Lecture Notes **70** (2021).

[10] C. K. Andersen et al., Nature Physics **16**, 875 (2020).

[11] D. Gottesman, (2009).

[12] J. Roffe, Contemporary Physics **60**, 226 (2019).

[13] S. J. Devitt, W. J. Munro, and K. Nemoto.

[14] S. Krinner et al., Nature **605**, 669 (2021).

[15] Z. Chen et al., Nature 2021 595:7867 **595**, 383 (2021).

[16] A. N. Cleland, SciPost Physics Lecture Notes **49**, 049 (2022).

[17] P. Campagne-Ibarcq et al., Nature 2020 584:7821 **584**, 368 (2020).

[18] H. K. Lau and M. B. Plenio, Phys. Rev. Lett. **117**, 100501 (2016).

[19] I. L. Chuang, D. W. Leung, and Y. Yamamoto, Phys. Rev. A **56**, 1114 (1997).

[20] B. M. Terhal, J. Conrad, and C. Vuillot, Quantum Science and Technology **5**, 043001 (2020).

[21] A. Blais, S. M. Girvin, and W. D. Oliver, Nat. Phys. **16**, 247 (2020).

[22] L. Hu et al., Nat. Phys. **15**, 503 (2019).

[23] M. H. Michael et al., Phys. Rev. X **6**, 031006 (2016).

[24] A. L. Grimsmo and S. Puri, PRX Quantum **2** (2021).

[25] W. Cai, Y. Ma, W. Wang, C. L. Zou, and L. Sun, Fundamental Research **1**, 50 (2021).

[26] A. J. Brady, A. Eickbusch, S. Singh, J. Wu, and Q. Zhuang, Progress in Quantum Electronics (2023).

[27] D. Lachance-Quirion et al., (2023).

Appendices