Quantum Computing with IBM Q

Report of Contributions

https://agenda.infn.it/e/31546

Contribution ID: **1** Type: **not specified**

Introduzione / setup

Contribution ID: **2** Type: **not specified**

IBM Quantum Network: overview and resources

Friday, 1 July 2022 09:30 (1 hour)

Presenter: Dr GROSSI, Michele (CERN)

Contribution ID: **3** Type: **not specified**

Hamiltonian evolution of the dynamics of QCD-inspired field theory models

Friday, 1 July 2022 10:50 (20 minutes)

In this project, we plan to study the dynamics of simple field theoretic models, that can be studied with available QC systems, and are inspired by Quantum Chromodynamics. One can study the dynamics of simple non-abelian gauge theories, that retains significant conceptual similarity with the more complex SU(2) and SU(3) gauge theory. One can explore the dynamics and measure observables of e.g. the D4 gauge group or of the 120-element icosahedral group on small 2D (and eventually 3D) lattice grids, assessing the complexity of the relevant quantum codes, verifying the algorithms through emulation and finally quantifying reliability on actual QC systems.

Presenters: ERCOLESSI, Elisa (BO); FACCHI, Paolo (Istituto Nazionale di Fisica Nucleare); MONTANGERO, Simone (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **4** Type: **not specified**

Circumventing the sign problem for LQCD-simulations

Friday, 1 July 2022 10:30 (20 minutes)

In this project, we plan to study the application of quantum computing techniques to the investigation of the thermodynamical properties of simple toy models, again inspired by QCD, in contexts in which the infamous “sign-problem” makes classical Monte Carlo simulation conceptually impossible. We will develop and test quantum algorithms able to completely solve the problem, and compare them with mixed
quantum-classical algorithms, discussing the corresponding theoretical complexities and reliabilities on NISQ machines.

Presenter: D’ELIA, Massimo (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **5** Type: **not specified**

Exploring Quantum Computing

Friday, 1 July 2022 11:10 (20 minutes)

In this project we plan to explore the potential of Quantum Systems from the computational point of view. We aim to focus on general combinatorial problems that may be of interest for INFN applications (e.g. graph coloring for sceduling problems), designing algorithms, and investigate computational complexity and programming issues. In particular we aim to use quantum machines as accelerators developing hybrid solvers. Also, we are interested in investigating quantum machine learning algorithms.

Presenter: SCHIFANO, Sebastiano (FE)

Contribution ID: **6** Type: **not specified**

Quantum Machine Learning for Event Classification and Event Simulation in Nuclear Physics, High-Energy Physics and Gravitational Wave experiments

Friday, 1 July 2022 11:30 (20 minutes)

In this project we plan to address the opportunities offered by Quantum Machine Learning for event classification and event simulation at nuclear physics, high-energy physics and gravitational wave experiments. We draw on already developed work in the area of jet-tagging in events from the LHCb experiment and develop further more advanced algorithms, evaluating the cost-benefit tradeoff of a larger number of qbits and comparing results of the quantum algorithms with the state-of-the-art offered by well-established classical algorithms.

Presenters: PALOMBA, Cristiano (Istituto Nazionale di Fisica Nucleare); ZULIANI, Davide (Istituto Nazionale di Fisica Nucleare); LUCCHESI, Donatella (Istituto Nazionale di Fisica Nucleare); SESTINI, Lorenzo (Istituto Nazionale di Fisica Nucleare); ASTONE, Pia (Istituto Nazionale di Fisica Nucleare); GIAGU, Stefano (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **7** Type: **not specified**

Quantum simulation of the Nucleon-Nucleon potential

Friday, 1 July 2022 11:50 (20 minutes)

In this project we plan to explore the possibility to use a QC as a coprocessor for the study of the nucleon-nucleon interaction. The spin-dependent part of the nucleon-nucleon potential has matrix elements among the four possible spin-states of the two nucleons, so it can be associated and time-evolved in a two-qbit state. We plan to study the effectiveness of this approach, using already developed simulation algorithms, focusing with special interest on the development and test of a mixed-mode classical-quantum global simulation package.

Presenters: PEDERIVA, Francesco (TIFP); PEDERIVA, Francesco (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **8** Type: **not specified**

Quantum simulations of collective neutrino oscillations

Friday, 1 July 2022 12:10 (20 minutes)

In extreme astrophysical environments like core collapse supernovae, neutron star mergers and the early universe, neutrino flavor oscillations can be substantially modified by neutrino-neutrino scattering. Models of this process require the solution of a strongly coupled many particle problem. In this project we aim to exploit the similarity between the neutrino flavor Hamiltonian and a many-spin system to design quantum simulations to describe out-of-equilibrium flavor processes. In particular we intend to exploit the availability of pulse level control in superconducting qubit systems to increase the reliability of dynamical simulations.

Presenter: ROGGERO, Alessandro (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **9** Type: **not specified**

Quantum graph networks for particle track reconstruction

Friday, 1 July 2022 12:30 (20 minutes)

In this project we plan to explore the effectiveness of a quantum enhancement to the Neural Network approach to the problem of charged particle tracking. We plan to explore options to re-engineer classical Graph Neural Networks of increasing complexity inside a quantum algorithms, exploring theoretical and practical limitations and comparing theoretical efficiency and experimenting with actual implementation.

Presenters: RIZZI, Andrea (Istituto Nazionale di Fisica Nucleare); BOZZI, Concezio (Istituto Nazionale di Fisica Nucleare); BONACORSI, Daniele (Istituto Nazionale di Fisica Nucleare)