

SYLG 1: Symposium Quantum Simulators of Lattice Gauge Theories

Time: Friday 11:00–13:00

Location: P 1

Invited Talk

SYLG 1.1 Fri 11:00 P 1

Quantum Simulation of Lattice Gauge Theories with Cold Atoms and Ions — ●PETER ZOLLER — Institute for Theoretical Physics, University of Innsbruck, and Institute for Quantum Optics and Quantum Information, Austrian Academy of Sciences, Innsbruck, Austria

We review recent theory proposals and experimental advances in quantum simulation of lattice gauge theories with quantum optical systems of cold atoms and ions, both from the perspective of condensed matter and high energy physics [1,2]. Our discussion starts with the lattice Schwinger model as 1+1 dimensional lattice QED, where we illustrate the challenge of implementing gauge invariance and the associated local conservation laws (Gauss laws) in cold atom implementations. We discuss analog and digital quantum simulation of the lattice Schwinger model both in a Wilson and quantum link formulation, and summarize recent experimental results [3] on real-time evolution of the Schwinger mechanism of spontaneous creation of electron-positron pairs on a few qubit ion trap quantum computer. In addition, we extend our discussion to quantum simulation of non-Abelian lattice gauge theories realized with atoms in optical lattices, and provide illustrations of simple models of quantum simulation of "nuclear physics".

[1] U.-J. Wiese, *Annalen der Physik* 525, 777 (2013) [2] E. Zohar, J.I. Cirac and B. Reznik, *Rep. Prog. Phys.* 79, 014401 (2015) [3] E. A. Martinez, C. A. Muschik, P. Schindler, D. Nigg, A. Erhard, M. Heyl, P. Hauke, M. Dalmonte, T. Monz, P. Zoller and R. Blatt, *Nature* 534, 516 (2016)

Invited Talk

SYLG 1.2 Fri 11:30 P 1

Quantum Simulations with Cold Trapped Ions — ESTEBAN A. MARTINEZ¹, CHRISTINE A. MUSCHIK^{2,3}, PHILIPP SCHINDLER¹, DANIEL NIGG¹, ALEXANDER ERHARD¹, MARKUS HEYL^{2,4}, PHILIPP HAUKE^{2,3}, MARCELLO DALMONTE^{2,3}, THOMAS MONZ^{2,3}, PETER ZOLLER^{1,2}, and ●RAINER BLATT^{1,2} — ¹Institut für Experimentalphysik, Universität Innsbruck — ²Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Innsbruck — ³Institut für Theoretische Physik, Universität Innsbruck — ⁴Physik Department, Technische Universität München

The quantum toolbox of the Innsbruck ion-trap quantum computer is

applied to simulate the dynamics and to investigate the propagation of entanglement in a quantum many-body system represented by long chains of trapped-ion qubits [1]. Moreover, using the quantum toolbox operations, universal (digital) quantum simulation was realized with a string of trapped ions [2]. Here we report the experimental demonstration of a digital quantum simulation of a lattice gauge theory, by realizing (1 + 1)-dimensional quantum electrodynamics (the Schwinger model) on a few-qubit trapped-ion quantum computer [3]. We map the original problem to a spin model by eliminating the gauge fields in favor of exotic long-range interactions, which can be directly and efficiently implemented on an ion trap architecture.

[1] P. Jurcevic et al., *Nature* 511, 202 (2014).

[2] B. P. Lanyon et al., *Science* 334, 57 (2011).

[3] E. A. Martinez et al., *Nature* 534, 516 (2016).

Invited Talk

SYLG 1.3 Fri 12:00 P 1

Studies of hot and dense nuclear matter at the Large Hadron Collider — ●BOLESŁAW WYSŁOUCH — MIT, Cambridge, MA USA

Over the last few years the Large Hadron Collider spent several months colliding heavy nuclei and protons with heavy nuclei at relativistic energies. The extremely hot matter created in these collisions exhibits unusual properties. The high density plasma of quarks and gluons behaves like a strongly interacting liquid and it absorbs very energetic partons. We use large particle detectors and various experimental techniques to understand its properties. In this talk I will introduce the overall research program and present the latest results.

Invited Talk

SYLG 1.4 Fri 12:30 P 1

Lattice gauge theory beyond QCD — ●CLAUDIO PICA — CP3-Origins, University of Southern Denmark, Campusvej 55, DK-5230 Odense M, Denmark

Simulations of lattice gauge theories can play a key role in advancing our theoretical understanding of strongly coupled gauge theories relevant for extensions of the Standard Model and the LHC physics program.

In this talk I will review the state of BSM lattice studies aimed to chart the phase diagram of non-supersymmetric gauge theories and to search for new models of strong dynamics beyond QCD.