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Quantum Information Processing with Trapped Ions and Photons

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Abstract
In this talk, the basic toolbox of the Innsbruck quantum information processor based on a string of trapped Ca+ ions will be reviewed. For quantum information processing, the toolbox operations are employed for quantum computations [1], for quantum simulations [2], and with optical cavities and photons they are used for the implementation of quantum interfaces [3] for the realization of quantum networks.
For quantum computation, a scalable Shor algorithm was realized [1] with a string of trapped Ca+ ions. Towards scaling the trapped ion quantum computer, we encode one logical qubit in entangled states distributed over seven trapped-ion qubits. We demonstrate the capability of the code to detect one bit flip, phase flip or a combined error of both, regardless on which of the qubits they occur. Furthermore, we apply combinations of the entire set of logical single-qubit Clifford gates on the encoded qubit to explore its computational capabilities [4]. The quantum toolbox is further applied to carry out both analog and digital quantum simulations. The basic simulation procedure will be presented and its application will be discussed for a variety of spin Hamiltonians. Moreover, a spectroscopic technique is presented to study artificial quantum matter and use it for characterizing quasiparticles in a many-body system of trapped atomic ions [5]. For the realization of a quantum interface, trapped Ca+ ions in a cavity QED setup allow entanglement of a qubit with a photon and quantum state mapping [3].

[1] T. Monz et al., Science **351**, 1068 (2016).
[2] P. Jurcevic et al., Nature **511**, 202 (2014).
[3] T. Northup and R. Blatt, Nature Photonics **8**, 356 (2014).
[4] D. Nigg et al., Science **345**, 302 (2014).
[5] P. Jurcevic et al., Phys. Rev. Lett. **115**, 100501 (2015).

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בבניין פיסיקה, חדר סמינרים לידוב 620
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at the Physics Building, Seminar Room Lidow 620

Host: Distinguished Professor Moti Segev