Q 7: Quanteninformation (Ionen)

Zeit: Montag 15:00–16:00 Raum: 5L

Q 7.1 Mo 15:00 5L

Individuelle Adressierung und bedingte Dynamik von gespeicherten Ionen mit RF-Strahlung — •Michael Johanning[1], Alexander Braun[1], Vladimir Elman[1], Werner Neuhauser[2] und Christof Wunderlich[1] — [1]Universität Siegen, Institut für Physik, Walter-Flex-Straße 3, 57068 Siegen — [2]Universität Hamburg, Institut für Laserphysik, Luruper Chaussee 146, 22761 Hamburg

Ein beliebiger Quantenalgorithmus kann aus 1-Qubit Gattern und bedingter Quantendynamik mit wenigstens zwei Qubits (z. B. *CNOT*-Gatter) synthetisiert werden. Hierfür ist zum Einen eine individuelle Adressierung der Qubits und zum Andern deren Wechselwirkung untereinander erforderlich. Wir demonstrieren erstmalig i) die individuelle Adressierung von elektrodynamisch gespeicherten Ionen mit Radiofrequenzstrahlung im Frequenzraum, und ii) die Kopplung der internen Dynamik der Ionen an deren Bewegungszustände auch bei nahezu verschwindendem Lamb-Dicke-Parameter (d.h. vernachlässigbarem Photonenrückstoß). Damit werden wesentliche Voraussetzungen geschaffen für Quanten-Informationsverarbeitung mit Ionen-Spin-Molekülen. Den experimentellen Nachweis führen wir mit Hilfe eines RF-optischen Doppelresonanz-Experimentes mit $^{172}Yb^{+}$-Ionen gespeichert in einer linearen Paul-Falle.

Q 7.2 Mo 15:15 5L

Error-resistant Single Qubit Gates with Trapped Ions — •Nuala Timoney[1], Vladamir Elman[1], Cornelius Weiss[1], Michael Johanning[1], Werner Neuhauser[2], and Christoph Wunderlich[1] — [1]Fachbereich Physik, Universität Siegen, 57068 Siegen — [2]Institut für Laser-Physik, Universität Hamburg

Coherent operations constitutive for the implementation of single and multi-qubit quantum gates with trapped ions are demonstrated that are robust against variations in experimental parameters and intrinsically indeterministic system parameters. In particular, single qubit gates developed using optimal control theory [1] are demonstrated for the first time with trapped ions. Their performance as a function of error parameters is systematically investigated and compared to composite pulses [2].

The two level quantum mechanical system is realized on the $S_{1/2}$(F=0) $\leftrightarrow$ $S_{1/2}$(F=1, m_F=0) transition in $^{171}Yb^{+}$ confined in a Paul trap, driven by microwave radiation close to 12.6 GHz. Shaped pulses and composite pulses have been realized that are specifically designed to tackle off-resonance errors, timing errors, or power variations of the driving field.

Good agreement is seen between simulated results and the measured ones. Higher experimental fidelities are obtained with the aforementioned shaped and composite pulses over an extended parameter regime than with a simple pulse. [1] T.E. Skinner, T.O. Reiss, B. Luy, N. Khaneja and S. Glaser, J. Mag. Res. **163**, 8 (2003). [2] H. Cummins, G. Llewellyn, and J. Jones, Phys. Rev. A **67**, 042308 (2003)

Q 7.3 Mo 15:30 5L

Generation of Dicke States in Distant Qubits Using Linear Optics — •Christoph Thiel[1], Joachim von Zanthier[1], Thierry Bastin[2], Enrique Solano[3], and Girish S. Agarwal[4] — [1]Institut für Optik, Information und Photonik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany — [2]Institut de Physique Nucléaire, Atomique et de Spectroscopie, Université de Liège au Sart Tilman, Liège, Belgium — [3]Physics Department, ASC, and CeNS, Ludwig-Maximilians-Universität, Munich, Germany — [4]Department of Physics, Oklahoma State University, Stillwater, OK, USA

We propose a method for generating symmetric Dicke states (like e.g. W states) of distant particles. Unlike former proposals, ours is capable of producing Dicke states of an arbitrary number of particles based on linear optics and photodetection.

In particular, we consider a chain of stored ions in a Paul trap or, equivalently, a chain of neutral trapped atoms, where each of them is driven in a Λ-configuration. All atoms are initially excited into the upper state and the spontaneously emitted photons are recorded by single photodetectors. In front of each detector a polarization analyzer determines the polarization state of the registered photon. We show that for generating a particular Dicke state there exists, at least, one suitably designed geometry of non-local detection events that will enforce that particular outcome in the long-lived atomic state.

The proposed probabilistic scheme does not require auxiliary systems like the use of collective motional degrees of freedom, or single cavity modes, and is feasible with current technology.

Q 7.4 Mo 15:45 5L

Trapped ion chain as a neural network: Error resistant quantum computation — Marisa Pons[1], Veronica Ahufinger[2,3], Christof Wunderlich[4], Anna Sanpera[2,5], •Sibylle Braungardt[6], Aditi SenDe[6], Ujjwal Sen[6], and Maciej Lewenstein[2,6] — [1]Departamento de Física Aplicada I, Universidad del País Vasco, 20600 Eibar, Spain. — [2]ICREA - Institució Catalana de Recerca i Estudis Avançats, Passeig Lluis Companys 23, E-08010 Barcelona, Spain*. — [3]Grup d*Optica, Departament de Física, Universitat Autònoma de Barcelona, 08193 Bellaterra (Barcelona), Spain. — [4]Fachbereich Physik, Universität Siegen, 57068 Siegen, Germany. *Fachbereich Physik, Universität Siegen, 57068 Siegen, Germany. — [5]Grup de Física Teòrica, Departament de Física, Universitat Autònoma de Barcelona, 08193 Bellaterra (Barcelona), Spain. — [6]ICFO-Institut de Ciències Fotòniques, 08860 Castelldefels (Barcelona), Spain.

We consider experimentally feasible chains of trapped ions with pseudo-spin half, and *nd models that can potentially be used to implement error resistant quantum computation. We consider protocols for implementing a universal set of quantum logic gates in the system, by adiabatic passage of a few low-lying energy levels of the whole system. We show that the *delity of the computation remains virtually unchanged when introducing noise to the system, if the noise is not too strong. The noise resistance of the system is achieved by encoding the qubits distributed over the whole system, and is similar in spirit to that of classical neural networks.