PhD position in Ion-Photon Entanglement

A fully funded 3.5 year PhD position is available in the Ion Trap Cavity-QED and Molecular Physics (ITCM) Group in the Department of Physics & Astronomy at the University of Sussex.

For more information please contact Prof Matthias Keller (m.k.keller@sussex.ac.uk).

Introduction:

Entanglement is at the heart of quantum information processing. Up to 14 qubits have been entangled in ion strings [1] using collective phonon excitations. An alternative to the vibrational coupling of ions is provided by photons. By analogy with phonon-based gates, the internal states of ions can be entangled with the states of photons, which in turn can establish a long-range interaction between ions in the string. To enhance the coupling between ions and single photons, a high-finesse optical cavity is required [2]. In this setting, gates between arbitrary ions coupled to the cavity mode can be realized [3]. The goal of the project is the first implementation of a photon-based gate for ion qubits.

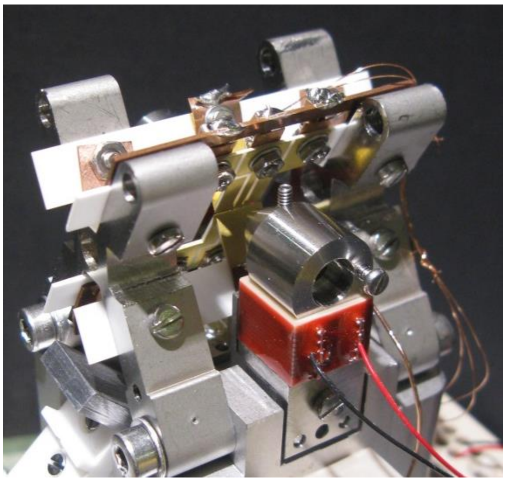

Figure 1: *Miniature linear ion trap with a transverse cavity where multi-ion quantum gates will be realized during the project.*

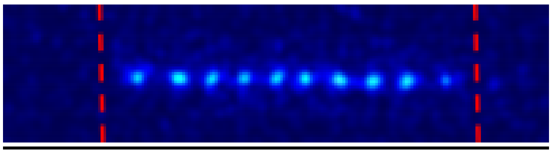

Figure 2: *Fluorescence image of ten ions pumped simultaneously by a beam along the trap axis and by the cavity field in a Raman excitation scheme. The extension of the cavity mode is indicated by red lines. This demonstrates that all ions couple to the cavity field, which establishes a long range interaction between them.*

Methodology and Project Plan:

In the Ion-Trap Cavity-QED group, we have set up a miniature trap-cavity system optimized for strong ion-photon coupling. A linear ion trap is combined with an optical cavity whose axis is orthogonal to that of the trap (Fig. 1). In this way, any ions in a string interacting with the cavity field can be coupled (see Fig. 2). Which ions participate in a quantum gate is controlled by addressing them with a laser injected from the top.

The simplest gate to realize entangles two ions in the cavity through the partial exchange of a single photon. Initially, one ion is prepared in the ground state, the other in a metastable state. As soon as coupling to the cavity is established, the ions perform a cavity-assisted Rabi-oscillation via the Raman transition connecting the two states. Stopping the Rabi-oscillation after a p/2-pulse, each ion is in a superposition of the two basis states such that the state of the system is entangled. The entanglement must be verified and quantified. Entangled states respond to qubit-rotations in a characteristic way, so that the amount of entanglement can be estimated. More complex gates are possible by making use of the Zeeman substructure of calcium ions.

[1] T.Monz et al., Ph.Rev.Lett. 106, 130506 (11).

[3] M. Feng, Phys. Rev. A 66, 054303 (2002).

[2] M. Keller et al., Nature 431, 1075 (2004).

Skills and training:

An important part of this PhD project is the skills development and training. Local training through lecture courses, transferable skills training modules and practical training in the laboratory will be complemented by SEPNet wide training events. These include workshops and training schools.

Award Amount

£14,553 (2017/18) per annum tax-free bursary and waiver of UK/EU fees each year for 3.5 years, as well as funding for research training and travel. Additional funding may also be available to support placements with outside partners for a further period of six months in total.

Eligibility

Applicants should hold, or expect to hold, a UK undergraduate degree in physics or engineering. If you are unsure about the equivalence of your qualifications, contact us at mpsresearchsupport@sussex.ac.uk

Due to funding restrictions, the studentship is open to UK and EU resident students only. However, we also welcome applications from self-funded non-EU students

Procedure

Apply on-line via the University of Sussex portal, http://www.sussex.ac.uk/study/phd/apply. State in the Funding section of the application form that you are applying for the "PhD Studentships in Experimental Atomic Physics."