Contribution ID: **96** Type: **Oral**

Coherent manipulation of a single ion inside and outside the Lamb-Dicke regime

Tuesday 14 January 2020 14:30 (30 minutes)

While three-dimensional sub-Doppler cooling of ions in a Paul trap has become routine, such cooling is harder to realise in a Penning trap. We have recently demonstrated optical sideband cooling of a single ion as well as the axial and planar configurations of a 2 ion crystal [1,2]. We will present preliminary results of the creation of a superposition of motional states to investigate interference fringes using more than two Fock states.

Since the initial proposal of using trapped ions for quantum information processing [3], a considerable amount of research has been put into satisfying the criteria for a universal quantum computer. State preparation and readout of a single qubit have been realised with infidelities below the threshold for fault tolerant quantum computing [4,5]. Entangled states of up to 14 ions have been prepared [6] and single and two-qubit gates have been realised with infidelities as low as 10^{-6} and 10^{-3} respectively [7] in linear Paul traps. However, heating rates and off-resonant excitations are still a main limitation when increasing the gate speed and reducing the ion-electrode distance.

We are investigating the implementation of gates outside the Lamb-Dicke regime. A higher Lamb-Dicke (LD) parameter leads to a stronger interaction between the ion's internal degrees of freedom as well as larger amplitudes of higher order red and blue sideband transitions. We therefore investigate how to mitigate higher order sideband effects in gate operations with the goal of reducing gate time and also relaxing the temperature constraints associated with it.

We have built a new large-scale linear Paul trap with blade design that will be driven at low frequencies in order to reach a high LD parameter, while keeping low heating rates. We will initially work with an optical qubit driven by narrow-band radiation at 729nm. We also intend to use a Zeeman qubit that will be driven with Raman transitions in order to reach a higher effective LD parameter. Preliminary results of single qubit gates will be presented.

[1] G. Stutter et al., J. Mod. Opt. 65, 549 (2018)
[2] M. K. Joshi et al. Phys. Rev. A 99, 013423 (2019)
[3] A. Sørensen and K. Mølmer, Phys. Rev. Lett. 82, 1971 (1999).
[4] A. Myerson et. al., Phys. Rev. Lett. 100, 200502 (2008).
[5] T. Harty et. al., Phys. Rev. Lett. 113, 220501 (2014).
[6] T. Monz et. al., Phys. Rev. Lett. 106, 130506 (2011).
[7] C. Ballance et. al., Phys Rev Lett. 117, 060504 (2016).

Author: MOSCA TOBA, Jacopo (Imperial College London)

Co-authors: CORFIELD, Oliver (Imperial College London); Mr LEE, Chungsun (Imperial College London); Dr HEINRICH, Johannes (Imperial College London); Dr WEBSTER, Simon (Imperial College London); Dr MINTERT, Florian (Imperial College London); THOMPSON, Richard Charles

Presenter: MOSCA TOBA, Jacopo (Imperial College London)

Session Classification: Quantum Information & Computing 1

Track Classification: Quantum Information & Computing