State of the art experimental apparatus for fast entangling gates in trapped multi-ion crystals

11 Page limit

(Short) intro to trapped ion QC and Theory on Fast Gates schemes: ~ 2 pages

* Motivating why QC important. ~ 1 paragraph

* Trapped Ion QC - General idea of spin (ion) coupled with HO (Trapping potential) and how this satisfies QC requirements. ~ 1-2 paragraph

* Entangling gates MS gate. Statement of Hamiltonian and how this is experimentally realised. ~ 1 paragraph

* Fast Gate Schemes (Non-Adiabatic Entanglement). Amplitude shaped pulses. ~ 1 sentence and reference
  - Why we want to move to quadrupole optical transition rather than Raman (Scattering error and squeezing term)

* Carrier Nulling. (excerpt from paper starts) ~ 2 paragraphs

Experimental results from Carrier Nulling (excerpts from paper): ~ 2+ pages

* Description of Blade ~ 1 figure + 1 paragraph

* Phase control scheme ~ 1 paragraph

* Proof of principle on Blade apparatus ~ 2 paragraph (statement of results) 2 figures

* RBM work ~ few sentences

* Could dependence on AC shift with position/field intensity be an issue? ~ 1 paragraph

FastGates buildup: ~ 4 pages

* Motivation for why we want a new system (compare with Blade) ~ 1 paragraph

* Description of FastGates – central figure of full physical experiment and figure of control systems ~ 2 paragraphs large figure
  - In effect list all the benefits over Blade - and how FG fits into requirements for NISQ?

Now looking at components of new system from center outward:

* Ca40 energy diagram ~ 1 paragraph and energy level figure
  - Simple energy structure. Less spectator modes compared to Ca43 -> less off resonant transitions. But sensitive to B field.

* NPL trap, trap frequencies, substrate bias for crystal rotation ~ 1 paragraph 1 figure
  - What trap freq do we want for fast gates

* In vacuum system details ~ 1 paragraph 1 figure

* Dual Optical Access High NA system ~ few sentences

* Single Ion Addressing with AOD, power requirements ~ 1 paragraph
  - This is potentially a drain of time – time bound looking into this.

* Addressing and Readout optics design? ~ short 1 figure

* Extension to standing wave single ion addressing – ideas/design for phase feedback ~ few sentences 1 figure?

* 729 system design, PDH locking, FNC ~ 1 paragraph

Outlook: ~ 1 page

* Overall goals of project
  - Optical phase control of laser field at the ion.
  - Fastgates on multi ion chain.

* Immediate tasks: Finishing vacuum work, trap on table. Trapping ions

* Proposed first experiments?
  1st paper: EOM to keep stark shift the same as pulse amplitude changes