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**Title**

* Control and acquisition system to characterize and implement **dynamic connectivity** on Rydberg atom arrays
* Control and acquisition system for quantum simulation with dynamic connectivity …
* …

**Abstract**

* This thesis introduces systems and methods to perform controlled experiments on systems of atoms for quantum simulation.
* [Key result 1]
* [Key result 2]
* Unique contributions
* These results will find application in …

**Chapter 1: STATEMENT THAT SUMMARIZES THE CHALLENGE AND OPPORTUNITY**

**Quantum simulation[ors] for materials discovery**

* [Overview on quantum simulation and quantum computing]
  + Why is a quantum simulator needed?
    - Simulating material properties to discover new materials
  + What are the key requirements to build a quantum simulator?
    - Controllability, scalability and tunability
  + Rydberg atom as a platform for quantum simulation
    - Show controllability, scalability and tunability
* Load, rearrange, evolve and readout
  + Trace out the experimental apparatus and explain quantum simulation on Rydberg platform
* Cool, trap, reconfigure and simulate on Rydberg platform
  + Briefly summarize vacuum, cooling, control, trapping, imaging, reconfiguration and rydberg system with hardware
* Near-term applications of Rydberg atom arrays
  + Simulating spin models
  + Quantum computing
  + Leveraging dynamic connectivity for digital quantum simulation
* Key references
  + Cooper2019

**Chapter 2: Leveraging dynamic connectivity to emulate fully-coupled system**

* [Introduction problem, significance, why now (literature comparison), summary of key results]
* Connectivity affects power of noisy quantum simulators
  + Spatial qubit connectivity
  + Temporal qubit connectivity
* [Theory] Protocol to emulate fully-coupled qubit architecture
  + Atom displacement technicalities
  + 5-step protocol to realize dynamic connectivity
    - approaches
* [Methods]
  + To quantify the performance of our protocol, we perform numerical simulations. EXPLAIN HOW DATA WERE GATHERED
* [Results] Characterizing errors in dynamically connected system
  + Coherent errors
    - Gate error
    - Dephasing error
  + Incoherent errors
    - Erasure error
* [Discussion/Conclusions: future work]

**Chapter 3: Ving Control and acquisition system**

* Introduction: Unique contributions
* Hardware architecture in the lab - introduce components and layout of devices in the lab
  + NIDAQ
  + Pseudo-clock
  + Camera
  + Arbitrary waveform generator
* Software architecture and workflow
  + Software architecture
    - Labscript suite and M-LOOP
      * Runmanager
        + global params
        + Unpacking list of global params
      * Run viewer
      * BLACS
        + transition\_to\_buffered
        + transition\_to\_manual
      * Lyse
        + Image processing
        + Integrating M-LOOP
      * Camera server
  + Software workflow
    - One experimental cycle
      * Control signal definition
      * Control signal execution
      * Image acquisition
      * Image analysis
      * Next shot generation
* Discuss the relevance of this chapter in context

**Chapter 4: Characterizing the experiment with control and acquisition system**

* 2D MOT
  + Theory for generating 2D MOT
  + Experimental parameters
  + Maximizing atom density in 2D MOT with machine learning
    - optimizing cooler frequency
    - optimizing repumper frequency
    - full parameter space exploration
* 3D MOT
* Single atom in tweezers

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**Chapter XXX: Generating large, homogeneous arrays of optical traps**

* Generating optical traps with SLM
  + Phase retrieval problem
  + GS algorithm
  + Modified GS algorithm
* Prototyping station: design, building, and optimization
* Open-loop optimization – GS algorithm
* Closed-loop optimization
* challenges and opportunities