We are studying non-equilibrium dynamics in this system. This means that observable quantities are oscillating in time. These dynamics are interesting because

On Rydberg atom arrays an interesting feature of non-equilibrium dynamics was there exists certain initial states that revive quiet strongly despite being quenched into a large parameter space. This behaviour is said to be due to a special set of eigenstates and in interesting when looking at finding system which could be more robust to external perturbations. Non equilibruim dynamics are an interesting because …

Looking at the local quench we add a new dimensionality to our study. We look at how locally addressing a system affects the system globally. We can see that a quench result in a propagation throughout the system.

This propagation is interesting as is a measure of how fast information spreads throughout the system.

**Motivation**

Is there a way we can use quantum information theory/quantum correlations to navigate through the complex landscape of non-equilibrium quantum many body dynamics.

-quantum corelations can help us understand equilibrium dynamics well (Rydberg crystals)

-quantum correlations in particular entanglement entropy are believed to help us understand how and on what time scale a quantum system thermalises (reaches equilibrium)

-quantum control, understanding how information an correlations spread throughout the system could help us with this.

**Non-Equilibrium dynamics**

**What is it?**

Equilibrium (Thermodynamics) – the system has reached a state in which no further macroscopic change is noticeable

For a quantum system to be in equilibrium means that global observables remain near constant in time, steady state. So for a quantum system not in equilibrium means that observables which are fluctuating in time.

Note: this is different from a system being in it ground state. A system can be spread across energy state and reach equilibrium

**Why do we care?**

* Non equilibrium physics in general is very interesting. A rich unexplored landscape with complex behaviour. Not sure of the specific applications but non equilibrium behaviour shows up everywhere form the cosmology of the universe to glass formation in dense fluids. Starting to have the technology to start being able to have a look at some of this stuff. (https://www.bristol.ac.uk/physics/research/theory/areas/non-equilibrium-many-body-physics/)
* Exploring the parameter space.
* Easier to explain equilibrium quantum mechanics, much harder to explain the non-equilibrium regime.
* Opens a big question on whether isolated quantum system reach equilibrium. Thermalisation.
* How quantum correlations of the system evolve over time.
* How information spreads through the system.

**How do we do it in our system**

We perturb the Hamiltonian on time scales much faster than that of the system. Such that the state of the system is projected into a superposition of energyeigenstates.

**Clarity**

**Motivation**

* Non equilibrium quantum many body dynamics

**Contents**

**Introduce Rydberg atoms**

**Introduce Rydberg interaction**

**How adiabatically we can form Rydberg crystal**

**Global Quenching**

* 7 atom global quench with detuning diagram

**Local Quenching (Adding a new dimensionality)**

* 7 atom local quench with detuning diagram

**Energy understanding**

* After quench eigenenergies bar chart

**Probing entanglement**

**Area for further study**