**Week 17**

This week was mainly dedicated to preparing the talk for the project seminars. The task itself was very useful as forced me to think about condensing down the key ideas about the project. What do I want to say about this system and what we have done?

Through the process of preparing the presentation two main ideas came up:

1. 1D Rydberg atom arrays as an \*\*entry point\*\* to studying out of equilibrium dynamics of isolated quantum systems

2. Entanglement entropy being a key to start understanding the characteristics of an isolated quantum system taken out of equilibrium. In an analogous way to entropy in classical systems.

This first idea emphasises that this system is introduces us to deeper topics surrounding out of equilibrium dynamics such as quantum thermalisation and information scrambling. The accessibility of the set-up allows us to start understanding what these concepts mean and why they are important. For example, we note that our system does not display thermal behaviour for the number of atoms we are looking at (3-9), but by looking at coherences between energy eigenstates and the scaling and growth of entanglement entropy after a quench we can start to see how thermal behaviour could be achieved for a higher number of atoms. Moreover, in the case of the Z2 quench we can also recognise behaviour which seems far off anything thermal at least initially.

The second idea recognises that entanglement entropy seems to have a big role in our system and may be related to why we see certain behaviours. For example, looking at the propagation of entanglement entropy after a local quench hints at the formation of pair wise correlations going on in the system. Could a dimer model come in play? Moreover, studying the scaling of entanglement entropy across the chain following a global quench showed an initial area law – is this in some ways related to the fact we see ordered revivals in our system.

With this in mind, the two next areas I think we should start to direct our focus to are:

\*\*Initial Area Law of Z2 following global quench\*\*

- Can we link this to the revival of the Z2 state by considering the reduced number of states stratifying an area law. See video bellow for comparision

\*\*Pairwise correlation following local quench and the breakdown of this behaviour\*\*

- Can we directly see this behaviour by looking at the correlation between pairs of atoms.

- Does concurrence give us more insight

- Does this effect what falls in the L-B bound

Below, I have a look at how the Entanglement entropy as a function bipartite system size (splitting system in two parts as A and B and computing the entanglement entropy for different sizes) evolves over time in order to look at the presence of area and volume laws. I consider that case of initial states, ket(0..0) and Z2, and globally quench the states by evolving them with a 0 detuning Hamiltonian (they are both excited states of this Hamiltonian). In the animation, we note that the entanglement of the ket(0..0) initial state grows straight to a volume law whereas the Z2 initial state starts out in an area law and then grows to a volume law. I will need to look into further weather this sort of behaviour can be said to be behind revivals and scars. My guess is that is that, since area laws states make up a much smaller proportion of the parameter space, when we have an area law we restrict the allow states the system can be in and this prompts the Z2 state to appear. That being said it, is unclear if the two things are specifically correlated and will need to be looked into more.

I think the animation below demonstrates very nicely why entanglement entropy is interesting to probe on a non-equilibrium system, like a fluid in a way entanglement is constantly evolving throughout the system. I would be interesting to see the resulting behaviour from a local quench