# Thesis Summary

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I am working on my Master's thesis *[May '18 - present]* under the guidance of Prof. Soumya Bera. The aim of the project is to explore phase transitions in many body quantum systems when they are driven out of equilibrium.

We explore the one dimensional tight binding non-interacting fermion model with periodic boundary conditions. This model is driven by an external time dependent electric field. We introduce quasi-periodicity in the model by including Aubry-Andre type chemical potential term. [2]

$$H = -\sum_{i=1}^{L} \left( e^{-\frac{i}{L}A_0 \sin wt} c_i^\dagger c_{i+1} \; + \; e^{\frac{i}{L}A_0 \sin wt} c_{i+1}^\dagger c_i \right) \; + \; \mu_0 \sum_{i=1}^{L} \cos\left(2\pi\sigma i + \alpha\right) c_i^\dagger c_i \tag{1}$$

It is well known that the single particle eigenstates of nearest neighbour quasi-periodic tight binding model show transition from localized to extended state. We want to explore the similar transitions in many-particle states of driven quasi-periodic model and its implications on local observables.

The dimension of the Hilbert space for the chain with $L$ sites is $2^L$ which scales exponentially with system size. This exponential scaling makes the problem hard to solve by direct integration of Schrödinger equation. We evaluate the evolution of the two point correlators in Heisenberg picture and use them to calculate the dynamics of local observables [1]. This method reduces the time evolution to $\mathcal{O}(L^2)$ problem. The dynamical response of the system is analyzed by monitoring von Neumann entanglement entropy, charge current, occupation density and occupation imbalance between even and odd sites.

We analyzed the system in 4 different regimes, viz., clean system ($\mu_0 = 0$), critical point ($\mu_0 = 2$) , below and above critical point; all starting with initially half filled state. The imbalance, the observable defining the difference between odd and even site occupation, goes down to zero in $\mu_0 < 2$ regime signifying extended states. Whereas in $\mu_0 > 2$ case, the imbalance has finite mean value which could be the sign of a state localized at a particular site. All other observables also show the distinct behaviours in different phases. The results were documented in the report and the progress for the first stage of thesis was evaluated by faculty committee earning the grade point evaluation of 10 out of 10.

At present, I am investigating different drive protocols to monitor the charge current in the system. I am also analyzing the results for possible power law decays in the occupation density. I am also working on obtaining analytical expressions corroborating with general trends in numerical results. This might be essential for explaining the physics at the critical point.


1. D. S. Bhakuni, A. Sharma, *Phys. Rev. B* **98**, 045408 (4 July 2018).
2. T. Cadez, R. Mondaini, P. D. Sacramento, *arXiv preprint arXiv:1808.10238* (2018).