Rydberg Atoms in a Ladder Geometry: Quench Dynamics and Floquet Engineering

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Over the past decade, Rydberg atom quantum simulator platforms have emerged as novel quantum simulators for physical systems ranging from condensed matter to particle physics. On a fundamental level, these platforms allow for a direct test of our understanding of the emergence of quantum statistical mechanics starting from the laws of quantum dynamics. In this poster, I focus on the fate of quantum dynamics in a model of Rydberg atoms arranged in a square ladder geometry, with a Rabi frequency 2Ω and a detuning profile which is staggered along the longer direction with amplitude Δ. As the staggering strength Δ is tuned from $\Delta/\Omega = 0 \rightarrow \infty$, the model exhibits a wide class of dynamical phenomena, ranging from (i) quantum many-body scars (QMBS) ($\Delta/\Omega \sim 0, 1$), (ii) integrability-induced slow dynamics and approximate Krylov fractures ($\Delta/\Omega \gg 1$) where the system only relaxes to the generalized Gibbs ensemble consistent with the emergent approximate conservation laws. Additionally, I shall show that by leveraging the underlying chiral nature of the spectrum of the Hamiltonian, it is possible to design Floquet protocols leading to dynamical signatures reminiscent of discrete time-crystalline order and exact Floquet flat bands. Finally, I discuss how these dynamical phenomena are affected when we deviate from the ideal model considered, such as accuracy of implementation of the Floquet protocols, long-range van der Waals interactions and inevitable influences from the environment in the form of pure dephasing and the finite lifetime of the Rydberg excited state.

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[2] Mainak Pal and Tista Banerjee **(arXiv:2504.15230)**