I am a Ph.D student in the Physics department, I work with Stephan Haas and Lorenzo Campos Venuti. Our research has been focussed on non-equilibrium dynamics in closed systems. Such systems have been realized experimentally using arrays of cold atoms cooled to a Bose-Einstein condensate, and trapped in an optical lattice [1]. They are generally modelled using a Bose-Hubbard type of Hamiltonian. We are currently analyzing the dynamics of such a system following an abrupt quench (a change in the system parameters).

As described above, finite cold atom arrays that have been studied experimentally are modelled using a Bose-Hubbard Hamiltonian. The numerical simulation of such systems can be a daunting task since the number of degrees of freedom is extremely large. For example, one dimensional array of 10 site, with 5 of them occupied by bosons requires a Hilbert space of dimension $6^{10}$ to simulate exactly. Hence, our simulation based study has generally focussed on systems with a low density, and dynamics near the ground state, where a large part of the Hilbert space can effectively be ignored.

One of the key steps in studying quantum dynamics is matrix diagonalization and extraction of eigenvalues and eigenvectors. Of these, the lowest eigenvalues and the corresponding eigenvectors are especially important when studying the behaviour of a system that is known to fluctuate around its ground state.

[2] describes a GPU based approach to perform diagonalization of a Bose-Hubbard Hamiltonian matrix and study its low energy properties. The authors describe techniques to pre-process the Hamiltonian to effectively store the large matrix and use the Lanczos algorithm to extract its eigenvalues.

The explicit time evolution of a 1D quantum system could be visualized to show the hopping of particles from one site to another following a quench. Since this is a quantum system and superpositions are possible, varying opacity could be used to show the existence of a superposition.

References

[1] Quantum phase transition from a superfluid to a Mott insulator in a gas of ultracold atoms : http://www.nature.com/nature/journal/v415/n6867/abs/415039a.html