Time-dependent many-body dynamics with cold atoms

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In recent years, there has been a lot of interest in systems of cold atoms loaded into optical lattices (standing waves of laser light), because these systems offer the possibility to engineer many-body lattice Hamiltonians on a microscopic level with a great deal of control. These Hamiltonians include lattice models that are used to describe important quantum phases in solid-state physics (including some associated with high-Tc superconductors), which gives us a new tool to explore these phenomena. In addition, the time-dependent control over the system parameters, and the lack of strong dissipative processes makes it possible to observe time-dependent coherent many-body dynamics in these systems over long time periods.

This possibility to study time-dependent processes is strongly complemented by the recent development of time-dependent numerical methods for many-body systems, especially time-dependent density matrix renormalisation group methods. These make possible the direct calculation of coherent dynamics for 1D systems that are not too far from equilibrium. Using such methods, it is possible to make quantitative predictions for experiments involving these systems, with applications ranging from transport properties to state engineering.

I will give an introduction to these systems and their time-dependent dynamics. We are interested in exploring the possibility of applying quantum control techniques in this context, to find more efficient ways of preparing interesting many-body states.