Dynamics in one-dimensional chains of bosons

Ultracold atoms are an ideal setting to study non-equilibrium quantum many-body dynamics in a very controlled way. I will present a series of experiments in the context of strongly correlated atomic bosons in one-dimensional geometry. Specifically, we study the dynamics of one-dimensional chains after a sudden quench of the system's Hamiltonian, for which we independently control J, the (coherent) tunneling rate, U, the strength of the interaction, and E, a tilt along the longitudinal direction of the chains. For a quench to U≈E we couple to nearest neighbors collectively and observe characteristic oscillations in the number of double occupancies that we analyze in the many-body context [1,2]. For U/2≈E, U/3≈E etc. we observe collective long-range tunneling to next-nearest neighbors and beyond. In particular, for U/3≈E we observe dynamics due to the higher-order super-exchange interaction scaling as J^3/U^2 [3]. For J≈U<<E we observe interaction-induced quantum phase revivals, and for J≈U≈E we find evidence for the transition to the quantum chaotic regime [4]. If time allows, I will give an outlook on our endeavor to realize ultracold bosonic molecular systems with "real" long-range interactions [5].

[1] *Many-body quantum quench in an atomic one-dimensional Ising chain*, F. Meinert et al., Phys. Rev. Lett. 111, 053003 (2013)

[2] *Observation of Density-Induced Tunneling,* O. Jürgensen, et al., Phys. Rev. Lett. in print, preprint at: arXiv:1407.0835 (2014)

[3] *Observation of many-body long-range tunneling after a quantum quench*, F. Meinert et al., Science 344, 1259 (2014)

[4] *Interaction-induced quantum phase revivals and evidence for the transition to the quantum chaotic regime in 1D atomic Bloch oscillations*, F. Meinert et al., Phys. Rev. Lett. 112, 193003 (2014)

[5] *Ultracold dense samples of dipolar RbCs molecules in the rovibrational and hyperfine ground state*, T. Takekoshi et al, Phys. Rev. Lett. in print, preprint at: arXiv:1405.6037 (2014)