Journal club 16/12/2014 on
Tunneling dynamics of bosonic Josephson junctions assisted by a cavity field
G. Szirmai, G. Mazzarella, and L. Salasnich, arXiv:1412.1014

Negative quench induced excitation dynamics for ultracold bosons in one-dimensional lattices ,
S.I. Mistakidis, L. Cao, and P. Schmelcher
arXiv:1412.1375 [cond-mat.quant-gas]

ABSTRACT: The nonequilibrium dynamics following a quench of strongly repulsive bosonic ensembles in one-dimensional finite lattices is investigated by employing interaction quenches and/or a ramp of the lattice potential. Both sudden and time-dependent quenches are analyzed in detail. For the case of interaction quenches we address the transition from the strong repulsive to the weakly-interacting regime, suppressing in this manner the heating of the system. The excitation modes such as the cradle process, the local breathing mode and the density-wave tunneling are examined via local density observables. In particular, the cradle mode is inherently related to the initial delocalization and, following a negative interaction quench, can be excited only for incommensurate setups with filling larger than unity. Complementary for setups with subunit filling the cradle mode is accessible with the aid of a negative quench of the lattice depth. Our results shed light on possible schemes to control the cradle and the breathing modes. Finally, employing the notion of fidelity we study the dynamical response of the system after a diabatic or adiabatic parameter modulation for short and long evolution times. The evolution of the system is obtained numerically using the ab-initio multi-layer multi-configuration time-dependent Hartree method for bosons which permits to follow non-equilibrium dynamics including the corresponding investigation of higher-band effects.

Topological States in a One-Dimensional Fermi Gas with Attractive Interactions ,
Jonathan Ruhman, Erez Berg, and Ehud Altman
arXiv:1412.3444 [cond-mat.quant-gas]

ABSTRACT: We describe a novel topological superfluid state, which forms in a one-dimensional Fermi gas with Rashba-like spin-orbit coupling, a Zeeman field and intrinsic attractive interactions. In spite of total number conservation and the presence of gapless excitations, Majorana-like zero modes appear in this system and can be linked with interfaces between two distinct phases that naturally form at different regions of the harmonic trap. As a result, the low lying collective excitations of the system, including the dipole oscillations and the long-wavelength phonons, are doubly degenerate. While backscattering from point impurities can lead to a splitting of the degeneracies that scales algebraically with the system size, the smooth confining potential can only cause an exponentially small splitting. We show that the topological state can be uniquely probed by a pumping effect induced by a slow sweep of the Zeeman field from a high initial value down to zero field.

Interacting surface states of three-dimensional topological insulators,
T. Neupert, S. Rachel, R. Thomale, and M. Greiter
arXiv:1412.2766 [cond-mat.str-el]

ABSTRACT: We numerically investigate the surface states of a strong topological insulator in the presence of strong electron-electron interactions. We choose a spherical topological insulator geometry to make the surface amenable to a finite size analysis. The single-particle problem maps to that of Landau orbitals on the sphere with a magnetic monopole at the center that has unit strength and opposite sign for electrons with opposite spin. Assuming density-density contact interactions, we find superconducting and anomalous (quantum) Hall phases for attractive and repulsive

interactions, respectively, as well as chiral fermion and chiral Majorana fermion boundary modes between different phases. Our setup is preeminently adapted to the search for topologically ordered surface terminations that could be microscopically stabilized by tailored surface interaction profiles.

Do Majorana Fermions really Obey Non-Abelian Statistics?,
Qiu-Bo Cheng, Jing He, and Su-Peng Kou
arXiv:1412.2195 [cond-mat.str-el]

ABSTRACT: Recently, Majorana fermions (MFs) have attracted intensive attention because of their possible non-Abelian statistics. This paper points out MFs in topological superconductors neither obey non-Abelian statistics nor Abelian statistics. Instead, MFs obey gamma-statistics that is an anti-commutating representation of braiding group. Smoking-gun numerical evidence to identify MF's statistics is presented. Finally, the implications of this work are given for topological quantum computation of MFs in topological superconductors.

Dynamical generation of Floquet Majorana flat bands in s-wave superconductors,
Amrit Poudel, Gerardo Ortiz, and Lorenza Viola
arXiv:1412.2639 [cond-mat.supr-con]

ABSTRACT: We present quantum control techniques to engineer flat bands of symmetry-protected Majorana edge modes in s-wave superconductors. Specifically, we show how periodic control may be employed for designing time-independent effective Hamiltonians, which support Floquet Majorana flat bands, starting from equilibrium conditions that are either topologically trivial or only support individual Majorana pairs. In the first approach, a suitable modulation of the chemical potential simultaneously induces Majorana flat bands and dynamically activates a pre-existing chiral symmetry which is responsible for their protection. In the second approach, the application of effective parity kicks dynamically generates a desired chiral symmetry by suppressing chirality-breaking terms in the static Hamiltonian. Our results demonstrate how the use of time-dependent control enlarges the range of possibilities for realizing gapless topological superconductivity, potentially enabling access to topological states of matter that have no known equilibrium counterpart.

Theory of the many-body localization transition in one dimensional systems,
Ronen Vosk, David A. Huse, and Ehud Altman
arXiv:1412.3117 [cond-mat.dis-nn]

ABSTRACT: We formulate a theory of the many-body localization transition based on a novel real space renormalization group (RG) approach. The results of this theory are corroborated and intuitively explained with a phenomenological effective description of the critical point and of the "badly conducting" state found near the critical point on the delocalized side. The theory leads to the following sharp predictions: (i) The delocalized state established near the transition is a Griffiths phase, which exhibits sub-diffusive transport of conserved quantities and sub-ballistic spreading of entanglement. The anomalous diffusion exponent $\alpha < 1/2$ vanishes continuously at the critical point. The system does thermalize in this Griffiths phase. (ii) The many-body localization transition is controlled by a new kind of infinite randomness RG fixed point, where the broadly distributed scaling variable is closely related to the eigenstate entanglement entropy. Dynamically, the entanglement grows as logt at the critical point, as it also does in the localized phase. (iii) In the vicinity of the critical point the ratio of the entanglement entropy to the thermal entropy, and its variance (and in fact all moments) are scaling functions of L/ξ, where L is the length of the system and ξ is the correlation length, which has a power-law divergence at the critical point.