Journal club 26/05/2015 on
Rotation of quantum impurities in the presence of a many-body environment by Richard Schmidt and Mikhail Lemeshko, PRL **114**, 203001 (2015).

Probing Atomic Structure and Majorana Wavefunctions in Mono-Atomic Fe-chains on Superconducting Pb-Surface,
by Remy Pawlak, Marcin Kisiel, Jelena Klinovaja, Tobias Meier, Shigeki Kawai, Thilo Glatzel, Daniel Loss, and Ernst Meyer
arXiv:1505.06078 [physics.atm-clus]

Abstract: Motivated by the striking promise of quantum computation, Majorana bound states (MBSs) in solid-state systems have attracted wide attention in recent years. In particular, the wavefunction localization of MBSs is a key feature and crucial for their future implementation as qubits. Here, we investigate the spatial and electronic characteristics of topological superconducting chains of iron atoms on the surface of Pb(110) by combining scanning tunneling microscopy (STM) and atomic force microscopy (AFM). We demonstrate that the Fe chains are mono-atomic, structured in a linear fashion, and exhibit zero-bias conductance peaks at their ends which we interprete as signature for a Majorana bound state. Spatially resolved conductance maps of the atomic chains reveal that the MBSs are well localized at the chain ends (below $25nm$), with two localization lengths as predicted by theory. Our observation lends strong support to use MBSs in Fe chains as qubits for quantum computing devices.

Thermometry and cooling of a Bose-Einstein condensate to 0.02 times the critical temperature,
Ryan Olf, Fang Fang, G. Edward Marti, Andrew MacRae, and Dan M. Stamper-Kurn
arXiv:1505.06196 [cond-mat.quant-gas]

Abstract: Ultracold gases promise access to many-body quantum phenomena at convenient length and time scales. However, it is unclear whether the entropy of these gases is low enough to realize many phenomena relevant to condensed matter physics, such as quantum magnetism. Here we report reliable single-shot temperature measurements of a degenerate 87Rb gas by imaging the momentum distribution of thermalized magnons, which are spin excitations of the atomic gas. We record average temperatures as low as $0.022(1)_{stat}(2)_{sys}$ times the Bose-Einstein condensation temperature, indicating an entropy per particle, $S/N \approx 0.001k_B$ at equilibrium, that is well below the critical entropy for antiferromagnetic ordering of a Bose-Hubbard system. The magnons themselves can reduce the temperature of the system by absorbing energy during thermalization and by enhancing evaporative cooling, allowing low-entropy gases to be produced within deep traps.

Z2 topological liquid of hard-core bosons on a kagome lattice at 1/3 filling,
by Krishanu Roychowdhury, Subhro Bhattacharjee, and Frank Pollmann
arXiv:1505.05998 [cond-mat.str-el]

Abstract: We consider hard-core bosons on the kagome lattice in the presence of short range repulsive interactions and focus particularly on the filling factor 1/3. In the strongly interacting limit, the low energy excitations can be described by the quantum fully packed loop coverings on the triangular lattice. Using a combination of tensor-product state based methods and exact diagonalization techniques, we show that the system has an extended Z2 topological liquid phase as well as a lattice nematic phase. The latter breaks lattice rotational symmetry. By tuning appropriate parameters in the model, we study the quantum phase transition between the topological and the symmetry broken phases. We construct the critical theory for this transition using a mapping to an Ising gauge theory that predicts the transition to belong to the $\mathcal{O}(3)$ universality class.

Interaction Protected Topological Insulators with Time Reversal Symmetry,
by Raul A. Santos and D.B. Gutman
arXiv:1505.05979 [cond-mat.str-el]

ABSTRACT: Anderson's localization on the edge of two dimensional time reversal (TR) topological insulator (TI) is studied. For the non-interacting case the topological protection acts accordingly to the Z2 classification, leading to conducting and insulating phases for odd and even fillings respectively. In the presence of repulsive interaction the phase diagram is notably changed. We show that for sufficiently strong values of the interaction the zero temperature fixed point of the TI is conducting, including the case of even fillings. We compute the boundaries of the conducting phase for various fillings and types of disorder.

Thickness dependence of the interfacial Dzyaloshinskii-Moriya interaction in inversion symmetry broken systems,
by Jaehun Cho, Nam-Hui Kim, Sukmock Lee, June-Seo Kim, Reinoud Lavrijsen, Aurelie Solignac, Yuxiang Yin, Dong-Soo Han, Niels J. J. van Hoof, Henk J. M. Swagten, Bert Koopmans, and Chun-Yeol You
arXiv:1505.05965 [cond-mat.mtrl-sci]

ABSTRACT: In magnetic multilayer systems, a large spin-orbit coupling at the interface between heavy metals and ferromagnets can lead to intriguing phenomena such as the perpendicular magnetic anisotropy, the spin Hall effect, the Rashba effect, and especially the interfacial Dzyaloshinskii-Moriya (IDM) interaction. This interfacial nature of IDM interaction has been recently revisited because of its scientific and technological potential. Here, we demonstrate an experimental technique to straightforwardly observe the IDM interaction, namely Brillouin light scattering. The non-reciprocal spin wave dispersions, systematically measured by Brillouin light scattering, allow not only the determination of the IDM energy densities beyond the regime of perpendicular magnetization but also the revelation of the inverse proportionality with the thickness of the magnetic layer, which is a clear signature of the interfacial nature. All together, our experimental and theoretical approaches involving double time Green,s function methods open up possibilities for exploring magnetic hybrid structures for engineering the IDM interaction.

Evolution of the Hofstadter butterfly in a tunable optical lattice,
by F. Yilmaz, F. Nur Ünal, and M. Ö. Oktel
arXiv:1505.05318 [cond-mat.quant-gas]

ABSTRACT: Recent advances in realizing artificial gauge fields on optical lattices promise experimental detection of topologically non-trivial energy spectra. Self-similar fractal energy structures generally known as Hofstadter butterflies depend sensitively on the geometry of the underlying lattice, as well as the applied magnetic field. The recent demonstration of an adjustable lattice geometry [L. Tarruell *et al.*, Nature **483**, 302–305 (2012)] presents a unique opportunity to study this dependence. In this paper, we calculate the Hofstadter butterflies that can be obtained in such an adjustable lattice and find three qualitatively different regimes. We show that the existence of Dirac points at zero magnetic field does not imply the topological equivalence of spectra at finite field. As the real-space structure evolves from the checkerboard lattice to the honeycomb lattice, two square lattice Hofstadter butterflies merge to form a honeycomb lattice butterfly. This merging is topologically non-trivial, as it is accomplished by sequential closings of gaps. Ensuing Chern number transfer between the bands can be probed with the adjustable lattice experiments. We also calculate the Chern numbers of the gaps for qualitatively different spectra and discuss the evolution of topological properties with underlying lattice geometry.