Journal Club

Ettingshausen effect due to Majorana modes
Chang-Yu Hou, Kirill Shtengel, Gil Refael, Paul M. Goldbart,
arXiv:1203.5793
The presence of Majorana zero-energy modes at vortex cores in a topological superconductor implies that each vortex carries an extra entropy s_0, given by $(k_B/2)\ln 2$, that is independent of temperature. By utilizing this special property of Majorana modes, the edges of a topological superconductor can be cooled (or heated) by the motion of the vortices across the edges. As vortices flow in the transverse direction with respect to an external imposed supercurrent, due to the Lorentz force, a thermoelectric effect analogous to the Ettingshausen effect is expected to occur between opposing edges. We propose an experiment to observe this thermoelectric effect, which could directly probe the intrinsic entropy of Majorana zero-energy modes.

How robust are Majorana modes in multiband semiconductor wires?
Jong Soo Lim, Llorens Serra, Rosa Lopez, Ramon Aguado,
arXiv:1202.5057
We study the emergence of Majorana bound states (MBS) in multiband semiconductor wires with Rashba spin-orbit (SO) coupling, proximity coupled to an s-wave superconductor and in the presence of an external magnetic field. We consider long, but finite, *multiband wires (namely, quasi-1D wires with dimensions $L_x \gg L_y$). Our numerically exact results demonstrate that interband mixing coming from Rashba SO (Rashba mixing) hybridizes Majorana pairs originating from different transversal modes while simultaneously closing the effective gap. Thus, regions were many MBS coexist are effectively trivial owing to Rashba mixing. On the contrary, Majorana physics is robust provided that only one single transversal mode, not necessarily the lowest one, contributes with a Majorana pair. We also find that Majorana physics is fragile with respect to orbital effects induced by any small out-of-plane component of the magnetic field.*

Transport spectroscopy of NS nanowire junctions with Majorana fermions
Elsa Prada, Pablo San-Jose, Ramon Aguado,
arXiv:1203.4488
We investigate the differential conductance dI/dV of normal-superconductor nanowire junctions in the presence of spin-orbit coupling and magnetic field. As the Zeeman field crosses the critical value B_c of the topological transition, a Majorana bound state (MBS) is formed, giving rise to a sharp zero-bias anomaly (ZBA) in the tunneling dI/dV, in agreement with previous works. We identify novel features beyond this picture, such as topological signatures in the transparent contact limit or the development of a ZBA for $B < B_c$ for long spin-orbit lengths. While this latter scenario is unrelated to Majorana physics for short contacts, an additional regime exists in which two MBSs may arise inside a long contact region for $B < B_c$, inducing a ZBA before the closing of the bulk gap, as observed in recent experiments from the Kouwenhoven group.

Observation of a roton collective mode in a two-dimensional Fermi liquid
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Nature **483**, 576 (2012)
Understanding the dynamics of correlated many-body quantum systems is a challenge for modern physics. Owing to the simplicity of their Hamiltonians, 4He (bosons) and 3He (fermions) have served as model systems for strongly interacting quantum fluids, with substantial efforts devoted to their understanding. An important milestone was the direct observation of the collective phonon-roton mode in liquid 4He by neutron scattering, verifying Landaus prediction1 and his fruitful concept of elementary excitations. In a Fermi system, collective density fluctuations (known as zero-sound in 3He, and plasmons in charged systems) and incoherent particlehole excitations are observed. At small wavevectors and energies, both types of excitation are described by Landaus theory of Fermi liquids2, 3. At higher wavevectors, the collective mode enters the particlehole band, where it is strongly damped. The dynamics of Fermi liquids at high wavevectors was thus believed to be essentially incoherent. Here we report inelastic neutron scattering measurements of a monolayer of liquid 3He, observing a roton-like excitation. We find that the collective density mode reappears as a well defined excitation at momentum transfers larger than twice the Fermi momentum. We thus observe unexpected collective behaviour of a Fermi many-body system in the regime beyond the scope of Landaus theory. A satisfactory interpretation of the measured spectra is obtained using a dynamic many-body theory4.

3-dimensional structure of a sheet crumpled into a ball
Anne Dominique Cambou, Narayanan Menon,
arXiv:1203.5826
When a thin sheet is crushed into a small three-dimensional volume, it invariably forms a structure with a low volume fraction but high resistance to further compression. Being a far-from-equilibrium process, forced crumpling is not necessarily amenable to a statistical description in which the parameters of the initially flat sheet and the final confinement fully specify the resulting crumpled state. Instead, the internal geometry and mechanical properties of the crumpled ball may reflect the history of its preparation. Our X-ray microtomography experiments reveal that the internal 3-dimensional geometry of a crumpled ball is in many respects isotropic and homogeneous. In these respects, crumpling recapitulates other classic nonequilibrium problems such as turbulence, where a system driven by long-wavelength, low-symmetry, forcing shows only rather subtle fingerprints of the forcing mechanism. However, we find local nematic ordering of the sheet into parallel stacks. The layering proceeds radially inwards from the outer surface. The extent of this layering increases with the volume fraction, or degree of compression.