JOURNAL CLUB
August 4th 2015

1. **Helicons in Weyl semimetals**
   Francesco M.D. Pellegrino, Mikhail I. Katsnelson, and Marco Polini
   arXiv:1507.03140

   Helicons are transverse electromagnetic waves propagating in three-dimensional (3D) electron systems subject to a static magnetic field. In this work we present a theory of helicons propagating through a 3D Weyl semimetal. Our approach relies on the evaluation of the optical conductivity tensor from semiclassical Boltzmann transport theory, with the inclusion of all Berry curvature corrections. We demonstrate that the axion term characterizing the electromagnetic response of Weyl semimetals dramatically alters the helicon dispersion with respect to that in non-topological metals. We also discuss axion-related anomalies that appear in the plasmon dispersion relation.

2. **8π-periodic Josephson effect in time-reversal invariant interacting Rashba nanowires**
   Chris J. Pedder, Tobias Meng, Rakesh P. Tiwari, and Thomas L. Schmidt
   arXiv:1507.0888

   We investigate narrow quantum wires with strong Rashba spin-orbit coupling and electron-electron interactions. We show that virtual transitions between subbands lead to umklapp scattering which can open a partial gap in the spectrum even in the presence of time-reversal symmetry. Using the superconducting proximity effect to gap out the remaining modes, we show that the system can host zero-energy states at its edges, which are protected by time-reversal symmetry. We present the parameter regime in which these bound states will emerge. Similarly to Majorana bound states, they will produce a zero-bias peak in the differential conductance. In contrast to the Majorana fermions, however, their fourfold degeneracy leads to an 8π-periodicity of the Josephson current due to tunneling of fractionalized excitations with charge $e/2$.

3. **Observation of a Helical Luttinger-Liquid in $InAs/GaSb$ Quantum Spin Hall Edges**
   Tingxin Li et al.
   arxiv: 1507.08362

   We report on the observation of a helical Luttinger-liquid in the edge of $InAs/GaSb$ quantum spin Hall insulator, which shows characteristic suppression of conductance at low temperature and low bias voltage. Moreover, the conductance shows power-law behavior as a function of temperature and bias voltage. The results underscore the strong electron-electron interaction effect in transport of $InAs/GaSb$ edge states, which is controllable by gates. Realization of a tunable Luttinger-liquid offers a one-dimensional model system for future studies of predicted correlation effects.

4. **Cooper pair splitting in a nanoSQUID geometry at high transparency**
   R. Jacquet, J. Rech, T. Jonckheere, A. Zazunov, and T. Martin
   arXiv:1507.08460

   We describe a Josephson device composed of two superconductors separated by two interacting quantum dots in parallel, as a probe for Cooper pair splitting. In addition to sequential tunneling of electrons through each dot, an additional transport channel exists in this system: crossed Andreev reflection, where a Cooper pair from the source is split between the two dots and recombined in the drain superconductor. Unlike non-equilibrium scenarios for Cooper pair splitting which involves superconducting/normal metal "forks", our proposal relies on an Aharonov-Bohm measurement of the DC Josephson current when a flux is inserted between the two dots. We provide a path integral approach to treat arbitrary transparencies, and we explore all contributions for the individual phases (0 or π) of the quantum dots. We propose a definition of the Cooper pair splitting efficiency for arbitrary transparencies, which allows us to find the phase associations which favor the crossed Andreev process. Possible applications to experiments using nanowires as quantum dots are discussed.

5. **Discovery of a topological semimetal phase coexisting with ferromagnetic behavior in $Sr_{1-y}MnSb_2 (y \sim 0.08)$**
   J.Y. Liu, J. Hu, D. Graf et al.
   arxiv: 1507.07978

   In this letter, we report a new type of quasi-two dimensional (2D) topological semimetal phase arising from 2D Sb layers in $Sr_{1-y}MnSb_2$ ($y \sim 0.08$), which coexists with ferromagnetic behavior. In this material, we observed strong Shubnikov-de Haas (SdH) oscillations from low field in magnetotransport measurements. Our analyses of the SdH oscillations, together with Hall resistance measurements, reveal remarkable signatures of relativistic fermions, including light effective quasiparticle mass, high carrier mobility, and a π Berry phase accumulated along the cyclotron orbit. Given $Sr_{1-y}MnSb_2$ shows ferromagnetic behavior up to $> 400K$, it offers a wonderful opportunity to explore the time reversal symmetry breaking Weyl state.

6. **Observation of a robust zero-energy bound state in iron-based superconductor Fe(Te,Se)**
   J-X. Yin, ZhengWu et al.
   Nature Physics 11, 543 (2015)

   In superconductors, electrons are paired and condensed into the ground state. An impurity can break the electron pairs into quasiparticles with energy states inside the superconducting gap. The characteristics of such in-gap states reflect accordingly the properties of the superconducting ground state. A zero-energy in-gap state is particularly noteworthy, because it can be the consequence of non-trivial pairing symmetry or topology. Here we use scanning tunnelling microscopy/spectroscopy to demonstrate that an isotropic zero-energy bound state with a decay length of $10\AA$ at each interstitial iron impurity in superconducting Fe(Te,Se). More noticeably, this zero-energy bound state is robust against a magnetic field up to 8 T, as well as perturbations by neighbouring impurities. Such a spectroscopic feature has no natural explanation in terms of impurity states in superconductors with s-wave symmetry, but bears all the characteristics of the Majorana bound state proposed for topological superconductors, indicating that the superconducting state and the scattering mechanism of the interstitial iron impurities in Fe(Te,Se) are highly unconventional.

7. **Robust measurement of superconducting gap sign changes via quasiparticle interference**
   P. J. Hirschfeld, D. Altenfeld, I. Eremin, and I.I. Mazin
   arxiv: 1507.0831

   Phase-sensitive measurements of the superconducting gap in Fe-based superconductors have proven more difficult than originally anticipated. While quasiparticle interference (QPI) measurements based on scanning tunneling spectroscopy are often proposed as definitive tests of gap structure, the analysis typically relies on details of the model employed. Here we point out that the temperature dependence of momentum-integrated QPI data can be used to identify gap sign changes in a qualitative way, and present an illustration for s and $s++$ states in a system with typical Fe-pnictide Fermi surface.