- **Electrically Tunable Quantum Spin Hall State in Topological Crystalline Insulator Thin films**
  Junwei Liu, Liang Fu
  arXiv:1501.05632v2
  Based on a combination of $k \cdot p$ theory, band topology analysis and electronic structure calculations, we predict the (111) thin films of the SnTe class of three-dimensional (3D) topological crystalline insulators realize the quantum spin Hall phase in a wide range of thickness. The nontrivial topology originates from the inter-surface coupling of the topological surface states of TCI in the 3D limit. The inter-surface coupling changes sign and gives rise to topological phase transitions as a function of film thickness. Furthermore, this coupling can be strongly affected by an external electric field, hence the quantum spin Hall phase can be effectively tuned under experimentally accessible the electric field. Our results show that (111) thin films of SnTe-class TCI can be an ideal platform to realize the novel applications of quantum spin Hall insulators.

- **Single-Valley Engineering in Graphene Superlattices**
  Yafei Ren, Xinzhou Deng, Changsheng Li, Jeil Jung, Changgan Zeng, Zhenyu Zhang, Qian Niu, Zhenhua Qiao
  arXiv:1501.05553v1
  The two inequivalent valleys in graphene preclude the protection against inter-valley scattering offered by an odd-number of Dirac cones characteristic of Z2 topological insulator phases. Here we propose a way to engineer a chiral single-valley metallic phase with quadratic crossover in a honeycomb lattice through tailored $\sqrt{3}N * \sqrt{3}N$ or $3N * 3$ superlattices. The possibility of tuning valley-polarization via pseudo-Zeeman field and the emergence of Dresselhaus-type valley-orbit coupling are proposed in adatom decorated graphene superlattices. Such valley manipulation mechanisms and metallic phase can also find applications in honeycomb photonic crystals.

- **Phase structure of mass- and spin-imbalanced unitary Fermi gases**
  Dietrich Roscher, Jens Braun, Joaquín E. Drut
  arXiv:1501.05544v1
  We study the phase diagram of mass- and spin-imbalanced unitary Fermi gases, in search for the emergence of spatially inhomogeneous phases. To account for fluctuation effects beyond the mean-field approximation, we employ renormalization group techniques. We thus obtain estimates for critical values of the temperature, mass and spin imbalance, above which the system is in the normal phase. In the unpolarized, equal-mass limit, our result for the critical temperature is in accordance with state-of-the-art Monte Carlo calculations. In addition, we estimate the location of regions in the phase diagram where inhomogeneous phases are likely to exist. We show that an intriguing relation exists between the general structure of the many-body phase diagram and the binding energies of the underlying two-body bound-state problem, which further supports our findings. Our results suggest that inhomogeneous condensates form for mass imbalances $m_\downarrow/m_\uparrow \geq 3$. The extent of the inhomogeneous phase in parameter space increases with increasing mass imbalance.

- **Superconducting Gap Renomalization around two Magnetic Impurities: From Shiba to Andreev Bound States**
  Tobias Meng, Jelena Klinovaja, Silas Hoffman, Pascal Simon, Daniel Loss
  arXiv:1501.07901
  We study the renormalization of the gap of an s-wave superconductor in the presence of two magnetic impurities. For weakly bound Shiba states, we analytically calculate the part of the gap renormalization that is sensitive to the relative orientation of the two impurity spins. For strongly exchange coupled impurities, a quantum phase transition from a sub-gap Shiba state to a supra-gap Andreev state is identified and discussed by solving the gap equation self-consistently by numerics.

- **Observation of optical polarization Möbius strips**
  T. Bauer, P. Banzer, et al.
  DOI: 10.1126/science.1260635
  Möbius strips are three-dimensional geometrical structures, fascinating for their peculiar property of being surfaces with only one "side" - or, more technically, being "non-orientable" surfaces. Despite being easily realized artificially, the spontaneous emergence of these structures in nature is exceedingly rare. Here, we generate Möbius strips of optical polarization by tightly focusing the light beam emerging from a q-plate, a liquid crystal device that modifies the polarization of light in a space-variant manner. Using a recently developed method for the three-dimensional nano-tomography of optical vector fields, we fully reconstruct the light polarization structure in the focal region, confirming the appearance of Möbius polarization structures. The preparation of such structured light modes may be important for complex light beam engineering and optical micro- and nano-fabrication.