Academic Report (2020-21)

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Research Summary:

We continued our work on topological quantum matter, focussing this year on edge states, Weyl semimetals and also on quasiparticles that occur in these materials as excitations - abelian anyons, non-abelian excitations like Majorana modes and their even more exotic cousins, parafermions.

The work on shining light on bilayer graphene to obtain chiral co-propagating Luttinger liquids at the interface of two polarisations was published. We are now studying the chiral edge states obtained by gating bilayer graphene. In particular, we are looking for reconstruction of these edge states in the presence of electron-electron interactions. We have also been studying the interacting electron system in domain walls in silicene and other spin-orbit coupled materials and in particular, have been trying to see whether we can tune the Kondo effect in the helical Luttinger liquid that is obtained at the domain wall, via gates.

Our work on multicritical points in topological phase transitions was published, as also our work on the interface between $\nu = 3$ and $\nu = 4$ quantum Hall systems. We have continued our work on edge modes and have studied a circuit where the path from the source of electric current to the drain necessarily passes through a segment consisting solely of neutral modes. We find that the neutral modes carry information using which it is possible to reconstruct the DC charge current at the drain. We show that our protocol can be used as a detector of all kinds of neutral modes.

We have also given a new formalism to study anyons in terms of the Kohn-Sham density functional theory, and shown by comparing the theory with exact results from few anyon systems, that it can both qualitatively and quantitatively capture the relevant physics, and may turn out to be a new tool for studying anyons in other contexts as well. We have also been studying parafermion excitations, which can be constructed by the proximity of chiral edge states of quantum Hall systems with superconductors. Our aim is to study detection of parafermions using an Aharonov-Bohm ring setup.

We have studied Fermi arc reconstruction at a junction of two Weyl semi-metals (WSM) twisted by an angle with respect to each other, and shown that there exists regions in the parameter space where the Fermi arcs disconnect from the projections of the Weyl nodes and become normal Fermi loops. These surface states are true surface states and decay exponentially into the bulk. We are also currently studying Weyl semi-metals in a magnetic field in the Hofstader regime, where the lattice length is comparable to the magnetic length, where we have found not only found new WSM phases we have also found new insulating phases which do not occur in the absence of a magnetic field. Finally, we have also been working on a normal metal - insulator - WSM junction in the thin and thick barrier limits to study electrical conductances and thermal conductances through such junctions.

We have also working on a hybrid setup involving a superconductivity-proximitised quantum spin Hall insulator and a quantum anomalous Hall insulator for chiral injection of electrons. Our aim is to show how to engineer a phase space where the Majorana mode will be stable to disorder and amenable to detection.

4. *Exotic quastiparticles in condensed matter systems*, Emerging trends in quantum matters, statistical and biological physics, Bhubaneswar, India, Institute of Physics, Bhubaneswar, 23 November, 2020.

Other Activities:

1. Divisional Associate Editor, Physical Review Letters, American Physical Society, 2018 -2020, 2021 - .

2. Convenor, Endowment committee (HRI) till December 31, 2020.