Seminar, Department of Physical Sciences, Bose Institute, Kolkata

Aspects of interacting and disordered fermions on hyperbolic lattices

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Abstract: Hyperbolic lattices constitute a unique platform to study various novel quantum phenomena on a negatively curved space and identify the imprints of spatial curvatures therein. In this talk, first I will show a simple classification scheme on the family of two-dimensional bipartite hyperbolic lattices, resulting from simple but canonical spin-independent tight-binding model for free electrons, yielding three classes of ballistic quantum fluids on negatively curved space, namely Dirac liquids, Fermi liquids, and flat bands, that are, respectively, characterized by a vanishing, a finite, and a diverging density of states near the band center or zero-energy [1]. Next, I will show that such systems can be susceptible to different types of spontaneously ordered phases (such as the charge and spin density-waves) once Hubbard-like electronic interactions are considered, giving rise to dynamic mass generations in half-filled systems [2].

In the second half of the talk, I will exclusively focus on hyperbolic Dirac systems in which orderings can only take place beyond critical strengths of interactions via a quantum phase transition. I will propose two realistic approaches to trigger such dynamic mass generations on curved space Dirac liquids at sufficiently weak interactions. I show that (a) application of external magnetic fields [3, 4] and (b) rotational symmetric strain [5] give rise to a finite density of states near zero-energy in noninteracting systems, conducing various mass ordering at weak coupling.

Finally, I will discuss the role of disorder or impurities on hyperbolic Dirac liquids. I show that in contrary to our traditional wisdom, planar dirty hyperbolic Dirac liquids show two distinct quantum phase transitions as the disorder strength is gradually increased in the system. First the ballistic system undergoes a semimetal-to-metal transition at moderate disorder strength, which is subsequently followed by the Anderson metal-to-insulator transition, both being absent in two-dimensional Euclidean Dirac liquids, realizable on honeycomb lattices, for example [6].

I will close the talk with some possible future directions to further unfold unique quantum aspects of hyperbolic crystals.

References:

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