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Phase Diagram of Massive Dirac Fermions with Tunable Interactions in High Magnetic Fields[1] R.N. BHATT, Department of Electrical Engineering and Princeton Center for Theoretical Science, Princeton University, Princeton, NJ 08544, Z. PAPIC, Department of Electrical Engineering, Princeton University, Princeton, NJ 08544, Y. BARLAS, National High Magnetic Field Laboratory, Florida State University, Tallahassee, FL 32310, D.A. ABANIN, Princeton Center for Theoretical Science, Princeton University, Princeton, NJ 08544
— We study the strongly correlated states of massive fermions in two dimensions with Berry's phase π and 2π, in the limit of high magnetic fields. Due to the chiral band structure and massive carriers, the effective Coulomb interactions depend on the external magnetic field, and lead to a number of phases within a single low-lying Landau level. The tunability of the interactions allows the study of the transitions between phases in a more direct manner than in GaAs-based systems where the form of the interactions is independent of the magnetic field. We map the phase diagram at partial fillings $\nu = 1/3, 1/2, 3/5$ of the low-lying Landau levels, and find transitions between fractional quantum Hall states, compressible Fermi-liquid-like states, as well as charge-density-waves. We also find a new, broad regime of the effective interactions which favor the paired non-Abelian states. Our study identifies the strongly correlated phases expected in high-mobility graphene, bilayer graphene, topological insulators, and other materials with the non-trivial Berry phases, and provides a realistic method for studying the phase transitions between them.

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