TT 31: Topology: Quantum Hall Systems

Time: Wednesday 15:00–16:45 Location: H31

Invited Talk TT 31.1 Wed 15:00 H31

Quantum Skyrmion Hall Effect — •Ashley Cook — MPI-PKS, Dresden, Germany

Motivated by recent discovery of additional topologically non-trivial phases of matter in lattice models beyond established classification schemes, we generalise the framework of the quantum Hall effect (QHE) to that of the quantum skyrmion Hall effect (QSkHE). This involves one key generalisation: considering particles on a two-sphere, which see a U(1) monopole, one can project to the lowest Landau level (LLL). Upon performing such a projection, the position coordinates become proportional to SU(2) generators by quenching of kinetic energy. An almost point-like LLL corresponds to matrix representation size for the SU(2) generators of N by N, with N small. The key generalisation is that such an almost point-like LLL with small orbital degeneracy can still host an intrinsically 2+1 dimensional topologically non-trivial many-body state. Equivalently, in regimes in which spin has previously been treated as a label (small N), spin encodes some finite number of spatial dimensions, in general. This many-body state can play the role, in the QSkHE, that a charged particle plays in the QHE.

TT 31.2 Wed 15:30 H31

Electric Field Induced Second-Order Anomalous Hall Transport in an Unconventional Rashba System — •Ankita Bhattacharya and Annica Black-Schaffer — Uppsala University, Sweden

Nonlinear responses in transport experiments may unveil information and generate new phenomena in materials that are not accessible at linear order due to symmetry constraints. While the linear anomalous Hall response strictly requires the absence of time-reversal symmetry, the second order, thus nonlinear, Hall response needs broken inversion symmetry. Recently, much effort has been made to obtain a second-order Hall voltage in response to a longitudinal ac driving current, both to obtain information about band geometric quantities and for its useful technological applications in rectification and frequency doubling. Typically, additional material engineering is required in noncentrosymmetric systems to obtain second-order responses since it obeys a stringent crystallographic symmetry constraint. To circumvent this, an alternative route is to apply a dc electric field. In our work, we uncover an electric field induced second-order anomalous Hall effect in an inversion-broken system possessing unconventional Rashba bands. We establish that the quantum metric, a geometrical feature of electronic wave functions providing information on non-trivial structure of Bloch bands, is responsible for providing the nonlinear Hall response. We are able to find a highly tunable electric field induced second-order anomalous Hall transport in probably the simplest system in 2D, which should be uncomplicated to verify experimentally due to multiple materials already being proposed.

TT 31.3 Wed 15:45 H31

Topological Thermal Hall Effect in the Geometrically Frustrated Magnet Gd_2PdSi_3 — •Parisa Mokhtari[1,2], Daiki Yamaguchi[1], Rinsuke Yamada[1], Akiko Kikkawa[3], Philipp Gegenwart[2], Yasujiro Taguchi[3], Yoshinori Tokura[1,3], and Max Hirschberger[1,3] — [1]Department of Applied Physics and Quantum-Phase Electronics Center, The University of Tokyo, Bunkyo-ku, Tokyo 113-8656, Japan — [2]Experimental Physics VI, Center for Electronic Correlations and Magnetism, University of Augsburg, 86135 Augsburg, Germany — [3]RIKEN Center for Emergent Matter Science, Wako, Saitama 351-0198, Japan

Geometrical frustrated Skyrmion lattices exemplify nontrivial topological states with non-zero scalar spin chirality and a finite Berry curvature in real space. In 2019, T. Kurumaji *et al.* reported a large topological Hall effect in the skyrmion phase in Gd_2PdSi_3 related to the spin chirality of the ground state [1].

In this talk, I will present the thermal Hall conductivity of the frustrated triangular-lattice magnet Gd_2PdSi_3. By entering the skyrmion lattice ground state, the field-dependent thermal Hall effect sharply increases against the adjacent incommensurate phases, similar to the electric Hall conductivity behaviour. Eventually, I will investigate the relationship of Hall entropy to the charge current and discuss the non-dissipativity of topological quantum transport in the geometrically frustrated magnet Gd_2PdSi_3.

[1] T. Kurumaji *et al.*, Science **365**, 914 (2019).

TT 31.4 Wed 16:00 H31

Orbital Magnetization of Dirac Electrons on Curved Surfaces — •Maximilian Fürst — Universität Regensburg

Orbital magnetic response of 2D, (almost) free electrons has extensively been studied in the past, starting from the discovery of Landau levels of Schrödinger [1]/(massless) Dirac [2] electrons with a linear/squareroot dispersion in the field strength B. Apart from Landau diamagnetism, this leads to De-Haas-van-Alphen type oscillations of the susceptibility, that are periodic in 1/B [3]. Confining (massless) Dirac electrons on a curved surface predominantly leads to unusual oscillations of the susceptibility with periodicity in B. We discuss three example surfaces (Sphere, Cone, Pseudosphere) in a coaxial magnetic field.

[1] L. Landau, Z. Phys. A 64, 629 (1930).
[2] J. W. McClure, Phys. Rev. 104, 666 (1956).
[3] L. Heße, K. Richter, Phys. Rev. B 90, 205424 (2014).

TT 31.5 Wed 16:15 H31

Probing Fractional Statistics through Aharonov-Bohm Oscillations in Hanbury-Brown-Twiss Geometry — •Felix Puster, Matthias Thamm, and Bernd Rosenow — Institut für Theoretische Physik, Universität Leipzig, Brüderstraße 16, 04103 Leipzig, Germany

Since the theoretical prediction of anyonic excitations in the fractional quantum Hall effect, experimental evidence for their fractional statistics has been highly sought. In recent years, experiments have determined fractional braiding phases, providing clear evidence for fractional exchange phases. However, the braiding phase fixes the exchange phase of the particles only up to modulo Pi, leaving ambiguity in its exact value. Therefore, experiments capable of determining the exchange phase unambiguously are desired. To this end, we revisit the Hanbury-Brown-Twiss (HBT) geometry in the fractional quantum Hall regime. Our calculations extend previous theoretical work by incorporating an Aharonov-Bohm (AB) phase, finite temperature, and a finite distance between the tunneling points. We compute the current and current-current correlation functions and find that the anyonic exchange phase enters the AB oscillations in both quantities as an additive shift. While this shift is expected for the current-current correlations due to two-particle interference, for the current we interpret it as another example of time domain braiding of anyons – a phenomenon previously reported in geometries with tunneling of anyons across a quantum point contact.

TT 31.6 Wed 16:30 H31

Dipole Representation of Composite Fermions in Graphene's Quantum Hall Systems — •Sonja Predin — Scientific Computing Laboratory, Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

The even-denominator fractional quantum Hall effect has been observed in graphene's fourth Landau level (N = 3) [1]. Motivated by recent studies [2] on pairing and the nature of the ground state in this system, we extend the dipole representation of composite fermions to adapt it to graphene's quantum Hall systems, focusing on half-filled Landau levels. We derive an effective Hamiltonian incorporating particle-hole symmetry. At the Fermi level, the energetic instability of the dipole state is driven by the interplay between topology and symmetry, pushing the system towards a critical state. While paired states are considered, our findings demonstrate that a boost-invariant state lacking well-defined pairing instabilities is energetically favorable stable state, suggesting the absence of pairing instabilities in this system.

[1] Y.Kim,A.C.Balram,T.Taniguchi,K.Watanabe,J.K.Jain, J.H.Smet, Nat. Phys. 15, 154 (2019).
[2] A.Sharma, S.Pu, A.C.Balram, J.K.Jain, PRL 130, 126201 (2023).
[3] S.Predin, A.Knežević, M.V.Milovanović, PRB 107, 155132 (2023).
[4] S. Predin, arXiv:2408.10375.