HL 29: Quantum Transport and Quantum Hall effects (joint session HL/TT)

Time: Wednesday 15:00–16:15 Location: POT/0006

HL 29.1 Wed 15:00 POT/0006

High Harmonic Hall Currents Driven by Curved Conducting Nanoarchitecture — •Ching-Hao Chang[1,2], Botsz Huang[1,2], Wei-Xiang Yin[1,2], and Xiao Zhang[3] — [1]Department of Physics, National Cheng Kung University Tainan, Taiwan — [2]Center for Quantum Frontiers of Research and Technology (QFort), National Cheng Kung University Tainan 70101, Taiwan — [3]Institute for Theoretical Solid State Physics Leibniz Institute for Solid State and Materials Research Dresden Helmholtzstr. 20, D-01069 Dresden, Germany

We theoretically establish a realizable non-perturbative mechanism for generating high harmon- ics (up to 6th order) in Hall currents within curved two-dimensional nanoarchitectures. Unlike previously explored perturbative mechanisms based on inversion symmetry breaking or Berry curvature, the high-harmonic generation demonstrated here is driven by magnetic-field dipoles induced purely by nanoscale curvature under an applied uniform magnetic field. We develop a theory showing that these harmonics originate from unique snake orbits induced by the interplay between an alternating electric field and curvature-induced magnetic-field dipole. Moreover, we establish quantitative control over harmonic suppression and enhancement by tuning the amplitude and orientation of the magnetic field, uncovering distinct symmetry-based even/odd harmonic selection rules. These findings provide a tunable platform for engineering nonlinear currents in curved electronics, with potential applications in developing high-frequency Hall sensors and THz devices.

HL 29.2 Wed 15:15 POT/0006

Gate-tunable isospin switching in graphene Mach-Zehnder electronic interferometers — •Antonio Lacerda-Santos, Lilian Seyve, Yassine Setti, Bikash Barik, Leo Pugliese, Preden Roulleau, and Cosimo Gorini — SPEC, CEA, CNRS, Université Paris-Saclay, 91191 Gif-sur-Yvette, France

Graphene has become an exciting platform for electron (quantum) optics experiments [1]. Compact electronic interferometers can be realised via p-n interfaces, which in quantizing magnetic fields host counter-propagating chiral edge states. In a paradigmatic architecture with a single junction, such quantum Hall states form a Mach-Zehnder interferometer [2, 3]. The precise position of such edge states is set by the electrostatics of a given device [4], which can be determined to great accuracy with the self-consistent Schrödinger-Poisson solver Pescado [5].

We perform electrostatic and quantum transport simulations accompanying conductance measurements in a graphene Mach-Zehnder interferometer, and show that remote gates can be used to control the position of the p-n junction on sub-nanometer scales. Such a fine control does not meaningfully affect the edge state positions and lengths, but induces valley-isospin oscillations. The interferometer thus behaves as a tunable valley-isospin transistor.

[1] H. Chakraborti et al., J.Phys.:Condens.Matter 36 (2024) 393001 [2] D.S.Wei et al, Science Advances 3, e1700600 (2017) [3] M. Jo et al, PRL 126, 146803 (2021) [4] I.M. Flor et al, PRB 105, L241409 (2022) [5] A. Lacerda-Santos, arXiv:2507.03131v1

HL 29.3 Wed 15:30 POT/0006

Phase-coherent autonomous nonequilibrium demon — •José Balduque[1,2] and Rafael Sánchez[1,2,3] — [1]Departamento de Física Teórica de la Materia Condensada, Universidad Autónoma de Madrid, Madrid, Spain. — [2]Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, Madrid, Spain — [3]Instituto Nicolás Cabrera (INC), Universidad Autónoma de Madrid, Madrid, Spain.

Mesoscopic conductors enable the efficient management and useful conversion of not only thermal resources but also nonequilibrium electron distributions. The latter scenario makes it possible to define demonic modes of operation, in which the entropy of a subsystem is autonomously reduced without extracting net particles or energy from the subsystem that provides the nonequilibrium resource [1]. We propose an implementation of such a nonequilibrium demon, or N-demon, in a multiterminal system that exploits carrier coherence. This is achieved by directly coupling the demonic subsystem to an isothermal two-terminal conductor via a scanning tip, enabling the local injection of electrons in a nonthermal distribution that participates in the phase-coherent interference processes governing the system's transport response [2]. In this way, we uncover an extrinsic, nonlocal, and phase-tunable transport response induced by the demon [3].

[1] R. Sánchez, et al., Phys. Rev. Lett. 123, 216801 (2019).
[2] R. Sánchez, et al., Phys. Rev. B, 105, 239903 (2022).
[3] J. Balduque and R. Sánchez, in preparation.

HL 29.4 Wed 15:45 POT/0006

Exploring the Influence of Electron Density on the Giant Negative Magnetoresistance — •Lina Bockhorn[1], Christian Reichl[2], Werner Wegscheider[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Germany — [2]Laboratorium für Festkörperphysik, ETH Zürich, Switzerland

Ultra-high mobility two-dimensional electron gases exhibit a robust negative magnetoresistance at zero magnetic fields, characterized by a temperature-independent peak around $B = 0\,\mathrm{T}$ and a temperature-dependent giant negative magnetoresistance (GNMR) at higher fields [1-4]. By varying the electron density in situ, we gain valuable insights into the nature of GNMR. Our study shows a significant dependence of GNMR on electron density, suggesting that scattering potential variations [5] may not be fully addressed in current theoretical models. By examining these dependencies for different temperatures, we enhance the understanding of unresolved aspects of GNMR theory, potentially bridging the gap between experimental observations and theoretical predictions.

[1] L. Bockhorn et al., Phys. Rev. B 83, 113301 (2011).
[2] L. Bockhorn et al., Phys. Rev. B 90, 165434 (2014).
[3] L. Bockhorn et al., Appl. Phys. Lett. 108, 092103 (2016).
[4] L. Bockhorn et al., Phys. Rev. B 109, 205416 (2024).
[5] Y. Huang et al., Phys. Rev. Materials 6, L061001 (2022).

HL 29.5 Wed 16:00 POT/0006

A topological field-effect memristor — •Fabian Hartmann[1], Manuel Meyer[1], Selena Barragan[1], Sergey Krishtopenko[1,2], Jean-Baptiste Rodriguez[3], Eric Tournie[3], Benoit Jouault[2], Gerald Bastard[1], Frederic Teppe[2], Lukas Worschech[1], Victor Lopez-Richard[4], and Sven Höfling[1] — [1]Lehrstuhl für Technische Physik, Julius-Maximilians-Universität Würzburg — [2]L2C, CNRS-Université de Montpellier, France — [3]IES, Université de Montpellier, France — [4]Departamento de Fisica, Universidade Federal de Sao Carlos, Brazil

Quantum and neuromorphic computing rely on unconventional materials and device functionalities, yet achieving resilience to imperfections and reliable operation remains a major challenge. This has motivated growing interest in topological materials that provide robust and low-power operation while preserving coherence. However, integrating topological transport with memory functionality into a reconfigurable device has remained elusive. Here, we realize a topological field-effect memristor in which topological protection preserves edge state coherence, enabling the coexistence of coherent transport and non-volatile memory functionality. Utilizing inverted InAs/GaInSb/InAs trilayer quantum wells, we realize a quantum spin Hall insulator that exploits its intrinsic floating-gate behavior. This feature allows one to reconfigure the conventional field-effect transistor operation into memristive functionality with broad electric-field tunability. One resistance state is entirely governed by dissipationless, coherent transport.