Prize Talk PRV I Mon 13:15 H 0105

Transversal transport coefficients in spintronics — •Ingrid Mertig — Martin-Luther-Universität Halle-Wittenberg, 06099 Halle — Laureate of the Max-Born-Prize 2024

Spintronics is an emerging field in which charge, spin and orbital moment of electrons are utilized for transport. Most of the spintronic effects, like giant and tunnel magnetoresistance, are based on spinpolarized currents which show up in magnetic materials; these are already widely used in information technology and in data storage devices.

The next generation of spintronic effects is based on spin currents which occur in metals as well as in insulators, in particular in topologically nontrivial materials. The latest development is related to currents of the orbital moment. The spin currents are always related to the spin-orbit interaction. An orbital current can be generated whenever an object has a translational and rotational degree of freedom. All effects offer the opportunity for future low energy consumption electronics.

The talk will present a unified picture, based on topological properties, of a whole zoo of transversal transport coefficients: the trio of Hall, Nernst, and quantum Hall effects, all in their conventional, anomalous, spin and orbital moment flavor. The formation of transversal charge, spin and orbital moment currents as response to longitudinal gradients is discussed. Microscopic insight into all phenomena is presented by means of a quantum mechanical analysis based on the Dirac equation in combination with a semi-classical description which can be very elegantly studied within the concept of Berry curvature.

Prize Talk PRV II Wed 13:15 H 0105

Emergence and Self-Organisation in Biological Systems — •Erwin Frey — Ludwig-Maximilians-Universitaet Muenchen, Muenchen, Germany — Laureate of the Max-Planck-Medal 2024

Isolated systems tend to evolve towards thermal equilibrium, a special state that has been a research focus in physics for more than a century. By contrast, most processes studied in living and life-like systems are driven and far from thermal equilibrium. A fundamental overarching hallmark of all these processes is the emergence of structure, order, and information, and we are facing the major challenge of identifying the underlying physical principles. Two exciting problems are the self-organised formation of spatio-temporal patterns and the robust self-assembly of complex structures. In both fields, there have been recent advances in understanding the underlying physics that will be reviewed in this talk.

Prize Talk PRV III Thu 13:15 H 0105

Superconducting diode effect, magnetochiral anisotropy and other nonreciprocal effects in φ_0 Josephson junctions — Simon Reinhardt[1], Tim Ascherl[1], Andreas Costa[1], Johanna Berger[1], Sergei Gronin[1], Geoffrey Gardner[2], Tyler Lindemann[2], Michael Manfra[2], Jaroslav Fabian[1], Christoph Strunk[1], and •Nicola Paradiso[1,3] — [1]University of Regensburg — [2]Purdue University — [3]Laureate of the Walter-Schottky-Prize 2024

The simultaneous breaking of spatial inversion and time-reversal symmetry enables the observation of two fascinating phenomena in homogeneous Josephson junctions: the anomalous φ_0-shift and the supercurrent diode effect. Here, we report about experiments demonstrating the origin and the link between the two effects. Our main platform is a 2D electron gas in InGaAs/InAs/InGaAs, where superconductivity is induced by proximity with an epitaxial Al layer. In single Josephson junctions, an in-plane field perpendicular to the current induces a magnetochiral anisotropy for the inductance [1], whose sign changes at the onset of a 0-π-like transition [2] for the Andreev bound states. In 2D arrays of multiterminal junctions, the φ_0-shift breaks the symmetry of the pinning potential, giving rise to nonreciprocal vortex dynamics. Finally, SQUID experiments [3] with gated junctions reveal the connection between anomalous φ_0-shift, higher harmonics in the current-phase relation and diode effect.

[1] C. Baumgartner et al., Nat. Nano. 17, 39-44 (2021).
[2] A. Costa et al., Nat. Nano. 18-1266-1272 (2023).
[3] S. Reinhardt et al. arXiv:2308.01061 (2023).