PCS NEWSLETTER

QR to PCS Webpage

August 2024

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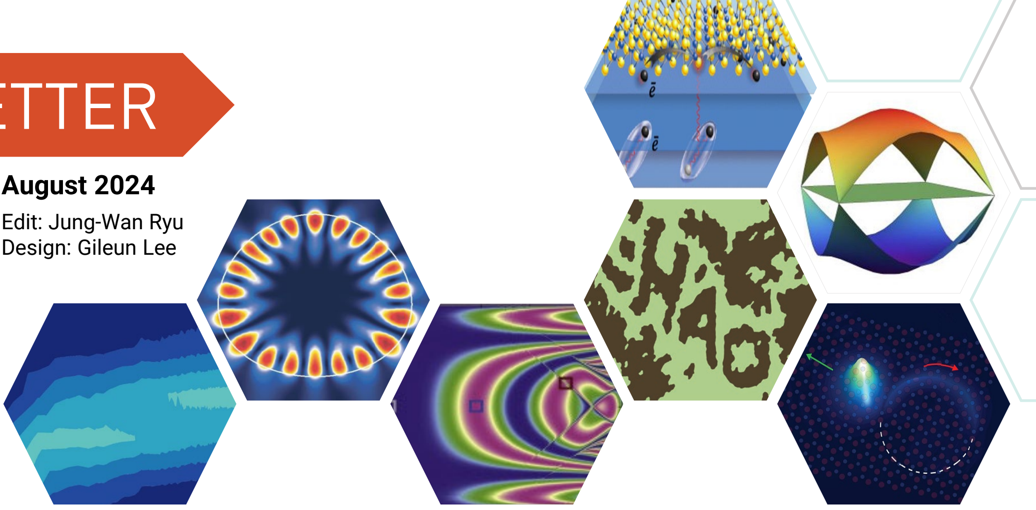


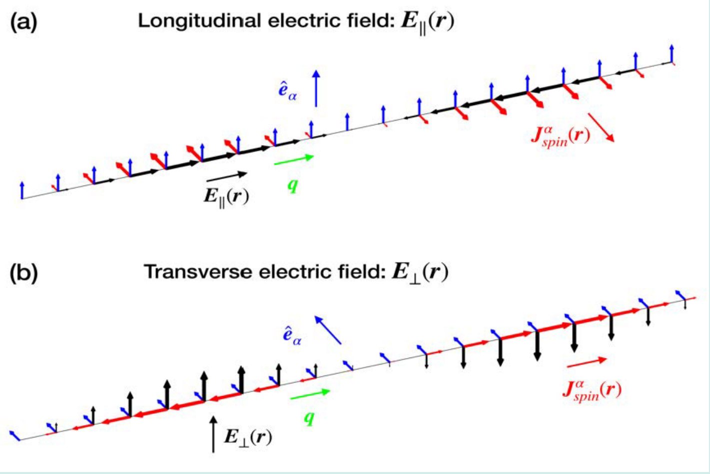
Awards

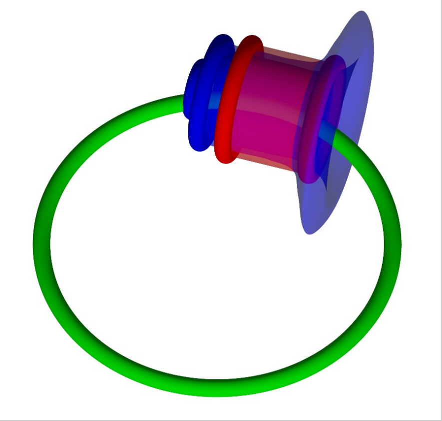
Congratulations!
Dr. Kabyashree Sonowal won the Humboldt Research Fellowship (two years) to join the Ultrafast Quantum Dynamics Group at Philipps-Universität Marburg (Germany).

New Research Results

Phonon-mediated spin transport in quantum paraelectric metals
Kyoung-Min Kim and Suk Bum Chung
[npj Quantum Materials 9, 51 (2024)]

In this study, the authors develop a spin-transport theory specific to quantum paraelectric metals. They demonstrate that these metals can acquire phonon-mediated Rashba spin-orbit interactions through thermally excited transverse optical phonons. Consequently, spin transport coefficients, such as spin Hall conductivity, exhibit non-vanishing components in response to non-uniform external electric fields. Additionally, the authors discover that these spin transport coefficients display distinctive quadrupolar wave characteristics rather than the usual isotropic features.

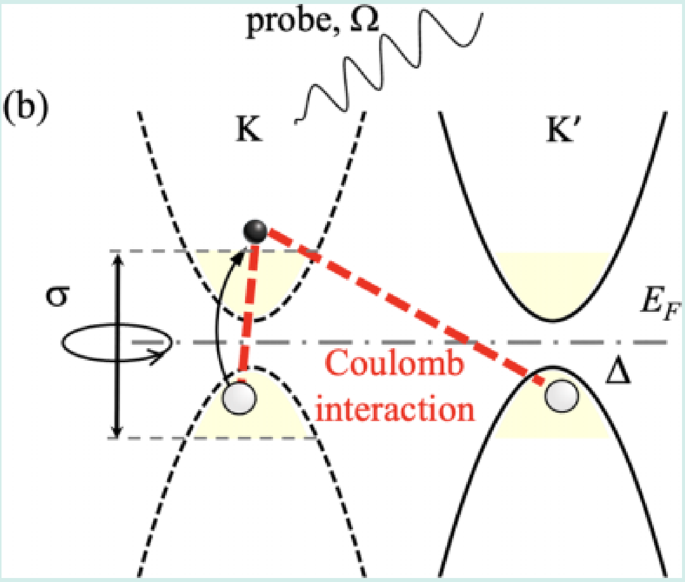




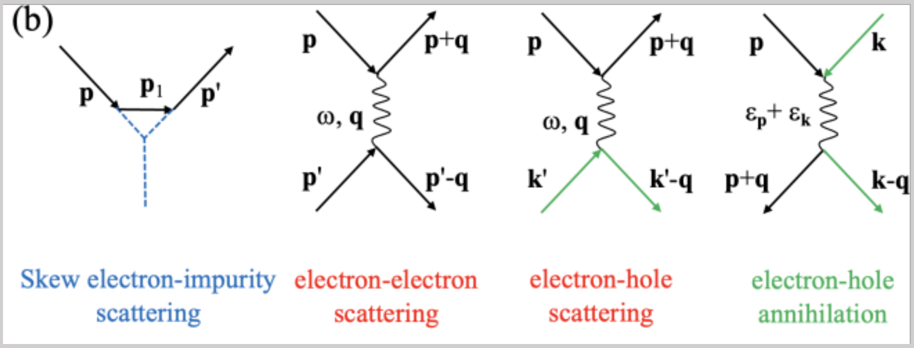
Twisted lattice gauge theory: Membrane operators, three-loop braiding, and topological charge
Joe Huxford, Dung Xuan Nguyen, and Yong Baek Kim
Phys. Rev. B 110, 035117 (2024)

In 3+1 dimensional topological phases, loop-like excitations can exist alongside point-like ones, allowing unique braiding interactions. The authors examine these loop-like excitations in a 3+1d Hamiltonian model of the Dijkgraaf-Witten theory of a finite Abelian group and the 4-cocycle twist. By constructing membrane operators, the authors identify braiding relations and fusion rules, including interactions between linked loops.

Role of Coulomb interaction in the valley photogalvanic effect
V. M. Kovalev, A. V. Parafilo, O. V. Kibis, and I. G. Savenko
Phys. Rev. B 109, 245414 (2024)



Novel two-dimensional Dirac materials like monolayer graphene or transition-metal dichalcogenides attract physicists' attention due to various exciting properties, such as the relativistic spectrum or the two-valley structure of the charge carriers' dispersion. The latter gives access to so-called valleytronics – an area that exploits control over the valley degree of freedom to manipulate transport properties. For instance, the circular polarized electromagnetic (EM) field may change electron population at a given valley due to a photoinduced interband transition, whereas the interplay between a linearly polarized EM field (probe field) and trigonal warping of electron dispersion results in a valley photogalvanic effect. The authors investigated an electron-hole Coulomb interaction-related contribution to the valley photogalvanic current. They demonstrated that electron-hole scattering dominates electron-electron scattering and might be comparable with the bare valley photogalvanic effect.



Renormalization of the valley Hall conductivity due to interparticle interaction V. M. Kovalev, D. S. Eliseev, A. V. Parafilo, V. M. Kovalev, O. V. Kibis, and I. G. Savenko
Phys. Rev. B Letters 110, L041301 (2024)

The authors develop a theory of a Coulomb interaction-mediated contribution to the valley Hall effect (VHE) in two-dimensional noncentrosymmetric gapped Dirac materials. They assume that the bare valley Hall current occurs in the system due to the presence of disorder caused by impurities and is determined by the valley-selective anisotropic skew scattering. Applying the Boltzmann transport equation to describe the electron and hole transport in the material, the authors calculate the renormalized VHE conductivity due to electron-electron and electron-hole scattering processes, considering two regimes: (i) an n-doped monolayer hosting a degenerate electron gas, and (ii) an intrinsic semiconductor with the Boltzmann statistics of electron and hole gases. In both regimes, the dominant mechanism of interparticle scattering is due to particles residing in different valleys. Moreover, in case (ii), in addition to direct scattering, electron-hole annihilation starts to play a role with the increase in temperature. It might even become the dominant mechanism of the Coulomb interaction-mediated VHE.

New Research Results

Non-Bloch band theory of subsymmetry-protected topological phases
Sonu Verma and Moon Jip Park
Phys. Rev. B 110, 035424 (2024)

System	Conventional BBC (BZ-topology)	Generalized BBC (GBZ-topology)
SPT phases	✓	✓
SPT phases + local/global deformations	×	✓

Bulk-boundary correspondence (BBC) of symmetry-protected topological (SPT) phases relates the non-trivial topological invariant of the bulk to the number of topologically protected boundary states. Recently, a finer classification of SPT phases has been discovered, known as subsymmetry-protected topological (sub-SPT) phases, where a fraction of the boundary states are protected by the subsymmetry of the system, even when the full symmetry is broken. While the conventional topological invariant derived from the Bloch band is not applicable to describe the BBC in these systems, the authors propose to use the non-Bloch topological band theory to describe the BBC of sub-SPT phases. Using the concept of the generalized Brillouin zone (GBZ), where Bloch momenta are generalized to take complex values, they show that the non-Bloch band theory naturally gives rise to a non-Bloch topological invariant, whose physical meaning corresponds to the reflection amplitude in the scattering matrix, establishing the BBC in both SPT and sub-SPT phases. The non-Bloch topological invariant characterizes the hidden intrinsic topology of the GBZ under translation symmetry-breaking boundary conditions. The topological phase transitions are characterized by the generalized momenta touching the GBZ, which accompanies the emergence of diabolic or band-touching points. Additionally, the authors discuss the BBCs in the presence of local or global full-symmetry or subsymmetry-breaking deformations.

Puzzle of the Month

July puzzle solution:

x=29. Simply introduce the three unknown radii and write down three equations for four unknowns. Luckily the radii can be eliminated leading straight to the answer.

The correct solution was sent in by Amnon Aharony, Victor Kagalovsky and Oleg Utesov (in time order). Congratulations!

Puzzle of the month:

find the pair of smallest consecutive natural numbers whose digit sums are both divisible by 7.

Send your solution to eun@ibs.re.kr
The winner will be announced in the next issue.