PCS NEWSLETTER

QR to PCS Webpage

January 2024
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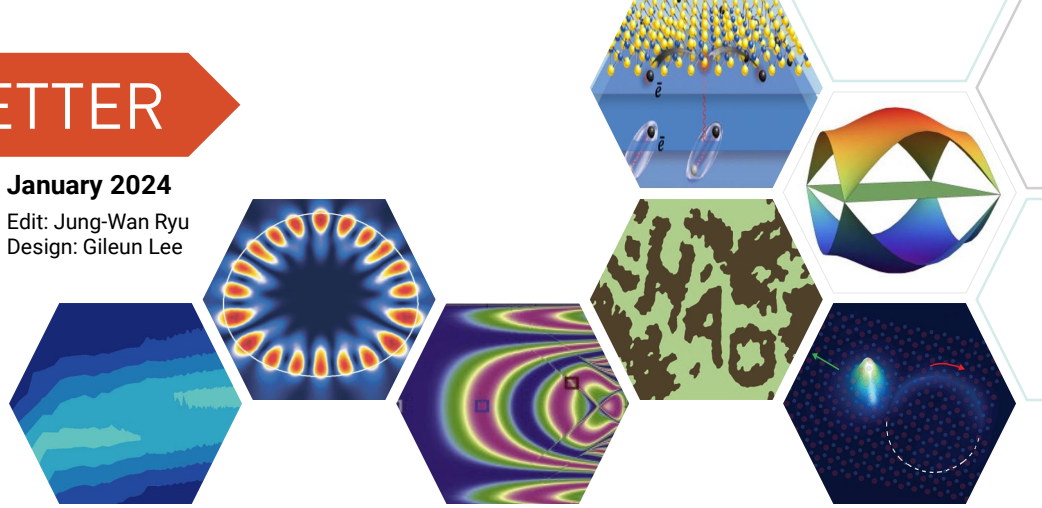


PCS Seminars

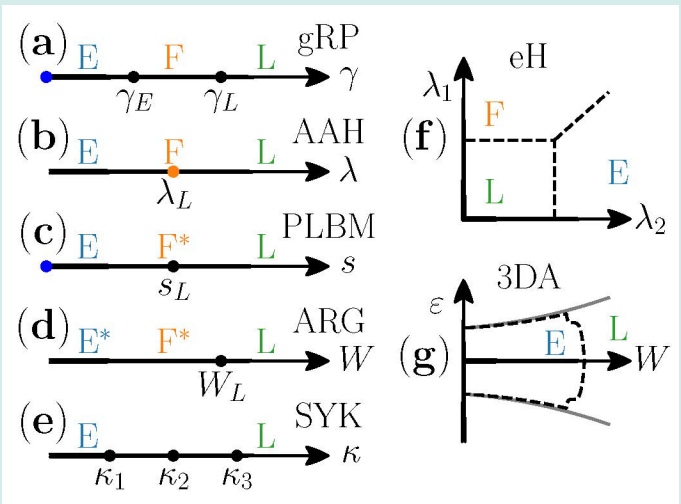
"Superconducting qubits for large-scale quantum computers - Status of development in Korea and global trend"
by Yong-Ho LEE, Korea Research Institute of Standards and Science, Korea (December 14)
IBS Physics Colloquium @ Daejeon

You can find more seminars on ***this page***.

PCS Workshops and Meetings

PCS, with KIAS successfully hosted *KIAS-IBS-PCS Workshop Correlation and Topology in Quantum Matter* on December 18 – 21, 2023. We enjoyed 22 talks with 60 participants.

New Research Results



Machine learning wave functions to identify fractal phases
Tilen Čadež, Barbara Dietz, Dario Rosa, Alexei Andreanov, Keith Slevin, and Tomi Ohtsuki
Phys. Rev. B 108, 184202 (2023)
The authors demonstrate that an image recognition algorithm based on a convolutional neural network provides a powerful procedure to differentiate between ergodic, non-ergodic extended (fractal) and localized phases in various systems: single-particle models, including random-matrix and random-graph models, and many-body quantum systems, whose phase diagrams are shown in Figure. The network can be successfully trained on a small data set of only 500 wave functions (images) per class for a single model. The trained network can then be used to classify phases in the other models and is very efficient. The authors discuss the strengths and limitations of the approach.

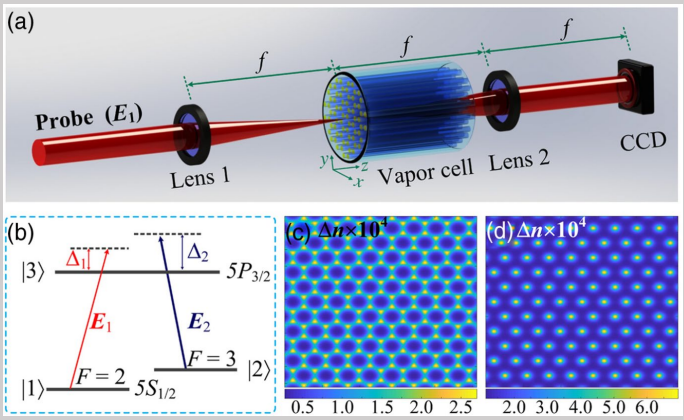
New Research Results

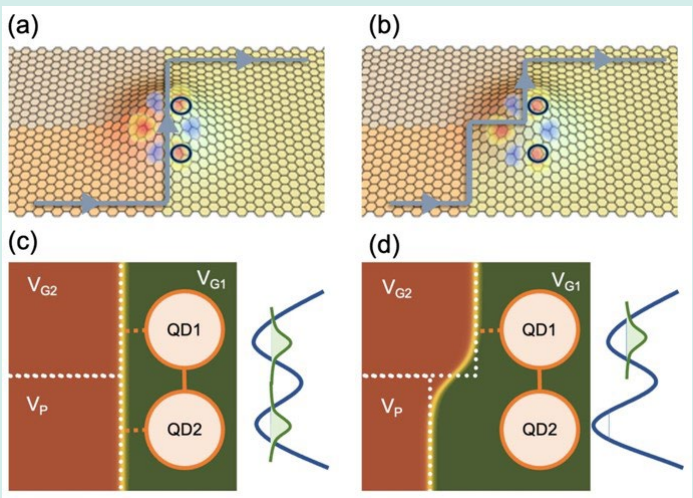
Simultaneous creation of multiple vortex-antivortex pairs in momentum space in photonic lattices

Feng Li, Sergei V. Koniakhin, Anton V. Nalitov, Evgeniia Cherotchenko, Dmitry D. Solnyshkov, Guillaume Malpuech, Min Xiao, Yanpeng Zhang, Zhaoyang Zhang

Advanced Photonics 5(6), 066007 (2023)

Engineering of the orbital angular momentum (OAM) of light due to interaction with photonic lattices reveals rich physics and motivates potential applications. The authors report the experimental creation of regularly distributed quantized vortex arrays in momentum space by probing the honeycomb and hexagonal photonic lattices with a single focused Gaussian beam. For the honeycomb lattice, the vortices are associated with Dirac points. However, they show that the resulting spatial patterns of vortices are strongly defined by the symmetry of the wave packet evolving in the photonic lattices and not by their topological properties. Their findings reveal the underlying physics by connecting the symmetry and OAM conversion and provide a simple and efficient method to create regularly distributed multiple vortices from unstructured light.





A strain-engineered graphene qubit in a nanobubble

Hee Chul Park, JungYun Han and Nojoon Myoung

Quantum Sci. Technol. 8, 025012 (2023)

The authors have conducted a comprehensive study of hybrid quantum systems at mesoscopic scales, proposing an intriguing system, a nanobubble on graphene. The nanobubble offers a pathway to the creation of novel qubit systems with extensive tunability. In this research, they introduce a controllable qubit within a graphene nanobubble (NB), featuring emergent two-level systems (TLSs) induced by pseudo-magnetic fields (PMFs). their investigation reveals that strain-induced PMFs in an NB can give rise to double quantum dots, and these quantum states can be manipulated either through local gate potentials or the application of PMFs.

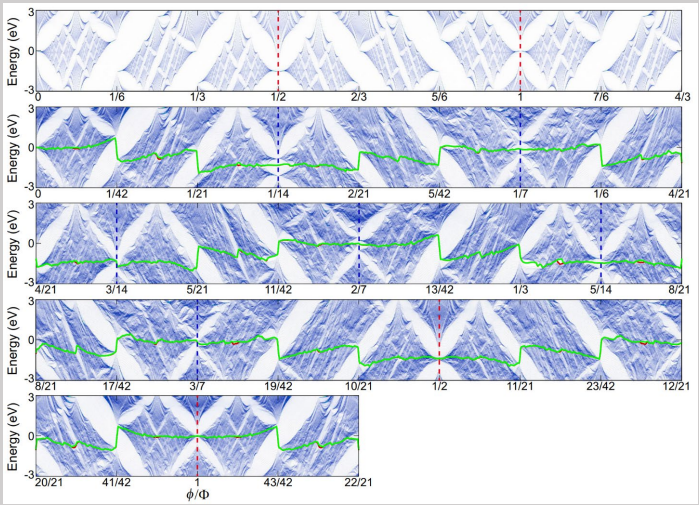
New Research Results

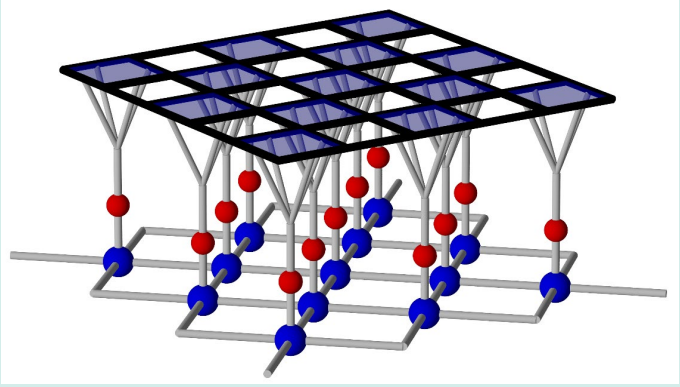
Replica higher-order topology of Hofstadter butterflies in twisted bilayer graphene

Sun-Woo Kim, Sunam Jeon, Moon Jip Park & Youngkuk Kim

npj Computational Materials 9, 152 (2023)

Hofstadter butterfly is the exotic fractal energy spectrum of electrons. It appears in the presence of the extremely strong magnetic field where the radius of the cyclon orbit becomes comparable to the length scale of the crystalline lattice. Twisted bilayer graphene can be a promising platform to realize the Hopfstadter butterfly since the moire pattern genuinely possesses the large lattice length scale. However, in theory-wise, the computation of such fractal patterns is a notorious problem, since the large moire unit cell becomes even larger due to the magnetic field. In this work, the authors reveal the hidden translational symmetry in the problem of the Hopfstadter butterfly of the twisted bilayer graphene. Using this translational symmetry, they reveal that electron spectrum exhibits recursive higher-order topological features, leading to the emergence of higher-order topological insulator (HOTI) phases with distinct corner states. These HOTIs replicate the original ones, showcasing self-similarity in the Hofstadter spectrum. Furthermore, numerous replicas of the original HOTIs are identified, each featuring localized corner states and real-space topological markers, emphasizing symmetry-protected topology in quantum fractals.





Gaining insights on anyon condensation and 1-form symmetry breaking across a topological phase transition in a deformed toric code model

Joe Huxford, Dung Xuan Nguyen, Yong Baek Kim

SciPost Phys. 15, 253 (2023)

The authors examine the condensation and confinement mechanisms exhibited by a deformed toric code model that describes both sides of a phase transition from a topological phase to a trivial phase. Their findings reveal an unconventional confinement mechanism that governs the behavior of the toric code excitations within the trivial phase. The authors describe how the degeneracy arises in both phases in terms of spontaneous symmetry breaking of a generalized (1-form) symmetry and explain why such symmetry breaking is compatible with the trivial phase. The present study implies the existence of subtle considerations of recently posited connections between topological phases and broken higher-form symmetries.

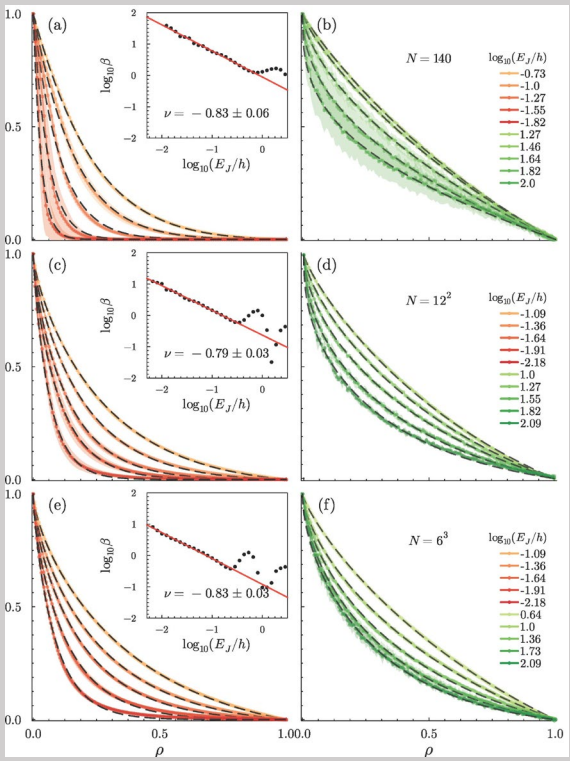
New Research Results

Thermalization slowing down in multidimensional Josephson junction networks

Gabriel M. Lando and Sergej Flach

Phys. Rev. E Letters 108, L062301 (2023)

The authors characterize thermalization slowing down of Josephson junction networks in one, two and three spatial dimensions for systems with hundreds of sites by computing their entire Lyapunov spectra. Different ratios of Josephson coupling to energy density give birth to two distinct universality classes of thermalization slowing down near integrability. Although these had been previously observed in unitary circuit maps, this is the first time such a classification was shown to be valid also for Hamiltonian systems.



Puzzle of the Month

December puzzle solution:

We asked for positive integers, so b=0 does not count (which would lead to the trivial solution a=2024 and c=2023). There is one nontrivial solution: a=647, b=2, c=675.
The first correct solution was submitted by Victor Kagalovsky. Congratulations!
Slightly later we also received correct solutions from Oleg Utesov and Budhaditya Bhattacharjee, and later also from Alireza Akbari. Well done!

Puzzle of the month:

You have N > 1 identical candles. One candle burns down completely during M hours. On the first day you light one candle for one hour. On the second day you light two candles for one hour. On the third day you light three candles for one hour. And so on. Finally on the Nth day you light all N candles for one hour. Is it possible that all candles will be burned down after that? What are the conditions for N and M?

Hint: M < N. Try it first for N=2,3,4,5,6,7,8,9.

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