PCS NEWSLETTER

QR to PCS Webpage

April 2025

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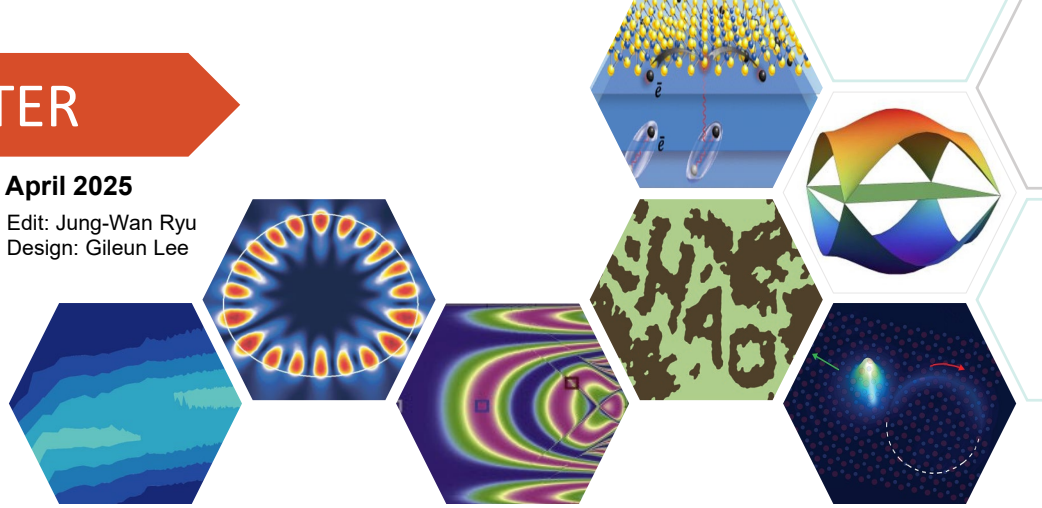
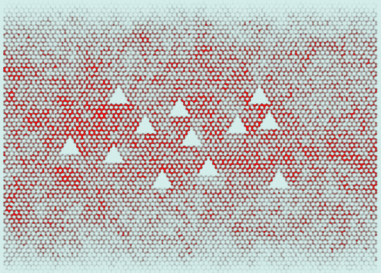


PCS Workshops and Meetings



PCS will run and host International Workshop on *Exciton-Polaritons in Semiconductor Microstructures and Quantum Optics* on April 28 - May 2, 2025.

PCS IBS Seminars

"Effects of correlations in disorder on localization and ergodicity breaking in long-range systems"

by Ivan Khaymovich, Nordic Institute for theoretical physics, Sweden (March 27)

You can find more seminars on this page.

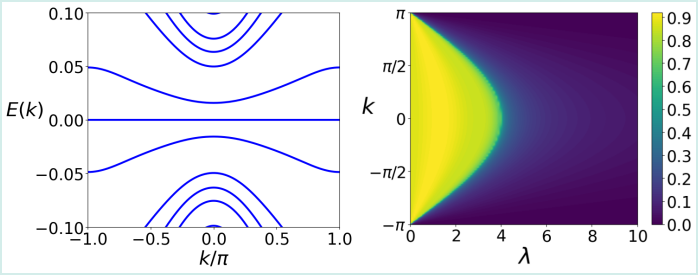
New Research Results

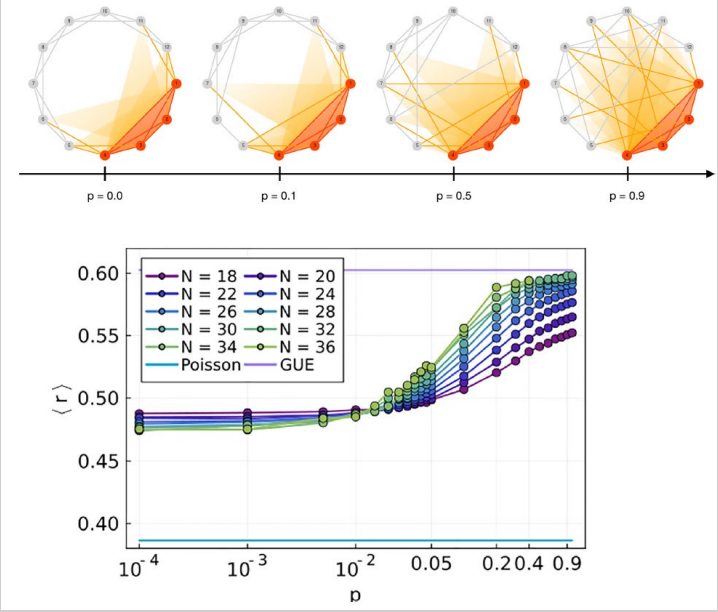
Flat bands in tight-binding lattices with anisotropic potentials

Arindam Mallick and Alexei Andreanov

Phys. Rev. B 111, 014201 (2025)

The authors consider tight-binding model Hamiltonians on Bravais lattices with anisotropic potentials that vary along a given direction. They construct anti-PT symmetric Hamiltonians with an E=0 flatband by tuning the hoppings and the shapes of potentials, which are illustrated for square lattices with bounded and unbounded potentials. Unlike flatbands in short-ranged translationally invariant Hamiltonians, the authors conjecture that their E=0 flatbands do not host compact localized states. Instead, the flatband eigenstates exhibit a localization transition along the potential direction upon increasing the potential strength for bounded potentials, while unbounded potentials always lead to localization.





From Dyson models to many-body quantum chaos

Alexei Andreanov, Matteo Carrega, Jeff Murugan, Jan Olle, Dario Rosa, and Ruth Shir

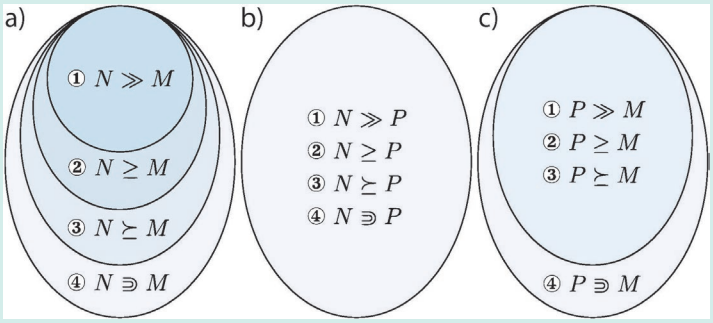
Phys. Rev. B 111, 035147 (2025)

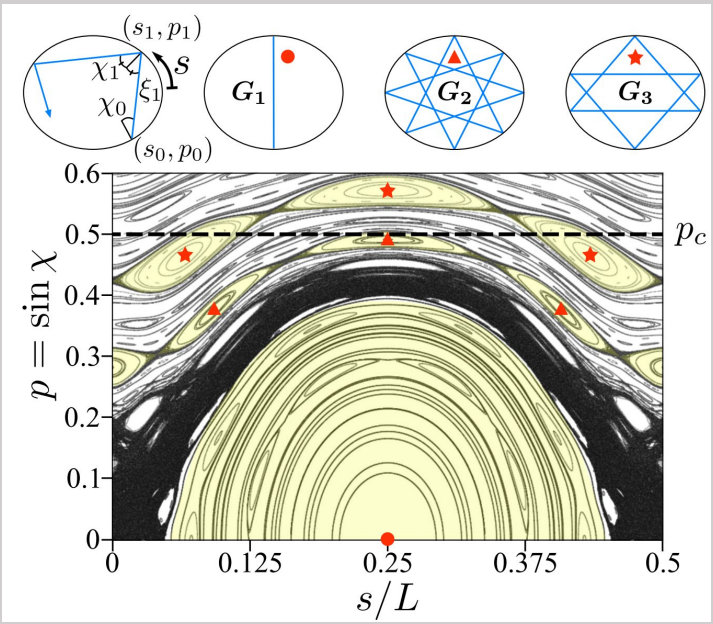
A deep understanding of the mechanisms underlying many-body quantum chaos is one of the big challenges in contemporary theoretical physics. The authors tackle this problem in the context of a set of perturbed quadratic Sachdev-Ye-Kitaev (SYK) Hamiltonians defined on graphs. This allows them to disentangle the geometrical properties of the underlying single-particle problem and the importance of the interaction terms, showing that the former is the dominant feature ensuring the single-particle to many-body chaotic transition. Their results are verified numerically with state-of-the-art numerical techniques, capable of extracting eigenvalues in a desired energy window of very large Hamiltonians. Their approach essentially provides a new way of viewing many-body chaos from a single-particle perspective.

New Research Results

Entropic partial orderings of quantum measurements
Adam Teixidó-Bonfill, Joseph Schindler and Dominik Šafránek
Phys. Scr. 100, 015298 (2025)

Measurement in quantum physics is defined by a set of projectors, or more generally, by the set of POVM elements (positive operator valued measure). Generally, it is understood that some measurements can be more informative than others. For example, one is certainly more informative than the other if all the outcomes of the second can be predicted knowing the outcomes of the first measurement. The authors investigated this and other notions "more informative", for example, measurements that give rise to a different corresponding entropy.





Decay rates of optical modes unveiling the island structures in mixed phase space
Chang-Hwan Yi, Barbara Dietz, Jae-Ho Han and Jung-Wan Ryu
Phys. Rev. A 111, 033509 (2025)

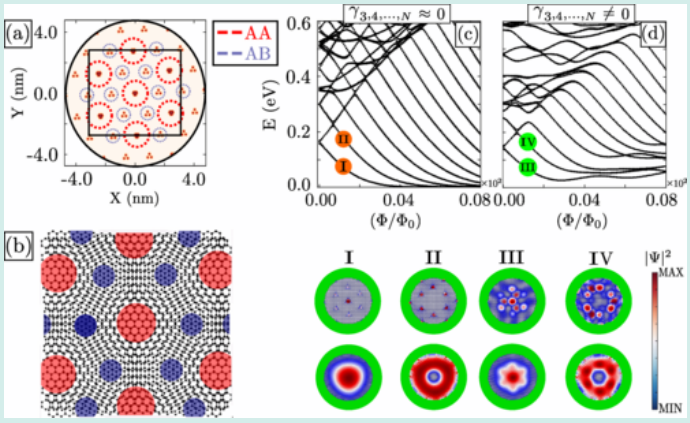
The authors explore the decay rates of optical modes in asymmetric microcavities with mixed phase space across a wide range of wavelengths that extend deep into the semiclassical, i.e., short-wavelength, limit. Implementing an efficient numerical method, they computed 106 eigenmodes and discovered that certain decay rates form sequential separate branches with increasing wave number that eventually merge into smooth curves. The analysis of the localization properties and Husimi distributions reveals that each branch corresponds to a periodic orbit in the closed classical system. Their findings show that these decay rates gradually resolve the structure of the islands in mixed phase space as they approach the short-wavelength limit. The authors present an effective semiclassical model incorporating wave-number-dependent localization, Fresnel reflection, and the Goos-Hänchen shift and demonstrate that these effects are crucial in accounting for the observed branches of decay rate curves.

New Research Results

Energy levels and Aharonov-Bohm oscillations in twisted bilayer graphene quantum dots and rings

N. S. Bandeira, Andrey Chaves, L. V. de Castro, R. N. Costa Filho, M. Mirzakhani, F. M. Peeters and D. R. da Costa

Phys. Rev. B 111, 125409 (2025)

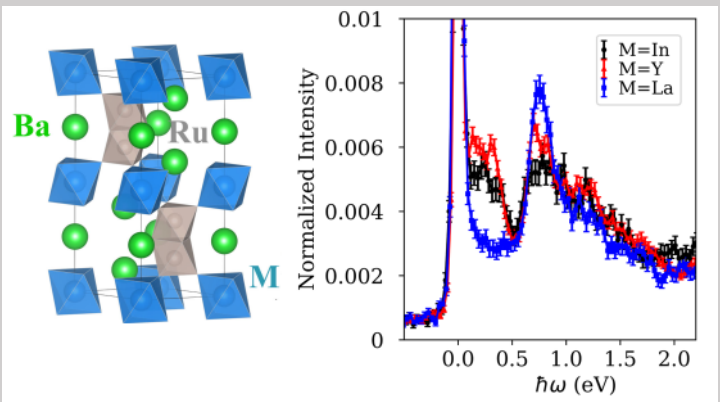


The authors investigate the energy levels of quantum dots (QDs) and quantum rings (QRs) in twisted bilayer graphene (tBLG) under a perpendicular magnetic field. By modeling these confinement structures with a circular site-dependent staggered potential, they create an energy gap that eliminates edge effects. Using a tight-binding model with interlayer hopping parameters, they explore how different twist angles affect the energy spectra. Their findings show that for twist angles near 0° or 60°, the energy levels reflect a mix of AA and AB/BA stacking effects, while for intermediate angles (10°–50°), the low-energy levels remain nearly independent of rotation. Notably, the lowest-energy states in QRs exhibit oscillations tied to the moiré pattern, and at high magnetic fields, the energy levels of QDs and QRs become nearly identical, highlighting the interplay of trigonal warping and electron localization.

Exploring a New Regime of Molecular Orbital Physics in 4*d* Cluster Magnets with Resonant Inelastic X-Ray Scattering

Bo Yuan, Beom Hyun Kim, Qiang Chen, Daniel Dobrowolski, Monika Azmanska, G. M. Luke, Shiyu Fan, Valentina Bisogni, Jonathan Pelliciari

Phys. Rev. Lett. 134, 106504 (2025)



Cluster Mott insulators arise from the interplay between strong local correlations and molecular orbital hybridization. In this study, the authors investigate Ru-dimer systems Ba3MRu2O9 (M = In, Y, La) using resonant inelastic x-ray scattering (RIXS) and theoretical analysis. They reveal a novel regime where large hopping and weak spin-orbit coupling create fragile electronic states that change abruptly with slight structural variations from different M-site ions. Their results explain the materials' unusual magnetic behavior and highlight 4d Ru clusters as a promising platform for exploring quantum phase transitions driven by molecular orbital physics.

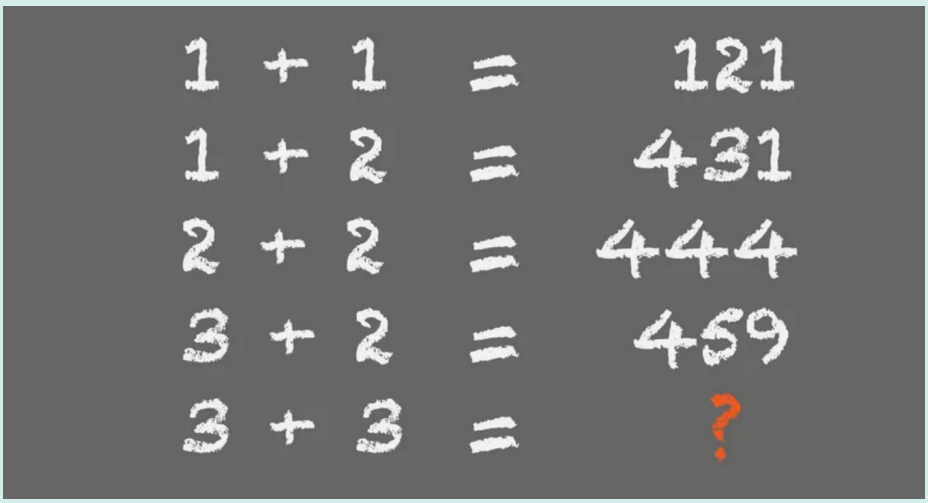
Puzzle of the Month

March puzzle solution:

The bike moved from left to right, blue is the front wheel track, red the rear wheel track. Why? Read the hint from the previous newsletter. We have to find the curve whose tangent is always crossing the other curve at the same distance. There are four possibilities - blue front or rear, red rear or front, and any of the two directions. Blue can not be rear, since some tangents never cross the red curve on the picture. So blue is front, red is rear. Plot the tangents to red, and find that its intersection with the blue to the right is always constant, while its intersection with the blue to the left is not. So we conclude that the bike moved from left to right.

The correct solution was communicated by Oleg Utesov, congratulations!

Puzzle on the month:



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