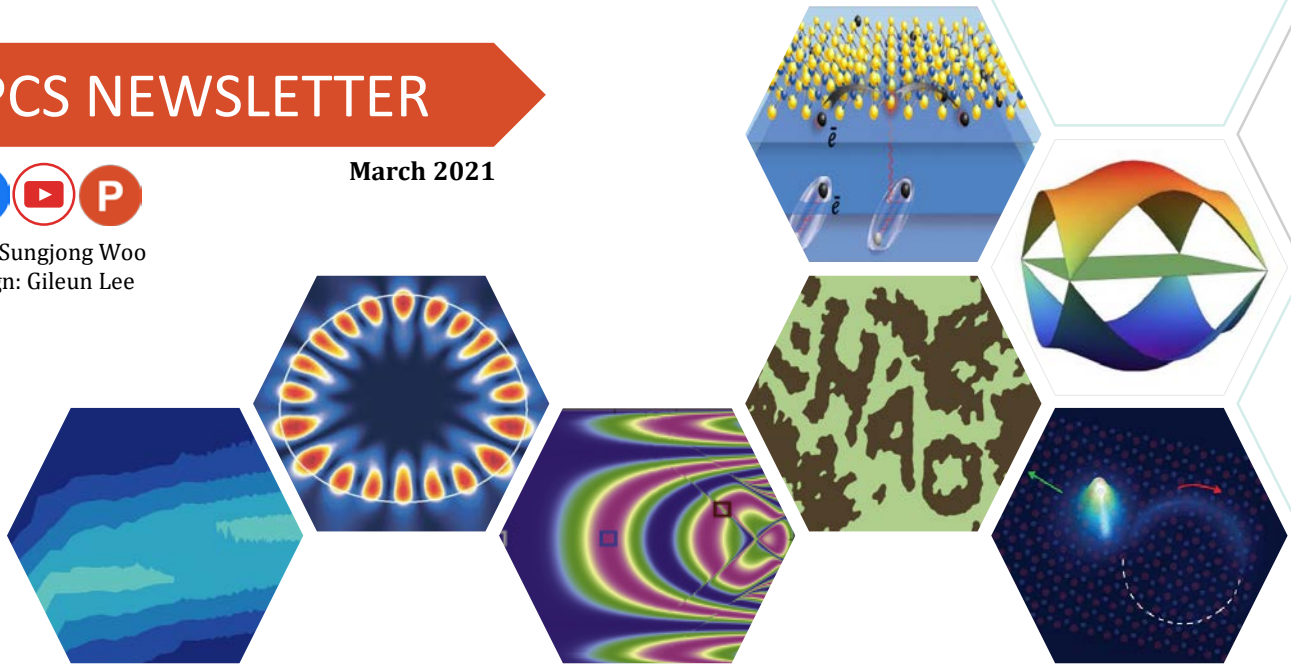
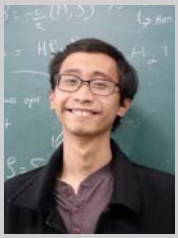
PCS NEWSLETTER

March 2021

Edit: Sungjong Woo
Design: Gileun Lee



New members



PCS welcomes two new graduate student members of University of Science and Technology, **Sanghoon Lee** and and **Muhammad Taufiq Murtadho**.

Sanghoon Lee is interested in various physical properties of flat bands.
Muhammad Taufiq Murtadho is interested in quantum information and thermodynamics in open quantum systems.

PCS Workshop announcements

Open Quantum Dynamics and Thermodynamics

Dates: **March 22 – March 26, 2021**
Location: **PCS Video Conference (further details: pcs@ibs.re.kr)**
Scientific coordinators**:**
Peter Talkner (University of Augsburg, Germany)
Tapio Ala-Nissila (Aalto Univ., Finland & Loughborough Univ., UK)
Jayendra Nath Bandyopadhyay (BITS Pilani, India)
Juzar Thingna (PCS IBS)

Overview: The field of open quantum systems is undergoing a rapid phase of development due to the emergence of new devices based on quantum superposition and coherence. In this context, it is crucial to understand: (i) the thermodynamic behavior of small quantum systems, in particular when in contact with an environment; (ii) the related fluctuation relations that connect thermodynamic quantities such as work and free energy of the device; (iii) effects of intermediate and strong coupling to the environment; (iv) many-body effects and their persistence in the presence of dissipation. The aim of the workshop is to bring together leading researchers in this field to present new results and appropriate methodologies to identify and attack the relevant open problems of the field. The invited and contributed talks will cover these aspects related to open quantum systems and also to quantum computing, quantum heat engines, and optimal control of quantum systems.

Topics include:
- Strong coupling and non-Markovian (thermo-)dynamics
- Quantum machines
- Many-body open systems
- Driven open systems
- Fluctuation theorems

For Further information, please contact
Ms. Gileun Lee – pcs@ibs.re.kr
Visitor Program, PCS IBS, Daejeon, Korea

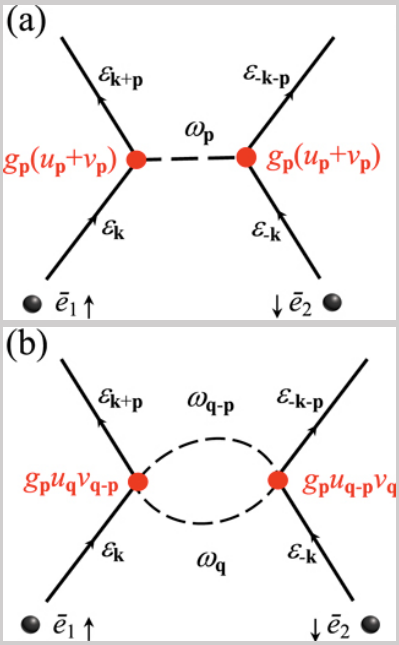
New research results

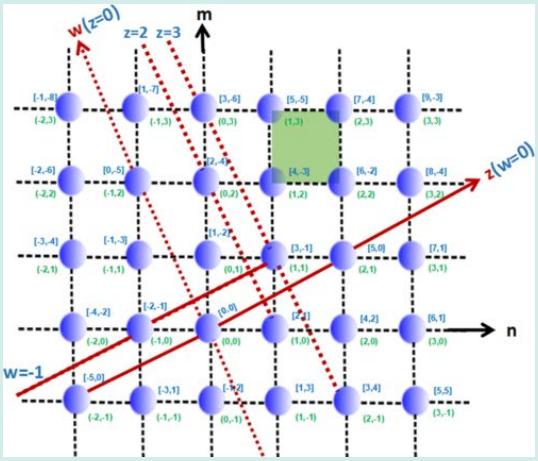
Theory of BCS-like bogolon-mediated superconductivity in transition metal dichalcogenides

New Journal of Physics **23**, 023023
(https://arxiv.org/abs/2005.00203)

Meng Sun, A. V. Parafilo, K. H. A. Villegas, V. M. Kovalev, and I. G. Savenko

The authors have discovered a novel mechanism of superconductivity, which is mediated by pairs of Bogoliubov quasiparticles (bogolons). It takes place in hybrid systems consisting of a two-dimensional electron gas in a transition metal dichalcogenide monolayer in the vicinity of a Bose–Einstein condensate. As a testbed, they consider a system of two-dimensional indirect excitons and show that the bogolon-pair-mediated electron pairing mechanism is stronger than phonon-mediated and single bogolon-mediated ones. The have developed a microscopic theory of bogolon-pair-mediated superconductivity, studied the temperature dependence of the superconducting gap and estimated the critical temperature of superconducting transition for various electron concentrations in the electron gas and the condensate densities.





Wannier-Stark flatbands in Bravais lattices

Physical Review Research **3**, 013174
(https://arxiv.org/abs/2009.02881)

Arindam Mallick, Nana Chang, Wulayimu Maimaiti, Sergej Flach, and Alexei Andreanov

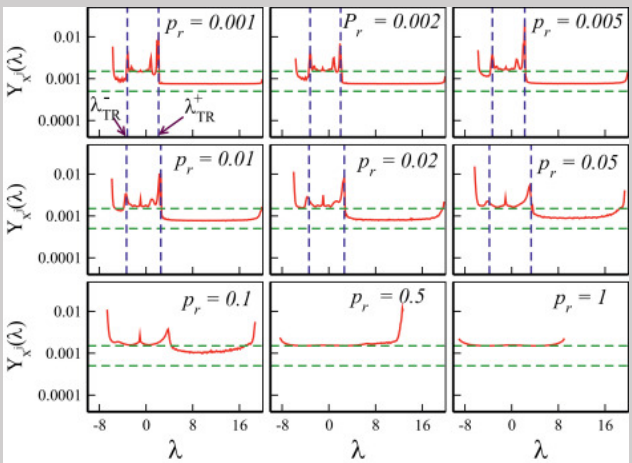
The authors have investigated the effect of adding a DC field to a Bravais lattice tight binding Hamiltonian results in Wannier-Stark flat energy bands and super-exponentially localized wave functions. All it needs is a commensurate field direction, and the absence of equipotential hoppings.

Multifractal analysis of eigenvectors of small-world networks

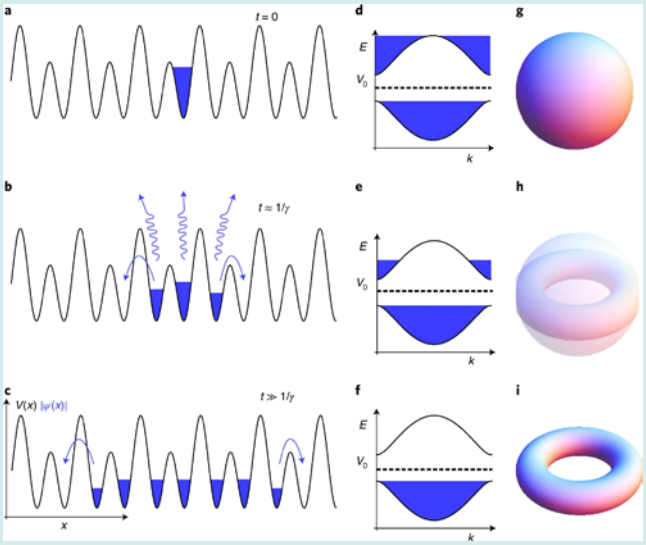
Chaos, Solitons & Fractals **144**, 110745
(https://arxiv.org/abs/2010.09024)

Ankit Mishra, Jayendra N. Bandyopadhyay, and Sarika Jalan

In their landmark paper in1998, Watts and Strogatz proposed a very simple model which captures the small-world transition characterized by the network's structural properties, high clsuetring of the nodes, and small diameter. In this article, the authors demonstrate the existence of another signature of the small-world transition based on changes in the multifractal properties of eigenvectors of underlying adjacency matrices. The results are relevant for a better understanding of dynamical behaviors of corresponding complex systems.



New research results



Probing bulk topological invariants using leaky photonic lattices

Nature Physics (https://arxiv.org/abs/2004.13215)

Daniel Leykam, and Daria A. Smirnova

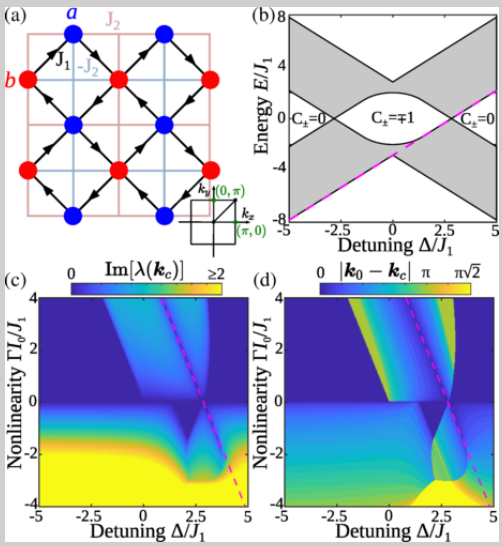
Topological invariants characterizing filled Bloch bands underpin electronic topological insulators and analogous artificial lattices for Bose–Einstein condensates, photonics and acoustic waves. In bosonic systems, there is no Fermi exclusion principle to enforce uniform band filling, which makes measuring their bulk topological invariants challenging. The authors show how to achieve the controllable filling of bosonic bands using leaky photonic lattices. Leaky photonic lattices host transitions between bound and radiative modes at a critical energy, which plays a role analogous to the electronic Fermi level. Tuning this effective Fermi level into a bandgap results in the disorder-robust dynamical quantization of bulk topological invariants such as the Chern number. Their findings establish leaky lattices as a highly flexible platform for exploring topological and non-Hermitian wave physics.

Probing Band Topology Using Modulational Instability

Physical Review Letters **126**, 073901 (https://arxiv.org/abs/2007.15853)

Daniel Leykam, Ekaterina Smolina, Aleksandra Maluckov, Sergej Flach, and Daria A. Smirnova

The authors analyze the modulational instability of nonlinear Bloch waves in topological photonic lattices. In the initial phase of the instability development captured by the linear stability analysis, long wavelength instabilities and bifurcations of the nonlinear Bloch waves are sensitive to topological band inversions. At longer timescales, nonlinear wave mixing induces spreading of energy through the entire band and spontaneous creation of wave polarization singularities determined by the band Chern number. Their analytical and numerical results establish modulational instability as a tool to probe bulk topological invariants and create topologically non-trivial wave fields.



Puzzle of the month

An airplane has 100 seats, and exactly 100 passengers board, one after the other. Each passenger has a correct boarding pass with its seat number printed on it. Among the passengers there is one called X, who does not care about the boarding pass, and who is not the last passenger. When a regular passenger boards, he chooses his seat. But when X boards, he simply chooses randomly and with equal probability an empty seat. The passengers who board after X choose either their seat if it is empty, or otherwise (i.e. if that is already occupied) randomly and with equal probability another empty seat. What is the probability that the last passenger will get his seat?

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

February puzzle answer:

1. 1/3
2. 13/27

The winners are: Kristian Hauser Villegas (1st) and Ihor Vakulchyk (2nd)