# PCS NEWSLETTER

May 2021

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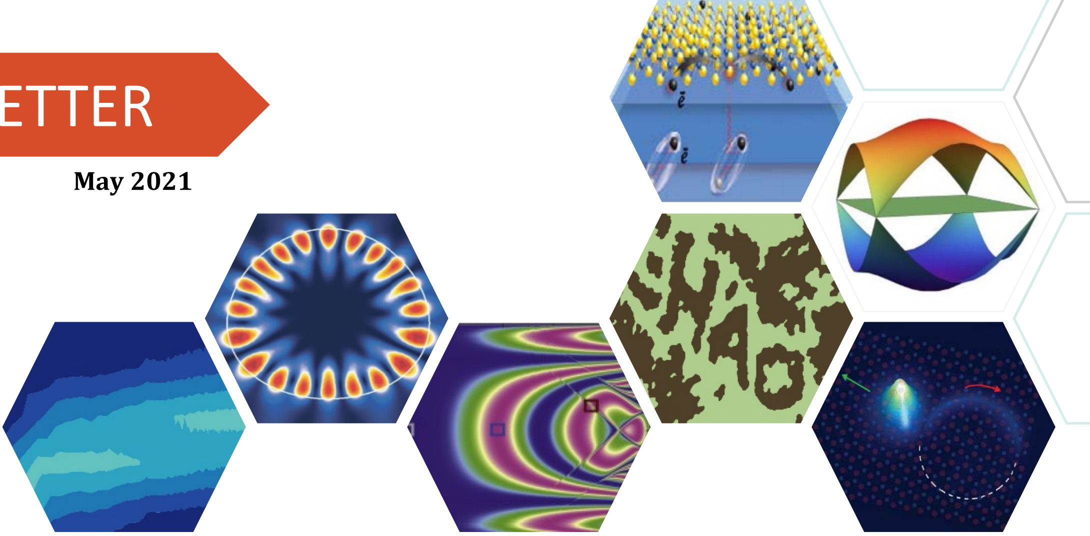


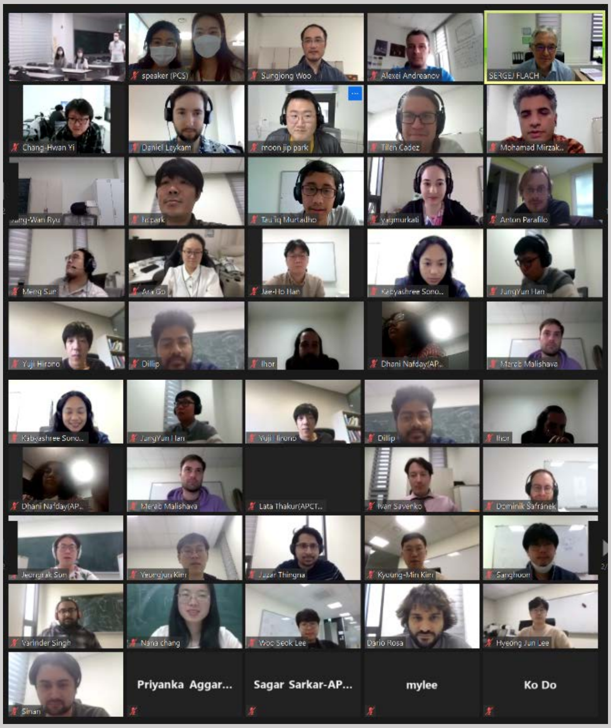
## New member

**Dr. Dillip Kumar Nandy** has joined PCS as a Research Fellow.

His research interests spans to different directions of physics such as few-body physics, fractional quantum Hall models (FQH) derived from conformal field theory (CFT), relativistic electronic structure calculation of atoms using many-body methods. In the few-body physics he especially studies various equilibrium and non-equilibrium phenomena involving ultracold quantum gases. In the study of FQH physics, he does numerical study of CFT-derived models to find out local models from their non-local counterpart. He also does rigorous calculations of different atomic properties using advanced methods such as relativistic coupled-cluster (RCC) method and many-body perturbation theory (MBPT).

## PCS Workshops and Meetings

PCS successfully hosted its **4th Retreat meeting 'Diving Into A Virtual World'** Apr. 28-30. We enjoyed a total of 45 short talks from all PCS members and guest participants from selected Junior Research groups of the Asia-Pacific Center for Theoretical Physics (Pohang).



PCS will run **the International Workshop Quantum Many-Body Dynamics: Thermalization and its Violations** through PCS Video Conference May 24-28.

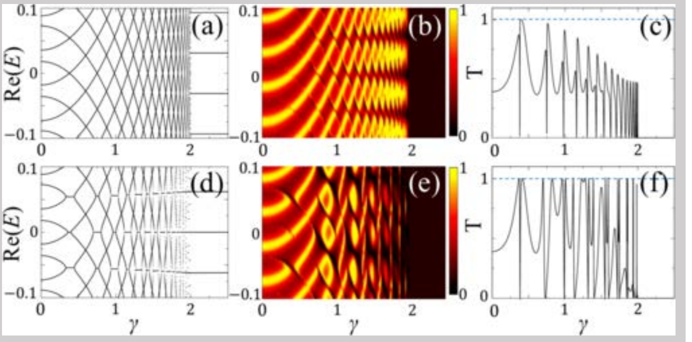
# New research results

## Nonorientability-induced PT phase transition in ladder lattices

Jung-Wan Ryu, Nojoon Myoung, Martina Hentschel, and Hee Chul Park

*Phys. Rev. A* **103**, 042207 (arXiv:2001.10221)

The authors have studied parity-time (PT) phase transitions in the energy spectra of ladder lattices caused by the interplay between nonorientability and non-Hermitian PT symmetry. The energy spectra show level crossings in circular ladder lattices with increasing on-site energy gain-loss because of the orientability of a normal strip. However, the energy levels show PT phase transitions instead of the avoided level crossings of a Hermitian situation in PT-symmetric Möbius ladder lattices due to the nonorientability of a Möbius strip. The latter effectively presents a perturbation that would cause avoided level crossing in a Hermitian situation, but leads, in the presence of PT symmetry, to locked real energy parts and conjugate values of the imaginary parts. They expect the combination of non-Hermiticity with real-space topological structures, like the PT-symmetric Möbius ladder lattice, to broaden the horizon of applications beyond existing non-Hermitian systems.

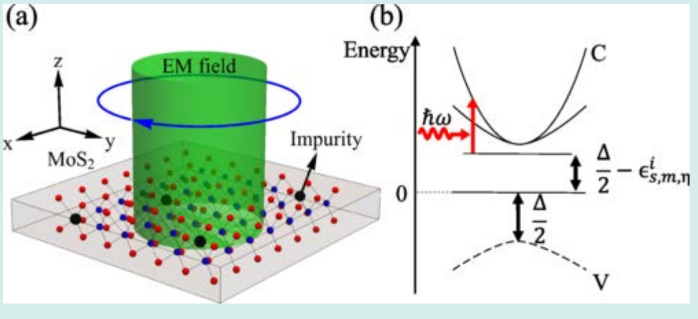



## Optical valleytronics of impurity states in two-dimensional Dirac materials

Dogyun Ko, A. V. Morozov, V. M. Kovalev, I. G. Savenko

*Phys. Rev. B* **103**, L161301 (arXiv:2010.13370)

There have been ascertained and stipulated the generic valley selection rules for optical transitions (in the THz range) from impurity states to the conduction band in two-dimensional gapped Dirac materials, taking a monolayer of $MoS_2$ as an example. An analytical model of a shallow impurity potential was employed, localizing electrons described by a spinor wave function. The absorbance spectrum (two-dimensional absorption coefficient) was found, and the authors have calculated the photon-drag electric current due to the impurity-band transitions.

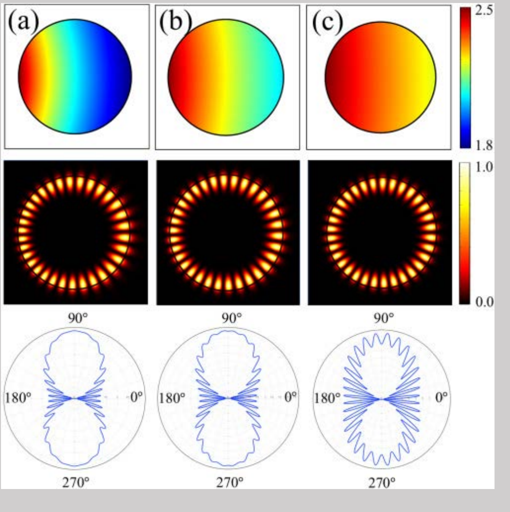


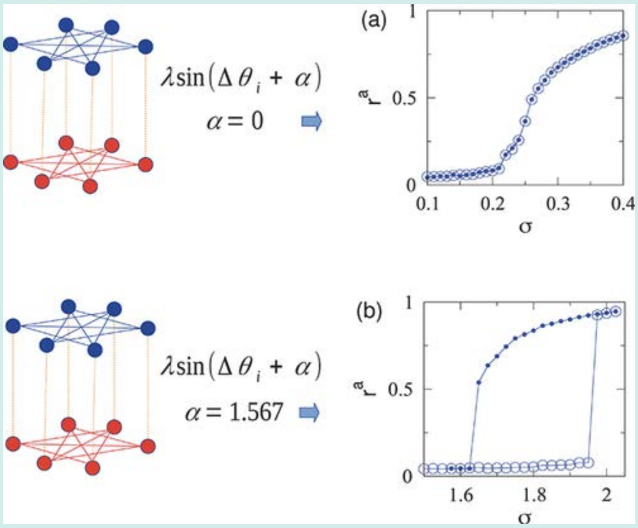

## Transformation cavities with a narrow refractive index profile

Jung-Wan Ryu and Jinhang Cho

*Opt. Lett.* **46(8)**, 1900 (arXiv:2102.09516)

Recently, gradient index cavities, or so-called transformation cavities, designed by conformal transformation optics, have been studied to support resonant modes with both high Q-factors and emission directionality. The authors have proposed a new design method for transformation cavities to realize a narrower width of the refractive index profile, a great advantage in experimental implementations, without losing the benefits of conformal mapping. It is expected that such transformation cavities with narrow refractive index profiles will make a breakthrough in the experimental implementation of microcavity lasers employing conformal transformation optics.






**Explosive synchronization in interlayer phase-shifted Kuramoto oscillators on multiplex networks**

Anil Kumar and Sarika Jalan

*Chaos* **31**, 041103 (arXiv:2101.04330)

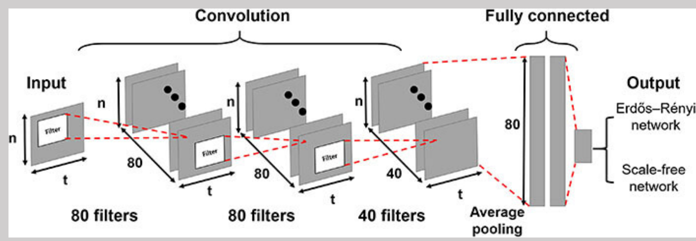
Different methods have been proposed in the past few years to incite explosive synchronization (ES) in Kuramoto phase oscillators. In this work, the authors show that the introduction of a phase shift in interlayer coupling terms of a two-layer multiplex network of Kuramoto oscillators can also instigate ES in the layers. They provide a rigorous mean-field analysis to predict critical coupling strength. They further extend the analytical calculations to classical single layer networks where few specific links are assigned phase-shifted interactions.

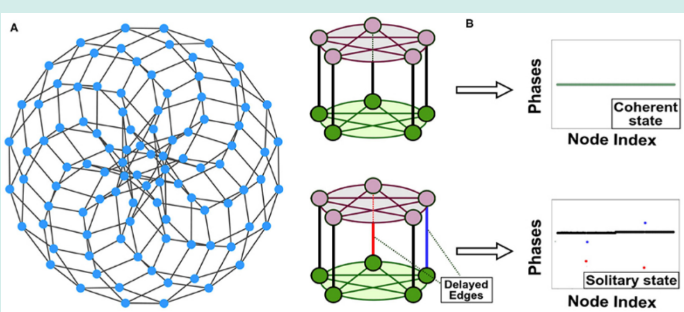
**Machine learning assisted network classification using symbolic time-series**

Atish Pandey, Woo Soek Lee, Subha Sanket Dutta, and Sarika Jalan

*Chaos* **31**, 031106

Machine learning techniques have been witnessing perpetual success in predicting and understanding behaviors of a diverse range of complex systems. By employing a deep learning method on limited time-series information of a handful of nodes from large-size complex systems, the authors label the underlying network structures in different classes. The two biggest advantages of their method over previous existing methods are its simplicity and requirement of the time evolution of one largest degree node to predict the classification of large-size networks with remarkable accuracy.




**Machine Learning assisted Chimera and Solitary states in Networks**

N Kushwaha, NK Mendola, S Ghosh, AD Kachhvah, S Jalan

*Front. Phys.* **9**, 513969 (arXiv:2011.01135)

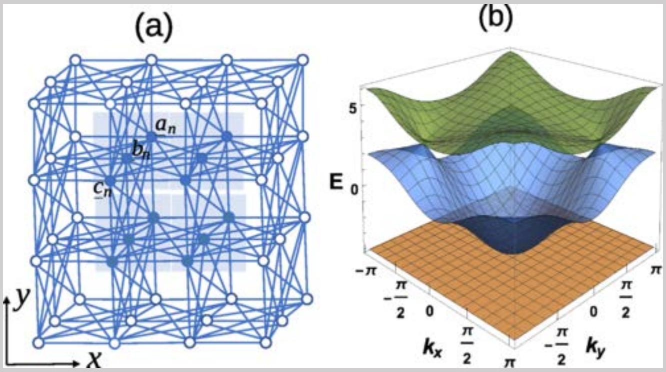
Symmetry breaking spatial patterns, referred to as chimera states, have recently been catapulted into the limelight due to their coexisting coherent and incoherent hybrid dynamics. Using supervised machine learning, the authors provide a methodology for designing experimental setups to create solitary and chimera states.

**Flat-band generator in two dimensions**

Wulayimu Maimaiti, Alexei Andreanov, and Sergej Flach

*Phys. Rev. B* **103**, 165116 (arXiv:2101.03794)

Flatbands -- dispersionless bands -- are an excellent testbed for novel physical phases due to their fine-tuned character: the accompanying macroscopic degeneracy makes any perturbations relevant, no matter how small. Short-range hopping Hamiltonians with flatbands support compact localised states (CLS), which allowed us to develop systematic flatband generators in 1D in Phys. Rev. B 95 115135 (2017) and Phys. Rev. B 99 125129 (2019). Here we extend this generator approach to 2D: the shape of the CLS turns into an important additional flatband classifier. We obtained analytical solutions for new classes of 2D flatband networks and rediscovered the known networks, such as checkerboard, kagome, Lieb and Tasaki lattices. Our generator generalises directly to 3D lattices.




## Puzzle of the month

New technologies invade our kitchens. Among them there is the electric egg cooker, also called egg boiler. The term ′egg steamer′ would suit better, since the eggs are steamed rather than boiled. The typical egg cooker can host up to seven eggs. We take exactly three eggs from the fridge and place them in the corresponding spots of the egg tray. The tray and the eggs are suspended above the heating plate. A certain and relatively small amount of water is poured into a measuring cup.

That water is then emptied into the heating plate. Note that the eggs are still fully suspended in air, without water contact. The transparent lid is put on top and is covering the entire device. There are small holes in the lid. The device is then switched on and powered at about 300-400 Watts. The water heats up and boils producing steam. The hot steam rises and heats up the eggs. Some vapor escapes through the lid holes. After approximately 17 steaming minutes all the water evaporated from egg cooker, and a loud beep signals to switch off the device. The eggs appear to be boiled to the desired degree of hard-boiling condition (hard boiling eggs in a pot with boiling water takes a bit less - about 14 minutes).

Now we want to repeat the experiment with four eggs. Do we need to add more water to the measuring cup, or less, or the same amount? Why? How much more or less if not the same? What is the egg shell temperature during the steaming process?

Send your solution to eun@ibs.re.kr

The winner will be announced in the next issue.

*April puzzle answer :*

Divide the unknown interval (1-999 at the beginning) into three equal length intervals. So initially 1-333, 334-666, 667-999.
Ask Shirin: 'Hey Shirin, I just picked a number between 334 and 666. Is yours larger than mine?
If Shirin says 'yes', then her number in in the interval 667-999.
If she says 'no' her number is in the interval 1-333.
If she replies 'don't know' her number is in 334-666.
Then divide the relevant interval again into three equal length sub-intervals, and repeat.

Note, since no further information on Shirin was given, we can not assume that she has a PhD in Mathematics or similar.
Therefore the submitted solutions by the following winners are formally correct,
but completely off the common sense, as they assume Shirin knows what a 3-adic number is, or what Chaitin's constant is (not).

The winners are: Dongok Kim (CAPP@IBS) and Ihor Vakulchyk (PCS@IBS).
Try to be more realistic next time!