PCS NEWSLETTER

July 2021

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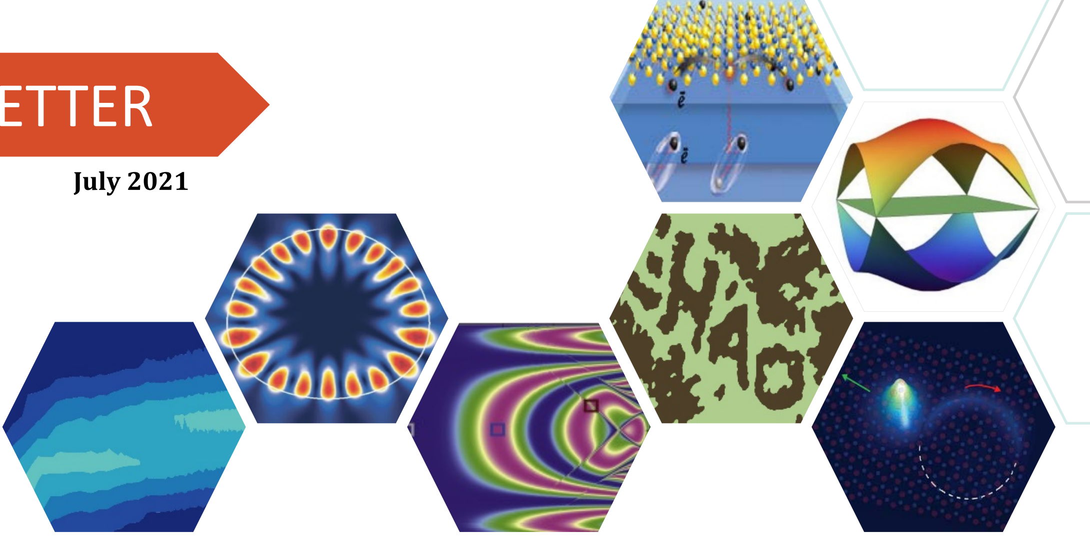


Recruitment

PCS is recruiting postdoctoral fellows and Ph.D students for two research teams, Quantum Chaos in Many-Body Systems led by Dario Rosa and Topological and Correlated Quantum Matter led by Moon Jip Park.

Member news

Congratulations!
Former PCS student trainee Nana Chang, who stayed at PCS from August 2019 through May 2021, has obtained her Ph.D at Beijing Normal University.

IBS Conference

We will organize an *IBS Conference on* ***Flatbands****, August 16 – 20, 2021*.
To apply for participation in the conference, complete the online application form by July 31, 2021.

For further information, see **pcs.ibs.re.kr** or contact the PCS Visitor Program at **pcs@ibs.re.kr**

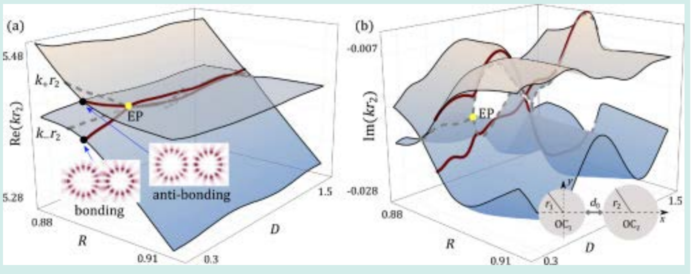
New research results

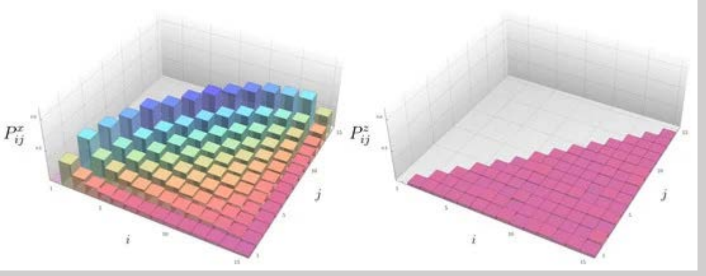
Salient role of the non-Hermitian coupling for optimizing conditions in multiple maximizations of inter-cavity light transfer

Hyeon-Hye Yu, Sunjae Gwak, Hyundong Kim, Jung-Wan Ryu, Chil-Min Kim, and Chang-Hwan Yi

Opt. Express **29**, 19998-20009

This paper unveils that non-Hermitian lossy couplings in an inter-cavity light transfer process are crucial for optimum light transfer. The results turn out the fact that the light transfer can have multiple maxima following the increased inter-cavity distance. The demonstrations are carried out in the vicinity of the so-called exceptional point (EP), covering both weak and strong coupling regimes. The results can contribute to realizing coupled-optical-cavity-based devices which is functional with an ultra-efficient light transfer, especially when the device scale is as small as the operation wavelength.





Unveiling Operator Growth Using Spin Correlation Functions

Matteo Carrega, Joonho Kim, and Dario Rosa

[Entropy 2021, **23**(5), 587](#)

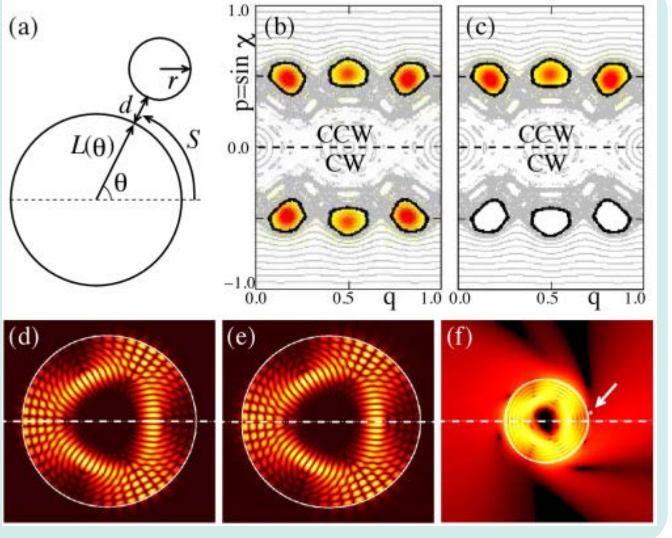
In this paper the authors present evidences that the time evolution of simple spin-spin correlation functions under a quantum quench can be used to detect the chaotic properties of the quench Hamiltonian. More in details, they argue that the strength of the late-time fluctuations can quantitatively distinguish between operator hopping and operator growth; the latter being at the hallmark of quantum chaos. Their proposal allows to detect the onset of quantum chaos without relying on the out-of-time-correlators, thus providing a promising new tool rather accessible in state-of-the-art quench setups.

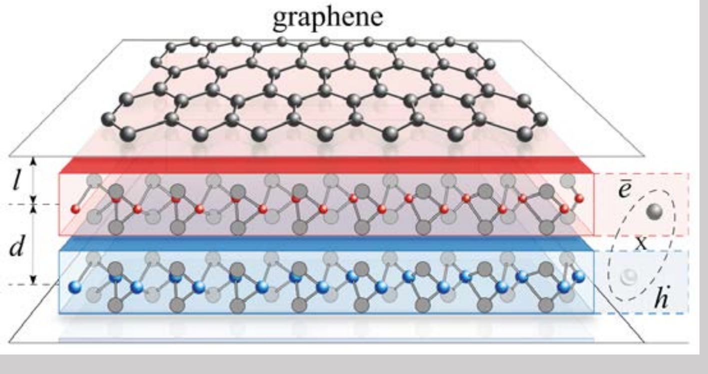
Rayleigh scatterer-induced steady exceptional points of stable-island modes in a deformed optical microdisk

Sunjae Gwak, Hyundong Kim, Hyeon-Hye Yu, Jinhyeok Ryu, Chil-Min Kim, and Chang-Hwan Yi

[Opt. Lett. **46**, 2980-2983](#)

In this paper, a formation of second-order non-Hermitian degeneracies, called exceptional points (EPs), in a chaotic oval-shaped dielectric microdisk is studied. Different symmetric optical modes localized on a stable period-3 orbit coalesce to form unidirectional propagating chiral EP modes. It is revealed that the scatterer positions for counterpropagating EP modes are far distant from one another and almost steady against varying scatterer sizes. The results can contribute to establishing a more solid platform for EP-based-device applications with flexibility and easy feasibility in obtaining EPs.





Bose–Einstein condensate-mediated superconductivity in graphene

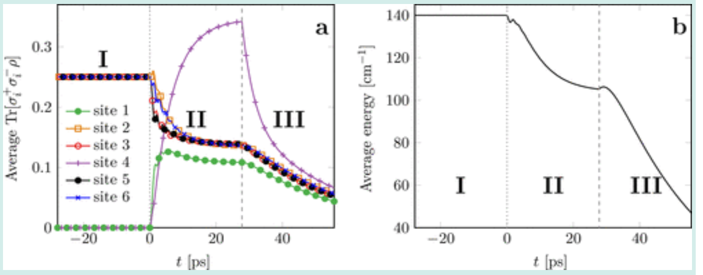
Meng Sun, A V Parafilo, K H A Villegas, V M Kovalev and I G Savenko

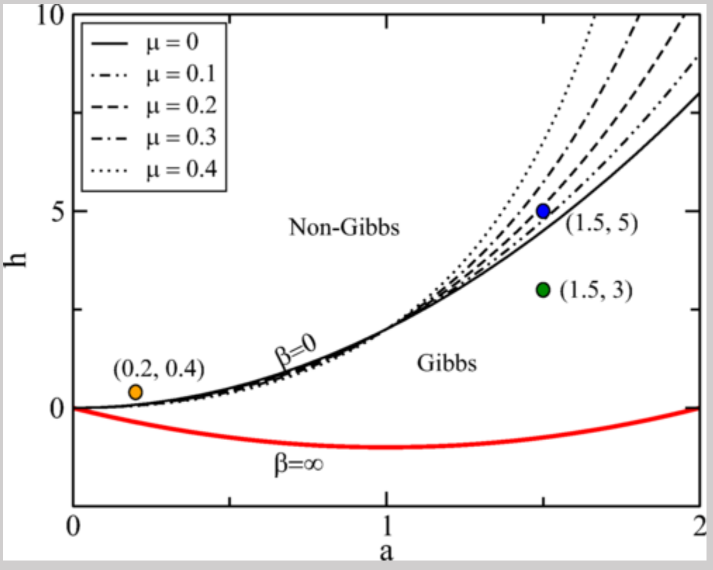
[2D Materials **8**, 031004](#) ([arXiv:2009.01007](#))

The authors propose a mechanism for Bardeen–Cooper–Schrieffer-like superconductivity in graphene placed in the vicinity of a Bose-Einstein condensate. Electrons in the graphene interact with the excitations above the condensate, called Bogoliubov quasiparticles (or bogolons) by Coulomb interaction. They study the behavior of the superconducting gap and calculate critical temperatures in cases with single-bogolon and bogolon-pair-mediated pairing processes, accounting for the complex band structure of graphene.

Comment on “Loss-Free Excitonic Quantum Battery”
Álvaro Tejero, Juzar Thingna, and Daniel Manzano
[J. Phys. Chem. C **125**, 7518-7520]

The authors comment on a previous study titled "Loss-Free Excitonic Quantum Battery," claiming that dissipative devices that possess decoherence-free subspaces can be efficient quantum batteries. The original claim was based on charge repositioning in the device, a commonly used measure in photosynthetic complexes. The authors show that such devices could not operate as a battery from a thermodynamic viewpoint since they cannot hold the energy to perform work. They turn out to be "leaky" batteries that continuously lose energy even though the charge is conserved.



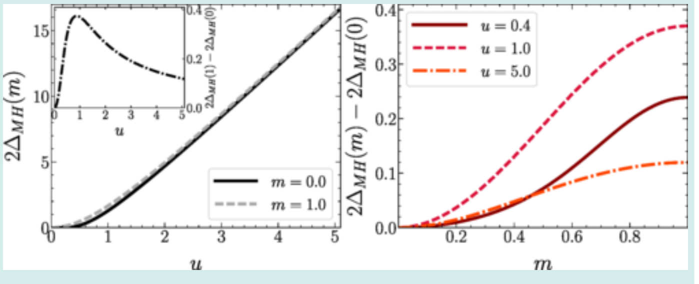


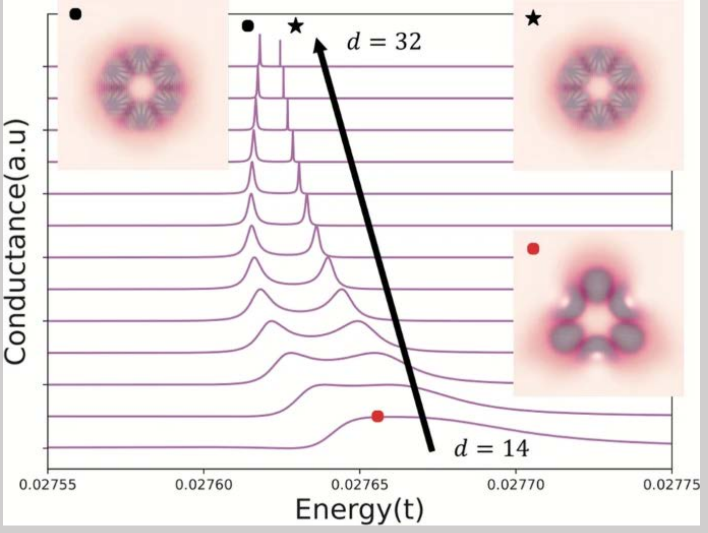
Thermalization in the one-dimensional Salerno model lattice
Thudiyangal Mithun, Aleksandra Maluckov, Bertin Many Manda, Charalampos Skokos, Alan Bishop, Avadh Saxena, Avinash Khare, and Panayotis G. Kevrekidis
[Phys. Rev. E **103**, 032211]

The Salerno model constitutes an intriguing interpolation between the integrable Ablowitz-Ladik model and the more standard (nonintegrable) discrete nonlinear Schrödinger one. The competition of local on-site nonlinearity and nonlinear dispersion governs the thermalization of this model. In this paper, the authors investigate the statistical mechanics of the Salerno one-dimensional lattice model in the nonintegrable case and illustrate the thermalization in the Gibbs regime. They have found that the thermalization in the non-Gibbs regime heavily depends on the finite system size using direct numerical computations for different parametric regimes.

One-particle spectral functions of the one-dimensional Fermionic Hubbard model with one fermion per site at zero and finite magnetic fields
José M. P. Carmelo, Tilen Čadež, and Pedro D. Sacramento
[Phys. Rev. B **103**, 195129]

Using the Bethe ansatz the authors study the one-particle spectral functions in the one-dimensional half-filled Hubbard model in both zero and finite magnetic field. The one-particle excitations are gapped and exhibit fractionalization leading to the phenomenon of the spin-charge separation. They calculate the Mott-Hubbard gap, the one-particle excitation spectra, the exponents of the power law divergencies along the most important lines in the spectra (called branch lines) and discuss the relation of our results to the condensed-matter and ultracold spin-1/2 atom systems.





Electronic states of graphene quantum dots induced by nanobubbles

Hee Chul Park, Minsol Son, Seung Joo Lee, and Nojoon Myoung

[Journal of the Korean Physical Society **78**, 1208-1214]

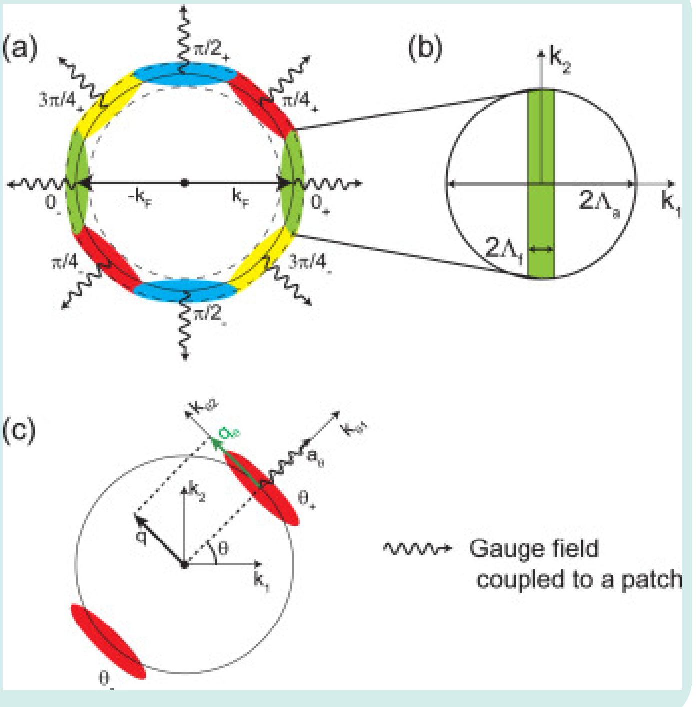
The authors study the electronic structures and quantum transport properties of graphene subject to a nano bubble, reporting that the presence of strain-induced pseudo-magnetic fields (PMFs) facilitates a strong confinement of Dirac fermions. A circular geometry of the nano bubble locally establishes the characteristic PMFs with C3 symmetry, resulting in threefold localized states according to the given symmetry. They demonstrate the formation of a graphene quantum dot induced by local strain via the conductance resonances. They also show a valley-polarization in the graphene QD due to the quantum interference between symmetric and anti-symmetric valley-coupled modes.

Role of generic scale invariance in a Mott transition from a U(1) spin-liquid insulator to a Landau Fermi-liquid metal

Jinho Yang, Iksu Jang, Jae-Ho Han, Ki-Seok Kim

[Annals of Physics **429**, 168462]

The authors investigate the role of generic scale invariance in a Mott transition from a U(1) spin-liquid insulator to a Landau Fermi-liquid metal. Here, the Mott quantum criticality is described by critical charge fluctuations while additional gapless excitations are U(1) gauge-field fluctuations coupled to a spinon Fermi surface in the spin-liquid state. They find that the curvature term along the angular direction of the spinon Fermi surface is responsible for divergence of the self-energy correction term in U(1) gauge-field fluctuations. Although such overdamped gauge-field fluctuation has no renormalization effects on the effective dynamics of charge fluctuations and spinon excitations, the coupling between U(1) gauge-field fluctuations and the two matter-field excitations persists at this Mott transition resulting in novel mean-field dynamics to explain the nature of the spin-liquid Mott quantum criticality.



Puzzle of the month

June puzzle answer:

About 10g less water is needed. The surface temperature is around 81 degrees Celsius.
The entire heat transfer to the eggs is due to latent heat from steam condensation.
Since the density of the steam is about 1600 times smaller than that of water, inelastic steam molecule collisions alone would result in about 11 days of preparation time. Approximating an egg by an equivalent amount of water, the energy to heat that water from 5 degrees to 100 degrees Celsius is about 24kJ. Since the latent heat per 1g of steam/water is 2264 J/g, we will return about 10g of steam through condensation back onto the heating plate. So we need less water for the same preparation time.
And since the time to steam is about 20% more than to boil, the temperature difference between the shell and the cold inner part (initially at 5 degrees Celcius) is about 20% smaller - instead of 95 degrees only 76. Plus the fridge temperature makes 81.
The experimental data are 12 g water, and 87 degrees Celcius. Not bad for a back on the envelope calculation.

The best and closest answer was delivered by Yeongjun Kim (IBS PCS). Congratulations!

Puzzle of the month:

An hour glass has all the sand in the bottom part. Measure the weight. Then put the clock on a scale with the sand in the top part. The sand will fall down, and for a certain time (say for 5 minutes) the scale will be in a stationary state, showing some weight. Is that more, equal, or less than the one from the first measurement?

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