PCS NEWSLETTER

October 2024

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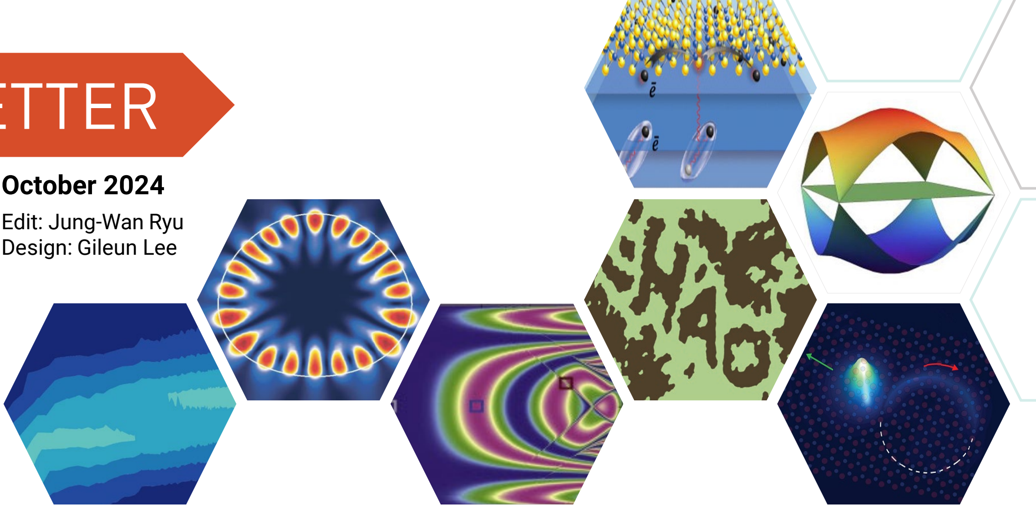


PCS IBS Seminars

"Probing dark energy and inflation using DESI"
by Hee-Jong Seo, Ohio University, USA (September 3), *IBS Physics Colloquium @ Daejeon*

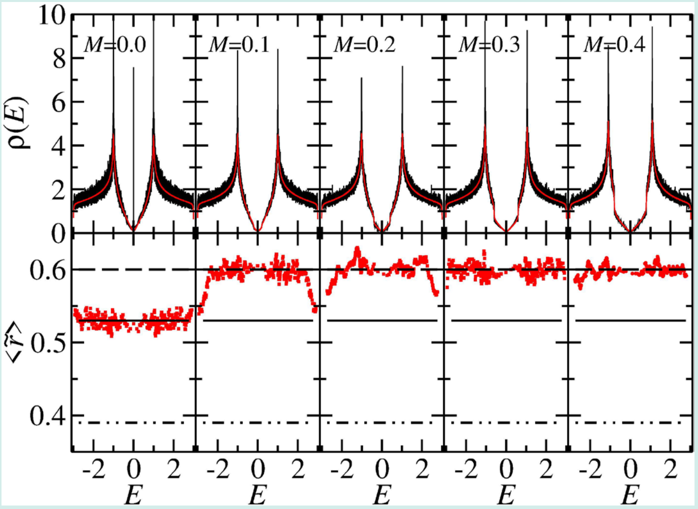
"Unification of observational entropy with maximum entropy principles"
by Joe Schindler, University Autonoma of Barcelona, Spain (September 24)

You can find more seminars on this page.

New Research Results

Haldane graphene billiards versus relativistic neutrino billiards
Dung Xuan Nguyen and Barbara Dietz
Phys. Rev. B 110, 094305 (2024)

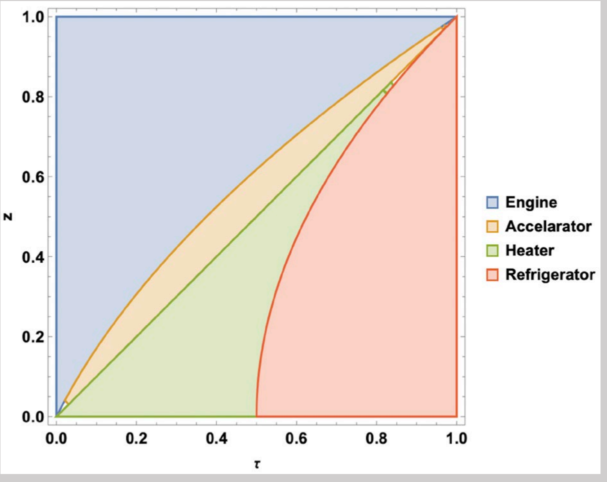
The study explores energy spectra fluctuations in finite-size honeycomb lattices, or "Haldane graphene billiards," influenced by the Haldane model. These billiards have different shapes and dynamics, and their spectral properties show a phase transition from nonrelativistic quantum billiards to neutrino billiards, especially near Dirac points where the spectrum follows the relativistic Dirac equation. The transition from nonrelativistic to relativistic behavior is controlled by adjusting Haldane parameters.



Institute for Basic Science

Center for Theoretical Physics of Complex Systems

New Research Results



Performance analysis of quantum harmonic Otto engine and refrigerator under a trade-off figure of merit

Kirandeep Kaur, Shishram Rebari and Varinder Singh

[J. Non-Equilib. Thermodyn. (2024)]

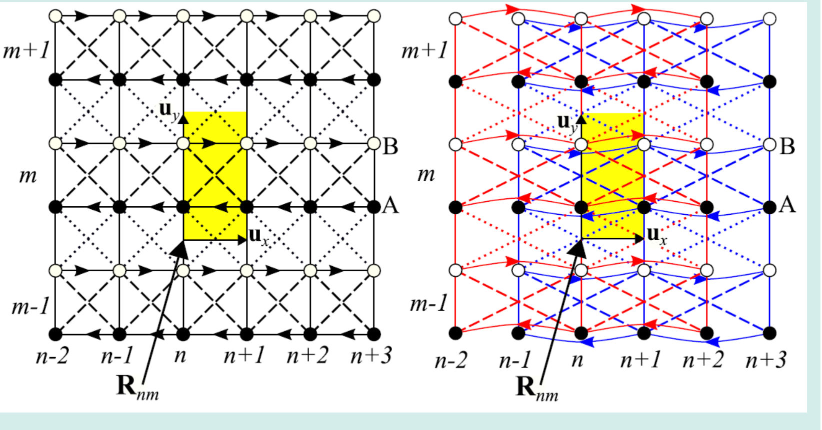
In this work, the authors investigate the optimal performance of the quantum Otto engine and refrigeration cycles of a time-dependent harmonic oscillator under a trade-off figure of merit for both adiabatic and nonadiabatic (sudden-switch) frequency modulations. For heat engines (refrigerators), the chosen trade-off figure of merit is an objective function defined by the product of efficiency (coefficient of performance) and work output (cooling load), thus representing a compromise between them. The authors obtain analytical expressions for the efficiency and coefficient of performance of the harmonic Otto cycle for the optimal performance of the thermal machine in various operational regimes. They show that the frictional effects give rise to a richer structure of the phase diagram of the harmonic Otto cycle. The authors identify the parametric regime for the operation of the Otto cycle as a heat engine, refrigerator, accelerator, and heater.

Engineering high Chern number insulators

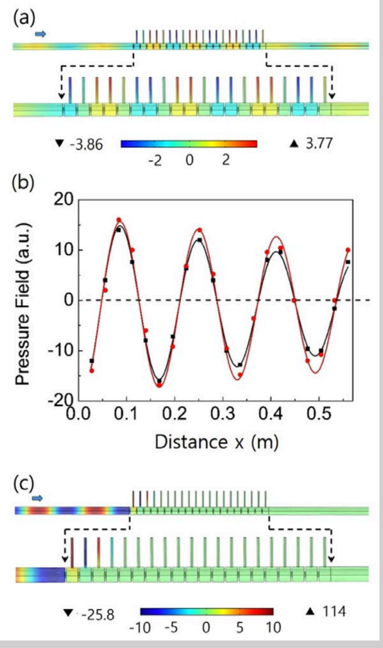
Sungjong Woo, Seungbum Woo, Jung-Wan Ryu & Hee Chul Park

[Journal of the Korean Physical Society (2024)]

The authors introduce a systematic method to directly construct two-dimensional Chern insulators that can provide any nontrivial Chern number. Their method is built upon the one-dimensional Rice–Mele model, which is well known for its adjustable polarization properties, providing a reliable framework for manipulation. By extending this model into two dimensions, they are able to engineer lattice structures that demonstrate predetermined topological quantities effectively. This research not only contributes the development of Chern insulators but also paves the way for designing a variety of lattice structures with significant topological implications, potentially impacting quantum computing and materials science.



New Research Results

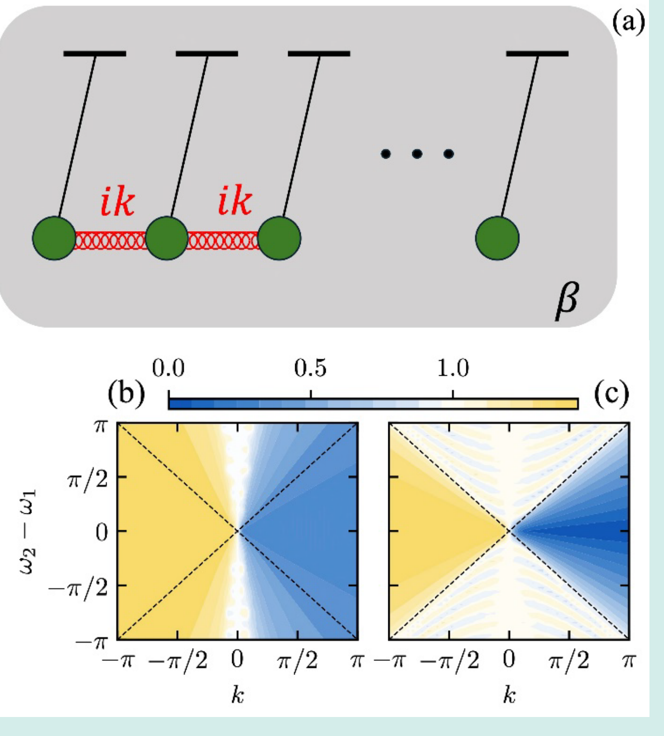


Realization of unidirectional zero reflection based on a loss–gain balanced metamaterial
Chang-Hwan Yi, Geo-Su Yim, Sang Hun Lee
[Appl. Phys. Lett. 125, 071702 (2024)]

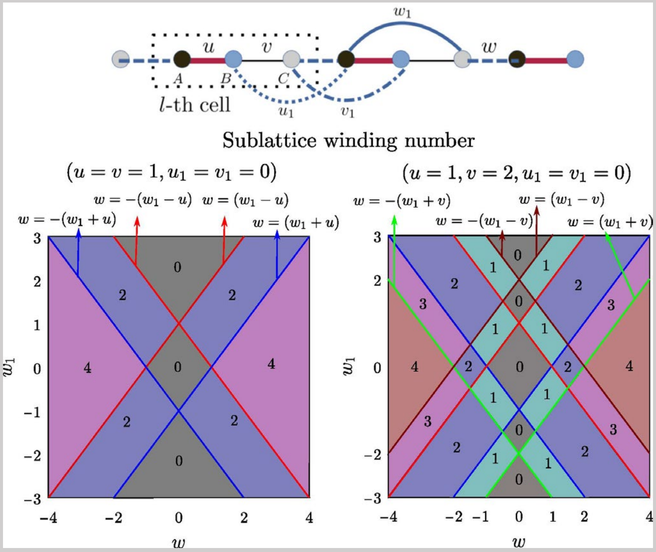
This study investigates the development of an acoustic metamaterial designed for unidirectional zero reflection based on parity-time symmetry principles. The metamaterial comprises one-dimensional unit cells made of orifice-type loss materials and cylindrical closed-end tubes as gain materials. Experimental analysis demonstrated the material's ability to achieve unidirectional zero reflection and bidirectional zero transmission under specific frequency conditions. These findings suggest that such materials could be useful in advanced acoustic control applications.

Energetic Cost for Speedy Synchronization in Non-Hermitian Quantum Dynamics
Maxwell Aifer, Juzar Thingna, and Sebastian Deffner
[Phys. Rev. Lett. 133, 020401 (2024)]

Quantum synchronization has attracted a lot of attention in recent years from a fundamental perspective, bringing classical ideas of synchronization to the quantum regime, and as a tool to design efficient quantum devices. The authors of this study ask two fundamentally relevant questions that would make quantum synchronization technologically relevant, namely, how long does it take for a quantum system to synchronize and what is the energetic cost of such synchronization? Using tools from quantum open systems, non-Hermitian physics, quantum thermodynamics, quantum speed limits, and quantum synchronization the authors not only bound the time and energy needed for a quantum system to synchronize but also show distinct quantum advantages. Specifically, the authors find that even though small quantum systems synchronize slower than their classical counterparts, they are energetically more efficient. Moreover, quantum synchronization is more resilient and robust than its classical counterpart. Thus quantum systems can synchronize in regimes where their classical counterparts can't do so. The theoretical findings are now experimentally tested at Yale and Harvard to help improve quantum communication protocols.



New Research Results



Bulk-boundary correspondence in extended trimer Su-Schrieffer-Heeger model

Sonu Verma and Tarun Kanti Ghosh

[Phys. Rev. B 110, 125424 (2024)]

The authors consider an extended trimer Su-Schrieffer-Heeger (SSH) tight-binding Hamiltonian keeping up to next nearest-neighbor (NNN)-hopping terms and on-site potential energy. The system lacks full chiral symmetry since the energy spectrum is not symmetric around zero, except at isolated Bloch wave vectors. The authors find three different kinds of topological phase transitions, which are classified based on the gap closing points in the Brillouin zone (BZ) while tuning the nearest-neighbor (NN)- and NNN-hopping terms. They find that quantized changes (in units of π) in two out of three Zak phases characterize these topological phase transitions in the inversion symmetric chain. Utilizing some concepts from non-Hermitian topological physics, the authors propose another bulk topological invariant, namely the sublattice winding number, which also characterizes the topological phase transitions. The sublattice winding number not only provides a relatively simple analytical understanding of topological phases but also successfully establishes bulk-boundary correspondence without inversion symmetry, which may help characterize the bulk-boundary correspondence of systems without chiral and inversion symmetry.

Puzzle of the Month

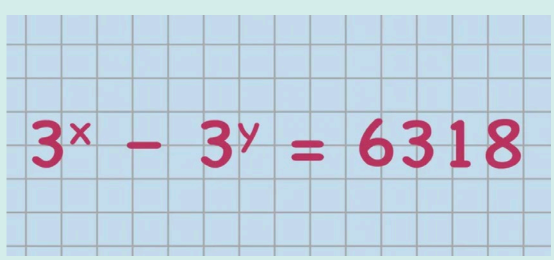
September puzzle solution:

'This sentence contains
1 times the number 0,
7 times the number 1,
3 times the number 2,
2 times the number 3,
1 times the number 4,
1 times the number 5,
1 times the number 6,
2 times the number 7,
1 times the number 8,
1 times the number 9.'

The correct solution was sent in by Oleg Utesov. Congratulations!

October puzzle:

Find all pairs of natural numbers x, y which solve



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