PCS NEWSLETTER

QR to PCS Webpage

September 2023
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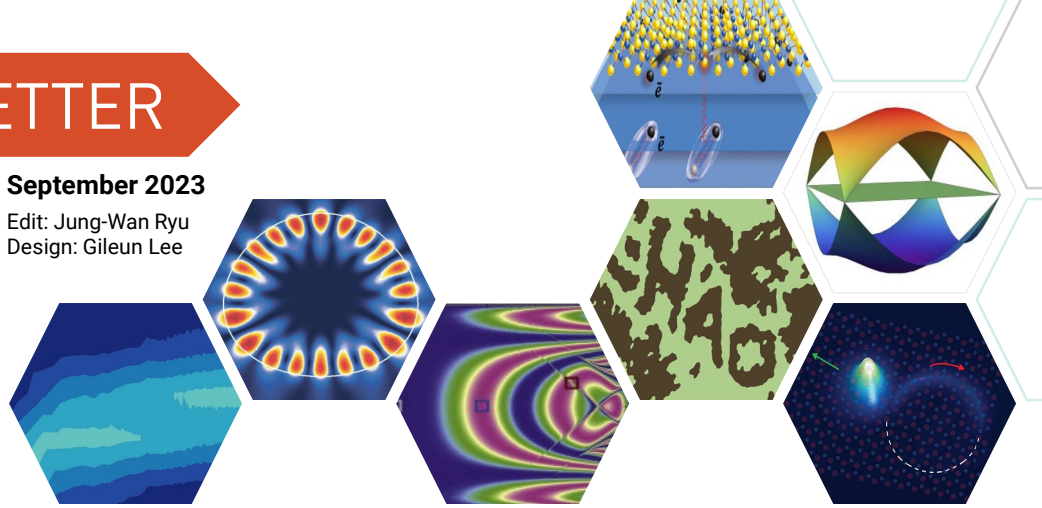


New Members

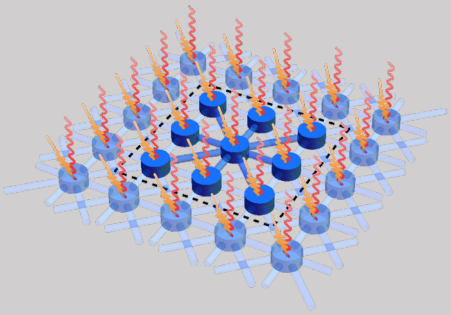
Dr. Budhaditya Bhattacharjee has joined PCS as a post-doctoral fellow. He recently received his PhD from the Indian Institute of Science, India. His main research interests are quantum chaos in many body systems, with a focus on operator complexity and entanglement dynamics, in both open and closed systems.

Awards

Congratulation!
Dr. Kabyashree Sonowal won the 'Excellence Award' from UST for her brilliant thesis.

PCS Workshops and Meetings

PCS will run and host International Workshop on Polaritons in Emerging Materials on September 11 – September 15, 2023.



PCS Seminars

"Superconducting Nanostrip Detectors for Dark-Matter Search"
by Karl K. Berggren, Massachusetts Institute of Technology, USA (August 1), *IBS Physics Colloquium @ Daejeon*

"Many-body localization in Wannier-Stark ladders with long-range interactions"
by Andrii Sotnikov, V.N. Karazin National University, Ukraine (August 8)

"Quantum thermal machines in coupled spin systems: The role of anisotropic interaction"
by Chayan Purkait, Indian Institute of Technology Ropar, India (August 10)

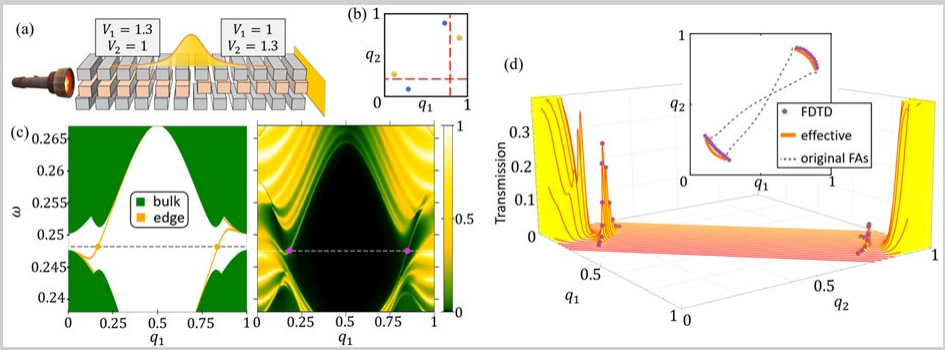
"Janh-Teller polaron in the spin-orbit multipolar magnetic oxide Ba2NaOsO6"
by Lorenzo Celiberti, University of Vienna, Austria (August 28)

"No-signaling nonlinear thermodynamic consistent models of open quantum dynamics"
by Rohit Kishan Ray, Indian Institute of Technology Kharagpur, India (August 29)

You can find more seminars on ***this page***.

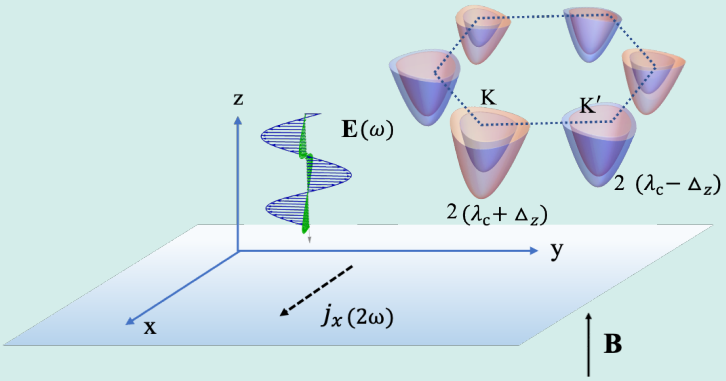
New Research Results

Fermi Arc Reconstruction in Synthetic Photonic Lattice
D.-H.-Minh Nguyen, Chiara Devescovi, Dung Xuan Nguyen, Hai Son Nguyen, and Dario Bercioux
Phys. Rev. Lett. 131, 053602 (2023)



This research confirms the existence of novel topological-protected interface states between two Weyl semimetals in a photonic lattice different from the well-known Fermi arcs. The authors investigate a trilayer photonic grating whose relative displacements between adjacent layers play the role of two synthetic momenta; the 1D system emulates 3D topological crystals, including Weyl semimetals, nodal line semimetals, and Chern insulators. The research paves the way for a better understanding of topological phenomena in photonic lattices and related systems, promising potential applications in designing novel photonic devices and materials with topological features.

New Research Results



Second-harmonic generation in fluctuating Ising superconductors

K Sonowal, A V Parafilo, M V Boev, V M Kovalev and I G Savenko

2D Materials 10, 045004 (2023)

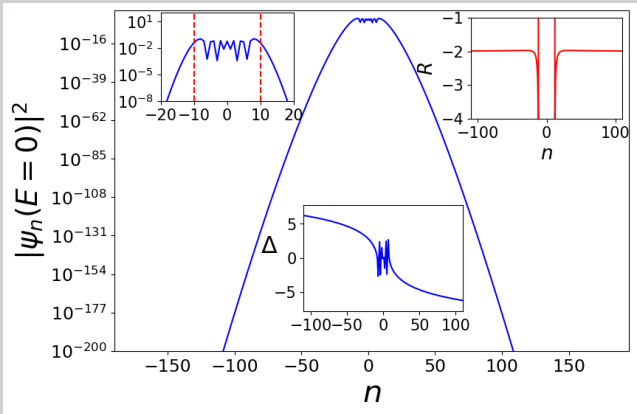
In this work, the authors investigate the second-harmonic generation (SHG) effect in a two-dimensional noncentrosymmetric transition metal dichalcogenide Ising superconductor in the fluctuating regime under the action of a uniform external electromagnetic field. There emerge two contributions to this effect, one conventional, which is due to the electron gas in its normal state, and the other one is of the Aslamazov–Larkin nature. Namely, it originates from the presence of fluctuating Cooper pairs in the system when the temperature approaches the temperature of the superconducting transition in the sample from above. Employing a usual approach to Ising superconductors, the authors lift the valley degeneracy by application of a weak out-of-plane external magnetic field, which produces a Zeeman effect. In calculations, the authors use the Boltzmann equations approach for the electron gas in the normal state, and the time-dependent Ginzburg–Landau equations for the fluctuating Cooper pairs, and show the emergence of SHG electric current characterized by a temperature-dependent broadening and a redshift.

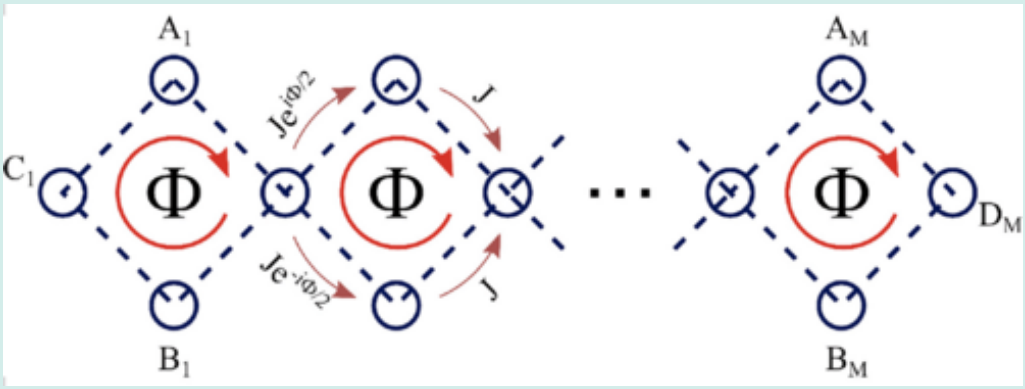
Intermediate superexponential localization with Aubry-André chains

Arindam Mallick, Alexei Andreanov, and Sergej Flach

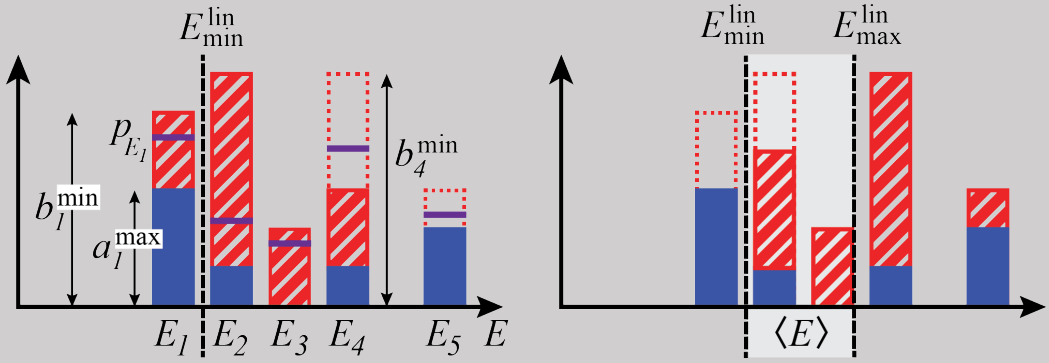
Phys. Rev. B 108, 064204 (2023)

The authors demonstrate the existence of an intermediate superexponential localization regime for eigenstates of the Aubry-André chain in both its metallic and insulating phases. While in the insulating phase, superexponential localization is periodically interrupted by weaker decaying tails to form the conventional asymptotic exponential decay, in the metallic phase, superexponential localization is a transient phenomenon. The superexponential decay emerges on intermediate length scales for large values of the winding length—the quasiperiod of the Aubry-André potential. A similar intermediate superexponential localization regime is demonstrated in quasiperiodic discrete-time unitary maps.



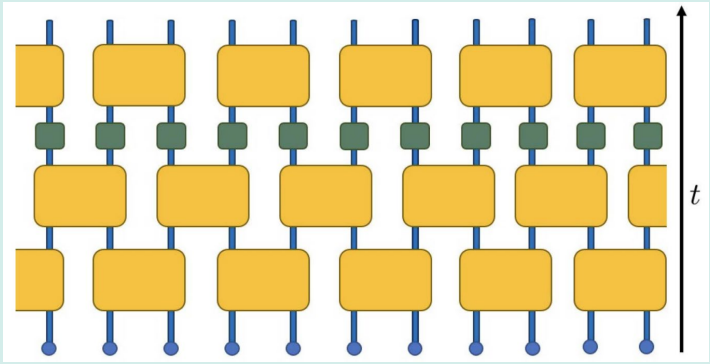


Conductance transition with interacting bosons in an Aharonov-Bohm cage
A. R. Kolovsky, P. S. Muraev, and S. Flach
Phys. Rev. A 108, L010201 (2023)
The authors study the transport of interacting bosons through an Aharonov-Bohm cage—a building block of flat-band networks —with coherent pump and sink leads. In the absence of interactions the cage is insulating due to destructive interference. They find that the cage stays insulating up to a critical value of the pump strength in the presence of mean-field interactions, while the quantum regime induces particle pair transport and weak conductance below the critical pump strength. A swift crossover from the quantum into the classical regime upon further pump strength increase is observed. The authors solve the time-dependent master equations for the density matrix of the many-body problem in the classical, pure quantum, and pseudoclassical regimes. They start with an empty cage and switch on driving. They characterize the transient dynamics, and the complexity of the resulting steady states and attractors. The results can be readily realized using experimental platforms involving interacting ultracold atoms, superconducting circuits, and photons on fine-tuned optical lattices.



Measuring energy by measuring any other observable
Dominik Šafránek and Dario Rosa
Phys. Rev. A 108, 022208 (2023)
The authors develop a method to estimate the probabilities of outcomes of a quantum observable, its mean value, and higher moments by measuring any other observable. It uses interplay and correlations between the measured observable, the estimated observable, and the state of the system. The authors apply this method to estimate the mean energy of states in four types of quantum many-body systems, and show that performing two-qubit measurements excludes 97.5% and 96.7% of the possible range of energies, respectively, when estimating the ground-state energy.

New Research Results



Universal Anderson localization in one-dimensional unitary maps

Ihor Vakulchyk, Sergej Flach

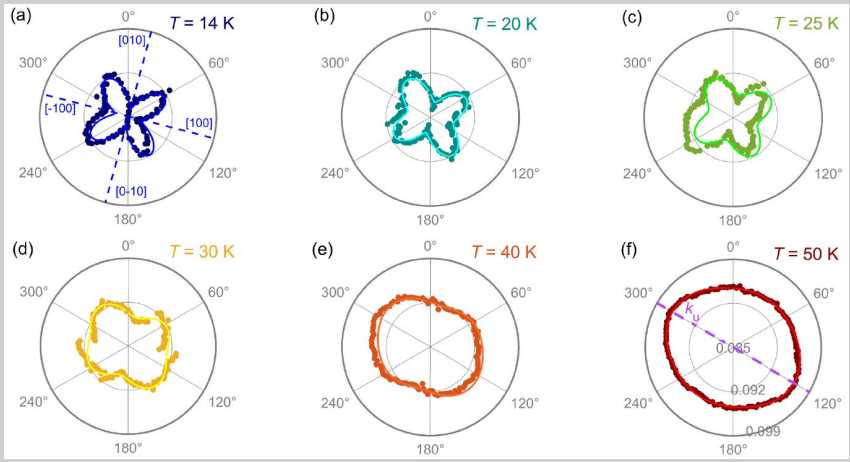
Chaos 33, 083134 (2023)

We study Anderson localization in discrete-time quantum map dynamics in one dimension with nearest-neighbor hopping strength θ and quasienergies located on the unit circle. We demonstrate that strong disorder in a local phase field yields a uniform spectrum gaplessly occupying the entire unit circle. The resulting eigenstates are exponentially localized. Remarkably this Anderson localization is universal as all eigenstates have one and the same localization length L_{loc}. We present an exact theory for the calculation of the localization length as a function of the hopping, $1/L_{loc} = \ln(|\sin(\theta)|)$, which is tunable between zero and infinity by variation of the hopping θ.

Direct observation of exchange anisotropy in the helimagnetic insulator Cu2OSeO3

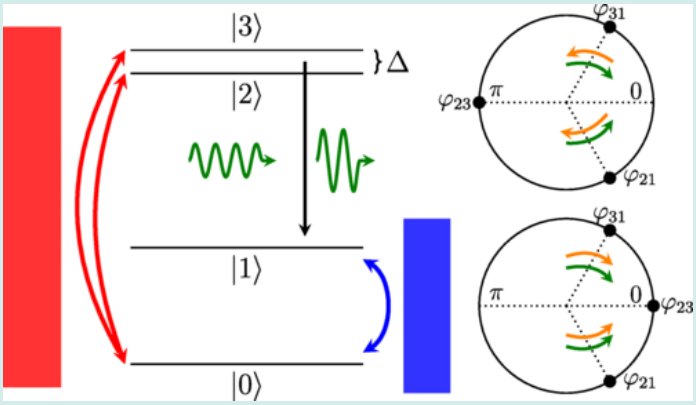
Priya R. Baral, Oleg I. Utesov, Chen Luo, Florin Radu, Arnaud Magrez, Jonathan S. White, and Victor Ukleev

Phys. Rev. Research 5, L032019 (2023)



The helical magnetic structures of cubic chiral systems are well explained by the competition among Heisenberg exchange, Dzyaloshinskii-Moriya interaction, cubic anisotropy, and anisotropic exchange interaction (AEI). Recently, the role of the latter has been argued theoretically to be crucial for the low-temperature phase diagram of the cubic chiral magnet Cu2OSeO3, which features tilted conical and disordered skyrmion states for a specific orientation of the applied magnetic field (H || [001]). In this study, the authors exploit transmission resonant x-ray scattering to directly quantify the strength of AEI in Cu2OSeO3 by measuring the conical spiral modulation vector as a function of the magnetic field direction. Using the proposed theoretical framework based on the perturbative treatment of anisotropic interactions, the authors find that the AEI continuously increases below 50 K, resulting in a conical spiral pitch variation of 10% in the (001) plane. The results contribute to establishing the interaction space that supports tilted cone and low-temperature skyrmion state formation, facilitating the goals for both a quantitative description and eventual design of the diverse spiral states existing amongst chiral magnets.

New Research Results



Deriving lower bounds on the efficiency of near-degenerate thermal machines via synchronization

Taufiq Murtadho, Juzar Thingna, and Sai Vinjanampathy

Phys. Rev. A 108, 012205 (2023)

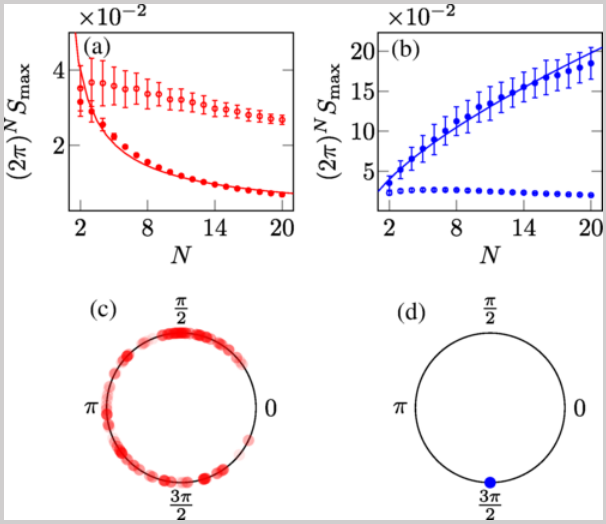
The authors study the relationship between quantum synchronization and the thermodynamic performance of a four-level near-degenerate extension of the Scovil–Schulz-DuBois thermal maser. The authors show how the existence of interacting coherences can potentially modify the relationship between synchronization and the coherent power output of such a maser. In particular, the cooperation and competition between interacting coherences cause the coherent heat and efficiency to be bounded by the synchronization measure in addition to the well-studied power synchronization bound. Overall, the results highlight the role of quantum synchronization in the working of a thermal machine.

Cooperation and Competition in Synchronous Open Quantum Systems

Taufiq Murtadho, Sai Vinjanampathy, and Juzar Thingna

Phys. Rev. Lett. 131, 030401 (2023)

This paper studies a connection between synchronization and thermodynamics in the quantum regime. In particular, the paper focuses on a multilevel extension of the Scovil–Schulz-DuBois thermal maser, which is able to synchronize as it performs its task due to continuous interaction with a laser. As the machine is scaled up, multiple synchronizing actors started to arise within the machine. Consequently, the synchronization behavior of the machine was not solely influenced by its interaction with lasers but also by the interplay between its various components. These distinct synchronization actors could both cooperate and compete with each other. The authors find that cooperation and competition are intimately related to the thermodynamic functionality of the machine, i.e. cooperation manifests in the case of refrigerator whereas competition occurs in the case of engine. Overall, their work investigates the effect of degeneracy and multilevel scaling of quantum synchronization and shows how different synchronizing mechanisms can cooperate and compete in quantum systems.



Puzzle of the Month

August puzzle answer:

(a) 1/3; (b) 13/27. Indeed: (a) out of four possibilities [bb, bg, gb, gg] one (gg) is ruled out. So 1/3 is left. (b) Let's call a son born on Tuesday b^T. Then we have [b^T g; g b^T; b^T b; b b^T]. In total we have 27 possibilities out of which 13 are acceptable.

Congratulations to Alireza Akbari and Merab Malishava whose correct answers arrived almost simultaneously!

Puzzle of the month:

There are 1000 marbles on the table. John and Mary play the following game: John starts and takes some marbles off the table. Then Mary takes some marbles off the table. Then John again, and so on. Note they each time they are allowed to remove only either 1, or 2, or 4, or 9, or 16 marbles. The winner is the one who removes the last marbles from the table. Is there a winning strategy? Who will win?

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