PCS NEWSLETTER

QR to PCS Webpage

August 2025

Edit: Jung-Wan Ryu
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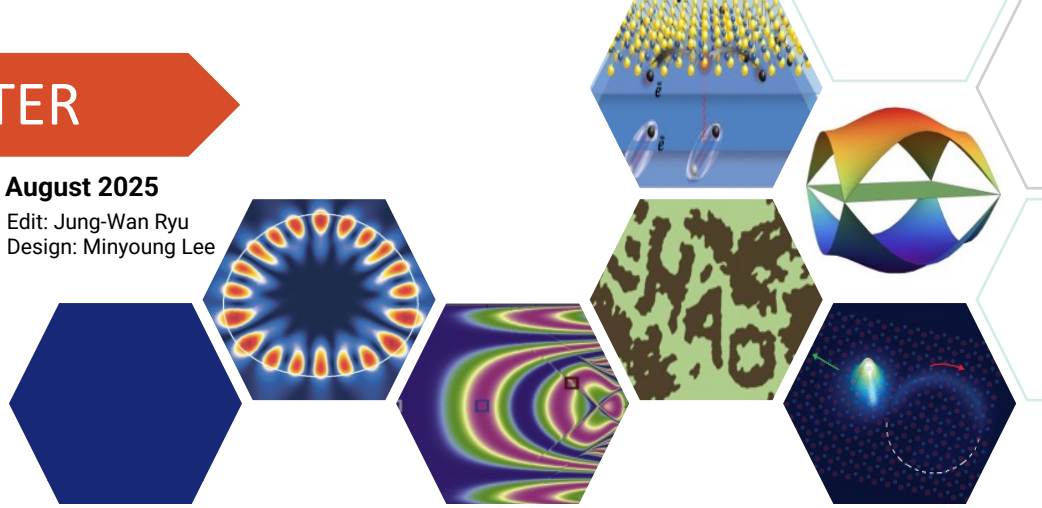


PCS IBS Seminars

"Electronic-structure studies of low-dimensional nanomaterials"
by Young Woo Choi, Sogang University, Korea (July 16)

"Extreme(s) Matter – Alien Melting Behaviour of Noble Gases"
by Elke Pahl, University of Auckland, New Zealand (July 17)

"Odd-frequency superfluidity from a particle-number-conserving perspective"
by Joachim Brand, Massey University, New Zealand (July 17)

"Periodically driven systems: a versatile toolbox for quantum simulation"
by Marin Bukov, Max Planck Institute for the Physics of Complex Systems, Germany (July 29), IBS Physics Colloquium @ Daejeon

You can find more seminars on this page.

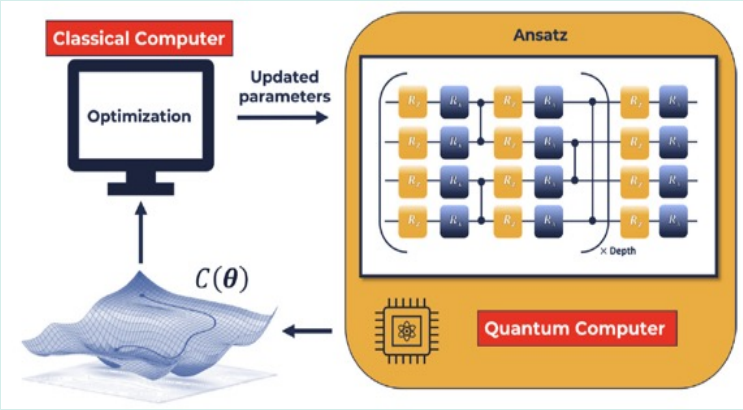
New Research Results

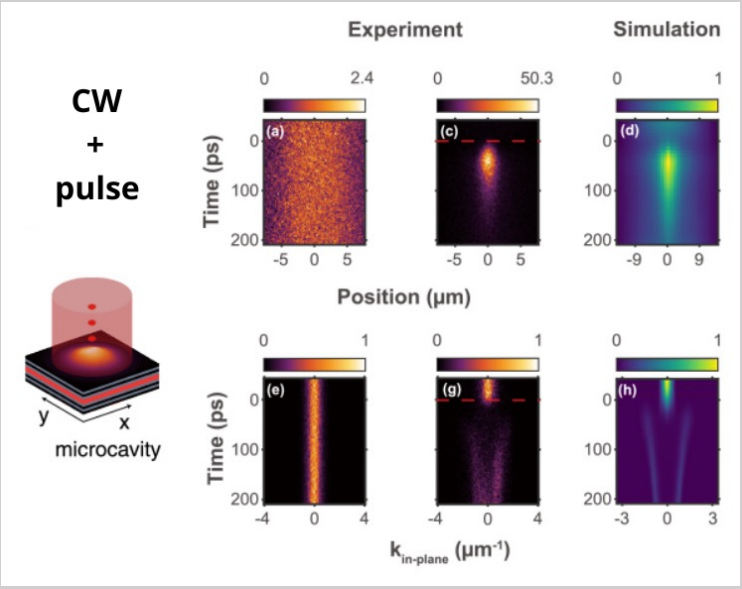
Shallow quantum circuits are robust hunters for quantum many-body scars

Gabriele Cenedese, Maria Bondani, Alexei Andreanov, Matteo Carrega, Giuliano Benenti, and Dario Rosa

Eur. Phys. J. Plus 140, 517 (2025)

Presently, noisy intermediate-scale quantum computers encounter significant technological challenges that make it difficult to generate large amounts of entanglement. The authors leverage this technological constraint as a resource and demonstrate that a shallow variational eigensolver can be trained to target quantum many-body scar states successfully. Scars are low-entanglement high-energy eigenstates of quantum many-body Hamiltonians, which are sporadic and immersed in a sea of volume-law eigenstates. The authors show that the algorithm is robust and can be used as a versatile diagnostic tool to uncover quantum many-body scars in arbitrary physical systems.





Exciton reservoir-induced destabilization and reformation of polariton condensate

Min Park, Sergei Koniakhin, Soohong Choi, Daegwang Choi, Suk In Park, S. Y. L. Park, Jin Dong Song, Yong-Hoon Cho, and Hyoungsoon Choi

Optics Express 33(8), 18530-18539 (2025)

The dynamics of a driven-dissipative polariton condensate in a GaAs microcavity under continuous and pulsed laser excitation was investigated. The condensate was destabilized and quenched by a femtosecond pulse, followed by a nonlinear luminescence surplus. A shrinking ring-like pattern in momentum space was observed using time-resolved photoluminescence as the condensate relaxed to its steady state. An abrupt blueshift in energy was detected after the pulse before equilibrium was restored. Simulations based on the driven-dissipative Gross-Pitaevskii equation confirmed the role of exciton reservoir-polariton interactions, clarifying their impact on polariton condensation.

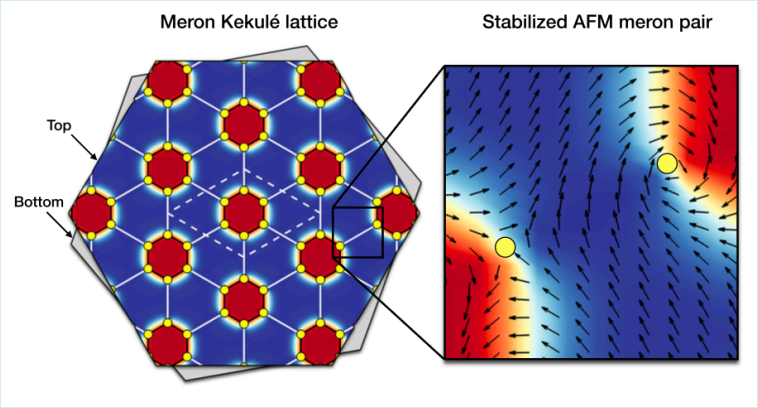
New Research Results

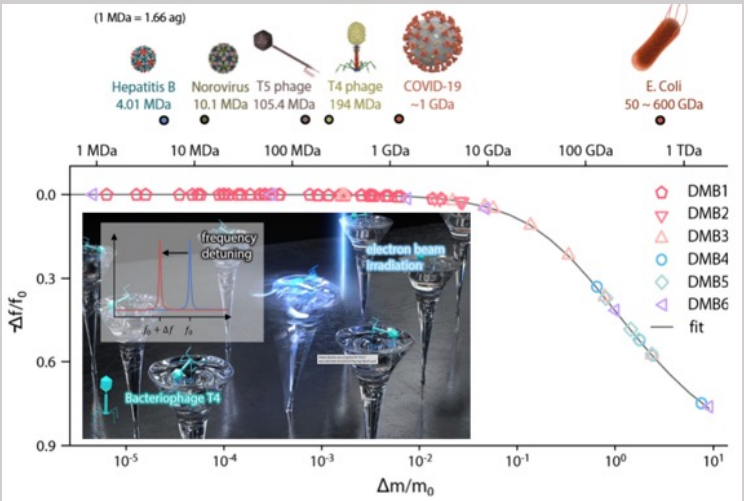
Emergence of Meron Kekulé lattices in twisted Néel antiferromagnets

Kyoung-Min Kim and Se Kwon Kim

npj Quantum Materials 10, 68 (2025)

A Kekulé lattice is an unconventional, distorted lattice structure characterized by alternating bond lengths, distinguishing it from naturally occurring atomic crystals. In this work, the authors report the formation of a Kekulé lattice composed of topological solitons known as merons, termed "Meron Kekulé lattices," in twisted bilayer antiferromagnets. They found that magnetic domain structures, modulated by twist-induced interlayer exchange coupling, support stable pairs of merons and antimerons arranged with alternating bond lengths. Furthermore, the authors demonstrated that the two bond lengths of the Meron Kekulé lattice can be precisely tuned by adjusting the parameters of the interlayer exchange interaction, offering extensive control over the meron lattice configuration in contrast to conventional magnetic systems. These discoveries pave the way for exploring topological solitons with distinctive Kekulé attributes.





Diamond Molecular Balance: Ultra-Wide Range Nanomechanical Mass Spectrometry from MDa to TDa

Donggeun Lee, Seung-Woo Jeon, Chang-Hwan Yi, Yanghee Kim, Yeeun Choi, Sang-Hun Lee, Jinwoong Cha, Seung-Bo Shim, Junho Suh, Il-Young Kim, Dongyeon Daniel Kang, Hojoong Jung, Cherlhyun Jeong, Jae-pyoung Ahn, Hee Chul Park, Sang-Wook Han and Chulki Kim

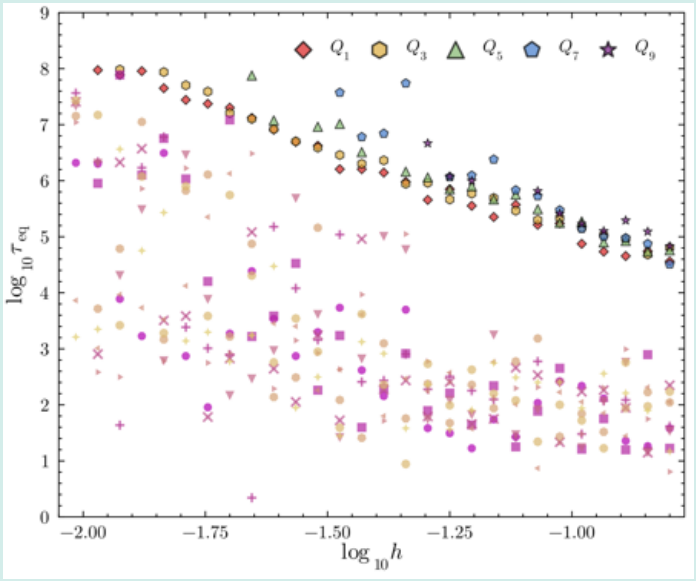
Nano Lett. 25(26), 10497-10503 (2025)

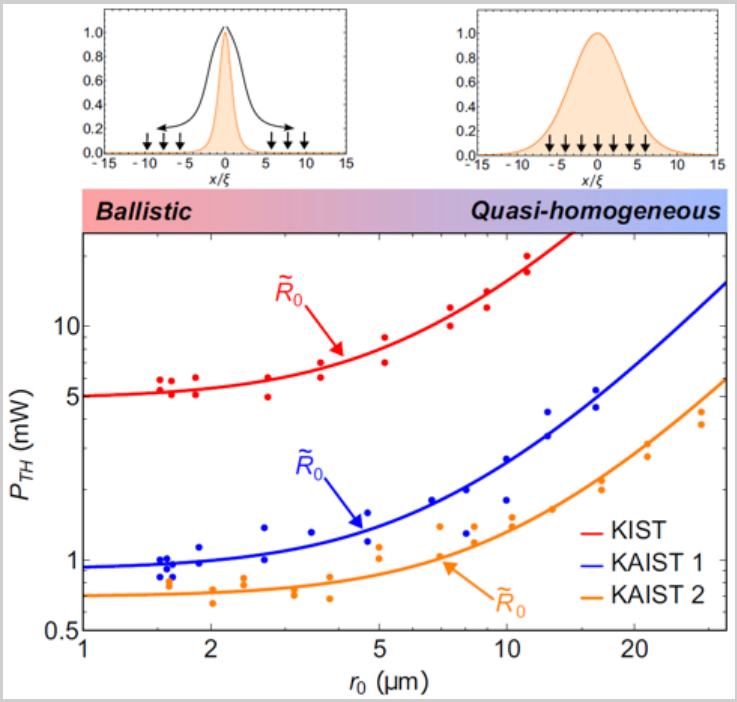
The authors introduce a diamond-based nanomechanical mass spectrometry platform that enables real-time, single-particle detection over an ultra-wide mass range from millidalton (mDa) to teradalton (TDa). By integrating high-quality single-crystal diamond resonators, the system achieves attogram-level sensitivity and long-term operational stability in diverse environments. Their team contributed theoretical modeling and analysis to optimize the sensor's mass responsivity and interpret frequency shifts across this broad range. This novel platform resolves individual molecular adsorption events without ionization, enabling accurate detection of biomolecules from small proteins to entire viruses and bacteria. The technology paves the way for transformative applications in virology, proteomics, and nanoscale material analysis.

New Research Results

Prethermalization in Fermi-Pasta-Ulam-Tsingou chains
Gabriel M. Lando and Sergej Flach
Physical Review E 112, 014206 (2025)

The observation of the Fermi-Pasta-Ulam-Tsingou (FPUT) paradox, namely the lack of equipartition in the evolution of a normal mode in a nonlinear chain on unexpectedly long times, is arguably the most famous numerical experiment in the history of physics. Seventy years after the original publication, most studies in FPUT chains still focus on long wavelength initial states similar to the original paper. It is shown here that all characteristic features of the FPUT paradox are rendered even more striking if modes with short(er) wavelengths are evolved instead. Since not every normal mode leads to equipartition, the authors also provide a simple technique to predict which modes, and in what perturbation order, are excited starting from an initial mode (root) in α-FPUT chains. The excitation sequences associated with a root are then numerically shown to spread energy at different speeds, leading to prethermalization regimes that become longer as a function of mode excitation number.





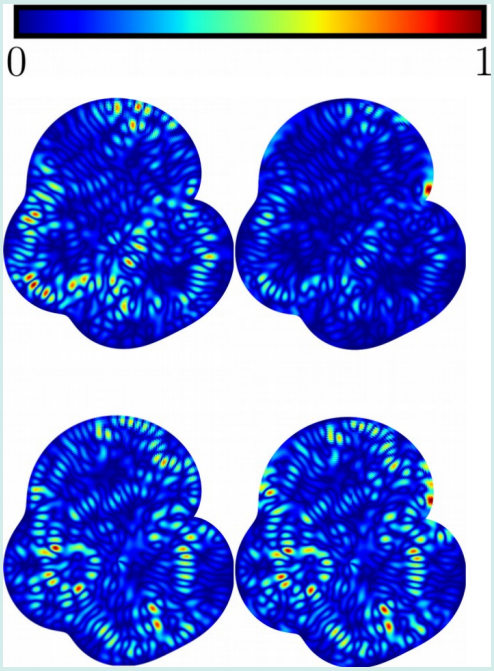
Universal condensation threshold dependence on pump beam size for exciton-polaritons
Oleg I. Utesov, Min Park, Daegwang Choi, Soohong Choi, Suk In Park, Sooseok Kang, Jin Dong Song, Alexey N. Osipov, Alexey V. Yulin, Yong-Hoon Cho, Hyoungsoon Choi, Igor S. Aranson & Sergei V. Koniakhin
Communications Physics 8, 286 (2025)

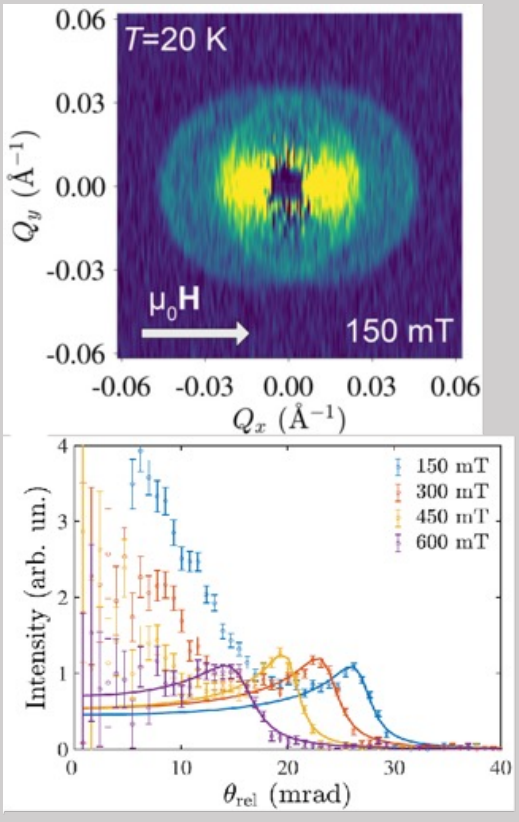
Comprehensive theoretical and experimental study of the condensation threshold for exciton-polaritons under incoherent Gaussian pumping is performed. Analytical theory reveals that it depends on a single length parameter governed by the condensate blueshift and linewidth at the threshold. Experiments with three different samples show a faithful agreement with the theory. Then, for practical applications, the authors can distinguish the regimes of small pumping spots (ballistic regime) and large pumping spots (quasi-homogeneous regime). For the former, they observe the fundamental limitation on the total pumping power required for the condensation.

New Research Results

Failure of the Conformal-Map Method for Relativistic Quantum Billiards
Barbara Dietz
Phys. Rev. Lett. 135, 030401 (2025)

In Xu et.al. [Phys. Rev. Lett. 110, 064102 (2013)] a numerical method is introduced -- an extension of the conformal-map method (CMM) of Robnik [J. Phys. A: Math. Gen. 17, 1049 (1984)] for nonrelativistic quantum billiards -- for the quantization of relativistic neutrino billiards consisting of a massless non-interacting spin-1/2 particle confined to a two-dimensional domain. The author demonstrates, that this method does not provide solutions of the associated Weyl (Dirac) equation, nor does it fulfill the boundary condition (BC) that the outgoing current should vanish, imposed on the spinor eigenfunctions to ensure confinement of the particle to the domain of the billiard. The analytical results are corroborated with numerical ones for non-relativistic and relativistic quantum billiards. The left part of the figure shows the outgoing current for the eigenstates obtained with an exact boundary integral method, the right one those computed with CMM for which it clearly deviates from zero along the boundary.





Helical spin dynamics in Cu2OSeO3 as measured with small-angle neutron scattering
Victor Ukleev, Priya R. Baral, Robert Cubitt, Nina-Juliane Steinke, Arnaud Magrez, Oleg I. Utesov
Struct. Dyn. 12, 044301 (2025)

Inelastic neutron scattering on spin waves of field-polarized phases of helimagnets is a simple yet effective tool for characterizing their dynamical properties. Using the recently proposed analytical expression for the corresponding data interpretation, the authors address the helical spin dynamics of the cubic helimagnet Cu2OSeO3. Due to weak magnon damping in this insulating compound, they observed the predicted bumps in the scattering intensity curves, allowing for high-accuracy fits of the data. Using the latter, temperature dependencies of the spin-wave stiffness and the damping parameter were obtained.

Puzzle of the Month

July puzzle solution:

5 moves. To figure, take just the top knight and label its field with Nr 1. Then start jumping (assume the second knight is not there) and restore the tight binding network:

*1**
48
*025
3769

Here the symbols * stand for nonexisting fields, just for convenience. So, this is a one-dimensional chain with exactly one appendix on site 6:

1-2-3-4-5-7-8-9-0
|
6

The two knights are initially positioned on sites {1,2} and have to be moved to sites {3,6}. It takes 5 moves
2->3->4->6
1->2->3

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

Puzzle of the month:

A large natural number is divisible by all integers 1,2,3,4,...,29,30 except for two consecutive ones. What are these two consecutive integers?

Send your solution to mylee1@ibs.re.kr
The winner will be announced in the next issue.