PCS NEWSLETTER

QR to PCS Webpage

December 2022

Edit: Sungjong Woo
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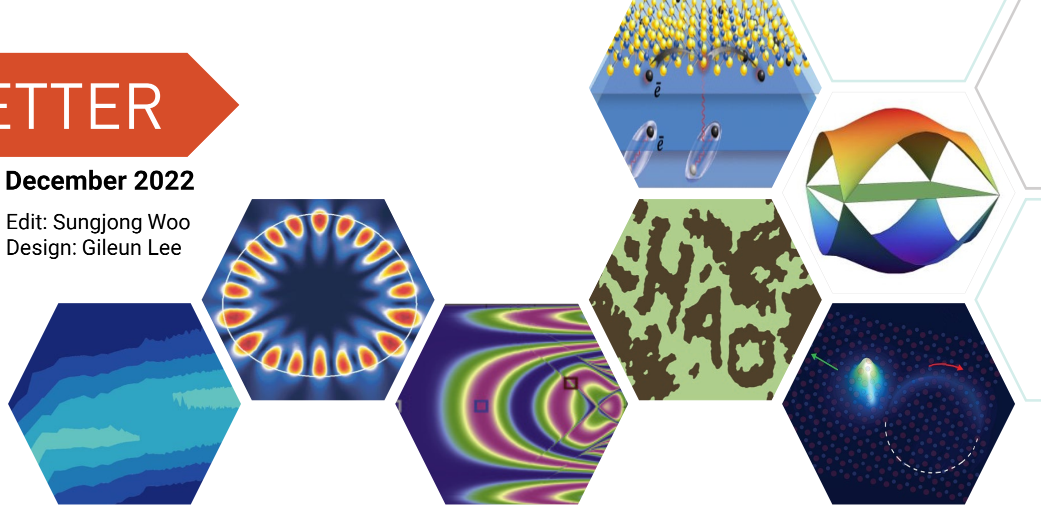


PCS IBS Seminars

"How strong can the electron-phonon interaction in metals be?"
by Emil Yuzbashyan, Rutgers University, USA (November 3)

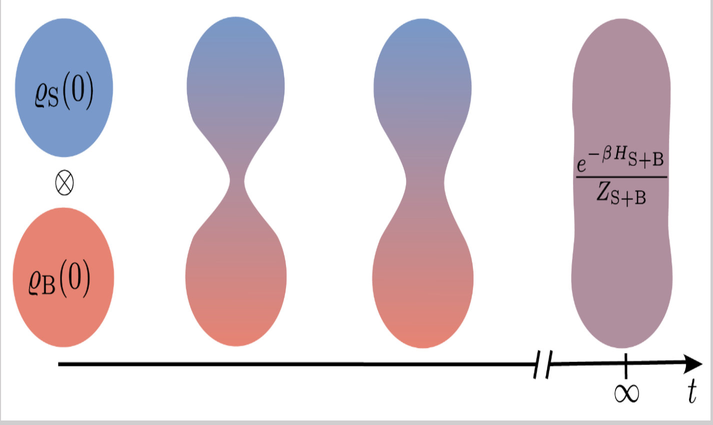
"Observational entropic study of Anderson localization"
by Ranjan Modak, Indian Institute of Technology Tirupati, India (November 15)

"Exploring Long Range Dipolar Interactions: From collective dipolar spin dynamics and layer exchange to light-mediated interactions and Pauli-Blocking"
by Thomas Bilitewski, Oklahoma State University, USA (November 17)

"Quantum Integrability"
by Emil Yuzbashyan, Rutgers University, USA (November 18)

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

New research results



Canonically Consistent Quantum Master Equation
Tobias Becker, Alexander Schnell and Juzar Thingna
Phys. Rev. Lett. 129, 200403
(arXiv:2205.12848)

In isolated quantum systems, correlated quantum states are essential for all emerging quantum technologies and have led to the 2022 noble prize in physics. In open quantum systems, however, the correlations between the system of interest and the reservoir are typically ignored under the Born approximation. Several attempts have been made to overcome this highly restrictive assumption but a rigorous theory has been lacking. In this work, the authors present an approach that allows correlations between the system and reservoir to build over time and correctly accounts for the long-time correlations as dictated by statistical mechanics (see illustration). They use the long-time highly correlated system-reservoir state and incorporates this knowledge in the dynamical theory resulting in the canonically consistent quantum master equation (CCQME). Surprisingly, the CCQME drastically improves upon the long-standing issue of unphysical negative probabilities, a common occurrence in approaches that rely on the Born approximation. Using a variety of models, that range from a damped harmonic oscillator to a dissipative spin chain, they show that it correctly reproduces the correlations built up in the regime of strong system-reservoir coupling. This theory paves a way to re-investigate nonequilibrium physics in presence of system-reservoir correlations impacting the fields of open quantum systems, quantum transport, and quantum thermodynamics.

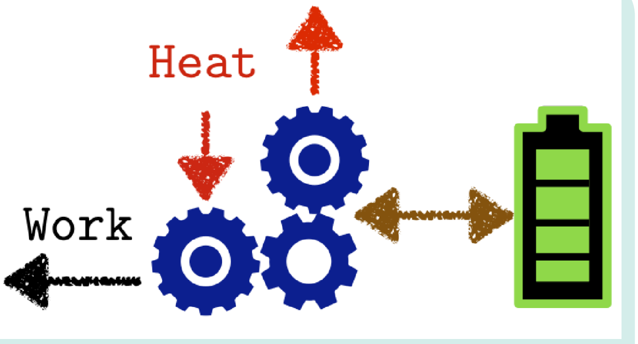
New research results

Charging quantum batteries via Otto machines: Influence of monitoring

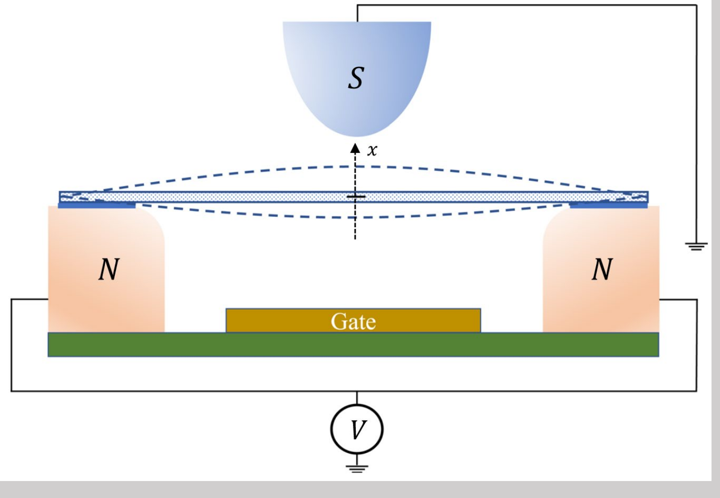
Jeongrak Son, Peter Talkner, and Juzar Thingna

Phys. Rev. A 106, 052202

(arXiv:2205.07440)



A new paradigm of the parasitic relationship between two quantum devices is studied, one in which a quantum engine feeds a quantum battery. As in the macroscopic world where an Otto engine may not only drive a car but also can charge the car battery, a microscopic quantum Otto engine may also charge a quantum battery. In this work, this process is characterized by a set of metrics of the engine (power, efficiency, etc.) and of the battery (charge stored, charging speed, etc.). These metrics are determined by measuring the energy content of the engine's working substance and of the battery. In particular, measurements of the battery significantly influence its charging process. The authors compare two monitoring strategies, one where the battery's energy is measured after each cycle and the other one with measurements only after a given, possibly large number of cycles. In both cases the engine performs some external work until the battery is about half charged, then it stops working as an engine. Despite the engine failing it continues charging the battery until the engine and the battery reach a asymptotic state. It turns out that the first strategy with frequent measurements favors the charging speed of the battery, whereas the second one leads to a better-charged battery, *i.e*, it holds more useful energy due to an inverted population and also to coherences that both can be extracted by means of unitary processes.



Pumping and Cooling of Nanomechanical Vibrations Generated by Cooper-Pair Exchange

Anton V. Parafilo, Leonid Y. Gorelik, Hee Chul Park and Robert I. Shekhter

Journal of Low Temperature Physics

(arXiv:2202.07924)

The crucial point of the nano-electromechanical (NEM) system performance is the nature of the coupling between electronic and mechanical degrees of freedom. In most cases, the coupling is associated with the localization of electronic charge or spin on the movable part of the device. In this work, the authors consider a carbon nanotube (CNT) suspended between two equally biased normal metal leads and coupled to a grounded superconducting STM tip via vacuum tunnel barrier. They predict the existence of a specific NEM coupling, which is based on "electron-pair sharing" between superconducting lead and nanotube (similar to covalent bonding known in the chemistry). It is demonstrated that the transition between pumping and cooling regimes of NEM system is controlled by the relative position of electronic level in the CNT and by the strength of tunnel coupling between CNT and STM tip.

New research results

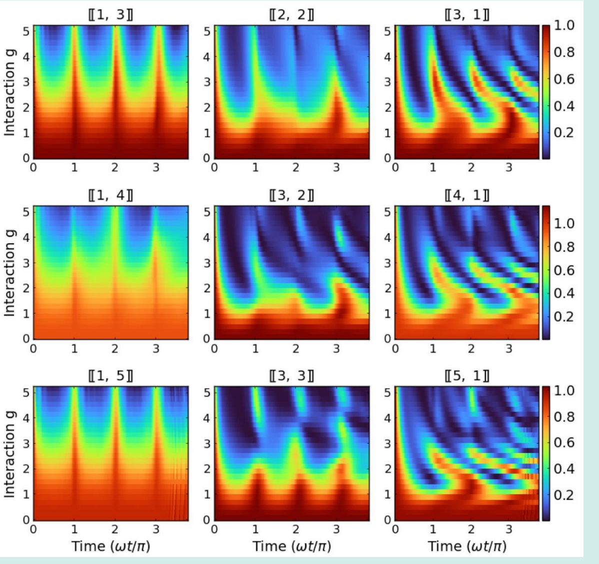
Sudden quench of harmonically trapped mass-imbalanced fermions

Dillip K. Nandy and Tomasz Sowiński

[Scientific Reports 12, 19710](#)

([arXiv:2209.05870](#))

The authors investigate dynamical properties of a few two-component harmonically trapped fermions following a sudden quench. Initially the system is prepared in a non-interacting ground state and then inter-component interaction is switched on suddenly. The nonequillibrium effect due to this sudden quench process is quantified through the Loschmidt echo between the unperturbed and perturbed initial states at different instants. More importantly, they studied the role of mass-imbalance and particle-imbalance of the two-components fermions on the Loschmidt echo dynamics in a given system size. The dynamical behavior of the Loschmidt echo is further supported by studying the evolution of the density in each component and inter-component correlation produced after the quench.

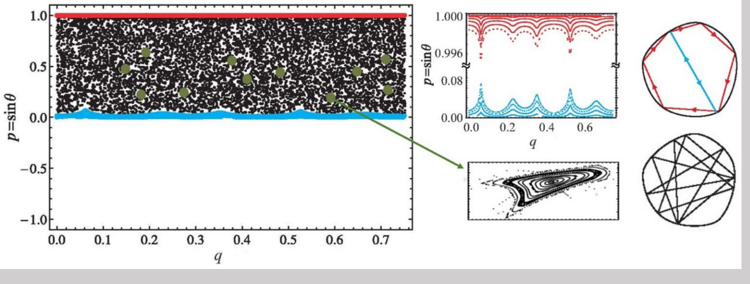


Unidirectionality and Husimi functions in constantwidth neutrino billiard

Barbara Dietz

[J. Phys. A: Math. Theor. 55, 474003](#)

The author investigates the spectral properties and Husimi functions of relativistic neutrino billiards consisting of a spin-1/2 particle governed by the Dirac equation and confined to a planar domain of constant-width by imposing boundary conditions on the spinor components. The classical dynamics of billiards with such a shape features unidirectionality, whereas in the corresponding nonrelativistic quantum billiard a change of the rotational direction of motion is possible via dynamical tunneling. Unidirectionality of the quantum dynamics would arise in the structure of the Husimi functions. They analyze them for neutrino billiards and come to the conclusion that in the ultra-relativistic limit (massless case) dynamical tunneling is absent. This is attributed to the unidrectionality of the local current arising from the boundary conditions.



Puzzle of the month

November puzzle answer:

Around 11:22 or 11:23. The accumulated height of snow is proportional to time and the speed of snowplow truck is inversely proportional to the height. Therefore the speed of truck is inversely proportional to time, *i.e*, $v = C/t$. The distance the truck goes for one hour from $t = t_0$ is integration of v from t_0 to $t_0 + 1$; $d(t_0) = C(\ln(t_0 + 1) - \ln(t_0))$. Let us say that the snowplow begins at $t = t_1$. With hour as the unit of time, the condition of quiz is $d(t_1) = 2d(t_1 + 1)$, *i.e*, $\ln(t_1 + 1) - \ln(t_1) = 2(\ln(t_1 + 2) - \ln(t_1 + 1))$ that gives a quadratic equation for t_1, $t_1^2 + t_1 - 1 = 0$. The answer for the equation is $t_1 = (-1 + \mathrm{sqrt}(5))/2.0 = 0.618$. Therefore the snow plow should have started at 0.618 hour before noon, which is about 11:22am.

Congratulations to Sungjong Woo (PCS) for the correct answer! The above solution text was sent in by Sungjong.

Puzzle of the month:

A bike has one of its pedals at its lowest point (and the other pedal at its highest point).
We fix a rope to the lowest point pedal and gently pull backwards.
Which way will the bike move?

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