Invited Talks

Influence matrix approach to many-body dynamics and quantum impurity models

Dmitry Abanin (University of Basel)

Dynamical properties of a many-body system are determined by its properties as a quantum bath: the systems that thermalize act as an efficient bath, while integrable and many-body localized (MBL) systems fail to do so. I will describe a new approach to quantum many-body dynamics, inspired by the notion of the Feynman-Vernon influence functional (IF), which captures the properties of a quantum bath. I will consider interacting spin systems, and formulate an equation satisfied by their influence functionals. Surprisingly, this equation can be solved exactly for a class of many-body systems – perfect dephasers – which act as Markovian baths on their subsystems. More generally, I will show that, viewed as a fictitious wave function in the temporal domain, influence functional can be described by tensor-network methods. The efficiency of this approach is based on the behavior of temporal entanglement of the IF — a quantity that I will introduce — which remains low in very different physical regimes, including fast thermalization, integrability, and many-body localization. Switching gears, I will argue that IF approach provides an efficient method for non-equilibrium quantum impurity models, where electrons in the leads are non-interacting. I will illustrate this by studying quenches in the Anderson impurity model. This theoretical framework further can be naturally applied in dynamical mean-field theory algorithms.

Quantum synchronization

Christoph Bruder (University of Basel)

Experimental progress in optomechanical systems, in trapped-ion setups, and in supercon- ducting circuit-QED architectures has motivated the study of synchronization in quantum systems. In my talk I would like to describe theoretical approaches to the synchronization problem for quantum oscillators and discuss some of the issues and open questions [1-4].

[1] N. Lörch, S.E. Nigg, A. Nunnenkamp, R.P. Tiwari, and C. Bruder, Phys. Rev. Lett. 118, 243602 (2017).
[2] A. Roulet and C. Bruder, Phys. Rev. Lett. 121, 053601 (2018).
[3] A. Roulet and C. Bruder, Phys. Rev. Lett. 121, 063601 (2018).
[4] M. Koppenhöfer, C. Bruder, and A. Roulet, Phys. Rev. Research 2, 023026 (2020).

Topology of gapless and gapped phases of quantum many-body systems

Akira Furusaki (RIKEN)

Topological pump of correlated systems

Yasuhiro Hatsugai (Tsukuba University)

We have recently discussed several topological pumps of correlated systems in relation to the bulk-edge correspondence where symmetry protection and U(1) gauge invariance play crucial roles[1]. After explaining the development, a topological pump of the SU(Q) quantum chain will be discussed [2].

[1] Y. Kuno and Y. Hatsugai, Phys. Rev. Research 2, 042024(R)(2020), Phys. Rev. B 104, 045113, (2021), Phys. Rev. B 104, 125146, (2021).
[2] Y. Hatsugai and Y. Kuno, arXiv:2210.xxxxx

Spin-orbital dynamics of localized electrons

Shintaro Hoshino (Saitama University)

We propose a general framework to analyze Mott insulators from first principles calculation data. Based on the realistic multiorbital Hubbard model, the effective model for the localized electron are derived by the second-order perturbation theory with respect to the inter-site hopping and are described by SU(N) generators. This realistic Kugel-Khomskii model is solved by means of the mean-field theory, which is identical to the dynamical mean-field theory in the strong interaction limit. We also apply the classical Monte Carlo with the SU(N) coherent state. The present scheme can be applied to any Mott insulators with reasonable numerical cost.

Fate of Topological Edge States in Nonunitary/Nonlinear Floquet Systems

Norio Kawakami (Kyoto University)

We discuss topological transitions in nonunitary/nonlinear time evolution of Floquet systems. We first investigate nonunitary Floquet topological phases driven by PT-symmetric quantum walks. We find PT-symmetry breaking for topological edge states between regions with different bulk topological properties. This theoretical prediction is confirmed experimentally for single photons by temporally alternating photon losses. We then explore a related topic, i.e. anomalous topological edge states in a nonlinear Floquet system. The linear stability analysis elucidates that Floquet stationary edge states experience a sort of transition between two regions: edge states having extremely long or short life time. We characterize these transitions by Krein signatures, or equivalently the pseudo-Hermiticity breaking.

Microscopic investigation of chiral crystals

Hiroaki Kusunose (Meiji University)

We discuss the order parameter of chiral crystals and possible cross-correlated responses, based on the symmetry-adapted multipole basis.

Theory of absorption in the frustrated 2D spin system $SrCu_2(BO_3)_2$

Shin Miyahara (Fukuoka University)

The frustrated 2D spin system $SrCu_2(BO_3)_2$ is realization of the Shastry-Sutherland model. Spin excitation spectra have been investigated by ESR and IR and spin gap and bound states of two triples excitations are observed. However, the origin and mechanism of the observations are still mystery. We consider electromagnetic couplings in $SrCu_2(BO_3)_2$ and show that the spin gap excitation and the bound states of two triplets are electro-active in the dimer singlets phase in the Shastry-Sutherland model.

Unified framework on conductivities as a response to the time-dependent gauge field

Masaki Oshikawa (ISSP – University of Tokyo)

Conductivity is one of the most important characteristics of materials. Recently, nonlinear conductivities are of increasing experimental and theoretical interest, but the subject is largely open. In this talk I discuss our recent approach to the fundamentals of the nonlinear optical conductivities. A system under the periodic boundary condition in one direction can be regarded as a "ring". A static magnetic flux through the ring induces the quantum mechanical Aharonov-Bohm effect. Furthermore, increasing the flux over time induces a uniform electric field in the system. The uniform electric conductivity can be regarded as the response of the system to the increase of the magnetic flux. This not only allows a unified formulation of the "frequency sum rule" (f-sum rule).

Nonunitary Superconductivity in Complex Quantum Materials

Aline Ramires (PSI)

In this talk, I present a comprehensive discussion on nonunitary superconductivity in complex quantum materials. Starting with a brief review of the notion of nonunitary superconductivity, I discuss its spectral signatures in simple models with only the spin as an internal degree of freedom. In complex materials with multiple internal degrees of freedom, there are many more possibilities for the development of nonunitary order parameters. I provide examples focusing on d-electron systems with two orbitals, applicable to a variety of materials. We discuss the consequences for the superconducting spectra, highlighting that gap openings of band crossings at finite energies can be attributed to a nonunitary order parameter if this is associated with a finite superconducting fitness measure. I speculate that nonunitary superconductivity in complex quantum materials is in fact very common and can be associated with multiple cases of time-reversal symmetry breaking superconductors.

Multiscale space-time ansatz for response functions of quantum systems

Hiroshi Shinaoka (Saitama University)

Response functions of quantum systems, which are central objects in theoretical calculations, live in high-dimensional space-time domains. The numerical treatment of these objects suffers from the curse of dimensionality, which hinders the application of sophisticated many-body theories to interesting problems. We propose a multiscale space-time ansatz for response functions of quantum systems. The ansatz consists of two ingredients. The space-time dependence is mapped to auxiliary qubit degrees of freedom describing exponentially different length scales. We further assume the separation of length scales, which allows significant compression of numerical data and efficient computation such as Fourier transform. We numerically verify the validity of the ansatz for a variety of systems from equilibrium to non-equilibrium ones. Furthermore, we demonstrate numerical efficiency.

Nonlinear terahertz spectroscopy of superconductors: Higgs mode and beyond

Naoto Tsujio (University of Tokyo)

Recent advances in the nonlinear terahertz spectroscopy allows one to explore coherent dynamics and collective excitations of superconductors in the energy scale of the superconducting gap. Among such excitations exists the Higgs mode, an amplitude oscillation of the order parameter, which is a condensed-matter analog of Higgs particle in high-energy physics. I will talk about recent studies on the Higgs mode and beyond using nonlinear terahertz spectroscopy.

Triple-q partial orders of electric quadrupoles in correlated materials

Hirokazu Tsunetsugu (ISSP - University of Tokyo)

I present our theoretical work on triple-q and other orders of electric quadruples in correlated materials with a fcc lattice structure. We consider situations that a local ground state is a non-Kramers doublet Γ_3 and it has two-components of quadrupole degrees of freedom, which also couple Γ_3 with a singlet excited state. We have built a canonical microscopic model Hamiltonian for those systems and determined its mean-field phase diagram in the parameter space of two coupling constants and temperature. One of the main results is a remarkable stability of triple-q partially ordered phases in the high temperature region. We have analyzed their stability and instabilities towards other ordered phases based on a phenomenological Landau theory. I also comment on an interesting change of wavefunction's geometrical phase upon varying the strength of quadrupole interactions.

Nonreciprocal property and resultant optical response of superconductors

Hikaru Watanabe (University of Tokyo)

In this presentation, we present a theory of the nonreciprocal optical responses of parity-breaking superconductors. Our results of superconducting and nonreciprocal optical responses capture the mechanism similar to that in the normal state and importantly identify the anomalous mechanism. The anomalous mechanism originates from what can appear only in the superconducting state, which we call the nonreciprocal superfluid density and conductivity derivative.

Nonthermal electronic orders

Philipp Werner (University of Fribourg)

Recent pump-probe experiments suggest that electronic orders in correlated solids can be enhanced or induced by nonequilibrium protocols. While the mechanisms are not always understood, theoretical studies have revealed relevant concepts such as entropy cooling or entropy trapping. Using the nonequilibrium generalization of dynamical mean field theory, different strategies for inducing nonthermal electronic orders have been explored and these studies provide guiding principles for future experiments. I will give an overview of the current theoretical results, with a focus on nonthermal superconducting and excitonic states.

Contributed Talks

Elementary derivation of the stacking rules of invertible fermionic topological phases in one dimension

Omer Mert Aksoy (PSI)

Invertible fermionic topological (IFT) phases are gapped phases of matter with nondegenerate ground states on any closed spatial manifold. When open boundary conditions are imposed, nontrivial IFT phases support gapless boundary degrees of freedom. Distinct IFT phases in one-dimensional space with an internal symmetry group G_f have been characterized by a triplet of indices $([(\nu,\rho)],[\mu])$. IFT phases of matter form an Abelian group structure under the operation of "stacking". In this talk, I will first give an operational definition of the indices $([(\nu,\rho)],[\mu])$ from the perspective of the boundary. I will then show an elementary derivation of the stacking rules of IFT phases with any symmetry group G_f, i.e., I will provide an explicit formula for $([(\nu_\wedge,\rho_\wedge)],[\mu_\wedge])$ that is obtained from stacking two IFT phases characterized by the triplets of boundary indices $([(\nu_1,\rho_1],[\mu_1])$ and $([(\nu_2,\rho_2],[\mu_2])$.

Magnetoelectric classification of Skyrmions

Sayantika Bhowal (ETHZ)

We develop a general theory to classify magnetic skyrmions and related spin textures in terms of their magnetoelectric multipoles. Since magnetic skyrmions are now established in insulating materials, where the magnetoelectric multipoles govern the linear magnetoelectric response, our classification provides a recipe for manipulating the magnetic properties of skyrmions using applied electric fields. We apply our formalism to skyrmions and anti-skyrmions of different helicities, as well as to magnetic bimerons, which are topologically, but not geometrically, equivalent to skyrmions. We show that the non-zero components of the magnetoelectric multipole and magnetoelectric response tensors are uniquely determined by the topology, helicity and geometry of the spin texture. Therefore, we propose straightforward linear magnetoelectric response measurements as an alternative to Lorentz microscopy for characterizing insulating skyrmionic textures.

Thermal Ising Transition in the Spin-1/2 J_1–J_2 Heisenberg Model

Olivier Gauthé (EPFL)

The spin-1/2 Heisenberg model on the square lattice with nearest-neighbor coupling J_1 and next-nearest coupling J_2 (J_1-J_2 model) is a paradigmatic model of frustrated magnetism. Thirty years ago, Chandra, Coleman and Larkin predicted the occurrence of a finite temperature phase transition in this model, however direct numerical evidence for the spin-1/2 case has been impossible to obtain so far. Using finite-temperature tensor network algorithms, we provide the first unambiguous and direct evidence of an Ising transition in the collinear phase of this model. We obtained consistent data that exhibit a spontaneous breaking of the C_{4v} symmetry, a very narrow specific heat peak and a diverging correlation length all together.

Electronic transport in graphene with out-of-plane disorder

Yifei Guan (EPFL)

Real-world samples of graphene often exhibit various types of out-of-plane disorder--ripples, wrinkles and folds--introduced at the stage of growth and transfer processes. These complex out-of-plane defects resulting from the interplay between self-adhesion of graphene and its bending rigidity inevitably lead to the scattering of charge carriers thus affecting the electronic transport properties of graphene. We address the ballistic charge-carrier transmission across the models of out-of-plane defects using tight-binding and density functional calculations while fully taking into account lattice relaxation effects. The observed transmission oscillations in commensurate graphene wrinkles are attributed to the interference between intra- and interlayer transport channels, while the incommensurate wrinkles show vanishing backscattering and retain the transport properties of flat graphene. The suppression of backscattering reveals the crucial role of lattice commensuration on the electronic transmission. Our results provide guidelines to controlling the transport properties of graphene in presence of this ubiquitous type of disorder.

Possible restoration of particle-hole symmetry in the 5/2 Quantized Hall State at small magnetic field

Loic Herviou (EPFL)

Motivated by the experimental observation of a quantized 5/2 thermal conductance at filling $\nu=5/2$, a result incompatible with both the Pfaffian and the Antipfaffian states, we have pushed the expansion of the effective Hamiltonian of the 5/2 quantized Hall state to third-order in the Landau level mixing $\kappa=E_c / h\omega_c$, where E_c is the Coulomb energy and ω_c the cyclotron frequency. Exact diagonalizations of this effective Hamiltonian show that the difference in overlap with the Pfaffian and the AntiPfaffian induced at second-order is reduced by third-order corrections and disappears around $\kappa=0.5$, suggesting that these states are much closer in energy at smaller magnetic field than previously anticipated. Furthermore, we show that in this range of κ the finite-size spectrum is typical of a quantum phase transition, with a strong reduction of the energy gap and with level crossings between excited states. These results point to the possibility of a quantum phase transition at smaller magnetic field into a phase with an emergent particle-hole symmetry that would explain the measured 5/2 thermal conductance of the 5/2 quantized Hall state.

Magnetoelectric Cavity Magnonics in Skyrmion Crystals

Tomoki Hirosawa (Aoyama Gakuin University)

Recently, a strong coupling between magnons and microwave photons in a cavity has attracted much attention. While previous works have focused on the magnetic coupling between magnons and photons via the Zeeman effect, multiferroic materials host electromagnons that can be excited by oscillating electric fields. Here, we present a theory of magnetoelectric magnon-photon coupling in

cavities hosting noncentrosymmetric magnets. Analogously to nonreciprocal phenomena in multiferroics, the magnetoelectric coupling is time-reversal and inversion asymmetric. This asymmetry establishes a means for exceptional tunability of magnon-photon coupling, which can be switched on and off by reversing the magnetization direction.
Taking the multiferroic skyrmion-host Cu_2OSeO_3 as an example, we reveal the electrical activity of skyrmion eigenmodes and propose it for magnon-photon splitting of ``magnetically dark'' elliptic modes. Furthermore, we predict a cavity-induced magnon-magnon coupling between magnetoelectrically active skyrmion excitations. We discuss applications in quantum information processing by proposing protocols for all-electrical magnon-mediated photon quantum gates, and a photon-mediated SPLIT operation of magnons. Our study shows magnetoelectric cavity magnonics as a novel platform for realizing quantum-hybrid system.

Sine-square deformed mean-field theory

Masataka Kawano (TU Munich)

We propose an efficient and unbiased protocol for evaluating quantum states with any large-scale emergent structures. There is a growing demand to understand such phases including magnetic skyrmions, twisted bilayer graphene, and high-Tc cuprates with doping. However, all known methods require a prior knowledge of their structure or period, and the results often depend on numerical conditions, making it difficult to understand the nature of these phases. Our protocol, sine-square deformed mean-field theory, overcomes this issue. We use a sine-squared envelop function to spatially deform a real-space Hamiltonian, rendering the quantum state insensitive to the mismatch of the order and lattice, and the result for the thermodynamic limit is already obtained for a relatively small size. We show how our proposed method works by applying it to hole-doped and spin-orbit coupled strongly correlated electron systems.

Kagome chiral spin liquid in transition metal dichalcogenide moiré bilayers

Johannes Motruk (University of Geneva)

Bilayers of transition metal dichalcogenides (TMDs) have recently emerged as promising platforms to study strongly correlated electrons in two dimensions. In particular, the low-energy physics of these systems can be described by extended Hubbard models on the triangular lattice. At certain fillings and parameter regimes, generalized Wigner crystals can occur in which the translational invariance of the charge distribution is spontaneously broken. In this work, we investigate TMD heterobilayers at a filling of 3/4 holes or electrons per moiré unit cell where these are almost entirely localized on a kagome lattice. By expanding the tight-binding model describing the system, we derive an effective spin model on this kagome lattice that includes up to third-neighbor Heisenberg and Dzyaloshinskii–Moriya interactions. We then employ density matrix renormalization group simulations to explore the possibilities of realizing quantum spin liquids in this model in experimentally realistic parameter ranges and show how WSe_2/WS_2 heterobilayers can be tuned to exhibit a chiral spin liquid ground state.

Topological strongly correlated superconductor $CeRh_2As_2$

Kosuke Nogaki (Kyoto University)

The recent discovery of superconductivity in $CeRh_2As_2$ clarified an unusual *H*-*T* phase diagram with two superconducting phases and paved a new way to realize topological superconductivity [1]. In $CeRh_2As_2$, the inversion symmetry is locally broken at the Ce sites. Surprisingly, the phase diagram was predicted in theoretical work about locally noncentrosymmetric superconductors [2]. The similarity of these phase diagrams between the experiment [1] and theory [2] suggests that the local inversion symmetry breaking plays an essential role in $CeRh_2As_2$, and the superconducting phase in the high magnetic field region is the pair-density-wave (PDW) state. The most crucial property of the

PDW state is the odd-parity superconducting state with spin-singlet pairing. The character of the PDW state suggests a possibility of topological superconductivity as spin-triplet superconductors are.
In the first half of this talk, using the group theory, we derived the Fermi-surface formula of Z_2 invariants specifying the topological crystalline superconductivity protected by the nonsymmorphic glide symmetry [3]. Furthermore, we conducted the first-principles calculation for the electronic structure of $CeRh_2As_2$. Combining the results, we evaluate the Z2 invariants and found the topological crystalline superconductivity [4].
Despite the above success, there are some issues to be resolved. First, the microscopic mechanism of superconductivity in $CeRh_2As_2$ has not been uncovered. The experimental observations indicate that strong correlation effects impact the electronic state of $CeRh_2As_2$. Second, although the experimentally observed phase diagrams resemble the theoretical prediction qualitatively, the parity transition field of the experiment is more significant than that of the weak-coupling theory by a factor of five. This discrepancy has discouraged a conclusive interpretation [1,2].
In the second half of this talk, we discuss strong correlation effects in $CeRh_2As_2$. We find XY-type magnetic fluctuation consistent with a recent NMR study [5]. Our theoretical results also show that the parity transition field is significantly enhanced by electron correlation effects in the superconducting phase diagram. The obtained theoretical values of the parity transition field well reproduce the experimental value [6].

[1] S. Khim et al., Science 373, 1012 (2021).
[2] T. Yoshida, M. Sigrist, and Y. Yanase, Phys. Rev. B 86, 134514 (2012).
[3] M. Sato, Phys. Rev. B 81, 220504(R) (2010).
[4] K. Nogaki, A. Daido, J. Ishizuka, and Y. Yanase, Phys. Rev. Res. 3, L032071 (2021).
[5] S. Kitagawa et al., J. Phys. Soc. Jpn. 91, 043702 (2022).
[6] K. Nogaki and Y. Yanase, Phys. Rev. B 106, L100504 (2022).

Phonon-Mediated Spin-Triplet Superconductivity in Chiral Crystals

Rikuto Oiwa (Meiji University)

We discuss possible phonon-mediated spin-triplet pairings unique to chiral crystals, on their microscopic mechanisms and pairing symmetries.

Hidden projector embedding in the Affleck-Kennedy-Lieb-Tasaki model and the PXP model

Keita Omiya (PSI – EPFL)

Quantum many-body scar (QMBS) is a new class of weak ergodicity-breaking. Some non-integrable models host non-thermal eigenstates called scar states which violate eigenstate thermalization hypothesis (ETH). Since the quench experiment using Rydberg atoms showed their existence, many models having scar states and several recipes to construct such models have been identified. However, the Affleck-Kennedy-Lieb-Tasaki (AKLT) model and the PXP model, an effective model of the experiment, have eluded thorough understanding. In this talk, I show that both the AKLT model and the PXP model can be expressed as a generalized Shiraishi-Mori form, which is a very common construction of Hamiltonian hosting scar states once Hilbert space is suitably enlarged. I further show a wide class of constrained models could possess this structure.

Dissipation-engineered family of nearly dark states in many-body cavity-atom systems

Lin Rui (ETHZ)

Three-level atomic systems coupled to light have the capacity to host dark states. We study a system of V-shaped three-level atoms coherently coupled to the two quadratures of a dissipative cavity. The interplay between the atomic level structure and dissipation makes the phase diagram of the open system drastically different from the closed one. In particular, it leads to the stabilization of a continuous family of dark and nearly dark excited many-body states with inverted atomic populations as the steady states. The multi-stability of these states can be probed via their distinct fluctuations and excitation spectra, as well as the system's Liouvillian dynamics which are highly sensitive to ramp protocols. Our model can be implemented experimentally by encoding the two higher-energy modes in orthogonal density-modulated states in a bosonic quantum gas.

Building crystalline topological superconductors from Shiba lattices

Martina Ondina Soldini (University of Zurich)

Localized or propagating Majorana boundary modes are the key feature of topological superconductors. While being a rarity in natural compounds, the tailored manipulation of quantum matter offers novel opportunities for their realization. Specifically, lattices of Shiba bound states that arise when magnetic adatoms are placed on the surface of a conventional superconductor can be used to create topological bands within the superconducting gap of the substrate. Scanning tunneling microscopy allows to experimentally create and probe adatom lattices with single atom precision to create topological crystalline superconductors. Their topological character and boundary modes are protected by the spatial symmetries of the adatom lattice. We developed a theoretical model for the experimentally realized lattices and identified signatures in the experimental measurements consistent with the realization of two types of mirror-symmetry protected topological superconductors: (i) with full bulk gap and topological edge as well as higher-order corner states and (ii) with symmetry-protected bulk nodal points. Our results show the immense versatility of Shiba lattices to design the topology and sample geometry of 2D superconductors.

Theoretical study of twisted bilayer $Bi_2(Te,Se)_3$

Ikuma Tateishi (RIKEN)

Recently, moiré superlattice systems, such as twisted bilayer graphene, have been very actively studied.
In this presentation, we propose twisted bilayer $Bi_2(Te,Se)_3$ as a new moiré superlattice system and show a result of our theoretical study on its novel topological properties. Untwisted $Bi_2(Te,Se)_3$ is one of the well-known topological insulators, and it is reported that the topological invariant of a thin film $Bi_2(Te,Se)_3$ strongly depends on the number of stacked layers. By driving the stacking-dependent phase transition with moiré superlattice structure, we show a twisted bilayer $Bi_2(Te,Se)_3$ has topological insulator domains and normal insulator domains in the moiré unit cell. We also show there are corresponding edge states at the domain boundaries, and they are quantized by a finite size effect of the boundaries and result in moiré flat bands. Moreover, in the moiré band structure, we have obtained topological insulator phases with moiré scale edge states that emerge from the domain-boundary edge states.

Skyrmions in twisted bilayer graphene

Glenn Wagner (University of Zurich)

Twisted bilayer graphene has attracted much attention due to the correlated insulators and the superconductivity observed in experiments. A recent proposal by Khalaf et al. links the two: The lowest-energy excitations of the insulating ground state are skyrmion excitations which carry one unit of charge, the excitations attract one another to form bound charge-2e objects which can then condense to form a superconductor. I will present results from a microscopic Hartree-Fock calculation that show that such a mechanism is a viable candidate for the superconductivity observed in experiments.

Universal properties of dissipative Tomonaga-Luttinger liquids with and without internal symmetry

Kazuki Yamamoto (Kyoto University)

In recent years, open quantum systems have been actively studied both experimentally and theoretically, as exemplified by driven-dissipative many-body systems and non-Hermitian (NH) quantum systems. In particular, high controllability of ultracold atoms has enabled observations of novel quantum phases unique to open quantum systems. Such experimental progress has facilitated investigations of NH quantum systems.
In this presentation, we demonstrate universal properties of dissipative Tomonaga-Luttinger (TL) liquids with and without internal symmetry by deriving correlation functions and performing finite-size scaling analysis. We first analyze a non-Hermitian XXZ spin chain as a prototypical correlated model in one-dimensional open quantum systems [1]. Our calculation is based analytically on the field theory with bosonization, the finite-size scaling approach in conformal field theory (CFT), and the Bethe-ansatz solution, and numerically on the density-matrix renormalization group analysis generalized to non-Hermitian systems (NH-DMRG). Importantly, we uncover that the model belongs to the universality class characterized by the complex-valued TL parameter in the massless regime with weak dissipation.
Then, we study universal scaling relations for dissipative TL liquids with SU(N) spin symmetry by using asymptotic Bethe-ansatz solutions and conformal CFT in one-dimensional non-Hermitian quantum many-body systems with SU(N) symmetry [2]. We uncover that the spectrum of dissipative TL liquids with SU(N) spin symmetry is described by the sum of one charge mode characterized by a complex generalization of $c = 1$ U(1) Gaussian CFT, and $N - 1$ spin modes characterized by level-1 SU(N) Kac-Moody algebra with the conformal anomaly $c = N - 1$, and thereby dissipation only affects the charge mode as a result of spin-charge separation in one-dimensional non-Hermitian quantum systems. The derivation is based on a complex generalization of Haldane's ideal-gas description, which is implemented by the SU(N) Calogero-Sutherland model with inverse-square long-range interactions.

[1] K. Yamamoto, M. Nakagawa, M. Tezuka, M. Ueda, and N. Kawakami, Phys. Rev. B 105, 205125 (2022)
[2] K. Yamamoto and N. Kawakami, arXiv:2207.04395

Doping asymmetry and layer-selective metal-insulator transition in trilayer $K_{3+x}C_{60}$

Changming Yue (University of Fribourg)

Thin films provide a versatile platform to tune electron correlations and explore new physics in strongly correlated materials. Epitaxially grown thin films of the alkali-doped fulleride K3+xC60, for example, exhibit intriguing phenomena, including Mott transitions and superconductivity, de- pending on dimensionality and doping. Surprisingly, in the trilayer case, a strong electron-hole doping asymmetry has been observed in the superconducting phase, which is absent in the three-dimensional bulk limit. Using density-functional theory plus dynamical mean-field theory, we show that this doping asymmetry results from a substantial charge reshuffling from the top layer to the middle layer. While the nominal filling per fullerene is close to n = 3, the top layer rapidly switches to an n = 2 insulating state upon hole doping, which implies a doping asymmetry of the super- conducting gap. The interlayer charge transfer and layer-selective metal-insulator transition result from the interplay between crystal field splittings, strong Coulomb interactions, and an effectively negative Hund coupling. This peculiar charge reshuffling is absent in the monolayer system, which is an n = 3 Mott insulator, as expected from the nominal filling.

Ref: Changming Yue, Yusuke Nomura, Philipp Werner, Phys. Rev. Lett. 129, 066403 (2022)