Thursday, August 3

10:30 **Hisao Hayakawa** (Kyoto University)
Opening address

10:40 **Massimiliano Esposito** (University of Luxembourg)
Title: Towards a Nonequilibrium Thermodynamics of Complex Systems

11:20 **Jose Nahuel Freitas** (University of Buenos Aires)
Title: Maxwell Demon that Can Work at Macroscopic Scales
Abstract: Maxwell's demons work by rectifying thermal fluctuations. They are not expected to function at macroscopic scales where fluctuations become negligible and dynamics become deterministic. We propose an electronic implementation of an autonomous Maxwell's demon that indeed stops working in the regular macroscopic limit as the dynamics becomes deterministic. However, we find that if the power supplied to the demon is scaled up appropriately, the deterministic limit is avoided and the demon continues to work. The price to pay is a decreasing thermodynamic efficiency. Our work suggests that novel strategies may be found in nonequilibrium settings to bring to the macroscale nontrivial effects so far only observed at microscopic scales.

11:40 **Haitao Quan** (Peking University)
Title: Achieving the maximum power of a Brownian heat engine
Abstract: The pursuit of achieving high power in micro-engines has gained increasing interests in recent years. We consider a heat engine with a single Brownian particle as the working substance and optimize control protocols of heat-engine cycles in general damped situation. We obtain results of the maximum power (EMP) for an arbitrary friction coefficient, ranging from the overdamped regime to the underdamped limit. It is demonstrated that our approach recovers previous results about EMP in both the overdamped regime and the underdamped

limit regime. In addition, by interpolating results from both the overdamped and underdamped limit, we derive an upper bound on the maximum power of Brownian heat engines $P_{¥mathrm{bound}}¥approx¥sqrt{¥lambda_{H}}T_{H}(1-¥sqrt{T_{L}/T_{H}})(1-¥sqrt{(1+T_{L}/T_{H})/2})/2$, where T_{L} and T_{H} are temperatures of two heat baths, and $¥lambda_{H}$ is the maximum stiffness of the cycle. Our results bring valuable insights for designing high-performance Brownian heat engines in experimental setups.

12:00 Lunch

13:30 **Ryusuke Hamazaki** (RIKEN)

Title: Universality and timescale of thermalization in isolated quantum systems

Abstract: How isolated quantum systems relax to thermal equilibrium is the fundamental problem in quantum statistical mechanics [1]. While local observables in generic systems are believed to thermalize after a long time via the eigenstate thermalization hypothesis (ETH) [2], to what extent the ETH universally holds is still an open question. Furthermore, understanding timescales for thermalization is another challenge beyond the theory of the ETH.

In this talk, we discuss our recent work on the universality and timescale of thermalization in isolated quantum systems. We first show our numerical verification of the universality of the ETH for realistic quantum many-body systems. We introduce few-body random matrix ensembles to model realistic systems and show that the ETH holds for most of them unless the range of the interactions is too long [3,4].

We then discuss rigorous bounds on timescales of relaxation dynamics in light of quantum speed limits. While conventional quantum speed limits do not provide meaningful consequences for macroscopic systems, we propose several distinct speed limits that are useful even for many-body systems. In particular, we show that the local conservation law of probability leads to qualitatively tighter speed limits for macroscopic transitions [5], which are relevant for timescales of thermalization from inhomogeneous initial states. We also discuss speed limits concerning the dynamics of local observables in locally interacting many-body systems [6].

[1] J. Eisert, M. Friesdorf, and C. Gogolin, Nat. Phys. 11, 124 (2015).
[2] M. Rigol, V. Dunjko, M. Olshanii, Nature 452, 854 (2008)
[3] S. Sugimoto, R. Hamazaki, and M. Ueda, Phys. Rev. Lett. 126 (12), 120602 (2021)
[4] S. Sugimoto, R. Hamazaki, and M. Ueda, Phys. Rev. Lett. 129 (3), 030602 (2022).
[5] R. Hamazaki, PRX Quantum 3 (2), 020319 (2022).
[6] R. Hamazaki, arXiv:2305.03190 (2023).

14:10 **Mao Tian Tan** (Asia Pacific Center for Theoretical Physics)

Title: Information Scrambling and Recovery in Inhomogeneous Quenches: An Exploration in Two-dimensional Conformal Field Theories

Abstract: In recent years, analytically tractable models of quench and Floquet dynamics have been constructed in two-dimensional conformal field theories by considering the time evolution generated by a family of inhomogeneous Hamiltonians which includes the sine-squared-deformed (SSD) Hamiltonian where the energy density profile is given by a sine-squared function.

When the thermal state is quenched by the SSD Hamiltonian, we find that all the quantum information in the system gets concentrated about a particular fixed point. We dub these agglomerations of quantum information "black hole-like" excitations and they carry as much information as the thermal entropy of the total system. Away from this fixed point, the rest of the system "reverse thermalizes" from the uniform thermal state into the ground state.

We also consider the quench of the thermofield double state which is equivalent to studying the operator entanglement of the unitary time evolution operator. This quantity measures the amount of information scrambled by the system's dynamics.

It was previously shown that holographic CFTs scramble information maximally. By introducing a sine-squared deformation, this information scrambling can be reduced and information can be recovered. Furthermore, genuine tripartite entanglement which is not shared by any two parties is produced in the process.

14:30 **Naoto Shiraishi** (University of Tokyo)

Title: Fluctuation-response relation of time-symmetric current around nonequilibrium stationary state

Abstract: The relation between fluctuation and response is an important subject in nonequilibrium statistical mechanics. In particular, the fluctuation and the response of current, a prominent example of time-antisymmetric quantity, has been studied well [1]. The fluctuation and the response of current are directly connected in systems around equilibrium, known as the fluctuation-response relation, which is recently extended to nonequilibrium stalling states [2].

In this presentation, we introduce a novel quantity called the time-symmetric current, which exhibits time-symmetry while closely resembling conventional current in various aspects. Intriguingly, the time-symmetric current also follows the same form of the fluctuation-response relation as the conventional current [3], indicating that it is indeed a proper time-symmetric counterpart. From an experimental perspective, the derived fluctuation-response relation can serve as a probe of the bare transition rate, particularly in cases with low time resolution apparatus [3].

We further extend the fluctuation-response relation of the time-symmetric current to general nonequilibrium stationary states [4]. By employing a fictitious stalling method, we modify and validate the fluctuation-response relation in the nonequilibrium non-stalling stationary states.

If time permits, we explore further physical implications of the time-symmetric current. Specifically, by considering the difference between the current and the time-symmetric current, we construct a martingale process on Markov jump processes, facilitating the derivation of various relations. As an illustrative example,

we directly derive the thermodynamic uncertainty relation from this novel viewpoint [5,6].

[1] N. Shiraishi, An Introduction to stochastic thermodynamics, Springer (2023).
[2] B. Altaner, M. Polettini, and M. Esposito, Phys. Rev. Lett. 117, 180601 (2016).
[3] N. Shiraishi, Phys. Rev. Lett. 129, 020602 (2022).
[4] N. Shiraishi, J. Stat. Mech. 033207 (2023).
[5] C. Dieball and A. Godec, Phys. Rev. Lett. 130, 087101 (2023).
[6] N. Shiraishi, in preparation

14:50 **Kay Brandner** (University of Nottingham)
Title: Thermodynamic Geometry for Quantum Thermal Machines

15:30 Break

15:50 **John Bechhoefer** (Simon Fraser University)
Title: Anomalous thermal relaxation in a colloidal system
Abstract: Naively, a hot object should take longer to cool than a warm one. Yet, some 2300 years ago, Aristotle remarked that "to cool hot water quickly, begin by putting it in the sun." In the 1960s, Erasto Mpemba similarly found that hot water can freeze more quickly than cold water, but such experiments have been hard to reproduce. Recently, we have observed this Mpemba effect in a more controlled setting, the thermal quench of a colloidal system immersed in water, which serves as a heat bath. The results are reproducible and agree quantitatively with calculations based on a recently proposed theoretical framework. Under the right conditions, we even find an exponential speed-up of cooling. Surprisingly, we also find that heating can be anomalous, the first observations of an inverse Mpemba effect. Our experiments give a physical picture of the generic conditions needed to accelerate relaxation to thermal equilibrium and support the idea that the

Mpemba effect is a prototype for a wide range of anomalous relaxation phenomena that may have significant technological application.

16:30 **Amit Kumar Chatterjee** (Kyoto University)

Title: Quantum Mpemba effect in a quantum dot with reservoirs

Abstract: Mpemba effect refers to the intriguing counter-intuitive phenomenon where hotter objects can cool down faster than colder objects. We demonstrate the quantum counterpart of Mpemba effect in a quantum dot coupled to two reservoirs, described by the Anderson model. We show that the system temperatures starting from two different initial values (hot and cold), cross each other at finite time (and thereby reverse their identities i.e. hot becomes cold and vice versa) to generate thermal quantam Mpemba effect. We provide necessary criterion for quantum Mpemba effect in density matrix elements and discuss such anomalous relaxation in other observables like energy and entropy.

Reference: A. K. Chatterjee, S. Takada, and H. Hayakawa, arXiv:2304.02411 (2023).

16:50 **Jae Dong Noh** (University of Seoul)

Title: Scaling of mean first passage times of random walks in fractal media

Abstract: In a random fractal embedded in the Euclidean space, the mean first passage time~(MFPT) is believed to obey the power law scaling with the distance between a source and a target site with a universal exponent. We find that the scaling law for the MFPT is not determined solely by the distance between a source and a target but also by their locations. The role of a site in the first passage processes is quantified by the random walk centrality. It turns out that the site of highest random walk centrality, dubbed as a hub, intervenes in first passage processes. We show that the MFPT from a departure site to a target site is determined by a competition between direct paths and indirect paths detouring via the hub. Consequently, the MFPT displays a crossover scaling between a short distance regime, where direct paths are dominant, and a long distance regime, where indirect paths are dominant. The two regimes are characterized by power laws with different scaling exponents. The crossover scaling behavior is confirmed by extensive numerical calculations of the MFPTs on the critical percolation cluster in two dimensional square lattices.

17:10 (Online) **Sebastian Diehl** (University of Cologne)

Title: Measurement induced phase transitions: new applications for non-equilibrium statistical mechanics?

Abstract: The quest for phases and phase transitions in general non-unitary quantum dynamics has been spotlighted by the recent discovery of measurement-induced phase transitions. They result from the competition of deterministic Schrödinger and random measurement dynamics, and surface in a qualitative change of the entanglement structure.

Here we first introduce instances of entanglement transitions in fermion systems, between a regime of logarithmic entanglement growth, and a quantum Zeno regime obeying an area law. We identify the relevant degrees of freedom driving the phase transition in terms of an effective field theory. This yields a physical picture in terms of a depinning from the measurement operator eigenstates induced by unitary dynamics, and places it into the BKT universality class.

In standard quantum mechanical observables however, these transitions are masked due to the degeneracy of measurement outcomes. We then point out a general route of gently breaking this degeneracy -- pre-selection -- which makes such transitions observable in state-of-the-art quantum platforms without modifying any of the universal properties. It reveals an intriguing connection to quantum absorbing state transitions.

Friday, August 4

9:00 (Online) **M. Cristina Marchetti** (UCSB)
Title: Nonreciprocal Patterns of Conserved Fields

9:40 **Kyogo Kawaguchi** (RIKEN)
Title: Probing the asymmetric rules of interactions in multicellular dynamics

10:20 Break

10:40 **Yongjoo Baek** (Seoul National University)
Title: Thermodynamically consistent active heat engines: entropy production, efficiency, and performance
Abstract: We propose a thermodynamically consistent, analytically tractable model of steady-state active heat engines driven by both temperature difference and a constant chemical driving. While the engine follows the dynamics of the Active Ornstein-Uhlenbeck Particle, its self-propulsion stems from the mechanochemical coupling with the fuel consumption dynamics, allowing for both even- and odd-parity self-propulsion forces. Using the standard methods of stochastic thermodynamics, we show that the entropy production of the engine satisfies the conventional Clausius relation, based on which we define the efficiency of the model that is bounded from above by the second law of thermodynamics. Using this framework, we obtain exact expressions for the efficiency at maximum power. The results show that the engine performance has a nonmonotonic dependence on the magnitude of the chemical driving, and that the even-parity (odd-parity) engines perform better when the size of the engine is smaller (larger) than the persistence length of the active particle. We also discuss the existence of a tighter upper bound on the efficiency of the odd-parity engines stemming from the detailed structure of the entropy production.

11:00 **Francisco Vega Reyes** (Universidad de Extremadura)

Title: Memory effects in complex fluids

Abstract: Memory in physical systems can be understood as either the ability to access/interpret features of the past history of the system or save and store features of its current state so that future states will have acess to this stored information. In both cases, the information is used by the system to select very specific time evolutions, in which case the system is said to be suject to a /memory effect/. We review a few cases of memory effects in soft matter, with special focus on thermal memory in complex fluids composed by macroscopic particles (either passive or active particles.). In particular, we will show that, as a consequence of thermal memory, anomalous and asymmetric cooling and heating can appear. We show theoretically how these memory effects are encoded in the features of the time evolution of the velocity distribution function. We also provide experimental evidence of this.

11:20 **Hugues Chaté** (CEA-Saclay & Beijing CSRC)

Title: Fragility and metastability of polar flocks

Abstract: Polar flocks, understood in the Vicsek/Toner-Tu sense of the collective motion of self-propelled particles aligning their velocities, remain central in active matter studies. They are a limit case of real situations: the fluid surrounding particles is ignored (“dry”), the particles are pointlike (“dilute”), so that alignment is the only interaction. Even though their relevance in the real world is limited (but not nil), they must be studied thoroughly since understanding them is crucial to approach more complicated and realistic systems.

These flocks have perhaps been best known for exhibiting true long-range (polar) orientational order in 2D, something impossible in equilibrium. Recently, however, evidence started accumulating that such ordered phases are both fragile and metastable. This talk will be mostly devoted to describing these findings and discussing their implications.

12:00 Lunch

13:30 **Naruo Ohga** (The University of Tokyo)

Title: Thermodynamic bound on the asymmetry of cross-correlations

Abstract: The principle of microscopic reversibility states that, in equilibrium, cross-correlations between two state observables are always symmetric under the exchange of observables. Thus, the asymmetry of cross-correlations is a fundamental, measurable, and often-used statistical signature of deviation from equilibrium. It quantifies the magnitude of various nonequilibrium phenomena, such as directed information flow, nonequilibrium circulation, and nonreciprocal motion.

Here we find and prove a simple and universal inequality that bounds the magnitude of asymmetry by the maximum thermodynamic affinity across cycles [1]. Our result applies to a large class of systems and all state observables, and it suggests a fundamental thermodynamic cost for various nonequilibrium functions quantified by the asymmetry. It also provides a powerful tool to infer affinity from measured cross-correlations, in a different and complementary way to the thermodynamic uncertainty relations.

As an application, our result is used to prove a thermodynamic bound on the coherence of noisy oscillations, which was previously conjectured by Barato and Seifert [2]. We also use our result to bound directed information flow in a biochemical signal transduction model.

[1] N. Ohga, S. Ito, and A. Kolchinsky, Phys. Rev. Lett., in press (arXiv:2303.13116).

[2] A. C. Barato and U. Seifert, Phys. Rev. E 95, 062409 (2017).

13:50 **Arnab Pal** (The Institute of Mathematical Sciences)

Title: Non-equilibrium Phenomena of Resetting

Abstract: Stopping a process in its midst -- only to start it all over again -- may prolong, leave unchanged, or even shorten the time taken for its completion. Among these three possibilities the latter is particularly interesting as it suggests that resetting can be used to facilitate the completion of complex processes which otherwise would hinder. We will introduce the problem of resetting using the example of paradigmatic Brownian motion, but will then explain why many unknowns compel us to generalise to arbitrary stochastic processes and resetting mechanisms. We will demonstrate how resetting serves as a universal smart strategy to expedite efficiency of generic macroscopic & microscopic non-equilibrium search processes, ion transport and to design improved performance and optimization in queuing systems. The talk will end by providing a glimpse of new learning that we gained from resetting based optical trap experiments.

14:10 **Namiko Mitarai** (The Niels Bohr Institute, University of Copenhagen)

Title: To grow, or not to grow? Bacterial growth, dormancy, and death

Abstract: Some bacteria can divide as fast as every 20 minutes in a good condition, while when the condition becomes too severe, the cells can enter dormancy where the division stops. The cells may tolerate the non-growing condition for days - though some of the cells may start dying after sometime. The dormant cells can restart the growth when the environment improves again. Interestingly, very often, even if the environment allows the growth of the cells, a subpopulation of them may stay/become dormant. A dormant sub-population appears useless at the first sight, but those cells are often more tolerant to stresses lethal to growing cells, such as antibiotics. We discuss experimental findings and mathematical models to analyze optimal strategies for bacterial growth and dormancy under feast-famine cycle in various scenario.

14:50 (Online) **Jinqiao Duan** (Great Bay University)

Title: The Most Probable Transition Pathways in Non-Gaussian Stochastic Dynamical Systems

Abstract: Dynamical systems under non-Gaussian Levy fluctuations manifest as nonlocality at a certain "macroscopic" level. Transition phenomena are special events for evolution from one metastable state to another, caused by the interaction between nonlinearity and uncertainty. Examples for such events are phase transition, pattern change, gene transcription, climate change, abrupt shifts, extreme transition, and other rare events. The most probable transition pathways are the maximal likely trajectory (in the sense of optimizing a probability or an action functional) between metastable states.

The speaker will present recent work (theory and methods) on the most probable transition pathways for stochastic dynamical systems, in the context of the Onsager-Machlup action functionals. This is joint work with Jianyu Chen, Xiaoli Chen, Ting Gao, Jianyu Hu and Wei Wei.

15:10 **Patrick Pietzonka** (Max Planck Institute for the Physics of Complex Systems)
Title: Thermodynamic cost for precision of general counting observables
Abstract: We analytically derive universal bounds that describe the trade-off between thermodynamic cost and precision for observables recording events related to some internal changes of an otherwise hidden physical system. The precision is quantified by the fluctuations in either the number of events counted over time or the times between successive events. Our results are valid for the same broad class of nonequilibrium driven systems considered by the thermodynamic uncertainty relation but, differently from the last, our results on precision extend to both time-symmetric and asymmetric observables. We show how optimal precision saturating the bounds can be achieved. For waiting time fluctuations of asymmetric observables, a phase transition of the optimal configuration arises, where higher precision can be achieved by combining several signals.

15:30 Break

15:50-17:50 Poster session

18:00 Banquet (@Coop in the Northern campus)

Saturday, August 5

9:00 **David Hilton Wolpert** (Santa Fe Institute)

Title: Stochastic thermodynamics of Boolean circuits, finite automata and Turing machines

Abstract: In this talk I will summarize recent results on how the thermodynamics of a physical system implementing a computation depends on the computation being performed and the precise physical system being used to perform it. I will start with some new results concerning the thermodynamic costs of performing a given computation in a (loop-free and branch-free) digital circuit. Next I will summarize some results concerning deterministic finite automata (DFA). After that I will review results on how considering the minimal entropy production (EP) of computing a desired output on a Turing machine (TM), rather than the minimal size of an input string that causes the TM to produce that output (i.e., the output's Kolmogorov complexity), results in a correction term to Kolmogorov complexity. I will end by describing the vast new set of research issues at the intersection of stochastic thermodynamics and computer science theory, issues that expand both fields.

9:40 **Dima Boriskovsky** (Tel-Aviv University)

Title: A nonlinear fluctuation-dissipation test for Markovian systems

Abstract: Fluctuation-Dissipation-Relations (FDR) connect the internal spontaneous fluctuations of a system with its response to an external perturbation. In this work we propose a nonlinear generalized FDR (NL-FDR) as a test for Markovianity of the considered non-equilibrium system, i.e. the violation of the NL-FDR indicates a non-Markovian process. Previously suggested FDRs are based on linear response and require a significant number of measurements. However, the nonlinear relation holds for systems out of equilibrium and for strong perturbations. Therefore, its verification requires significantly less data than the standard linear relation. We test the NL-FDR for two theoretical model systems: a particle in a tilted periodic potential and a harmonically bound particle, each either

driven by white noise (leading to Markovian test cases, which should obey the NL-FDR) or by colored noise (resulting in non-Markovian systems, which may not obey the relation). The degree of violation is systematically explored for the non-Markovian variants of our theoretical models. For the particle in the harmonically bound potential, all statistical measures entering the NL-FDR can be calculated explicitly and can be used to elucidate why the relation is violated in the non-Markovian case. In addition, we apply our formalism and test for Markovianity in an inherently out-of-equilibrium experimental system, a tracer particle, embedded in an active bath of self-propelled agents (bristlebots) and subject to a force applied by an external air stream. An experimental violation of the NL-FDR is witnessed by introducing an additional time scale to the process, when using bristlebots with two metastable speed states.

10:00 **Hyun-Myung Chun** (Korea Institute for Advanced Science)

Title: Nonequilibrium fluctuation-response relations in diffusion and chemical reaction networks

Abstract:

Hyun-Myung Chun∗, Qi Gao, and Jordan M. Horowitz

The response to perturbation and fluctuation in a system, whether in equilibrium or nonequilibrium, reveals fundamental relationships. Equilibrium systems exemplify this through the fluctuation- dissipation theorem, which connects a response function to an equilibrium correlation function. However, understanding the interplay between fluctuation and response in nonequilibrium requires exploring microscopic dynamics or steady-state distribution to identify the conjugate variable in a nonequilibrium correlation function. In this talk, I will delve into three distinct perturbation types applied to both nonequilibrium diffusive systems and chemical reaction networks, examining the unique nature of each corresponding response function. Remarkably, one of these perturbations unveils an equilibrium-like fluctuation-response relation that remains independent of microscopic dynamics. Additionally, I will derive thermodynamic bounds on the response functions for the remaining perturbations in one-dimensional diffusions and chemical reaction networks. Specifically, in the realm of chemical reaction networks, I will demonstrate that the response of the mean number of a chemical species is bound by number fluctuations and the maximum thermodynamic driving force, leading to trade-offs. These trade-offs persist in both linear and a particular class of nonlinear chemical reaction networks featuring a single species.

Reference

[1] H.-M. Chun, Q. Gao, and J. M. Horowitz, Physical Review Research 3, 043172 (2021)

[2] Q. Gao, H.-M. Chun, and J. M. Horowitz, Physical Review E 105, L012102 (2022)

[3] H.-M. Chun and J. M. Horowitz, J. Chem. Phys. 158, 174115 (2023)

10:20 Break

10:40 **Andreas Dechant** (Kyoto University)

Title: Thermodynamic constraints on the power spectral density

Abstract: We derive lower and upper bounds on the power spectral density of a fluctuating observable in continuous-time Markov processes. In equilibrium systems, the bounds are expressed in terms of the low and high-frequency behavior of the spectrum. Out of equilibrium, where we can generally observe oscillations, which manifest as peaks in the spectrum, we relate the height of these peaks to the amount of dissipation. Our results extend the recently developed framework of thermodynamic bounds on fluctuations from the time to the frequency-domain.

11:20 **Ken Sekimoto** (Universite PSL)

Title: Langevin function emerged from Langevin equation as martingale mean drift

Abstract: The martingale characterizes a kind of fairness or unbiased nature of the stochastic process which is associated with another stochastic process. If xt evolves according to the Langevin equation whose mean drift is at as function of xt, and that at as induced stochastic process is martingale in turn associated with the former process, then we show that the amplitude of at is the Langevin function,

which is originally the canonical response of a single classical Heisenberg spin under static field.

12:00 Lunch

13:30 **Bulbul Chakraborty** (Brandeis University)

Title: Rigidity and Flow in the proximity of jamming

Abstract: Diversity in the natural world emerges from the collective behavior of large numbers of interacting objects. Statistical physics provides the framework relating microscopic to macroscopic properties. A fundamental assumption underlying this approach is that we have complete knowledge of the interactions between the microscopic entities. But what if that, even though possible in principle, becomes impossible in practice ? Can we still construct a framework for describing their collective behavior ? Dense suspensions and granular materials are two often quoted examples of non-thermal systems where we face this challenge. These are systems where because of the complicated surface properties of particles, and the lack of Brownian motion, there is extreme sensitivity of the interactions to particle positions. In this talk, I will present a perspective based on notions of constraint satisfaction that provides a way forward. I will focus on our recent work on the emergence of elasticity in the absence of any broken symmetry, and sketch out other problems that can be addressed using this perspective.

14:10 **Giulia Garcia Lorenzana** (Ecole Normale Superieure and Universite Paris Cite)

Title: Can migration and disorder rescue ecological metacommunities from extinction?

Abstract: Complex interaction networks can allow spatially extended ecosystems to thrive even when demographic noise would drive species in isolation to extinction. Previous works have established that a network of local communities connected by dispersal and hosting a few species undergoes a second-order out-of-equilibrium phase transition between an extinction and a survival state. This transition falls in the universality class of Directed Percolation.

Here we will focus on the case of many-species metacommunities, modelled by Lotka-Volterra equations with random competitive interactions. We will show that in this case richer phase transition phenomena take place.
When the demographic fluctuations are strong the transition is continuous and analogous to the single-species case. At small demographic noise the transition becomes discontinuous and exhibits novel features that are a signature of the complexity of the ecosystem. In this regime, only possible in the presence of heterogeneity in the interaction network, the metacommunity is able to self-sustain in a region of parameter space in which single species would go extinct. Our work reveals the existence of a regime in which the dynamics of metacommunities displays hysteresis and because of the vicinity to a tipping point, ecosystems are subject to collapses upon small perturbations.

14:30 **Pablo Hurtado** (University of Granada)

Title: Scaling in driven fluids and the unreasonable effectiveness of Navier-Stokes-Fourier equations

Abstract: The stationary flow of a fluid driven out of equilibrium by boundary temperature and velocity gradients is one of the simplest yet most challenging examples of a nonequilibrium steady state. This steady state is described by the Navier-Stokes-Fourier equations, which dictate the macroscopic structure of the compressible, viscous, and heat-conducting fluid. In this work we uncover a new scaling property for the stationary solutions of the compressible Navier-Stokes-Fourier problem. For generic transport coefficients that depend nonlinearly on the hydrodynamic fields, we find that the density and temperature fields are functions of the fluid's pressure and a kinetic field that measures the quadratic excess velocity with respect to the ratio of the total heat current over the shear stress. This kinetic field obeys in turn a spatial scaling law controlled by the shear stress, which is inherited by the stationary density and temperature fields. The predicted scaling laws are confirmed via compelling data collapses from massive computer simulations of two paradigmatic molecular fluids, demonstrating along the way the unreasonable effectiveness of the hydrodynamic continuum equations to capture

the emergent properties of finite-sized molecular fluids. Overall, these scaling laws provide a novel way to characterize stationary flow in driven fluids.

14:50 **Itamar Procaccia** (The Weizmann Institute of Science)

Title: Anomalous Elasticity in Amorphous Solids: Screening by plasticity

Abstract: In this Lecture I will review some recent work in which it was shown that mechanical strains in amorphous solids are screened by the formation of plastic events that are typically quadrupolar in nature. At low densities the screening effect is reminiscent of the role of dipoles in dielectrics, while the effect at high density has no immediate electrostatic analog, and is shown to change qualitatively the form of elasticity theory, as seen for example in the observed displacement fields. High-density screening results in an undulating displacement field that strictly deviates from elasticity theory. I will argue that theoretical analysis, experimental measurements and numeric simulations of a variety of amorphous solids are in agreement with each other and provide support for the novel theory. Finally I will explain the relation of the present findings to the Kosterlitz-Thouless transition and to the Hexatic phase of two dimensional melting.