Italy-Israel Meeting on Non-Equilibrium Physics

April 11-13, Bar-Ilan University

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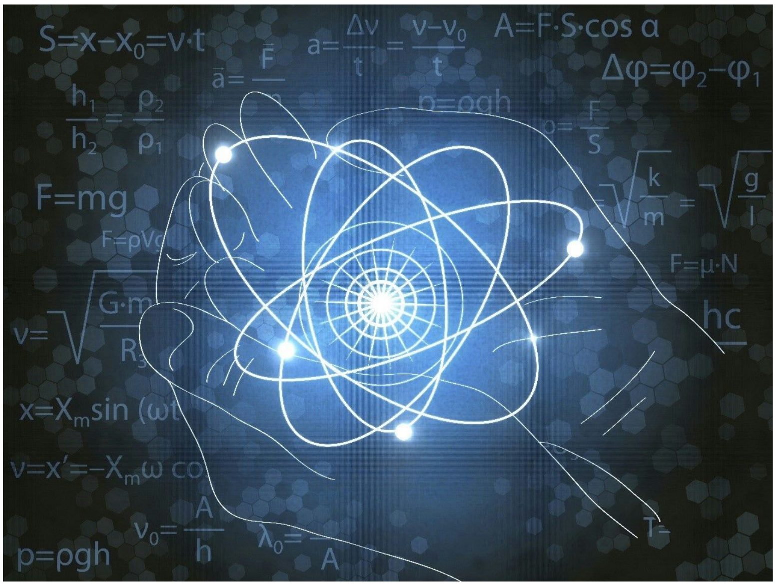

Abstract Book

1 LECTURES

1.1 Erez Aghion   Bar-Ilan University

Infinite-density function for diffusion of Sisyphus laser-cooled atoms
We present the Infinite-density function for the spatial diffusion of atoms undergoing Sisyphus laser-cooling. This process has already been shown to exhibit a reach variety of anomalous statistical effects. Our theory follows questions raised after an experiment by Sagi. el al., from the Weizmann institute (published, PRL, 2012), who studied the diffusion of ~1.5X10^6, Rb^87 atoms, in one dimension. With the infinite-density we now provide a theoretical description for the distribution of the atomic cloud, and predict the variance <x^2(t)> of the particles' position in the long time limit. However, this function is a very peculiar object in statistical physics, since it is non-normalizable. It points to the possibility to measure for the first time in the lab the result of a currently less known type of central limit theorem, which might be more common in physics then previously thought. It also points to an interesting bi-scaling behavior in the diffusion, and raises further questions about other implications of this theorem to this system.

1.2 Ehud Altman   Weizmann Institute of Science

Dynamics of many-body localized systems coupled to weak baths
Many-body localized systems present an interesting example of robust non-ergodic dynamics in a closed many-body system. How does coupling to a weak external bath, present in any realistic experiment, modify the relaxation dynamics? As a first example, I will consider coupling of electrons to a weak phonon bath represented by a random elastic network at low temperature. I will show that at low dimensions the random phonon bath is too weak to delocalize the electrons through the usual variable range hopping mechanism. Instead, the delocalization occurs through a many-body process involving a diverging number of phonons in the low temperature limit. This leads to a singular suppression of Mott's VRH rate. As a second example I will discuss the effect of inelastic light scattering on a many-body localized system of ultra-cold atoms. I will show how this coupling gives rise to anomalous slow relaxation in the MBL system.

1.3 Erez Berg Weizmann Institute of Science

Current-carrying quasi-steady states in a periodically driven many-body system
We investigate many-body dynamics in a one-dimensional interacting periodically driven system, based on a partially-filled version of Thouless's topologically quantized adiabatic pump. The corresponding single particle Floquet bands are chiral, with the Floquet spectrum realizing nontrivial cycles around the quasienergy Brillouin zone. For non-integer filling the system is gapless; here the driving cannot be adiabatic and the system is expected to rapidly absorb energy from the driving field. We identify parameter regimes where scattering between Floquet bands of opposite chirality is exponentially suppressed, opening a long time window where the many-body dynamics separately conserves the occupations of the two chiral bands. Within this intermediate time regime we predict that the system reaches a universal current-carrying quasi-steady state. The current carried by this state is determined solely by the density of particles in each band and the topological winding numbers of the Floquet bands. This remarkable behavior, which holds for both bosons and fermions, may be readily studied experimentally in recently developed cold atom systems.

1.4 Sylvain Bréchet EPFL Switzerland

Molecular Master equations
In order to describe molecular dissipation in general and more specifically magnetic dissipation occurring in a molecule, we adopt a quantum description of an open system that has specific molecular degrees of freedom and interacts with a bath that has the remaining degrees of freedom. The time evolution of the system is governed by quantum master equations, which we shall refer to as the molecular master equations. These equations determine the time evolution of the density operator, satisfying the von Neumann conditions. We consider a system coupled and correlated to a bath at statistical equilibrium. The distinction between the bath and the system is essentially determined by the respective time scales. The time scale associated to the bath must be much smaller than the time scale associated to the system. We attribute the vibrational and rotational molecular degrees of freedom as well as the electronic spin degrees of freedom to the system, and we assign the electronic orbital degrees of freedom to the bath. A molecular system is a bound system that is spatially localised, which implies that the state vectors describing such a system are restricted to a subspace of the Hilbert space associated to a general system consisting of nuclei and electrons. The electrons satisfy the exclusion principle, which requires the tensorial product of the spin Hilbert space and the orbital Hilbert space of an n-electron system to be antisymmetric under the action of the permutation group. According to the theory of the permutation group, such a tensorial product can be decomposed as the direct sum over the types of the irreducible representations of the permutation group of the tensorial product of the isotypic components associated to the system and to the bath. The isotypic component determine the total electronic spin. The coupling between different isotypic components in the quantum master equations allows the description of magnetic dissipation at the molecular level. The Hamiltonian of the system is expressed in terms of internal observables associated to physical properties of the system. In a classical framework, these observables would be described with respect to a rotating frame attached to the molecule. However, this is impossible in a quantum framework, since the positions of the nuclei, and thus the orientation of the molecule, are described by operators.

1.5 Iacopo Carusotto   BEC, Trento

Driven-dissipative vs. unitary quantum dynamics in quantum fluids of light: first successes and many exciting perspectives
I will begin with an introduction to the basic concept of quantum fluid of light when a many photon beam propagating in a nonlinear medium start displaying a collective behaviour as a fluid of many interacting particles. After reviewing the key experiments demonstrating Bose-Einstein condensation and superfluidity properties in such fluids, I will present some among the most exciting new directions of theoretical and experimental research in this field, namely quantum hydrodynamics in acoustic black hole configurations, quantum magnetism and synthetic dimensions for light, and conservative quantum dynamics in paraxial propagation.

1.6 Roberta Citro   INFN, Salerno

Dynamical stability of a periodically driven Sine-Gordon model
In the context of non-equilibrium physics the stability of periodically-driven many-body systems is the subject of several recent studies. According to the second law of thermodynamics, isolated equilibrium systems can only increase their energy when undergoing a cyclic process. For many-body interacting ergodic systems, it is assumed that that they will heat monotonously, approaching an infinite-temperature state. In contrast, for small systems such as a single spin, thermalization is not expected to occur and a periodic alternation of heating and cooling is predicted. Recently it has been shown, for a class of systems like the many-body localized one, that they remain localized at finite energy even for infinite driving frequencies. This is in contrast to ergodic systems which are expected to thermalize to an infinite temperature. How to describe the transition between these two opposite behaviors? Here we follow the path of considering a many-body analog of the Kapitza pendulum, the periodically-driven sine-Gordon model. This model is well suited for analytical treatments including the renormalization group and variational methods. By performing a high-frequency expansion, we show the emergence of a sharp “parametric resonance”, separating the absorbing from the non-absorbing regimes. This transition survives in the thermodynamic limit and leads to a non-analytic behavior of the physical observables in the long time limit. We apply different approaches to characterize the critical point at the transition. Classical and quantum experiments are proposed to verify the validity of these results.

1.7 Doron Cohen   Ben Gurion University

Chaos, metastability and ergodicity in atomtronic superfluid circuits
We clarify the role of "chaos" for the metastability criteria of flow states [1], and for the possibility to witness Rabi oscillations in a QUID-like setup [2]. We refer to coherent, as well as to stochastic-like features [3,4] in the dynamics and in the thermalization Process. [1] G. Arwas, A. Vardi, D. Cohen, Scientific Reports 5, 13433 (2015). [2] G. Arwas, D. Cohen, New Journal of Physics 18, 015007 (2016). [3] C. Khripkov, A. Vardi, D. Cohen, New J. Phys. 17, 023071 (2015). [4] I. Tikhonenkov, A. Vardi, J.R. Anglin, D. Cohen, Phys. Rev. Lett. 110, 050401 (2013).

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1.8 Itzhack Dana Bar-Ilan University

From Dynamical Localization to Quantum Antiresonance and Superweak Chaos: Theory and Experiment
This talk is a brief review of quantum-dynamical phenomena exhibited by paradigmatic and realistic models of Classical and Quantum Chaos, i.e., 1D periodically kicked systems. These phenomena have been experimentally realized during the last 22 years using atom-optics methods with cold atoms or BECs. The experimental results were found to agree very well with the theoretical ones based on the *single-particle* Schroedinger equation (SE) or nonlinear SE (NLSE). The most well known phenomenon is *dynamical localization* in momentum space [1], i.e., the quantum suppression of classical chaotic diffusion in this space, occurring for generic (irrational) values of a scaled Planck constant h_s. This phenomenon was first experimentally realized using cold atoms by the Raizen group at Austin [2]. A second phenomenon is *quantum resonance* (QR) [1-6], i.e., a ballistic evolution of the kinetic-energy expectation value, taking place for rational values of h_s. Despite this rationality of h_s, QR was experimentally realized using BECs by the Phillips group at NIST [3], with good agreement with single-particle-SE theory. Our group at BIU has studied several theoretical aspects of generalized QRs [4,5]. In particular, we have shown that a *QR-ratchet* in *momentum* space can emerge in asymmetric systems [5]. A simple case of such a ratchet was experimentally realized in collaboration with the Summy group at OSU [6]. For some parameter values, QR may degenerate to a diametrically opposite phenomenon, quantum antiresonance (QAR) [7,8], meaning that any wave-packet is essentially "frozen", i.e., it does not evolve in time under the kicks. The first studies of QAR, including those of our BIU group [7,8], seemed to indicate that this phenomenon is quite non-generic, being a quantum analogue of the apparently non-generic classical phenomenon of "*superweak chaos*" (SWC), discovered also by our group. Recently, however, we found that SWC can occur under generic conditions in a new system that we introduced, the "kicked Hall system" [9]. This system is equivalent to a harmonic oscillator periodically kicked by a time-modulated potential. QAR in the latter system, with an ordinary (non-modulated) kicking potential, was experimentally realized using BECs [10] and a good agreement was found with the theoretical results from a single-particle NLSE. [1] S. Fishman, D.R. Grempel, and R.E. Prange, Phys. Rev. Lett. 49, 509 (1982), and references therein. [2] F.L. Moore et al., Phys. Rev. Lett. 75, 4598 (1995). [3] C. Ryu et al., Phys. Rev. Lett. 96, 160403 (2006). [4] I. Dana and D.L. Dorofeev, Phys. Rev. E 73, 026206 (2006). [5] I. Dana and V. Roitberg, Phys. Rev. E 76, 015201(R) (2007). [6] I. Dana, V. Ramareddy, I. Talukdar, and G.S. Summy, Phys. Rev. Lett. 100, 024103 (2008). [7] I. Dana, Phys. Rev. Lett. 73, 1609 (1994); I. Dana and D.L. Dorofeev, Phys. Rev. E 72, 046205 (2005). [8] I. Dana, E. Eisenberg, and N. Shnerb, Phys. Rev. E 54, 5948 (1996), and references therein. [9] M. Ben-Harush and I. Dana, Phys. Rev. E, in press (https://faculty.biu.ac.il/~biuchaos/PAPERS/EH11433.pdf). [10] G.J. Duffy, A.S. Mellish, K.J. Challis, and A.C. Wilson, Phys. Rev. A 70, 041602(R) (2004).

1.9 Nir Davidson Weizmann Institute of Science

T.B.A.

1.10 Michele Fabrizio   SISSA, Trieste

Thermalisation in a Fermi liquid: few results and many questions
A Landau-Fermi liquid has all prerequisites to display thermalisation: a continuum of gapless single- and multi-particle excitations that can efficiently absorb and redistribute the excess energy that is initially supplied to drive the system out-of-equilibrium. However a deeper look into what a Landau-Fermi liquid really is suggests several counterarguments against thermalisation, starting from the famous one-to-one correspondence between non-interacting and interacting low-lying excited states hypothesised by Landau. In the talk I will briefly review some contradictory aspects of Landau-Fermi liquids, and present few results that, though not conclusive, yet imply that thermalisation in a Fermi liquid is still an open question.

1.11 Rosario Fazio   ICTP, Trieste & SNS, Pisa

Magnetic crystals and edge states in synthetic ladders
The joint action of a synthetic gauge potential and of atomic contact repulsion in a one-dimensional alkaline-earth(-like) fermionic gas with nuclear spin I leads to the existence of a hierarchy of fractional insulating and conducting states with intriguing properties. We unveil the existence and the features of those phases by means of both analytical bosonization techniques and numerical methods based on the density-matrix renormalization group algorithm. In particular, we show that the gapless phases can support helical modes, whereas the gapped states, which appear under certain conditions, are characterised both by density and magnetic order. Several distinct features emerge solely for spin I larger than 1/2, thus making their study with cold-atoms unique. We will finally argue that these states are related to the properties of an unconventional fractional quantum Hall effect in the thin-torus limit. The properties of this hierarchy of states can be experimentally studied in state-of-the-art cold-atom laboratories.

1.12 Ron Folman   Ben Gurion University

A self-interfering clock as a “which path” witness
In Einstein's general theory of relativity, time depends locally on gravity; in standard quantum theory, time is global—all clocks “tick” uniformly. We demonstrate [1] a new tool for investigating time in the overlap of these two theories: a self-interfering clock, comprising two atomic spin states. We prepare the clock in a spatial superposition of quantum wave packets, which evolve coherently along two paths into a stable interference pattern. If we make the clock wave packets “tick” at different rates, to simulate a gravitational time lag, the clock time along each path yields “which path” information, degrading the pattern's visibility. In contrast, in standard interferometry, time cannot yield “which path” information. This proof-of-principle experiment may have implications for the study of time and general relativity and their impact on fundamental effects such as decoherence and the emergence of a classical world. [1] Yair Margalit, Zhifan Zhou, Shimon Machluf, Daniel Rohrlich, Yonathan Japha, and Ron Folman, Science 349, 6253 (2015).

1.13 John Goold   ICTP, Trieste

Total correlations of the diagonal ensemble herald the many-body localization transition
The intriguing phenomenon of many-body localization (MBL) has attracted significant interest recently, but a complete characterization is still lacking. In this work, we introduce the total correlations, a concept from quantum information theory capturing multi-partite correlations, to the study of this phenomenon. We demonstrate that the total correlations of the diagonal ensemble provides a meaningful diagnostic tool to pin-down, probe, and better understand the MBL transition and ergodicity breaking in quantum systems. In particular, we show that the total correlations has sub-linear dependence on the system size in delocalized, ergodic phases, whereas we find that it scales extensively in the localized phase developing a pronounced peak at the transition. We exemplify the power of our approach by means of an exact diagonalization study of a Heisenberg spin chain in a disordered field.

1.14 Ilia Khait   Technion

Transport of weakly disordered liquids at infinite temperature
We study the dynamical properties of the one dimensional Heisenberg model at infinite temperature in the presence of quenched disorder. This model is expected to exhibit a many body localization (MBL) transition at strong disorder. We compute the local dynamical spin correlation function and the ac-conductivity using a non-perturbative continued fraction expansion. The expansion up to 15th order is sufficient to achieve convergence of our extrapolation scheme. Our main finding is the emergence of sub-diffusive transport (~ ω^(- beta)) beta < 1/2, for arbitrarily weak disorder. We confirm a scaling relation between the conductivity and spin correlation function. The lack of a true diffusive phase contrasts with previous results and expectations obtained from exact diagonalization studies.

1.15 Lev Khaykovich   Bar-Ilan University

Unitary Bose gas of atoms and atom-dimer mixtures.
Strongly interacting, dilute Bose gases are one of the most fundamental systems in few- and many-body physics, yet one of the least studied. Our abilities to explore the unitary Bose gases are limited by their inherent instability. We investigate the universal nature of these systems in thermal quasi steady state by studying the interplay between evaporation dynamics and three-body losses in two independent experiments performed on different atomic species: cesium-133 and lithium-7. Excellent agreement with theory over two orders of magnitude in temperature and four orders of magnitude in three-body loss rates demonstrates universality of the observed physics [1]. Next, we report on our effort to realize an atom-dimer unitary mixture in a gas of lithium-7 atoms and weakly bound dimers. This system is expected to show universal properties which, apart from being of interest by their own rights, can provide a different perspective for the study of unitary Bose gas of atoms. [1] "Universal loss dynamics in a unitary Bose gas", U. Eismann, L. Khaykovich, S. Laurent, I. Ferrier-Barbut, B.S. Rem, A.T. Grier, M. Delehaye, F. Chevy, C. Salomon, L.-C. Ha, C. Chin, to be published in Phys. Rev. X (2016).

1.16 Nethanel Lindner Technion

Floquet topological insulators: anomalous phases and steady state engineering
Periodically driven quantum systems provide a novel and versatile platform for realizing topological phenomena. In this talk I will discuss two routes for realizing topological steady states in these inherently non-equilibrium systems. First, I will describe how the interplay between periodic driving and disorder leads to robust topological phenomena, with has no static analogue: an “anomalous" two dimensional phase with chiral edge states that coexist with a fully localized bulk. I will show that this phase serves as the basis for a new topologically protected, far-from-equilibrium transport phenomenon: quantized non-adiabatic charge pumping. In the second part of my talk, I will focus on stabilizing desired steady states in periodically driven semiconductor systems, by utilizing its coupling to bosonic and fermionic baths.

1.17 José Lorenzana INFN, Roma

Manipulating electronic states with light
The joint action of a synthetic gauge potential and of atomic contact repulsion in a one-dimensional alkaline-earth(-like) fermionic gas with nuclear spin I leads to the existence of a hierarchy of fractional insulating and conducting states with intriguing properties. We unveil the existence and the features of those phases by means of both analytical bosonization techniques and numerical methods based on the density-matrix renormalization group algorithm. In particular, we show that the gapless phases can support helical modes, whereas the gapped states, which appear under certain conditions, are characterised both by density and magnetic order. Several distinct features emerge solely for spin I larger than 1/2, thus making their study with cold-atoms unique. We will finally argue that these states are related to the properties of an unconventional fractional quantum Hall effect in the thin-torus limit. The properties of this hierarchy of states can be experimentally studied in state-of-the-art cold-atom laboratories.

1.18 Oliver Morsch Universita' di Pisa

Simulating many-body systems with cold Rydberg atoms
Highly excited atoms – so-called Rydberg atoms – interact strongly with each other owing to their large polarizability. In recent years, ultra-cold Rydberg atoms have attracted much interest as a possible platform for quantum simulations of many body systems. In my talk I will briefly review recent advances in cold Rydberg physics and then go on to present the results of our experiments on kinetic constraints dynamical phase transitions and in cold clouds of rubidium Rydberg atoms. We were able to observe highly correlated dynamics of Rydberg excitations, reminiscent of colloidal and glassy materials, for resonant and off-resonant driving, as well as signatures of intermittency and phase coexistence when dissipation (spontaneous decay) is added to the dynamics. In those experiments the systems evolved semi-classically due to decoherence. I will discuss prospects for performing similar experiments in the partially or fully coherent regime, which would make it possible to create model systems for the many body dynamics of hundreds of interacting particles that cannot be simulated on classical computers. [1] M.M. Valado *et al.*, arXiv:1508:04384 (2015) [2] N. Malossi *et al.*, Phys. Rev. Lett. **113**, 023006 (2014)

1.19 Yoav Sagi Technion

Unconventional Superfluidity of Strongly Interacting Ultracold Fermi Gases

Experiments with ultracold Fermi gases offer two unique advantages: the strength of interactions can be tuned, and the potential trapping the particles can be tailored at will. Employing this in various clever ways, experiments in recent years have been able to provide accurate quantitative data on the different phases and many-body behavior of fermionic ensembles. While several of these experiments have been devoted to explore the nature of the normal state in the BCS-BEC crossover, it remains a controversial topic both experimentally and theoretically. I will present our contribution, including recent measurements of the spectral function and Tan’s contact of an almost homogeneous gas. Fits to data taken for different interaction strengths reveal the onset of pairing and decreasing spectral weight (or quasiparticle residue, Z) for the Fermi liquid. We extract the effective mass, pair correlation length, and Tan’s contact. Surprisingly, we find that Z vanishes abruptly and not gradually with increasing interaction, which signals a sudden breakdown of a Fermi liquid description and the disappearance of the Fermi surface. Understanding under what circumstances the Fermi surface collapses and Fermi liquid theory breaks down is one of the long-standing challenges in condensed matter physics.

1.20 Giuseppe Santoro SISSA, Trieste

On the adiabatic preparation of a Floquet Chern insulator

Inducing topological transitions by a time-periodic perturbation offers a promising route to controlling the properties of materials. Recent experiments [1] have mapped the phase diagram of the Haldane model, a prototypical Chern insulator, by driving ultra-cold fermionic atoms in a periodically modulated optical honeycomb lattice. Yet, a full theoretical understanding of how to adiabatically prepare the final topologically non-trivial Floquet state, starting from a trivial insulating state, is lacking, with a ``no-go theorem'' [2] suggesting that usual first Chern integral is not a suitable indicator. Here I will show that the physics behind the adiabatic preparation of a topologically non-trivial state involves a remarkable universal mechanism of selective population of edge-states, which results in controllable non-equilibrium currents flowing at the edges of the sample. The basic physics at play results from an exponentially small Landau-Zener ``avoided-crossing'' gap between edge states which forbids edge-state electrons to adiabatically follow the ground state as the perturbation is slowly turned on, akin to quantum annealing (QA) dynamics in glassy systems. I will illustrate this mechanism by studying the QA dynamics of graphene-like ribbons with phase-modulated nearest-neighbor hopping integrals of slowly increasing amplitude, a model that describes, for instance, an elliptically polarised laser beam shone on the system and slowly turned-on. I will show that the currents induced in the system display remarkably large periodic oscillations, but effectively flow solely at the edges upon time-averaging, and can be selectively controlled by focusing the laser beam on either edge of the system. The bulk undergoes a non-equilibrium topological transition, as signaled by a local Hall conductivity, the Chern marker introduced by Bianco & Resta [3] in equilibrium. The breakdown of this adiabatic picture in presence of intra-band resonances will be also discussed.

[#] Work done with Lorenzo Privitera.

[1] G. Jotzu, M. Messer, R. Desbuquois, M. Lebrat, T. Uehlinger, D. Greif, and T. Esslinger, Nature 515, 237 (2014).
[2] L. D’Alessio and M. Rigol, Nat. Commun. 6, 8336 (2015).
[3] R. Bianco and R. Resta, Phys. Rev. B 84, 241106 (2011).

1.21 Eran Sela   Tel Aviv University

Formation of collective Dicke states in optical microcavities
Motivated by recent experiments reporting Bose-Einstein condensation (BEC) of light coupled to incoherent dye molecules in a microcavity, I will show that due to a dimensionality mismatch between the 2D cavity-photons and the 3D random arrangement of molecules, the relevant degrees of freedom become collective Dicke states rather than individually thermalized excitations. These collective states can undergo a Dicke-BEC transition. For sufficiently high dye concentration the coupling of these Dicke states with light will dominate over local decoherence effects. This has remarkable effects on the emission spectrum that can be detected, including a strong suppression of vibrational satellites.

1.22 Sandro Stringari   INO, Trento

Linear and non linear dynamics in spinor Bose-Einstein condensates
In this talk I will present some recent results concerning the dynamic and superfluid behavior of spinor BECs both in the absence and in the presence of coherent coupling between the two spin species. Particular emphasis will be gven to the existence of non trivial solitonic solutions as well as to the role of spin-orbit coupling.

1.23 Vipin Kerala Varma   ICTP, Trieste

Coexistence of energy diffusion and spin subdiffusion in the ergodic phase of a many-body localizable spin chain
We consider the real-time transport of energy in the ergodic phase of the disordered Heisenberg chain at infinite temperature. Beginning from highly nonequilibrium initial states where energy is lumped into small or large sections of the chain, we employ large scale Krylov techniques to study the dynamics of thermalization in systems of sizes up to L=26. We present conclusive evidence for energy diffusion in a phase where the spins have previously been shown to only subdiffuse. This suggestive finding points towards a peculiar ergodic phase where particles do not diffuse but energy does, reminiscent of the situation in amorphous solids; this occurs well before the onset of the many-body localized phase where the equilibration of energy and spin density breaks down.

2 POSTERS

2.1 Or Alus Technion

Statistical description of mixed phase space systems
For most realistic Hamiltonian systems the phase space contains both chaotic and regular orbits, mixed in a complex, fractal pattern in which islands of regular motion are surrounded by a chaotic sea. The Henon map is an example of such a system. Though such dynamics has been extensively studied, a full understanding depends on many fine details that typically are beyond experimental and numerical resolution. This calls for a statistical approach. In particular transport in phase space is of greatinterest for dynamics, therefore the distributions of fluxes through island chains were computed. evidence for their universality was given. Also the statistics of the boundary circle winding numbers were calculated, contrasting the distribution of the elements of their continued fractions to that for uniformly selected irrationals. In particular results that contradict conjectures that were made in the past were found.

2.2 Sasha (Alexandra) Bakman Technion

Collapse and revival for a slightly anharmonic oscillator
The effect of quantum collapse and revival is a fascinating interference phenomenon. In this paper the phenomenon of collapse and revivals is demonstrated analytically and numerically for a slightly anharmonic Hamiltonian. The initial wave-function is a displaced ground state of a harmonic oscillator. We show that the effect is found for the expectation value of position as function of time. The effect is also found and studied for the fidelity, where two Hamiltonians have a slightly different classical frequency. The revival time in this case depends mainly on the ratio between the classical frequencies of the two Hamiltonians. Experimentally measuring this phenomenon can be used to determine the strength of the anharmonicity in quasi harmonic systems, as well as calculating small differences between Hamiltonians, which can result from Zeeman splitting.

2.3 Robert Englman Ariel University

Equilibration and thermalization of global and local observables in Generalized Gibbs Ensembless
Following our work "Local ergodicity in coupled harmonic vibrators: classical and quantal treatments" (J. Phys. A :Math. Theor. 49 (2016)115102) we extend the treatment to equilibration properties of energy-eigenstates, pure states, microcanonical and canonical GGE ensembles of interacting lattice bosons in one-to-three dimensions . The GGE multipliers are obtained for each of these. A maximum entropy analysis provides the optimal choice for maximal randomization required for "typicality".

2.4 Iliya Esin Technion

Transport properties of Floquet Insulators
Periodically driven systems have recently attracted interest as a promising tool for exploring new phases in quantum systems. In this work we study the transport properties in the steady state of resonatively periodically driven systems, in the presence of radiative recombination and electron-phonon interactions. We employ Keldysh techniques, to derive Boltzmann equation for the populations of the Floquet eigenstates. We solve the Boltzmann equation numerically and show that the system exhibits insulating behavior when coupled to external leads via energy filter centered on the Floquet gap. We support the numerical results by deriving a diffusion equation in the limit of small bias, and solving it exactly. Our results give promise for realizing Floquet topological insulators.

2.5 Bat-el Friedman Bar-Ilan University

Entanglement distribution of 1D disordered fermions in different quantum phases
Entanglement entropy is related to quantum phase transitions. Fermions in one dimensional disordered metallic wire can exhibit different quantum phases: insulating, metallic and superconducting. The entanglement distribution is sensitive to the quantum state and therefore different phases are characterized by different distributions. This qualitative behavior holds even for very small systems, a property which allows us to characterize the different distributions analytically. We show the analytic results for a four sites toy model, and numeric DMRG and RSRG results for larger systems.

2.6 Itay Hen University of Southern California

Quantum computing with many-body systems out of equilibrium
Recent developments in quantum technology have led to the design and manufacturing of experimental programmable quantum many-body processing chips containing hundreds of quantum bits. These devices, also known as 'D-Wave' chips, promise to solve optimization problems of practical relevance potentially faster than conventional computers by utilizing the unique properties of quantum mechanical dynamics. The quantum nature of these optimizers has recently become the center of a heated debate within the Quantum Computing community concerning the claimed superiority of these annealers over traditional devices and the degree to which they exploit quantum capabilities. In this talk, I will describe attempts to identify the `quantum signatures' of such devices and discuss experiments designed to find optimization problems that could benefit from quantum mechanical approaches.

2.7 Yonatan Japha Ben-Gurion University

Suppression and enhancement of decoherence in an atomic Josephson junction
We investigate the role of interatomic interactions when a Bose gas, in a double-well potential with a finite tunneling probability (a ``Bose Josephson junction''), is exposed to external noise. We examine the rate of decoherence of a system initially in its ground state with equal probability amplitudes in both sites. The noise may induce two kinds of effects: firstly, random shifts in the relative phase or number difference between the two wells and secondly, loss of atoms from the trap. The effects of induced phase fluctuations are mitigated by atom-atom interactions and tunneling, such that the dephasing rate may be \emph{suppressed} by half its single-atom value. Random fluctuations may also be induced in the population difference between the wells, in which case atom-atom interactions considerably *enhance* the decoherence rate. A similar scenario is predicted for the case of atom loss, even if the loss rates from the two sites are equal. We find that if the initial state is number-squeezed due to interactions, then the loss process induces population fluctuations that reduce the coherence across the junction. We examine the parameters relevant for these effects in a typical atom chip device, using a simple model of the trapping potential, experimental data, and the theory of magnetic field fluctuations near metallic conductors. These results provide a framework for mapping the dynamical range of barriers engineered for specific applications and set the stage for more complex atom circuits (``atomtronics'').

2.8 Lyran Kidon Tel Aviv University

Exact Calculation of the Time Convolutionless Master Equation Generator: Application to the Nonequilibrium Resonant Level Model
The generalized quantum master equation provides a powerful tool to describe the dynamics in quantum impurity models driven away from equilibrium. Two complementary approaches, one based on Nakajima--Zwanzig--Mori time-convolution (TC) and the other on the Tokuyama--Mori time-convolutionless (TCL) formulations provide a starting point to describe the time-evolution of the reduced density matrix. A key in both approaches is to obtain the so called ``memory kernel'' or ``generator'', going beyond second or fourth order perturbation techniques. While numerically converged techniques are available for the TC memory kernel, the canonical approach to obtain the TCL generator is based on inverting a super-operator in the full Hilbert space, which is difficult to perform and thus, all applications of the TCL approach rely on a perturbative scheme of some sort. Here, the TCL generator is expressed using a reduced system propagator which can be obtained from system observables alone and requires the calculation of super-operators and their inverse in the reduced Hilbert space rather than the full one. This makes the formulation amenable to quantum impurity solvers or to diagrammatic techniques, such as the nonequilibrium Green's function. We implement the TCL approach for the resonant level model driven away from equilibrium and compare the time scales for the decay of the generator with that of the memory kernel in the TC approach. Furthermore, the effects of temperature, source-drain bias, and gate potential on the TCL/TC generators are discussed. Exact calculation of the time convolutionless master equation generator: Application to the nonequilibrium resonant level model Kidon L., Wilner E.Y., and Rabani E., J. Chem. Phys., 143, 234110 (2015).

2.9 Francesco Peronaci SISSA, Trieste

Transient Dynamics of d-Wave Superconductors after a Sudden Excitation
Motivated by recent ultrafast pump-probe experiments on high-temperature superconductors, we discuss the transient dynamics of a d-wave BCS model after a quantum quench of the interaction parameter. We find that the existence of gap nodes, with the associated nodal quasiparticles, introduces a decay channel which makes the dynamics much faster than in the conventional s-wave model. For every value of the quench parameter, the superconducting gap rapidly converges to a stationary value smaller than the one at equilibrium. Using a sudden approximation for the gap dynamics, we find an analytical expression for the reduction of spectral weight close to the nodes, which is in qualitative agreement with recent experiments.

2.10 Francesca Pietracaprina Sapienza Università di Roma

The forward approximation as a mean field approximation for the Anderson and Many Body Localization transitions
We analyze the predictions of the forward approximation in some models which exhibit an Anderson (single-) or many-body localized phase. This approximation, which consists in summing over the amplitudes of only the shortest paths in the locator expansion, is known to over-estimate the critical value of the disorder which determines the onset of the localized phase. Nevertheless, the results provided by the approximation become more and more accurate as the local coordination (dimensionality) of the graph, defined by the hopping matrix, is made larger. In this sense, the forward approximation can be regarded as a mean field theory for the Anderson transition in infinite dimensions. The sum can be efficiently computed using transfer matrix techniques, and the results are compared with the most precise exact diagonalization results available. For the Anderson problem, we find a critical value of the disorder which is 0.9% off the most precise available numerical value already in 5 spatial dimensions, while for the many-body localized phase of the Heisenberg model with random fields the critical disorder hc=4.0±0.3 is strikingly close to the most recent results obtained by exact diagonalization. In both cases we obtain a critical exponent v=1. In the Anderson case, the latter does not show dependence on the dimensionality, as it is common within mean field approximations.

2.11 Lorenzo Privitera SISSA, Trieste

Quantum annealing and non-equilibrium dynamics of Floquet Chern insulators
The capability of inducing a topological phase transitions would give the possibility to access diverse exotic properties, both in materials and synthetic quantum matter. Periodic perturbation offers a route to generate dynamically such phases, the so called Floquet topological insulators. Here we show that the adiabatic preparation of a non-trivial state involves a selective population of edge-states, due to exponentially-small gaps preventing adiabaticity. We illustrate this, in the case of periodically driven system, by studying graphene-like ribbons with hopping's phases of slowly increasing amplitude, as, e.g., for a circularly polarized laser slowly turned-on. The induced currents have large periodic oscillations, but flow solely at the edges upon time-averaging, and can be controlled by focusing the laser on either edge. The bulk undergoes a non-equilibrium topological transition, as signaled by a time-dependent version of the local Chern marker introduced by Bianco \& Resta in equilibrium. The breakdown of this adiabatic picture in presence of intra-band resonances is discussed.

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2.12 Lukas Sieberer   Weizmann Institute of Science

Order, superfluidity, and vortex-unbinding in two-dimensional driven-dissipative condensates

Fluids of exciton-polaritons, excitations of two-dimensional semiconductor microcavities, show collective phenomena akin to Bose condensation. However, a fundamental difference from standard condensates stems from the finite lifetime of these excitations, which necessitate continuous driving to maintain a steady state. A basic question is how the paradigm of two-dimensional Bose condensation in thermal equilibrium, comprising algebraic order, superfluidity, and the loss of these features in a vortex unbinding transition, is modified under non-equilibrium conditions. We show that fluctuations of the phase of a driven-dissipative condensate lead to the destruction of algebraic order, even if the possible presence of vortices is not taken into account. Remarkably, despite the absence of algebraic order, a finite superfluid density persists. In a second step of our analysis, we study the effect of vortices, which is devastating: we find that unbound vortices proliferate and superfluidity is destroyed at any level of Markovian noise, which plays a role analogous to temperature in equilibrium. Our results implies, that recent apparent evidence for Bose condensation of exciton-polaritons must be an intermediate scale crossover phenomenon, while the true long distance correlations fall more rapidly.

2.13 Rajeev Singh   Bar Ilan University

Many-body localization and its signatures in quantum quenches

The presence of disorder in a non-interacting system can localize all the energy eigenstates, a phenomena dubbed Anderson localization. Many-body localization is an extension of this phenomena to include interactions. Effects of interactions show up in the logarithmic growth of entanglement after a global quench. We perform a systematic study of the evolution and saturation of entanglement and show that it can be used to detect the localization transition. We consider the bipartite fluctuation which also captures the transition and is promising as an experimental probe. We discuss the behavior of the system after a very long time in comparison to that in the thermal state and in the diagonal ensemble.

2.14 Pasha Tikhonov   Bar Ilan University

Emergence of helical edge conduction in graphene at the $\nu=0$ quantum Hall state

The conductance of graphene subject to a strong, tilted magnetic field exhibits a dramatic change from insulating to conducting behavior with tilt-angle, regarded as evidence for the transition from a canted antiferromagnetic (CAF) to a ferromagnetic (FM) $\nu=0$ quantum Hall state. We develop a theory for the electric transport in this system based on the spin-charge connection, whereby the evolution in the nature of collective spin excitations is reflected in the charge-carrying modes. To this end, we derive an effective field theoretical description of the low-energy excitations, associated with quantum fluctuations of the spin-valley domain wall ground-state configuration which characterizes the two-dimensional (2D) system with an edge. This analysis yields a model describing a one-dimensional charged edge mode coupled to charge-neutral spin-wave excitations in the 2D bulk. Focusing particularly on the FM phase, naively expected to exhibit perfect conductance, we study a mechanism whereby the coupling to these bulk excitations assists in generating back-scattering. Our theory yields the conductance as a function of temperature and the Zeeman energy - the parameter that tunes the transition between the FM and CAF phases - with behavior in qualitative agreement with experiment.