Online NITheP Workshop
Quantum Thermodynamics
23-27 November 2020

Monday, 23 November

Session Chair: Camille Lombard Latune

$11^{40} - 12^{00}$ Virtual Welcome

$12^{00} - 13^{00}$ Janet Anders (University of Exeter/University of Potsdam), Thermodynamics in the presence of coherences and strong coupling corrections

$13^{00} - 14^{00}$ Ahsan Nazir (University of Manchester), Environmental non-additivity in non-equilibrium quantum systems

Session Chair: Janet Anders

$18^{30} - 18^{50}$ Katérina Verteletsky (Trinity College Dublin), Work and heat in conventional and measurement powered quantum heat engines

$18^{50} - 19^{10}$ Alberto Imparato (Department of Physics and Astronomy, Aarhus University, Denmark), Quantum thermodynamically consistent local master equations

$19^{10} - 19^{30}$ Thiago de Oliveira (Universidade Federal Fluminsense), Counter-intuitive properties of a simple quantum heat engine

Session Chair: TBA

$19^{30} - 19^{50}$ Nathan Myers (University of Maryland, Baltimore County), Bosons Outperform Fermions: The Thermodynamic Advantage of Symmetry

$19^{50} - 20^{10}$ Felix Binder (IQOQI Vienna), Quantum Coherence and Ergotropy

$20^{10} - 20^{30}$ Nina Megier (UniMi, INFN Milano), Evolution equations for commutative quantum dynamics

Tuesday, 24 November

Session Chair: Obinna Abah

$11^{00} - 12^{00}$ Sebastian Deffner (UMBC), TBA

$12^{00} - 13^{00}$ Nelly Huei Ying Ng (Nanyang Technological University, Singapore), TBA

Wednesday, 25 November

Session Chair: Martí Perarnau-Llobet

$10^{00} - 10^{20}$ Juzar Thingna (Institute for Basic Science), Effect of measurement on quantum Otto heat engine

$10^{20} - 10^{40}$ Victor Mukherjee (Indian Institute of Science Education and Research Berhampur), Universal finite-time thermodynamics of many-body quantum engines from Kibble-Zurek scaling

$10^{40} - 11^{00}$ Gabriele De Chiara (Queen's University Belfast, UK), Quantum thermal machines powered by correlated baths

Session Chair: Ilya Sinayskiy

$11^{00} - 11^{20}$ Anton Trushechkin (Steklov Mathematical Institute of Russian Academy of Sciences), Redfield, local and global quantum master equations from the viewpoint of quantum stochastic limit

$11^{20} - 11^{40}$ Bibek Bhandari (Scuola Normale Superiore), Geometric Properties of Adiabatic Quantum Thermal Machines

$11^{40} - 12^{00}$ Loris Maria Cangemi (University of Naples "Federico II"), Optimal energy conversion in the absence of time-reversal symmetry

Session Chair: Camille Lombard Latune

$18^{30} - 19^{30}$ Gabriel Landi (Universidade de São Paulo), Thermodynamics of continuously measured quantum systems

$19^{30} - 20^{30}$ Iman Marvian (Duke University, USA), TBA

Thursday, 26 November

Session Chair: Felix Binder

$11^{00} - 11^{20}$ Camille Lombard Latune (University of KwaZulu-Natal, SA), Enhanced performances in quantum thermal machines and quantum thermometry based on collective effects

$11^{20} - 11^{40}$ Marco Cattaneo (IFISC (CSIC-UIB, Spain) and University of Turku (Finland)), Collision models can efficiently simulate any multipartite Markovian quantum dynamics

$11^{40} - 12^{00}$ Patryk Lipka-Bartosik (University of Bristol), All states are universal catalysts in quantum thermodynamics

Session Chair: Gabriele De Chiara

$12^{00} - 12^{20}$ Gonzalo Manzano (Institute for Quantum Optics and Quantum Information (IQOQI) Vienna), Thermodynamics of Gambling Demons

$12^{20} - 12^{40}$ Martí Perarnau- Llobet (University of Geneva), Quantum signatures in the work distribution

$12^{40} - 13^{00}$ Raam Uzdin (The Hebrew University of Jerusalem), Quantum circuit diagnostics using bounds on periodically driven systems

Session Chair: Gabriel Landi

$16^{00} - 17^{00}$ Obinna Abah (Queen's University Belfast, United Kingdom), TBA

$17^{00} - 18^{00}$ Markus P. Müller (Institute for Quantum Optics and Quantum Information, Vienna), On the repeatable use of quantum resources in thermodynamics

Friday, 27 November

Session Chair: Francesco Petruccione

$11^{00} - 12^{00}$ Erik Lutz (University of Stuttgart), Quantum Fluctuation Theorems beyond Two-Point Measurements

$12^{00} - 13^{00}$ Ronnie Kosloff (Hebrew University Jerusalem), Themodynamically consistent quantum Master equations

$13^{00} - 13^{20}$ Group Picture (zoom screenshot) and final remarks

List of Abstracts

Monday, 23 November

Thermodynamics in the presence of coherences and strong coupling corrections
Janet Anders

I will give an overview talk discussing a selection of the Exeter group's results in the field of quantum thermodynamics [1]. We will first identify a "quantum" task in quantum thermodynamics. To do so we set up a quantum thermodynamic process that removes quantum information in analogy to Landauer's erasure of classical information. The thermodynamic analysis of such a process uncovers that work can be extracted from quantum coherences in addition to the work that can be extracted from classical non-equilibrium states [2]. At the end of the talk I will briefly report on a new thermodynamic uncertainty relation that limits the accuracy of measuring the temperature and energy of a thermal quantum system [3]. Corrections to the standard uncertainty relation arise here because, unlike in standard thermodynamics, a small system's interaction with its environment is not negligible. The emerging relation unites thermodynamic and quantum uncertainties for the first time.

1 Quantum thermodynamics, S. Vinjanampathy, J. Anders, Contemporary Physics 57, 545 (2016).

2 Coherence and measurement in quantum thermodynamics, P. Kammer-lander, J. Anders, Scientific Reports 6, 22174 (2016).

3 Energy-temperature uncertainty relation in quantum thermodynamics, H. Miller, J. Anders, Nature Communications 9:2203 (2018).

Environmental non-additivity in non-equilibrium quantum systems
Ahsan Nazir

We consider quantum systems coupled simultaneously to multiple environments. Examples include solid-state photon emitters, with coupling both to vibrations and the electromagnetic field, and molecular nanojunctions, with coupling both to vibrations and electronic leads.

We show that enforcing additivity of such combined influences results in non-equilibrium dynamics that does not respect the Franck-Condon principle in the former case, and can lead to unphysical electronic current under equilibrium conditions in the latter. We overcome these shortcomings by employing a collective coordinate representation of the vibrational environment, which permits the derivation of a non-additive master equation.

When applied to a two-level emitter our treatment predicts a non-equilibrium steady-state with pronounced population inversion. Applied to a thermoelectric molecular nanojunction, we employ counting statistics to track electron flow between the system and the electronic leads. This reveals both strong-coupling and non-additive effects in the electron current, noise and Fano factor, as well as the thermoelectric power and efficiency.

Work and heat in conventional and measurement powered quantum heat engines
Katérina Verteletsky

We constructed a simple autonomous thermoelectric engine operated out of thermal equilibrium composed of two superconducting qubits coupled to separate heat baths and connected by a Josephson junction. By deriving analytical expressions for the Hamiltonian and steady-state solution of the master equation, we studied the dynamics of the machine.

We showed that, for this system, the fluctuations in the integrated work and heat over finite time intervals are not simply the variances of suitable system observables but employ more complex quantum correlation functions. In particular, the transfer of heat into the cold bath is equivalent to the process of spontaneous emission from a quantum light source, and its temporal correlations thus follow from Glauber's photodetection theory in quantum optics. In addition, by investigating the conditional dynamics of the excitation propagating through the system by way of two-time correlation functions, we revealed a cyclical, dynamical transfer of energy mimicking the chuffing of a classical steam engine.

Finally, we went beyond the conventional engine design and considered a machine where the heat baths were replaced by a measurement protocol. By

deriving and analyzing the periodic steady state of our machine, we showed that for such a design, an adaptive measurement scheme allows a net work production on average. These results offer an interesting basis for experimental implementation, especially in cases where the size of the device does not permit an efficient separation between the heat baths.

Quantum thermodynamically consistent local master equations
Alberto Imparato

Local master equations are a widespread tool to model open quantum systems, especially in the context of many-body systems. These equations, however, are believed to lead to thermodynamic anomalies and violation of the laws of thermodynamics. In contrast, here we rigorously prove that local master equations are consistent with thermodynamics and its laws without resorting to a microscopic model, as done in previous works. In particular, we consider a quantum system in contact with multiple baths and identify the relevant contributions to the total energy, heat currents and entropy production rate. We show that the second law of thermodynamics holds when one considers the proper expression we derive for the heat currents. We confirm the results for the quantum heat currents by using a heuristic argument that connects the quantum probability currents with the energy currents, using an analogous approach as in classical stochastic thermodynamics. We finally use our results to investigate the thermodynamic properties of a set of quantum rotors operating as thermal devices and show that a suitable design of three rotors can work as an absorption refrigerator or a thermal rectifier (arXiv:2008.04742).

Counter-intuitive properties of a simple quantum heat engine
Thiago R. de Oliveira

We present a simple quantum mechanism for efficiency increase in quantum thermal engines operating with a Otto cycle that do not involve any quantum correlation or coherence as previous studies. The mechanism is based on the structure of the energy spectrum; the fact that some of the levels do not couple to the external agent that realizes work. Besides an efficiency increase this mechanism also allow for many counter intuitive phenomenology when the bath temperatures change. For example, its thermodynamic efficiency may increase as their temperature difference decreases. Conversely, the engine may cease

to operate if the hotter bath becomes too hot, or the colder bath too cold, even in the limit of absolute zero temperature. Moreover, in some circumstance the engine may run in either sense of the same thermodynamic cycle, with the physical heat reservoirs exchanging the roles of 'hot' or 'cold' bath. Finally all these phenomena can be understood using a simple physical picture in terms of energy flows via each system level.

Bosons Outperform Fermions: The Thermodynamic Advantage of Symmetry
Nathan Myers

The recent miniaturization of heat engines to the nanoscale introduces the possibility of engines that harness quantum resources. The analysis of quantum engines provides important insight into how their efficiency compares to classical analogues and deepens our understanding of thermodynamic mechanisms at the quantum scale. We examine a quantum Otto engine with a harmonic working medium consisting of two particles to explore the use of wave function symmetry as an accessible resource. It is shown that a bosonic working medium displays enhanced performance when compared to distinguishable particles, while a fermionic working medium displays reduced performance. To this end, we explore the trade-off between efficiency and power output and the parameter regimes under which the system functions as engine, refrigerator, or heater. Remarkably, the bosonic system operates under a wider parameter space both when operating as an engine and as a refrigerator.

Quantum Coherence and Ergotropy
Felix Binder

Constraints on work extraction are fundamental to our operational understanding of the thermodynamics of both classical and quantum systems. In the quantum setting, finite-time control operations typically generate coherence in the instantaneous energy eigenbasis of the dynamical system. Thermodynamic cycles can, in principle, be designed to extract work from this nonequilibrium resource. Here, we isolate and study the quantum coherent component to the work yield in such protocols. Specifically, we identify a coherent contribution to the ergotropy (the maximum amount of unitarily extractable work via cyclical

variation of Hamiltonian parameters). We show this by dividing the optimal transformation into an incoherent operation and a coherence extraction cycle. We obtain bounds for both the coherent and incoherent parts of the extractable work and discuss their saturation in specific settings.

Evolution equations for commutative quantum dynamics
Nina Megier

Coupling of a quantum system to its environment is at the heart of a quantum thermodynamics. Accordingly, a father progress of quantum thermodynamics strongly relies on the understanding of many facets of the open quantum systems dynamics. In the study of the evolution of an open quantum system it is well known that alternative approximated descriptions are often useful. Here we show that also equivalent exact evolution equations can be introduced, investigating a newly introduced link between time local and time non-local master equations [1, 2]. Though these equations are in principle equivalent as their solutions are the same reduced density operator, the knowledge of both can be beneficial. Our approach, based on the damping basis representation, give some insights into the occurrence of different dephasing channels in time local and time non-local master equations and the non-Markovianity property of the exact and the approximated reduced dynamics.

1 N. Megier, A. Smirne, B. Vacchini, New J. Phys. 22: 083011, 2020

2 N. Megier, A. Smirne, B. Vacchini, Entropy 22(7): 796, 2020

Tuesday, 24 November

Sebastian Deffner
TBA

Nelly Huei Ying Ng
TBA

Wednesday, 25 November

Effect of measurement on quantum Otto heat engine
Juzar Thingna

In this talk, I'll introduce a method, known as repeated contacts, that allows us to infer the sum of the values of an observable taken during contacts with a pointer state [1]. I'll first show the superiority of this approach with the results of the same number of generalized Gaussian measurements of the considered observable. The proposed repeated contact approach could be beneficial to measure the work output of a quantum Otto heat engine and I'll demonstrate this using a two-level system as the working substance. I'll discuss the imperfect thermalizing engine under Landau-Zener work strokes and show that the repeated contact scheme is minimally invasive and gives enhanced performance metrics (efficiency, power output, and reliability) as compared to the standard repeated generalized Gaussian measurements.
References:

1 J. Thingna and P. Talkner, Phys. Rev. A 102, 012213 (2020)

Universal finite-time thermodynamics of many-body quantum engines from Kibble-Zurek scaling
Victor Mukherjee

I will talk about universality in the performance of finite-time many-body quantum engines operated close to quantum phase transitions. I will discuss how under very generic conditions, the output work of such an engine is governed by the Kibble-Zurek mechanism, i.e., it exhibits a universal power-law scaling with the driving speed through the critical points. The maximum power and the corresponding efficiency take a universal form, and are reached for an optimal speed that is governed by the critical exponents. Such universality in the output work and efficiency can be helpful in designing optimally performing many-body quantum engines operated close to criticality.

Quantum thermal machines powered by correlated baths
Gabriele De Chiara

We consider thermal machines powered by locally equilibrium reservoirs that share classical or quantum correlations. The reservoirs are modelled by the so-called collisional model or repeated interactions model. In our framework, two reservoir particles, initially prepared in a thermal state, are correlated through a unitary transformation and afterwards interact locally with the two quantum subsystems which form the working fluid. For a particular class of unitaries, we show how the transformation applied to the reservoir particles affects the amount of heat transferred and the work produced. We then compute the distribution of heat and work when the unitary is chosen randomly, proving that the total swap transformation is the optimal one. Finally, we analyse the performance of the machines in terms of classical and quantum correlations established among the microscopic constituents of the machine.

Reference:
G. De Chiara and M. Antezza, Phys. Rev. Research 2, 033315 (2020)

Redfield, local and global quantum master equations from the viewpoint of quantum stochastic limit
Anton Trushechkin

Quantum master equations are at the heart of theory of open quantum systems [1]. Many present-day works are devoted to the correct form of quantum master equation for a system weakly interacting with the bath. A known rigorous mathematic derivation leads to an equation (often referred to as the "global" mater equation) in the form of Gorini-Kossakowski-Lindblad-Sudarshan (GKLS). It has good properties (preservation of positivity, agreement with the second law of thermodynamics), but is too restrictive to cover all possible physical situations. Namely, all Bohr frequencies are assumed to be well separated from each other. If this is not the case, the Redfield equation with the so called non-secular terms and the so called local mater equation are discussed. However, the Redfield equation violates the positivity of the density operator and the local master equation violates the second law of thermodynamics.

In the talk, we approach the problem of the correct form of quantum mater equation from the viewpoint of quantum stochastic limit [2]. In contrast to other approaches, which describe the dynamics of the reduced density operator of the system, an approximate unitary dynamics of the system and bath together is rigorously derived in the quantum stochastic limit. Unitarity automatically guarantees the conservation of positivity. A unified approach to a rigorous derivation of the master equation in the GKLS form which includes secular, non-secular, and local terms is presented.

1 H.-P. Breuer, F. Petruccione, The Theory of Open Quantum Systems (Oxford University Press, 2002).

2 L. Accardi, Y.G. Lu, I. Volovich, Quantum Theory and Its Stochastic Limit (Springer, Berlin, 2002)

Geometric Properties of Adiabatic Quantum Thermal Machines
Bibek Bhandari

We present a general unified approach for the study of quantum thermal machines, including both heat engines and refrigerators, operating under periodic adiabatic driving and in contact with thermal reservoirs kept at different temperatures. We show that many observables characterizing this operating mode and the performance of the machine are of geometric nature. Heat-work conversion mechanisms and dissipation of energy can be described, respectively, by the antisymmetric and symmetric components of a thermal geometric tensor defined in the space of time-dependent parameters generalized to include the temperature bias. The antisymmetric component can be identified as a Berry curvature, while the symmetric component defines the metric of the manifold. We show that the operation of adiabatic thermal machines, and consequently also their efficiency, are intimately related to these geometric aspects. We illustrate these ideas by discussing two specific cases: a slowly driven qubit asymmetrically coupled to two bosonic reservoirs kept at different temperatures, and a quantum dot driven by a rotating magnetic field and strongly coupled to electron reservoirs with different polarizations. Both examples are already amenable for an experimental verification.

Optimal energy conversion in the absence of time-reversal symmetry
Loris Maria Cangemi

The performance of a periodically driven isothermal heat engine in the absence of time-reversal (TR) symmetry is investigated, employing as a working medium a single underdamped harmonic oscillator linearly coupled to a pair of driving fields [1]. We show that, in the anti-adiabatic driving regime, close-to-one conversion efficiency can be achieved with finite output power and vanishingly small output power fluctuations. We show that non-Markovian dynamics induced by non-Ohmic bath spectral density improves the power-efficiency

trade-off. We also discuss analogous models of energy converters, where the working medium is a single quantum two-level system [2] showing that, in the absence of TR symmetry, quantum coherence in the dynamics of the working medium can lead to violations of thermodynamics uncertainty relations.

1 L.M. Cangemi, M.Carrega, A. De Candia, V. Cataudella, G. De Filippis, M. Sassetti and G. Benenti, arXiv:2009.10904, submitted to Phys. Rev. Lett.

2 L.M. Cangemi, V. Cataudella, G. Benenti, M. Sassetti and G. De Filippis, arXiv:2004.02987, accepted for publication on Phys. Rev. B.

Thermodynamics of continuously measured quantum systems
Gabriel T. Landi

Irreversibility is intimately related to ignorance. The more one knows about a physical process, the more re- versible it is. The 2nd law of thermodynamics should therefore also take into account the amount of information acquired by the experimenter. In the quantum domain, however, this discussion becomes more delicate since measurements are inevitably invasive. In this talk I discuss recent results on the description of the 2nd law for continuously monitored bosonic systems [1]. Our approach is based on the use of quantum phase space tech- niques to characterize the thermodynamics, as first put forth in [2, 3]. Combining this with the framework of weak continuous measurements and stochastic master equations, we show that it is possible to construct a con- ditional 2nd law, given the measurement records. Moreover, we show that the difference between the conditional and unconditional 2nd laws is directly associated with the integrated information gained from the measurement records. Finally, I discuss a recent experimental assessment of this principle in an optomechanical system [4], where conditional and unconditional thermodynamic quantities were obtained at the single-trajectory level. Particularly interesting, we discuss the notion of an informational steady-state, where the act of continuously acquiring information keeps the system away from equilibrium, in a non-equilibrium steady-state.

1 A. Belenchia, L. Mancino, G. T. Landi, and M. Paternostro, accepted in Nature Quantum Information (2019), arXiv:1908.09382.

2 J. P. Santos, G. T. Landi, and M. Paternostro, Physical Review Letters 118, 220601 (2017), arXiv:1706.01145.

3 M. Brunelli, L. Fusco, R. Landig, W. Wieczorek, J. Hoelscher- Obermaier, G. Landi, F. L. Semião, A. Ferraro, N. Kiesel, T. Donner, G. De

Chiara, and M. Paternostro, Physical Review Letters 121, 160604 (2018), arXiv:1602.06958.

4 M. Rossi, L. Mancino, G. T. Landi, M. Paternostro, A. Schliesser, and A. Belenchia, Physical Review Letters 125, 080601 (2020), arXiv:2005.03429.

Iman Marvian

TBA

Thursday, 26 November

Enhanced performances in quantum thermal machines and quantum thermometry based on collective effects
Camille Lombard Latune

The dynamics and steady state properties of an ensemble of non-interacting spins change significantly according to the type of coupling with a bath. We compare the situation where the spins interact with a common bath, also referred to as collective bath coupling, with the situation where each spin interacts with an independent bath, referred to as independent couplings. The resulting differences in the spin ensemble's properties suggest that it could have some impacts in operations using thermal baths, like thermal machines and thermometry.

Focusing first on thermometry, we analyse the performances of temperature estimation of a thermal bath using an ensemble of spins. We find that collective coupling can result in higher precision of the temperature estimation, especially at high temperature, reaching even the Heisenberg scaling-inversely proportional to the number of spins.

In a second time, considering Otto engines, we show that collective coupling with a common bath can lead to a two-fold increase in the output power. The first increase is related to altered steady state properties of the spin ensemble (when compared to interaction with independent bath). The second is based on the accelerated equilibration induced by the common bath. We note also that this second increase in the output power is specific of cyclic machines and cannot appear in continuous thermal machines.

Collision models can efficiently simulate any multipartite Markovian quantum dynamics
Marco Cattaneo

Quantum collision models play a relevant role in quantum thermodynamics, and in particular in the study of the fundamental exchange of heat and work between subsystems and environment. Here, we introduce the Multipartite Collision Model to simulate the Markovian dynamics of any multipartite

open quantum system by expressing the system-environment interaction as elementary collisions between subsystems and ancillae, thus providing a simple decomposition in terms of elementary quantum gates for quantum computation. This model is able to reproduce the action of any local and global master equation at any bath temperature. Moreover, we develop a method to estimate an analytical error bound for any repeated interactions model, and we use it to show that the error of our model displays an optimal behavior. Finally, we prove that the Multipartite Collision Model is efficiently simulable on a quantum computer according to the dissipative quantum Church-Turing theorem, and it therefore requires a polynomial number of resources.

All states are universal catalysts in quantum thermodynamics
Patryk Lipka-Bartosik

Quantum catalysis is a fascinating concept which demonstrates that certain transformations can only become possible when given access to a specific resource that has to be returned unaffected. It was first discovered in the context of entanglement theory and since then applied in a number of resource-theoretic frameworks, including quantum thermodynamics. Although in that case the necessary (and sometimes also sufficient) conditions on the existence of a catalyst are known, almost nothing is known about the precise form of the catalyst state required by the transformation. In particular, it is not clear whether it has to have some special properties or be finely tuned to the desired transformation. In this work we describe a surprising property of multi-copy states: we show that in resource theories governed by majorisation all resourceful states are catalysts for all allowed transformations. In quantum thermodynamics this means that the so-called "second laws of thermodynamics" do not require a fine-tuned catalyst but rather any state, given sufficiently many copies, can serve as a useful catalyst.

Thermodynamics of Gambling Demons
Gonzalo Manzano

The stochastic nature of games at the casino allows lucky players to make profit by means of gambling. Like games of chance and stocks, small physical systems are subject to fluctuations, thus their energy and entropy become stochastic, following an unpredictable evolution. In this context, information

about the evolution of a thermodynamic system can be used by Maxwell's demons to extract work using feedback control. This is not always the case, a challenging task is then to develop efficient thermodynamic protocols achieving work extraction in situations where feedback control cannot be realized, in the same spirit as it is done on a daily basis in casinos and financial markets.

We introduce and realize gambling demons who, following a customary gambling strategy to stop a nonequilibrium process at stochastic times, are able to extract more average work than the free energy change. We derive second laws in the presence of gambling, and a set of universal stopping-time fluctuation relations for the work done in classical and quantum stochastic non-stationary processes.

We test experimentally our results in a single-electron box, where an electrostatic potential is used to drive the dynamics of individual electrons tunnelling into a metallic island. We also discuss the role of coherence and measurements in gambling for open quantum systems following quantum jump trajectories, where the combination of coherence and quantum measurements leads to a genuine extra term modifying the entropic balance.

Quantum signatures in the work distribution
Martí Perarnau-Llobet

An important result in classical stochastic thermodynamics is the work fluctuation–dissipation relation (FDR), which states that the dissipated work done along a slow process is proportional to the resulting work fluctuations. Here we show that slowly driven quantum systems violate this FDR whenever quantum coherence is generated along the protocol, and derive a quantum generalisation of the work FDR. The additional quantum terms in the FDR are found to lead to a non-Gaussian work distribution, in contrast to classical slow processes. Fundamentally, our result shows that quantum fluctuations prohibit finding slow protocols that minimise both dissipation and fluctuations simultaneously. Instead, we develop a quantum geometric framework to find processes with an optimal trade-off between the two quantities.

Quantum circuit diagnostics using bounds on periodically driven systems
Raam Uzdin

We derive a set of inequalities on the evolution of the survival probability in periodically driven quantum systems. By repeating the same circuit multiple times, we can detect 1) violation from perfect periodicity (e.g. due to a systematic drift in the controls). 2) Heat leaks that make the evolution non-unital. To obtain these inequalities we introduce the principle of "positivity" in Liouville space. Crucially, we can detect heat leak in scenarios that are impossible to detect by measuring observables after just one cycle (e.g. when the initial is at zero temperature). Generally, our method works very well for pure-states initial condition and therefore it is suitable for NISQ quantum processors. We verify our findings experimentally on the IBM Q platform. Our second main finding is that these inequalities exponentially converge to equality as the number of cycles increases. The exponential decay is universal in the sense that it appears for any circuit and for any initial condition provided that the driving is periodic. The decay rate is directly related to the "action" of the circuit. A deviation from exponential decay can be used as an indicator of the imperfection of the device at hand. We will present results from the IBM Q and discuss the potential of this method to diagnose problems in realizations of quantum circuits.

Obinna Abah
TBA

On the repeatable use of quantum resources in thermodynamics
Markus P. Müller

Catalysts, i.e. quantum systems that are involved in a process but are returned unchanged, are an integral part of quantum thermodynamics. In this talk, I discuss a notion of correlated catalysis, in which the quantum systems are returned locally unchanged but potentially correlated or entangled with the systems on which they act - a special case is given by Aberg's catalytic coherence. I show that this notion yields a one-shot operational interpretation of the nonequilibrium free energy F in the incoherent case, but that the coherent case is severely constrained by a no-broadcasting theorem for coherence. The latter is of independent interest: it forbids the distribution of timing (or other reference frame) information from a single quantum clock to several physical systems.

Friday, 27 November

Quantum Fluctuation Theorems beyond Two-Point Measurements
Erik Lutz

We derive detailed and integral quantum fluctuation theorems for heat exchange in a quantum correlated bipartite thermal system using the framework of dynamic Bayesian networks. Contrary to the usual two- projective-measurement scheme that is known to destroy quantum features, these fluctuation relations fully capture quantum correlations and quantum coherence at arbitrary times. We further obtain individual integral fluctuation theorems for classical and quantum correlations, as well as for local and global quantum coherences.

Themodynamically consistent quantum Master equations
Ronnie Kosloff

Thermodynamics entails a set of mathematical conditions on quantum Markovian dynamics. In particular, strict energy conservation between the system and environment implies that the dissipative dynamical map commutes with the unitary system propagator. Employing spectral analysis we prove the general form of the ensuing master equation. We compare this result to master equations obtained from standard microscopic derivations. The obtained formal structure can be employed to test the compatibility of approximate derivations with thermodynamics. For example, it designates that global master equations are the compatible choice. The axiomatic approach sheds light on the validity of the secular approximation in microscopic derivations, the form of the steady state in heat transport phenomena, and indicates the lack of exceptional points in the dynamics of open quantum systems.