2nd Quantum Thermodynamics Conference

Palma de Mallorca, Spain, April 19-24, 2015

	Monday 20	Tuesday 21	Wednesday 22	Thursday 23	Friday 24
8:45 -9:20	Bus to UIB				
1st session 9:30-11:30	Introduction 9:30	9:30 ADESSO	Poster prizes	9:30 SPLETTSTOESSER	9:30 ESPOSITO
	9:40 TALKNER	10:00 CAMPISI	9:40 BRUDERER	10:00 JEZOUIN	10:00 MOHAMMADY
	10:30 ALLAHVERDYAN	10:30 UZDIN	10:30 WEILENMANN	10:30 XUEREB	10:30 ABDELKHALEK
	11:00 PLASTINA	11:00 GELBWASER	11:00 HUBER	11:00 GARCÍA-PINTOS	11:00 SCHMIDT
11:30-12:00	Coffee break				
2nd session 12:00	12:00 GOGOLIN	12:00 PERARNAU	12:00 SÁNCHEZ	12:00 MANZANO	12:00 McCLOSKEY
	12:30 DE PASQUALE	12:30 GALLEGO	12:30 WHITNEY	12:30 LOSTAGLIO	12:30 BRUSCHI
	13:00 CORREA	13:00 DE CHIARA	13:00 S-Y HWANG	13:00 JEVTIC	MC meeting: ANDERS
	13:30-14:30 LUNCH				**14:00-15:00** LUNCH
3rd session 14:30-16:00	14:30-15:00 ACIN WG1 meeting	14:30-15:00 BRANDES WG2 meeting	**Excursion to Serra de Tramuntana**	14:30-15:00 TOLAZZI WG3 meeting Co-Chair: LUTZ	Extra time for MC meeting
4th session	Walk to IFISC & **POSTER SESSION**	16:00 FESHCHENKO		16:00 RONDIN	Bus to hotel/airport
		16:30 RAUER		16:30 DECHANT	
17:00		**guided tour & social dinner**		Bus to hotel	
17:30	Bus to hotel				

The 2nd Quantum Thermodynamics Conference is meant to be a reference for researchers working in thermodynamics in the quantum regime, in connection with quantum information theory and statistical physics. Two keynote, several invited and contributed talks as well as a poster session are scheduled, promoting young scientists. Time for discussions and workgroup meetings is allocated during the week. The rich program of scientific activities is completed by local outing and an excursion to Serra de Tramuntana (World Heritage Site by UNESCO) providing excellent opportunities to further connect with colleagues.

Invited Speakers

- Martin Bruderer (Ulm University, Germany) -keynote-
- Peter Talkner (Augsburg University, Germany) -keynote-
- Gerardo Adesso (University of Nottingham, UK)
- Massimiliano Esposito (University of Luxembourg)
- Anna Feshchenko (Aalto University, Finland)
- Sania Jevtic (Imperial College, UK)
- Martí Perarnau-Llobet (ICFO, Spain)
- Janine Splettstösser (Chalmers University, Sweden)

Invited WG meeting Chairs

- WG1: Antonio Acin (ICFO, Spain)
- WG2: Tobias Brandes (Technische Universität Berlin, Germany)
- WG3: Nicolas Tolazzi (Universität Mainz, Germany) & Eric Lutz (University of Erlangen-Nürnberg)

Scientific Committee

- Eric Lutz (University of Erlangen-Nürnberg) -CHAIR-
- Nicolas Brunner (Institute for Theoretical Physics University of Geneva)
- Jochen Gemmer (University of Osnabrück, Germany)
- Juan M.A. Parrondo (University Complutense of Madrid)
- Killian Singer (University of Mainz, Germany)
- Roberta Zambrini (IFISC, Spain)

Organizing committee

Institute of Cross-Disciplinary Physics and Complex Systems:

- Roberta Zambrini
- Rosa Lopez
- David Sanchez
- Llorenç Serra
- Fernando Galve

Sunday 19/4/2015

19:00 Welcome at Nautic hotel and (19:30) dinner at "el Club" restaurant

Monday 20/4/2015

8:45 bus from Nautic hotel to conference place (UIB Campus)

chair: **J.M.Parrondo**

9:30 Conference opening by Maxi San Miguel and Roberta Zambrini
9:40 **Peter Talkner,** Transient quantum fluctuation relations
10:30 **Armen Allahverdyan**, Nonequilibrium quantum fluctuations of work
11:00 **Francesco Plastina**, Non-adiabticity and irreversible entropy production

11:30-12:00 coffee break chair: **T.Short**

12:00 **Christian Gogolin**, Locality of temperature
12:30 **Antonella De Pasquale**, Temperature: a quantum estimation approach
13:00 **Luis A. Correa**, Individual quantum probes for optimal thermometry

13:30-14:30 lunch

14:30 **A. Acin**, WG1 meeting: Equilibration, thermalisation, and emergence of canonical states

16:00 walk to IFISC and **POSTER session** with coffee and beer

17:30 bus to Nautic hotel

Tuesday 21/4/2015

8:45 bus from Nautic hotel to conference place (UIB Campus)

chair: **J.Anders**

9:30 **Gerardo Adesso**, Optimal performance of quantum refrigerators
10:00 **Michele Campisi,** Nonequilibrium fluctuations in quantum heat engines: Theory, example, and possible solid state experiments
10:30 **Raam Uzdin,** Equivalence of different engine types in the quantum regime and quantum thermodynamic signatures
11:00 **David Gelbwaser-Klimovksy**, Strongly coupled quantum heat machines

11:30-12:00 coffee break chair: **J.Gemmer**

12:00 **Marti Perarnau-Llobet**, Work and correlations
12:30 **Rodrigo Gallego**, Defining work and heat from operational postulates
13:00 **Gabriele De Chiara**, Measuring work and heat in ultracold quantum gases

13:30-14:30 lunch

14:30 **Tobias Brandes,** WG2 meeting

chair: **L.Serra**

16:00 **Anna V. Feshchenko**, Experimental realization of a Coulomb gap refrigerator
16:30 **Bernhard Rauer**, Non-equilibrium dynamics of a one-dimensional Bose gas
17:00 bus to Palma
18:00 *Guided tour downtown*
20:00 *Social dinner at Caballito de Mar*

Wednesday 22/4/2015

8:45 bus from Nautic hotel to conference place (UIB Campus)

chair: **A.Winter**

9:30 Poster prizes announcement
9:40 **Martin Bruderer,** Controlling and Measuring Heat Transport in Ion Traps

10:30 **M. Weilenmann,** A Framework for Information Theoretic and Thermodynamic Entropies
11:00 **Marcus Huber**, The most energetic passive state

11:30-12:00 coffee break chair: **D. Sanchez**

12:00 **Rafael Sánchez,** Three terminal quantum Hall thermoelectrics
12:30 **Robert S. Whitney,** Maximum efficiency at given power output in 2 or 3 terminal thermoelectrics
13:00 **Sun-Yong Hwang**, Coupled Nonlinear Thermoelectric Transport in Normal-Quantum Dot-Superconductor Junctions

13:30-14:30 lunch

14:30 Serra de Tramuntana excursion (back to the hotel around 19:00)

Thursday23/4/2015

8:45 bus from Nautic hotel to conference place (UIB Campus)

chair: **R. Lopez**

9:30 **Janine Splettstoesser**, Heat currents and dephasing in flux qubits
10:00 **Sebastien Jezouin**, Quantum Limit of Heat Flow Across a Single Electronic Channel
10:30 **André Xuereb**, Thermodynamics of trajectories of a quantum harmonic oscillator coupled to N baths
11:00 **Luis Pedro García-Pintos**, Time scales of equilibration in physically relevant measurements

11:30-12:00 coffee break chair: **P. Skrzypczyk**

12:00 **Gonzalo Manzano Paule,** Fluctuation theorems and quantum mutual information
12:30 **Matteo Lostaglio**, Thermodynamics beyond free energy relations
13:00 **Sania Jevtic,** Exchange Fluctuation Theorem for Correlated Quantum Systems

13:30-14:30 lunch

14:30 **Nicolas Tolazzi** & Eric Lutz, WG3 meeting

chair: **J.Anders**

16:00 **Loïc Rondin**, Kramers' Turnover measured with a vacuum levitated nanoparticle
16:30 **Andreas Dechant**, An all-optical nanomechanical heat engine
17:00 bus to hotel Nautic

Friday 24/4/2015

8:45 bus from Nautic hotel to conference place (UIB Campus)

chair: **M. Bruderer**

9:30 **Massimiliano Esposito**, Quantum thermodynamics: A nonequilibrium Green's function Approach
10:00 **Hamed Mohammady**, Minimising the heat dissipation of maximal information erasure
10:30 **Kais Abdelkhalek,** Thermodynamic costs of quantum measurements
11:00 **Rebecca Schmidt**, Work and heat for two-level systems in dissipative environments: Strong driving and non-Markovian dynamics

11:30-12:00 coffee break chair: **P.Talkner**

12:00 **Ruari McCloske**y, Heat Fluxes and Quantum Correlations in Collision Models
12:30 **David Edward Bruschi**, Quantum thermodynamics for a model of an expanding universe

13:00 MC meeting: **Janet Anders**

14:00-15:00 lunch

15:00 Transfer back to hotel or airport

INVITED TALKS

Optimal performance of quantum refrigerators

L. A. Correa, J. P. Palao, D. Alonso, and **G. Adesso**

We establish upper bounds on the coefficient of performance at maximum cooling power for all known models of quantum absorption refrigerators. In the special case of endoreversible refrigerators coupled to unstructured bosonic baths, the bound is refined into an exact function of the Carnot coefficient of performance. We provide general design prescriptions to saturate the bounds, and investigate how they may be pushed beyond what is classically achievable by exploiting squeezed reservoirs.

Controlling and Measuring Heat Transport in Ion Traps

A. Bermudez, **M. Bruderer** and M. B. Plenio

Measuring and controlling heat flow on the nanoscale poses formidable practical difficulties as elementary devices such as switches and 'ampere meters' for thermal currents are not available. We propose to overcome this problem by realizing heat transport through a chain of trapped ions, where steady-state currents of local vibrations (vibrons) are induced by a constant temperature difference between the edges of the chain. We show how to efficiently control and measure these currents by coupling vibrons to internal ion states, which can be easily manipulated in experiments. Trapped-ion crystals therefore provide a promising platform for studying heat transport, e.g., through thermal analogues of quantum wires and quantum dots. Specifically, elusive phenomena such as the onset of Fourier's law may be observable in trapped-ion systems.

Quantum thermodynamics: A nonequilibrium Green's function Approach

M. Esposito and M. Galperin

We will discuss the difficulties encountered when attempting to formulate quantum thermodynamics for open quantum systems strongly coupled to their reservoirs. A consistent approach resolving these problems will be presented within the framework of nonequilibrium Green's functions. The four fundamental laws of thermodynamics are verified and can be used to characterize transport in steady-state as well as in driven devices.

[1] M. Esposito, K. Lindenberg and C. Van den Broeck, New J. Phys. 12, 013013 (2010)
[2] L. Pucci, M. Esposito and L. Peliti, J. Stat. Mech. (2013) P04005
[3] M. Esposito, M.A. Ochoa and M. Galperin, Phys. Rev. Lett. 114, 080602 (2015)

Experimental realization of a Coulomb gap refrigerator

A. V. Feshchenko, J. V. Koski and J. P. Pekola

We present the first experimental realization of a recently proposed Coulomb gap refrigerator [1, 2]. Our device is a normal single-electron transistor (SET) made of laterally proximized tunnel junctions [3]. At certain values of the bias and gate voltages, the current through the SET cools one of the junctions. The SET island is interrupted by a superconducting inclusion to permit charge transport while preventing heat flow. The temperature drop is measured with an NIS thermometer.

[1] J. P. Pekola, J. V. Koski, D. V. Averin, Phys. Rev. B 89, 081309(R) (2014)
[2] A. V. Feshchenko, J. V. Koski, J. P. Pekola, Phys. Rev. B 90, 201407(R) (2014)
[3] J. V. Koski, J. T. Peltonen, M. Meschke, and J. P. Pekola, Appl. Phys. Lett. 98, 203501 (2011)

Exchange Fluctuation Theorem for Correlated Quantum Systems

S. Jevtic, T. Rudolph, D. Jennings, Y. Hirono, S. Nakayama, and M. Murao

The Exchange Fluctuation Theorem (XFT) describes energy exchange between two thermal systems, and it is valid even if the systems finish arbitrarily far from equilibrium. An assumption made in the derivation of the XFT is that the two systems are initially uncorrelated. If we are to apply the XFT to quantum systems, then this assumption needs to be questioned. Our goal is to extend the XFT to describe the non-equilibrium exchange dynamics of correlated quantum states. The relation quantifies how the tendency for systems to equilibrate is modified in high-correlation environments.

Work and correlations

A. Acín, N. Brunner, D. E. Bruschi, K. V. Hovhannisyan, M. Huber, N. Friis, C. Klöckl, **M. Perarnau-Llobet**, and P. Skrzypczyk

We study the optimal interconversion between work and (quantum) correlations. Considering a set of uncorrelated thermal states, we derive bounds on both the mutual information and entanglement of formation that can be generated, as a function of the initial temperature and the available work. We also characterise the maximal temperature allowing for different types of entanglement generation. Finally, we consider the reverse question, i.e., the extractable work from a correlated state.

Heat currents and dephasing in flux qubits

S. Spilla, F. Hassler, A. Napoli, and **J. Splettstoesser**

Heat currents across Josephson junctions carried by quasiparticles are sensitive to the superconducting phase difference via Andreev reflection. As a result, heat currents due to accidental temperature gradients in flux qubits ``measure" the phase-dependent qubit state causing dephasing. We compare the emerging dephasing time for different flux qubit designs. We argue that even for vanishing temperature gradients, the study of heat conductances yields a phenomenological access to dephasing due to quasiparticle tunneling.

Transient quantum fluctuation relations

Peter Talkner

The statistics of work performed on a system that initially stays in equilibrium is constrained by so-called transient fluctuation relations known under the names of Jarzynski equality and Crooks relation. We shall introduce these relations and discuss their main prerequisites both for closed and open quantum systems. These prerequisites embrace the way how the work is determined, the time-reversal invariance of Hamiltonian systems as well as the proper identification of the system's free energy. The latter point being relevant for open systems.

M. Campisi, P. Talkner, P. Hanggi, Rev. Mod. Phys. 83, 771 (2011); ibid 1653 (2011).
P. Hanggi, P. Talkner, Nat. Phys. 11, 108 (2015).

CONTRIBUTED TALKS

Thermodynamic costs of quantum measurements

Kais Abdelkhalek and David Reeb

We investigate the thermodynamic costs of performing quantum measurements. For a measurement employing a probe, we generalize and improve the results by Sagawa and Ueda (PRL 102, 250602) to the genuinely quantum case where the measurement generates classical or quantum correlations. We provide explicit gap terms and identify inefficiencies in the measurement and the outcome storage. Finally, we apply our results to analyze the full Szilard engine cycle under possibly imperfect measurements.

Nonequilibrium quantum fluctuations of work

Armen Allahverdyan

The concept of work is basic for thermodynamics. I focus on the work done between two moments of time for a thermally isolated quantum system driven by a time-dependent Hamiltonian. I formulate two conditions needed for the fluctuating work to be physically meaningful for a system that starts its evolution from a non-equilibrium state. I propose a definition of fluctuating work that is free of previous drawbacks and that applies for a class of non-equilibrium initial states.

Quantum thermodynamics for a model of an expanding universe

Nana Liu, John Goold, Ivette Fuentes, Vlatko Vedral, Kavan Modi and **David Edward Bruschi**

We study thermodynamical properties of quantum fields in curved spacetime by considering the fields as quantum systems undergoing out-of-equilibrium transformations. We study non-equilibrium features by considering fluctuation relations and emergent irreversible features beyond the linear response regime. We specialise to an expanding universe setup and provide a fluctuation theorem which allows us to understand particle production due to the expansion of the universe as an entropic increase.

Nonequilibrium fluctuations in quantum heat engines: Theory, example, and possible solid state experiments

Michele Campisi, Jukka Pekola and Rosario Fazio

The stochastic thermodynamics of a quantum heat engine (including the statistics of efficiency and the compliance with the fluctuation relation) is illustrated by means of a two-qubit heat engine, where each qubit is coupled to a thermal bath and a two-qubit gate determines energy exchanges between the two qubits. We discuss possible solid state implementations with Cooper pair boxes and flux qubits, quantum gate operations, and fast calorimetric on-chip measurements of single stochastic events.

Individual quantum probes for optimal thermometry

Luis A. Correa, Mohammad Mehboudi, Gerardo Adesso and Anna Sanpera

In this talk, the task of interest is the precise estimation of the unknown temperature of a sample, by having a single quantum probe thermalize with it. I will use of the toolbox of parameter estimation, to assess the ultimate limitations on the achievable thermal sensitivity in this prototypical setup. The fundamental issue of temperature fluctuations in small systems will be thus revisited from a fresh perspective, arriving to relevant results for the practice of quantum thermometry.

An all-optical nanomechanical heat engine

Andreas Dechant, Nikolai Kiesel and Eric Lutz

We propose and theoretically investigate a nanomechanical heat engine. A levitated nanoparticle in an optical trap inside a cavity can be used to realize a Stirling cycle in the underdamped regime. The all-optical approach enables fast and flexible control of all thermodynamic parameters and the efficient optimization of the engine. We develop a systematic optimization procedure to determine optimal driving protocols and to evaluate the maximum power and the corresponding efficiency.

Measuring work and heat in ultracold quantum gases

Gabriele De Chiara, Augusto J. Roncaglia and Juan Pablo Paz

I will present a radically new method to measure heat and work in cold atomic gases. Using a light-matter interaction, known as the Faraday effect, we can measure the initial and final energy of an atomic ensemble before and after a thermodynamic transformation has taken place. For isolated systems this accounts for the work done on or extracted from the system thus verifying Jarzynski equality. For open systems there will also be a contribution of heat.

Temperature: a quantum estimation approach

Antonella De Pasquale, Davide Rossini, Rosario Fazio and Vittorio Giovannetti

We discuss the issue of temperature-locality in the quantum regime from the viewpoint of quantum estimation theory. Our strategy hinges upon the computation of the quantum Cramer-Rao Bound on the variance associated to the global temperature, via local measurements. In the low-temperature regime our approach emerges as a thermodynamics-rooted scheme able to operationally quantify the local distinguishability between the ground state and the first excited level of the system Hamiltonian.

Time scales of equilibration in physically relevant measurements

Luis Pedro García-Pintos, Anthony Short, Noah Linden, Artur Malabarba and Andreas Winter

We study the conditions under which a closed system equilibrates quickly with respect to some observable. Under certain conditions on the distribution of the matrix elements of observable and initial state, we find an upper bound on the time scales of equilibration giving much more realistic results than previously known bounds (which scale with the dimension of the system). As an application, we find a simple expression for the equilibration times of a system interacting with a thermal bath.

Strongly coupled quantum heat machines

David Gelbwaser-Klimovksy and Alan Aspuru-Guzik

A common denominator of quantum heat machines models is the weak coupling assumption, which limits the machine output. A possible way to overcome this limitation is to consider the strong coupling regime, where thermodynamic principles, may no longer hold. In this talk, I will explore this virtually unknown regime, showing the difference between weakly and strongly coupled quantum thermal machines, the advantage and limitations of each of them, and their relation with thermodynamic bounds.

Locality of temperature

Martin Kliesch, **Christian Gogolin**, Michael James Kastoryano, Arnau Riera and Jens Eisert

We present results leading to a local definition of temperature in spin- and fermionic-lattice systems, extending the notion of "intensivity of temperature" to interacting quantum models. We derive a perturbation formula for thermal states that captures the influence in terms of a generalized covariance. For this covariance we prove exponential clustering of correlations above a universal critical temperature implying stability of the thermal state against distant Hamiltonian perturbations.

The most energetic passive state

Antonio Acin, Karen V. Hovhannisyan, **Marcus Huber**, Marti Perarnau-Llobet, Paul Skrzypczyk and Jordi Tura

Passive states play a central role in thermodynamics as they are the only ones where no cyclic process can extract any amount of work. However operating on multiple copies of passive states unlocks the potential to extract some energy until the passive state with least possible energy (at a given entropy) is reached. We resolve the question how much unlockable work can be stored in passive states by deriving the general form of the most energetic passive state.

Coupled Nonlinear Thermoelectric Transport in Normal-Quantum Dot-Superconductor Junctions

Sun-Yong Hwang, Rosa Lopez and David Sanchez

We explore the thermoelectric current of a quantum dot attached to normal and superconducting leads with voltage and temperature bias. Inherent particle-hole symmetry in superconductor cancels subgap thermoelectric response. However, the Andreev bound states shift as thermal bias increases. Thus, the current can be tuned by temperature in combination with voltage in nonlinear regime. We also show the importance of quasiparticle tunneling in the generation of high thermopower sensitivities.

Quantum Limit of Heat Flow Across a Single Electronic Channel

Sebastien Jezouin, François Parmentier, Anne Anthore, Ulf Gennser, Antonella Cavanna, Yong Jin and Frédéric Pierre

Quantum physics predicts that there is a fundamental maximum heat conductance across a single transport channel and that this thermal conductance quantum is universal, independent of the type of particles carrying the heat. Such universality, combined with the relationship between heat and information, signals a general limit on information transfer. Here, we report on the quantitative measurement of the quantum limited heat flow for Fermi particles and across a single electronic channel.

Heat Fluxes and Quantum Correlations in Collision Models

Salvatore Lorenzo, **Ruari McCloskey**, Francesco Ciccarello, Mauro Paternostro and Massimo Palma

We focus on the process of thermalisation from the point of view of a quantum system coupled with an ancilla which is coupled to a bath. The aim is to see how the system relaxes depending on the choice of the intermediary ancilla and the system-ancilla and ancilla-environment coupling. Building on previous experience, we choose to work with collision models due to their accessibility and examine Landauer's principle as the system- ancilla ensemble evolves.

Thermodynamics beyond free energy relations

Matteo Lostaglio, David Jennings and Terry Rudolph

Recent studies developed fundamental limitations of quantum thermodynamics, in terms of a set of free energy relations. We show that these cannot properly describe quantum coherence in thermodynamics. We cast coherence as a fundamental resource of a quantum state and arrive at additional, independent thermodynamic relations, which naturally extend the existing ones. As an application, we show that the Szilard engine argument does not extend to quantum coherences without an appropriate activation.

Fluctuation theorems and quantum mutual information

Gonzalo Manzano Paule, Jordan M. Horowitz and J. M. R. Parrondo

In this talk I present a fluctuation theorem for the correlations created among the constituents of an isolated quantum system. This quantity, given by the mutual information, can be interpreted as an entropy production and its relation to time-reversal symmetry breaking is discussed. Our results are valid in a very broad range of situations and do not rely on specific details of the interaction nor on the shape of the initial (separable) states of the subsystems.

Minimising the heat dissipation of maximal information erasure

Hamed Mohammady, Masoud Mohseni and Yasser Omar

We find the global unitary evolution that minimises the heat transfer to a thermal reservoir conditional on maximising the erasure of a qubit. We consider the case when the reservoir is a d-dimensional subspace of a harmonic oscillator, and show that the optimal case exceeds Landauer's limit. We also consider the robustness, due to reservoir dimension, to energy-conserving dephasing. Finally, we consider two changes in the assumptions underlying Landauer's principle to attain better bounds.

Non-adiabticity and irreversible entropy production

Francesco Plastina, Antonio Alecce, Tony Apolalro, Giovanni Falcone, Gianluca Francica, Fernando Galve, Nicola Lo Gullo and Roberta Zambrini

I will discuss the thermodynamic properties of a closed quantum system brought out-of-equilibrium by some work performed on it, and show that the non-adiabatic part of the work (called inner friction) is intimately linked to the non-equilibrium entropy production. A specific fluctuation relation associated with the inner friction exists, which allows to show the connections among the inner friction, the speed of the thermodynamic transformation, and the occurrence of diabatic transitions.

Non-equilibrium dynamics of a one-dimensional Bose gas

Bernhard Rauer, Tim Langen, Sebastian Erne, Remi Geiger, Thomas Schweigler, Pjotrs Grisins, Igor Mazets, Thomas Gasenzer and Jörg Schmiedmayer

We investigate relaxation dynamics in a degenerate 1d Bose gas which we take out of equilibrium by coherently splitting it into two parts. In the subsequent evolution the relative phase field of the two condensates is monitored, providing a local probe for the system. This allows us to directly observe how the initial coherence between the two many-body systems is lost and how a steady state emerges. We explicitly show that this steady state is described by a generalized Gibbs ensemble.

Kramers' Turnover measured with a vacuum levitated nanoparticle

Loïc Rondin, Jan Gieseler, Romain Quidant, Christoph Dellago and Lukas Novotny.

Using a nanoparticle trapped in a bi-stable optical potential we experimentally measure the nanoparticle's transition rates for variable damping. This allows us to directly resolve the Kramers' turnover, i.e a rate maximum. Our measurements are in agreement with an analytical model that is free of adjustable parameters. This demonstrates levitated nanoparticles as an experimental platform for studying and simulating a wide range of stochastic processes and testing theoretical models predictions.

Three terminal quantum Hall thermoelectrics

Rafael Sánchez, Björn Sothmann and Andrew N. Jordan

We investigate the thermoelectric properties of a three-terminal quantum Hall conductor. We identify a contribution to the thermoelectric response that relies on the chirality of the carrier motion rather than on spatial asymmetries. The Onsager matrix becomes maximally asymmetric showing that thermoelectric measurements are sensitive to the chiral nature of the quantum Hall edge states. The possibility to generate spin-polarized currents in quantum spin Hall samples is also discussed.

Work and heat for two-level systems in dissipative environments: Strong driving and non-Markovian dynamics

Rebecca Schmidt, M Florencia Carusela, Jukka P. Pekola and Joachim Ankerhold

Work, moments of work and heat flux are studied for the generic case of a strongly driven two-level system immersed in a bosonic heat bath in domains of parameter space where perturbative treatments fail. This includes the interplay between non-Markovian dynamics and moderate to strong external driving. Exact data are compared with weak coupling approaches. Further, the role of system-bath correlations in the initial thermal state are addressed.

Equivalence of different engine types in the quantum regime and quantum thermodynamic signatures

Raam Uzdin and Ronnie Kosloff

We show that in the quantum regime different engine types like four-stroke, two-stroke and continuous engines are all thermodynamically equivalent and even have the same relaxation to steady state. Furthermore, it is shown that quantum engines have a quantum-thermodynamic signature. Cumulative work measurement for example can indicate the existence of quantum interference in the engine. This coherent dynamics enables work extraction far beyond the capabilities of a stochastic (dephased) engine.

A Framework for Information Theoretic and Thermodynamic Entropies

Mirjam Weilenmann, Lea Kraemer, Philippe Faist and Renato Renner

We study the application of an approach to thermodynamic entropy by Lieb and Yngvason to information-theoretic scenarios and establish a link between the phenomenological entropy known from thermodynamics and the von Neumann entropy important for information theory on a microscopic scale; two conceptually very different quantities. Simultaneously, entropic quantities relevant for thermodynamic non-equilibrium states are shown to correspond to the information-theoretic min- and max-entropies.

Maximum efficiency at given power output in 2 or 3 terminal thermoelectrics

Robert S. Whitney

Carnot efficiency is only achievable at zero power output. So what is the maximum efficiency at finite power output? The answer requires quantum theory, being ill-defined in classical thermodynamics. We use scattering theory to find the maximum efficiency for relaxation-free 2 terminal systems. We explore whether this maximum can be exceeded by adding relaxation, or with 3 terminal systems. The present answer seems to be "no".

Defining work and heat from operational postulates

Rodrigo Gallego, Henrik Wilming and Jens Eisert

Work is traditionally defined as the energy stored in a lifted weight (battery). In the quantum regime, fluctuations cease to be negligible, hence, the question arises of how to define work discounting the heat content of fluctuations. We propose an axiomatic approach to the definition of work. By imposing a set of postulates that any work measure fulfils, we show that work can be written as the free energy difference of the battery, but not as the energy difference as it is usually measured.

Thermodynamics of trajectories of a quantum harmonic oscillator coupled to N baths
Simon Pigeon, Lorenzo Fusco, **André Xuereb**, Gabriele De Chiara and Mauro Paternostro

We undertake a thorough analysis of the thermodynamics of the trajectories followed by a quantum harmonic oscillator coupled to N dissipative baths by using a new approach to large-deviation theory inspired by phase-space quantum optics. As an illustrative example, we study the archetypal case of a harmonic oscillator coupled to two thermal baths, allowing for a comparison with the analogous classical result, finding significant differences in the low-temperature limit.

POSTERS

1. Paul Erker, Karen Hovhannisyan, Marcus Huber, Alex Monras and Marti Perarnau-Llobet
Mutual majorization of quantum marginals and the optimal conversion of energy to correlations

2. Ian Ford
No long-term loans from the Bank of Entropy

3. Maria Isabel Alomar Bennassar, Llorenç Serra Crespí and David Sánchez Martín
Seebeck Effects in Two-Dimensional Electron Gases

4. Miguel Ambrosio Sierra Seco de Herrera and David Sánchez Martín
Nonlinear thermoelectric transport in Coulomb-blockaded quantum dots

5. Javier Osca, Daniel Ruiz and Llorenç Serra
Optical absorption of 2D Majorana nanowires

6. Antonio Alecce, Fernando Galve, Nicolino Lo Gullo, Roberta Zambrini, Francesco Plastina and Luca Dell'Anna
Quantum Otto Cycle with Inner Friction

7. Paul Erker
The Quantum Hourglass – a road towards thermal clocks

8. Kamil Korzekwa, Matteo Lostaglio, David Jennings and Terry Rudolph
Quantum coherence, time-translation symmetry and thermodynamics

9. Mohammad Mehboudi, Mariona Moreno-Cardoner, Gabriele de Chiara and Anna Sanpera
Thermometry in Strongly Correlated ultracold lattice gases

10. Pietro Liuzzo Scorpo, Luis A. Correa, Rebecca Schmidt and Gerardo Adesso
The role of quantum correlations in measurement-based feedback cooling

11. Bogna Bylicka
Features of Open Quantum Systems Dynamics

12. Senaida Hernández Santana, Karen Hovhannisyan, Arnau Riera, Luca Tagliacozzo, Marti Perarnau-Llobet and Antonio Acín
Local temperature in interacting spin systems

13. Matteo Carrega, Paolo Solinas, Alessandro Braggio, Maura Sassetti and Ulrich Weiss
Path-integral formulation of heat exchange in open quantum systems

14. Riccardo Bosisio, Francesco Mazza, Stefano Valentini, Giuliano Benenti, Rosario Fazio, Vittorio Giovannetti and Fabio Taddei
Separation of heat and charge currents for boosted thermoelectric conversion

15. Karen Hovhannisyan, Marti Perarnau-Llobet, Marcus Huber, Paul Skrzypczyk, Nicolas Brunner and Antonio Acin
Extractable work from correlations

16. Felix Binder, Sai Vinjanampathy, John Goold and Kavan Modi
Powerful quantum batteries

17. Eyal Heifetz and Eliahu Cohen
Toward a Thermo-Hydrodynamic Description of Quantum Mechanics

18. Max Frenzel, David Jennings and Terry Rudolph
Reexamination of Pure Qubit Work Extraction

19. Arnau Riera, Christian Gogolin, Martin Kliesch and Jens Eisert
Emergence of the Gibbs state in local Hamiltonians

20. Obinna Abah and Eric Lutz
Optimal performance of a quantum Otto refrigerator

21. Henrik Wilming, Rodrigo Gallego and Jens Eisert
Weak thermal contact is not universal for work extraction

22. Artur Malabarba, Anthony J. Short and Philipp Kammerlander
Clock-Driven Quantum Thermal Engines

23. Pietro Silvi, Giovanna Morigi, Tommaso Calarco and Simone Montangero
Emergence of quantum-classical interplay in 1D dynamical quantum phase transitions

24. Pjotrs Grisins, Bernhard Rauer, Tim Langen, Joerg Schmiedmayer and Igor Mazets
Dissipative cooling of degenerate Bose gases

25. Giulio Salvatori, Antonio Mandarino, Matteo G.A. Paris
Quantum metrology in Lipkin-Meshkov-Glick critical systems

Summaries of *all* contributions:
http://www.ifisc.uib-csic.es/qtd2/abstracts.html

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SOME USEFUL INFORMATION

The conference will take place at the Auditorium of the "Escola d'Hoteleria" (UIB Campus) with the exception of the poster session, that will be at IFISC (map in the following page).
Lunches will be served at the Restaurant of the "Escola d'Hoteleria".

Tessa Corral or Marta Ozonas will be at the help-desk at the auditorium entrance. Local organizers and support personnel will have colored badges.

- **Signature:**

COST funded participants need to sign the attendance list **every day** they attend the conference (this is very important as evidence for the COST funding). The list will be in the Auditorium during all the day.

- **Monday 20/4/2015:**

For the proper planning, **all** participants are requested to fill in the available forms at the help desk
– choosing between options 1 or 2 (see below) for the excursion to Sa Foradada.
– booking the lunch of Friday 24 (a special Thematic Buffet will be served).

Please, also communicate to Tessa or Marta, at the help-desk, if you do not intend to attend the guided tour and/or social dinner on Tuesday 21.

- **Menu of welcome and social dinners:**

EL CLUB (19/4/2015): "Trampó Mallorquí", Paella, dessert, water and wine (Rioja).

EL CABALLITO DE MAR (21/4/2014): Starters to share: "Buñuelos de Bacalao y sobrasada"; Mussels; Salad with chicken, bacon, cherrys, croutons and soya and honey vinaigrette; Gambusi shrimps. Main Course: "Suprema de Gallo de san Pedro"; Chocolate Pannacotta. Coffee. Water and wines: Verdejo Rueda and Rioja.

- **Excursion ¨Serra de Tramuntana ¨, Wednesday 22/4/2015**

If the weather is good, there will be 2 options. All participants will be asked to select their preference on Monday 20th

<table>
<tr><td colspan="2">14.30 Departure from UIB to Sa Foradada</td></tr>
<tr><td>GROUP 1: Guided tour around Son Marroig visiting the museum, gardens, the tower, Miramar Monastery and Sa Foradada viewpoint, where there will be a coffee break.

15.15 Son Marroig guided tour (house museum, gardens and tower)
16.00 Transfer to Miramar and tour
16.45 Transfer back to Sa Foradada viewpoint
17.00 Coffee at Sa Foradada</td><td>GROUP 2: Trekking down to Sa Foradada, stop for coffee break at a rocky beach, and trekking back to Sa Foradada viewpoint. The walk should take 1 hour and 45 minutes (distance of 6 km).

15.15 Walk to Sa Foradada
16.00 Coffee at Sa Foradada Restaurant
16.30 Walk back to Sa Foradada viewpoint
17.30 Arrival to Sa Foradada viewpoint</td></tr>
<tr><td colspan="2">17.30 Departure to Valldemossa
17.45 Visit/walk in Valldemossa
18.30 Transfer back to the hotel
19.00 Arrival at the hotel</td></tr>
</table>

Universitat de les Illes Balears

IFISC
Institut de Física Interdisciplinària i Sistemes Complexos

II International Conference on Quantum Thermodynamics

Universitat de les Illes Balears, Palma de Mallorca from 20 to 24 April 2015

WIFI network guide for the **IFISC** meeting

1. **Connect to the WiFi (or SSID) "uib_(key=password2014)" network.**
2. **Introduce the key "password2014"**
3. **Activate the dynamic IP configuration (DHCP). It's very usual to have dynamic configuration set on the wireless interfaces. Typically it won't be necessary to perform this step.**
4. **Open a web browser and try to access a website. Insert the following credentials in the web page that will appear:**

Username	Password
quantum	uib2015palma

WIFI network guide for EDUROAM users

Attendants coming from an institution that belongs to the Eduroam program can get connected to the "eduroam" wireless network. In order to get connected to this network, the credentials (username/password) served by the foreign institution must be used.

Note:

- **The connection to the "uib_(key=password2014)" and "eduroam" wireless network can be established from anywhere in the UIB campus (to know the wireless network availability a map can be found at http://www.cti.uib.es/eduroam).**

Terms and conditions of use of the WiFi user account:

- Anyone using the account must be somehow related to the **IFISC** meeting.
- The organization (**IFISC meeting**) is responsible for any action taken from this service with this user account.
- The wrong usage of the network service will cause the definitive deactivation of the account in addition to the corresponding measures on the part of the Universitat de les Illes Balears.

To get from the Conference Building (Escola d´Hoteleria de les Illes Balears) to the Metro Station and to the IFISC Building for the Poster Session you can go walking:

Escola d´Hoteleria Illes Balears

IFISC

Metro