

**Scientific Report: Cost MP1209 Thermodynamics in the Quantum Regime**  
**Avendi Hotel, Berlin (Germany)**  
**20<sup>th</sup> – 24<sup>th</sup> January 2014**

COST Action MP1209 held its first conference between 20<sup>th</sup> – 24<sup>th</sup> January 2014 in Berlin. The three Working Groups of the COST Action met for the second time on the 24<sup>th</sup> January 2014.

The Local Organiser was the QMIO Group at the FU Berlin: Jens Eisert, Mathis Friesdorf, Christian Gogolin, Albert Werner, Michael James Kastoryano, Janina Gertis, Earl T. Campbell, Rodrigo Gallego Lopez, Christian Krumnow, Martin Kliesch.

The programme committee was chaired by Tony Short of Bristol University and included Janet Anders, Mari Carmen Banuls, Lidia del Rio, Alberto Imparato, Eric Lutz, James Millen.

There were 8 invited speakers and 52 submitted talks from which 22 were selected (see Programme below).

**Working Group 1 Report – Antonio Acin**

Several talks at the conference were along the main points in WG1. Christian Gogolin, from Freie University of Berlin, and Peter Reinmann, from University of Bielefeld, discussed in their talks conditions under which quantum systems reach an equilibrium state and when this equilibrium state is thermal. Jochen Gemmer, from University of Osnabruck, talked about the implications for numerical simulations of typicality. Lea Santos, from Yeshiva University, study the inter-play between the initial state and the Hamiltonian governing the evolution in equilibration processes. Martin Kleisch, also from Freie University of Berlin, provided conditions necessary for a proper definition of local temperatures. Finally, Markus Muller, from the Perimeter Institute, presented a rigorous analytic proof of thermalization for translation-invariant quantum lattice systems with finite-range interaction of arbitrary strength. Apart from these talks, the poster sessions and the discussion sessions offer a perfect environment for discussing many results on quantum systems equilibrate, the main theme of the WG.

**Working Group 2 Report – Eric Lutz**

The first part of the discussion dealt with the question of the proper definition of work and entropies at the quantum level. The second part was devoted to accessing the role of quantum correlations, in particular entanglement, as a useful resource for work extraction in quantum thermodynamic, as well as the correct definition and existence of absolute negative temperatures. The above discussion topics echoed and complemented the talks given by Armen Allahverdyan (Uni Erevan), Mauro Paternostro (Uni Belfast) and John Gould (Uni Trieste) on the attainability of maximal efficiency in quantum Carnot engines and quantum fluctuation relations, by Philippe Faist (ETH Zurich), Joseph Renes (ETH Zurich), Ralph Silva (Uni Bristol) and Rodrigo Gallego (FU Berlin) on resource theory and correlated engines, as well as as Ronnie Kosloff (Hebrew University Jerusalem) and Ulrich Schneider (Uni Munich) on the third law of thermodynamics and the experimental realization of negative temperatures.

**Working Group 3 Report – Alberto Imparato**

Many of the discussions concerned the definition of the relevant thermodynamic quantities,

namely work and heat in the quantum regime, and the experimental techniques required for their measurements. These discussions were triggered by some of the talks given during the conference. In particular, James Millen presented his work on levitated microspheres in optical tweezers, and discussed how such a setup can be used as a test bed for many concepts in quantum thermodynamics. Mauro Paternostro discussed the problem of sampling the work distribution and the experimental test of the fluctuation relations in quantum systems. Udo Seifert presented a number of results in classical out-of-equilibrium physics, and a few experimental verifications, putting them in the context of quantum thermodynamics. Finally, the poster session and the discussion sessions provided an ideal context for a detailed discussion on all the topics of WG3.

## Programme

### Overview (preliminary)

Start	End	Su	Mo	Tu	We	Th	Fr
09:30	– 10:00		Opening	Peter Reimann	Johan Aberg	Alexia Auffeves	Nelly Ng Huei Ying
10:00	– 10:30		Michele Campisi	Jochen Gemmer	Joseph Renes	Ulrich Schneider	Philippe Faist
10:30	– 11:00		John Goold	Lidia del Rio	Rodrigo Gallego	Armen Allahverdyan	David Reeb
11:00	– 11:30		Break	Break	Break	Break	Break
11:30	– 12:00		Christian Gogolin	Paul Skrzypczyk	Rosa Lopez	Mauro Paternostro	Martin Kliesch
12:00	– 12:30		F. Heidrich-Meisner	Michal Horodecki	Gernot Schaller	James Millen	Lea Krämer
12:30	– 13:30		Lunch	Lunch	Lunch	Lunch	Wrap up
13:30	– 14:30		Discussion	Poster-session with drinks and snacks	Discussion	Discussion	Lunch
14:30	– 15:00	Ronnie Kosloff				WG meeting/ discussion	
15:00	– 15:30	Ralph F. Silva					
15:30	– 16:00						
16:00	– 16:30		Lea Santos		Geraldine Haack		
16:30	– 17:00		Markus P. Müller		Udo Seifert		
17:00	– 19:00	Get together				Outing	
19:00		Welcome dinner	Conference dinner				

### List of invited talks

- **Alexia Auffeves**, *Reversible information to energy conversions in a quantum hybrid system*
- **Christian Gogolin**, *Under what conditions do quantum systems thermalize?*
- **Johan Aberg**, *Catalytic Coherence*
- **Michele Campisi**, *Employing circuit QED to measure non-equilibrium work fluctuations*
- **Nelly Ng**, *The second laws of quantum thermodynamics*
- **Paul Skrzypczyk**, *Extracting work from individual quantum systems*
- **Peter Reimann**, *Thermalization of isolated macroscopic quantum systems: modeling the preparation effects*
- **Rosa López**, *AC/DC electrical and heat fluxes in Mesoscopic Conductors*

### List of contributed talks

- **Armen Allahverdyan**, *Carnot Cycle at Finite Power and Attainability of Maximal Efficiency*
- **David Reeb**, *A tight Landauer Principle with finite-size improvements*
- **Fabian Heidrich-Meisner**, *Non-equilibrium dynamics of interacting bosons in one dimensional optical lattices*
- **Gernot Schaller**, *Quantum transport far from equilibrium*
- **Géraldine Haack**, *The reabsorption effect with single-electron sources: heat current versus charge current*
- **James Millen**, *Cooling levitated nanospheres to the quantum ground state*
- **Jochen Gemmer**, *Dynamical Typicality: What is it and what are its physical and computational implications?*
- **John Goold**, *Use of quantum fluctuation relations in understanding closed and open system dynamics*
- **Joseph M. Renes**, *Extending the resource theory framework to general thermodynamical settings*
- **Lea F. Santos**, *Role of the initial state in many-body systems out of equilibrium: relaxation and thermalization*
- **Lea Krämer**, *An Axiomatic Relation between Information Theoretic and Thermodynamic Entropies*
- **Lidia del Rio**, *Relative thermalization*
- **Markus P. Müller**, *Thermalization and canonical typicality in translation-invariant quantum lattice systems*
- **Martin Kliesch**, *Locality of temperature*
- **Mauro Paternostro**, *Experimental test of fluctuation relations at the full quantum level*
- **Michal Horodecki**, *Single shot thermodynamic operations*
- **Philippe Faist**, *The Minimal Work Cost of Information Processing: Gambling Against the Second Law of Thermodynamics*
- **Ralph Silva**, *Entanglement enhances cooling in microscopic quantum fridges*
- **Rodrigo Gallego**, *Correlated thermal machines in the micro-world*

- **Ronnie Kosloff**, *Quantum refrigerators and the dynamical version of the III law of thermodynamics*
- **Udo Seifert**, *Stochastic thermodynamics: From principles to the efficiency of thermoelectric devices*
- **Ulrich Schneider**, *Thermodynamic stability and negative absolute temperatures*

#### List of posters

- **Antonella De Pasquale**, *Quantum parameter estimation theory*
- **Beatriz Olmos Sanchez**, *Facilitated Spin Models of Dissipative Quantum Glasses*
- **Fabian Heidrich-Meisner**, *Non-equilibrium dynamics of interacting bosons in one dimensional optical lattices*
- **Fernando Galve Conde**, *On the spectral origin of non-Markovianity: an exact finite model*
- **Francesco Mazza**, *Thermoelectric properties of multi-terminal quantum thermal devices*
- **James Millen**, *Levitated Microspheres*
- **Karen Hovhannisyan**, *Storing work in correlations: classical versus quantum*
- **Lorenzo Fusco**, *On the statistics of work in a quantum many-body system undergoing a process*
- **Luis Correa**, *Multi-stage quantum absorption heat pumps*
- **Marti Perarnau-Llobet**, *The role of entanglement in work extraction*
- **Mathis Friesdorf**, *Emergence of coherence and the dynamics of quantum phase transitions*
- **Max Frenzel**, *Work Extraction From A Pure Qubit Revisited*
- **Moritz Fuchs**, *Small nuclear spin environments in graphene quantum dots*
- **Obinna Abah**, *Efficiency of heat engines coupled to nonequilibrium reservoirs*
- **Pjotr Grisins**, *Quantum thermodynamics at the breakdown of integrability*
- **Raam Uzdin**, *The swap heat engine*
- **Roberta Zambrini**, *On the spectral origin of non-Markovianity: an exact finite model*
- **Rosa Lopez**, *Scattering*
- **Rosa Lopez**, *Thermoelectrical detection of Majorana states*
- **Thiago R. de Oliveira**, *A generalized quantum microcanonical ensemble from random matrix product states*

The attendance was as follows:

Sunday 19 January - 54 people (66% ESR, 16% female) (arrival and welcome dinner)  
Monday 20 January - 69 people (60% ESR, 17% female)  
Tuesday 21 January - 77 people (57% ESR, 18% female)  
Wednesday 22 January - 74 people (59% ESR, 18% female)  
Thursday 23 January - 73 people (60% ESR, 19% female)  
Friday 24 January - 67 people (64% ESR, 17% female)

COST supported 59 of the attendees.

Of the 8 invited speakers, 37% were female and 50% were ESRs.

Of the 22 submitted talks that were accepted, 18% of the speakers were female and 36% were ESRs.

Of the 20 posters, 25% were presented by females and 70% by ESRs.

Childcare facilities were offered at registration for the conference but not taken up.

Local Organiser Support for this event was €10,000.