COST Action MP1209 "Thermodynamics in the Quantum Regime"
End of Year 1 Newsletter

Friday 19th September 2014

****

Contents

****

****

First Year of Action – Overview

****

Events

The first Action year ended on 31st May. During the year we held the following events, all of which were well received & attended.

Working Group & MC Meeting – Pisa, October 2013
First International Quantum Thermodynamics Conference – Berlin, Jan 2014
Thermodynamics of Quantum Devices Workshop – Galilee, April 2014

In addition 12 STSMs were successfully completed.

Membership

During the year Croatia, FYR of Macedonia and France joined the Action bringing the number of signatory parties to 20 at the end of the first year. In addition we had International Partner Country agreements with Centre for Quantum Technologies / National University of Singapore,Singapore, University of Tokyo, Japan, University of Buenos Aires, Argentina and National Institute for Theoretical Physics, South Africa.

146 researchers from 69 individual institutions were participants of the network.

Achievements

The Action has made considerable progress towards the stated objective of bringing together researchers from different scientific communities, including those from the statistical physics and the quantum information theory, who were previously working in isolation and creating a platform for interdisciplinary research in quantum thermodynamics.

The Action is also becoming recognized as a leading authority in the emerging field of Quantum Thermodynamics, with MC members being approached, for example, to discuss a New Journal of Physics Focus Issue and dedicated book publications on the topic. The COST Action is also acting successfully as a springboard for new collaborative funding applications.

Key breakthroughs are listed here.

WG1 – Equilibration and thermalisation
New link developed between research on equilibration and thermalisation.
Quenches introduced to study thermal machines.
Explored new directions to equilibration using matrix models.
Progress made in formal mathematical considerations of thermalisation.
Answered questions of relative thermalisation requiring thermalisation and decoupling.
Solved the locality of temperature problem.
Addressed question on the clustering of correlations of high-temperature states.
Known numerical techniques have been used and new techniques have been developed for new work on understanding and characterising non-equilibrium quantum many-body systems.
WG2 – Information in Thermodynamics
Major breakthrough in deriving cooling power of quantum refrigerators close to zero temperature for the first time.
Determined efficiency of quantum Carnot engine at maximum power and conditions for achieving it.
Devised correlated quantum machines as a means to extract work from individual systems.
Significant breakthrough in applying stochastic thermodynamics to problem of thermoelectricity at the nanoscale.
Developed quantum thermodynamics resource theory and determined minimal single-shot work cost of state transfer under thermal and catalytic operations.
Discovery of an axiomatic relationship between information and thermodynamic entropies.
WG3 – Implementations
Developed theory and tested temperature predictions with a levitated and heated nanosphere in a non-equilibrium state (candidates for macroscopic quantum states).
New experimental proposal of a single ion quantum Otto engine coupled to a squeezed reservoir with high maximum power efficiency.
Discovery that the performance of a quantum absorption refrigerator can be pushed beyond the classical limit leading to superefficient quantum cooling with engineered thermal resources.
An interferometric scheme has been proposed to measure the characteristic function of the work in quantum systems for first time.
A new framework within which quantum heat engines and refrigerators operate has been set.

Thanks

We would like to say thank you to all members for their contributions, but in particular to the following:

- Vittorio Giovannetti & his team for organizing the Pisa meeting
- Mathis Friesdorf, Christian Gogolin, Jens Eisert & the rest of his team for organizing the Berlin meeting
- Amikam Levy & his team for organizing the Galilee workshop
- Lidia Del Rio & Mario Ziman for creating & maintaining the website
- Everyone who returned the year end questionnaire
- Working Group leaders – Jens Eisert & Antonio Acin (WG1), Eric Lutz & Terry Rudolph (WG2), Alberto Imparato & Peter Barker (WG3).

****

Year Ahead

****

The following events are planned for the second year of the Action:

Working Group Meeting – Belfast, August 2014
Winter Training School – Finland, January 2015
Second International Quantum Thermodynamics Conference – Mallorca, April 2015

STSM Calls will run throughout the year – details are on the website.

A call for hosts for events to be held in Years 3 & 4 will be run this year.

We will be looking to develop & start implementing a plan for dissemination to the scientific community, industry & wider general public, including outreach work.

****

Feedback

****

We are always looking to develop and improve the Action to make it as beneficial as possible. We have a short anonymous questionnaire - we'd appreciate it if you would complete this by 30th September so your views and ideas can be part of this process.

https://docs.google.com/forms/d/1ry-FLDOqXatXo5KVoBWSc6UdjjlgC6NDxsQmhX2RQJM/viewform?usp=send_form

****

Publications from 1st Year of Action

****

List of publications during the 1st year of the Action:

1. Abah, O., Lutz, E.
   "Efficiency of heat engines coupled to nonequilibrium reservoirs"
   Europhysics Letters EPL 106, 20001 (2014)
2. Allahverdyan, A., Hovhannisyan, K.V., Melkikh, A.V., Gevorkian, S.G.
   "Carnot Cycle at Finite Power: Attainability of Maximal Efficiency"
   Phys. Rev. Lett. 2013/109/248903
3. Allahverdyan, A.E., Wang, Q.A.
   "Adaptive machine and its thermodynamic costs"
   Phys. Rev. E 2013/87/032139
4. Beretta, G.P.
   "Steepest entropy ascent paths towards the Max-Ent distribution"
   Proceedings of the MaxEnt2013 conference, Canberra, Australia, December 15-20, 2013. ArXiv 1312.5043
5. Beretta, G.P.
   "Steepest-entropy-ascent and maximal-entropy-production dynamical models of irreversible relaxation to stable equilibrium from any non-equilibrium state. Unified treatment for six non-equilibrium frameworks"
   Proceedings of the 12th Joint European Thermodynamics Conference, Brescia, 1-5 July, 2013, ISBN9788889252222, pp. 100-109. ArXiv cond-mat-1306-3173
6. Binder, F., Vinjanampathy, S., Modi, K., Goold, J.
   "Operational thermodynamics of open quantum systems"
   arXiv:1406.2801 (2014)
7. Brunner, N., Huber, M., Linden, N., Popescu, S., Silva, R., Skrzypczyk, P.
   "Entanglement enhances cooling in microscopic quantum refrigerators"
   Phys. Rev. E 89, 032115 (2014).

8. Bulnes Cuetera, G., Esposito, M., Schaller, G., Gaspard, P.
"Effective fluctuation theorems for electron transport in a double quantum dot coupled to a quantum point contact"
Physical Review B 88, 115134 (2013), e-print:[1305.1830].
9. Burovski, E., Cheianov, V., Gamayun, O., Lychkovskiy, O.,
"Momentum relaxation of a mobile impurity in a one-dimensional quantum gas"
Phys. Rev. A 89, 041601(R) (2014).
10. Campisi, M.
"Fluctuation relation for quantum heat engines and refrigerators"
Journal of Physics A: Mathematical and Theoretical 47, 245001 (2014)
11. Campisi, M.
"Quantum Fluctuation Relations for Ensembles of Wave Functions"
New Journal of Physics, 15, 115008 (2013)
12. Campisi, M., Blattmann, R., Kohler, S., Zueco, D., Hänggi, P.
"Employing Circuit QED to Measure Nonequilibrium Work Fluctuations"
New Journal of Physics 15, 105028 (2013)
13. Cano-Andrade, S., von Spakovsky, M.R., Beretta, G.P.
"Steepest-Entropy-Ascent Quantum Thermodynamic Non-equilibrium Modeling of Decoherence of a Composite System of Two Interacting Spin-½ Systems"
Proceedings of the ASME 2013 International Mechanical Engineering Congress and Exposition IMECE2013, November 15-21, 2013, San Diego, California, USA, paper IMECE2013-63596.
14. Carlisle, A., Mazzola, L., Campisi, M., Goold, J., Semião, F.L., Ferraro, A., Plastina, F., Vedral, V., De Chiara, G., Paternostro, M.
"Out of equilibrium thermodynamics of quantum harmonic chains"
arXiv:1403.0629 (2014)
15. Correa, L.A., Palao, J.P., Adesso, G , Alonso, D
"Performance bound for quantum absorption refrigerators"
Phys. Rev. E 87, 042131 (2013)
16. Correa, L.A.
"Multi-stage quantum absorption heat pumps"
Phys. Rev. E 89, 042128 (2014)
17. Correa, L.A., Palao, J.P., Alonso, D., Adesso, G.
"Quantum-enhanced absorption refrigerators"
Sci. Rep. 4, 3949 (2014)
18. Del Rio, L., Hutter, A., Renner, R., Wehner, S.
"Relative Thermalization"
arXiv:1401.7997
19. Deng, J., Wang, Q., Liu, Z., Hänggi, P. , Gong, J.
"Boosting work characteristics and overall heat-engine performance via shortcuts to adiabaticity: Quantum and classical systems"
Phys. Rev. E **88**, 062122 (2013), [arXiv:1307.4182]
20. Dupuis, F., Kraemer, L., Faist, Ph., Renes, J. & Renner, R.
"Generalized Entropies. Proceedings of the XVIIth International Congress on Mathematical Physics, Aalborg, Denmark, 2012."
arXiv:1211.3141 [proceedings published on Oct. 2013]
21. Faist, P., Oppenheim, J., Renner, R.
"Gibbs-Preserving Maps outperform Thermal Operations in the quantum regime"
arXiv:1406.3618
22. Fusco, L., Pigeon, S., Apollaro, T.J.G., Xuereb, A., Mazzola, L., Campisi, M., Ferraro, A., Paternostro, M.
"Assessing the non-equilibrium thermodynamics in a quenched quantum many-body system via single projective measurements"
arXiv:1403.3150

23. Gelbwaser-Klimovsky, D., Erez, N., Alicki, R., Kurizkia, G.
"Work extraction via quantum nondemolition measurements of qubits in cavities: Non-Markovian effects"
Phys. Rev. A 2013 88, 022112
24. Gelbwaser-Klimovsky, D., Alicki, R., Kurizkia, G.
"Work and energy gain of heat-pumped quantized amplifiers"
EPL 2013 103 60005
25. Genes, C., Xuereb, A., Pupillo, G., Dantan, A.
"Enhanced optomechanical readout using optical coalescence"
Phys. Rev. A 88, 033855 (2013).
26. Goold, J., Paternostro, M., Modi, K.
"A non-equilibrium quantum Landauer principle"
arXiv:1402.4499
27. Goold, J., Poschinger, U., Modi, K.
"Measuring the heat exchange of a quantum process"
arXiv:1401.4088 (2014)
28. Gour, G., Müller, M.P., Narasimhachar, V., Spekkens, R.W., Yunger Halpern, N.
"The resource theory of informational nonequilibrium in thermodynamics"
arXiv:1309.6586
29. Horowitz, J.M., Esposito, M.,
"Thermodynamics with continuous information flow"
Phys. Rev. X [1402.3276]
30. Horowitz, J.M., Parrondo, J.M.R.,
"Entropy production along nonequilibrium quantum jump trajectories."
New Journal of Physics 15, 085028 (2013).
31. Horowitz, J.M., Sagawa, T., Parrondo, J.M.R.,
"Imitating Chemical Motors with Optimal Information Motors."
Physical Review Letters 111 010602 (2013).
32. Hovhannisyan, K.V., Perarnau-Llobet, M., Huber, M., Acin, A.
"Entanglement Generation is Not Necessary for Optimal Work Extraction",
Phys. Rev. Lett. 111, 240401 (2013).
33. Huber, M., Perarnau-Llobet, M., Hovhannisyan, K.V., Skrzypczyk, P., Klöckl, C., Brunner, N., Acin, A.
"Thermodynamic cost of creating correlations"
arXiv:1404.2169
34. Jordan, A.N., Sothmann, B., Sánchez, R., Büttiker, M.
"Powerful and efficient energy harvester with resonant-tunneling quantum dots"
Phys. Rev. B 87, 075312 (2013).
35. Kosloff, R.,
"Quantum Thermodynamics: A dynamical Viewpoint"
Entropy 15, 2100 (2013).
36. Kosloff, R., Levy, A.
"Quantum Heat Engines and Refrigerators: Continuous Devices"
Annual Review of Physical Chemistry, Vol 65 pages 365-393 (2014)
37. Liu, S., Hänggi P., Li, N., Ren, J., Li, B.
"Anomalous heat diffusion"
Phys. Rev. Lett. **112**, 040601 (2014), [arXiv:1306.3167]
38. Lostaglio, M., Jennings, D., Rudolph, T.
"Thermodynamic laws beyond free energy relations"
arXiv:1405.2188 (2014)
39. Lychkovskiy, O.,
"Perpetual motion of a mobile impurity in a one-dimensional quantum gas", Phys. Rev. A 89, 033619 (2014).

40. Mazzola, L., De Chiara, G., Paternostro, M.
"Detecting the work statistics through Ramsey-like interferometry"
Int J. Quant. Inf. 12, 1461007 (2014)
41. Millen, J., Deesuwan, T., Barker, P., Anders, J.
"Nanoscale temperature measurements using non-equilibrium Brownian dynamics of a levitated nanosphere"
Nature Nanotechnology (2014) doi:10.1038/nnano.2014.82
42. Müller, P., Adlam, E., Masanes, L., Wiebe, N.
"Thermalization and canonical typicality in translation-invariant quantum lattice systems"
arXiv:1312.7420
43. Nietner, C., Schaller, G., Brandes, T.,
"Transport with ultracold atoms at constant density"
Physical Review B 89, 013605 (2014), e-print:[1309.3488].
44. Parra-Murillo, C.A., Madronero, J., Wimberger, S.
"Quantum diffusion and thermalization at resonant tunneling",
Phys. Rev. A 89, 053610 (2014)
45. Roldán, É., Martínez, I.A., Parrondo, J.M.R., Petrov, D.
"Universal features in the energetics of symmetry breaking."
Nature Physics 10, 457 (2014).
46. Rossnagel, J., Abah, O., Schmidt-Kaler, F., Singer, K., Lutz, E.
"Nanoscale Heat Engine Beyond the Carnot Limit"
Physical Review Letters 112, 030602 (2014)
47. Sánchez, R., Sothmann, B., Jordan, A.N., Büttiker, M.
"Correlations of heat and charge currents in quantum dot thermoelectric engines"
New J. Phys. 15, 125001 (2013).
48. Schaller, Vogl, G. M., Brandes, T.,
"Transport as a sensitive indicator of quantum criticality"
J. Phys.: Condens. Matter 26, 265001 (2014), eprint:[1403.7611].
49. Sindona, A., Goold, J., Lo Gullo, N., Plastina, F.,
"Statistics of the work distribution for a quenched Fermi gas"
New Journal of Physics, 16 (2014) 045013
50. Sothmann, B., Sánchez, R., Jordan, A.N., Büttiker, M.
"Powerful energy harvester based on resonant-tunneling quantum wells"
New J. Phys. 15, 095021 (2013).
51. Steinigeweg, R., Khodja, A., Niemeyer, H., Gogolin, C., Gemmer, J.
"Pushing the Limits of the Eigenstate Thermalization Hypothesis towards Mesoscopic Quantum Systems"
Phys. Rev. Lett. 112, 130403
52. Strasberg, P., Schaller, G., Brandes, T., Esposito, M.
"Thermodynamics of Quantum-Jump-Conditioned Feedback Control"
Physical Review E 88, 062107 (2013), e-print:[1305.6589].
53. Talkner, P., Morillo, M., Yi, J. , Hänggi, P.
"Statistics of work and fluctuation theorems for microcanonical initial states"
New J. Phys. **15**, 095001 (2013), [arXiv:1305.2259]
54. Torrontegui, E., Kosloff, R.,
"Quest for absolute zero in the presence of external noise"
Phys. Rev. E 88, 032103 (2013).
55. Ulm, S., Rossnagel, J., Jacob, G., Degünther, C., Dawkins, S.T., Poschinger, U.G., Nigmatullin, R., Retzker, A., Plenio, M.B., Schmidt-Kaler, F., Singer, K.
"Observation of the Kibble-Zurek scaling law for defect formation in ion crystals"
Nature Communications 4, 2290 (2013).
56. Verley, G., Esposito, M., Willaert, T., Van den Broeck, C.,
"The unlikely Carnot efficiency"
Nature Communications [1404.3095]

57. Watanabe, G., Venkatesh, B.P., Talkner, P., Campisi, M., Hänggi, P.
"Quantum fluctuation theorems and generalized measurements during the force protocol"
Phys. Rev. E **89**, 032114 (2014), [arXiv:1312.7104]
58. Whitney, R.S.
"Most efficient quantum thermoelectric at finite power output"
Phys. Rev. Lett. 112, 130601 (2014)
59. Whitney, R.S.
"Thermodynamic and quantum bounds on nonlinear DC thermoelectric transport"
Phys. Rev. B 87, 115404 (2013)
60. Whitney, R.S.
"Nonlinear thermoelectricity in point-contacts at pinch-off: a catastrophe aids cooling"
Phys. Rev. B 88, 064302 (2013)
61. Xuereb, A., Genes, C., Pupillo, G., Paternostro, M., Dantan, A.
"Reconfigurable long-range phonon dynamics in optomechanical arrays"
Phys. Rev. Lett. 112, 133604 (2014).
62. Xuereb, A., Ulbricht, H., Paternostro, M.
"Optomechanical interface for probing matter-wave coherence"
Sci. Rep. 3, 3378 (2013).
63. Xuereb, A., Genes, C., Dantan, A.
"Collectively-enhanced optomechanical coupling in periodic arrays of scatterers"
Phys. Rev. A 88, 053803 (2013).
64. Zanchine, E., Beretta, G.P.
"Recent Progress in the Definition of Thermodynamic Entropy"
Entropy, Vol.16, 1547-1570 (2014); doi:10.3390/e16031547
65. Zhang, J., Zhang, T., Xuereb, A., Vitali, D., Li, J.
"More nonlocality with less entanglement in a tripartite atom-optomechanical system"
arXiv:1402.3872.

****

Administrative Information

****

Please send any items for inclusion in the next newsletter to Marion - costmp1209@gmail.com.

Kind regards,

Janet