MP 3: Thermodynamics and Field Theory

Zeit: Dienstag 16:30–18:25 Raum: Z6 - SR 1.012

Hauptvortrag MP 3.1 Di 16:30 Z6 - SR 1.012

Operational meaning of entropy and free energy without the thermodynamic limit — •Markus P. Müller — Institut für Quantenoptik und Quanteninformation, Boltzmanngasse 3, 1090 Wien, Österreich

Thermodynamics at the nanoscale is known to behave very differently from the familiar regime of the thermodynamic limit. It has been shown that quantum fluctuations lead to severe restrictions on work extraction and state transformations: e.g. the constraint of Helmholtz free energy decrease is replaced by an infinite sequence of "second laws" (cf. Brandao et al., PNAS 112, 2015). In contrast, here we show a surprising positive feature of small-scale thermodynamics which is absent in the standard regime: microscopic thermal machines can tame fluctuations by building up correlations with the particles on which they act. That is, these machines can increase their efficiency via clever "correlation engineering". We prove that they can thus extract or invest the Helmholtz free energy difference exactly and basically without any fluctuations, which restores the original form of the second law in the nano regime.

This result rests on new theorems on majorization of probability distributions which can also be applied in quantum information theory beyond thermodynamics: they allow us to give operational 'single-shot' interpretations of the von Neumannn entropy and the mutual information, without considering a large number of copies of a quantum state.

Based partially on arXiv:1707.03451.

10 min. break

MP 3.2 Di 17:25 Z6 - SR 1.012

Bilinear Ensembles in Quantum Control — •Gunther Dirr — Universität Würzburg, Emil-Fischer-Str. 40

First, we recall necessary and sufficient conditions for controlling finitely many parallel connected bilinear systems. From this we derive controllability conditions for finite "quantum ensembles" and, as a by-product, we extend a well-known controllability result for interconnected spin-systems. Finally, we generalize the previous ideas to infinitely many parallel connected bilinear systems. This leads to infinite dimensional bilinear control systems of particular structure. We will present first results for countably many "quantum ensembles".

MP 3.3 Di 17:45 Z6 - SR 1.012

Path algebras and the controllability of atom-cavity systems — •Michael Keyl — FU Berlin

In this talk we study controllability of a d-level atom interacting with the electromagnetic field in a cavity. The system is modelled by an ordered graph Γ. The vertices of Γ describe the energy levels and the edges allowed transitions. To each edge of Γ we associate a harmonic oscillator representing one mode of the electromagnetic field. The dynamics of the system (drift) is given by a natural generalization of the Jaynes-Cummings Hamiltonian. If we add in addition sufficient control over the atom, the overall system (atom and em-field) becomes strongly controllable, i.e. each unitary on the system Hilbert space can be approximated with arbitrary precision in the strong topology by control unitaries. A key role in the proof is played by a topological *-algebra which is (roughly speaking) a representation of the path algebra of Γ. It contains crucial structural information about the control problem, and is therefore an important tool for the implementation of control tasks like preparing a particular state from the ground state.

MP 3.4 Di 18:05 Z6 - SR 1.012

Quantum energy inequalities inside an uniaxial crystal — Christopher J. Fewster[1], •Christian Pfeifer[2], and Daniel Siemssen[3] — [1]Department of Mathematics, University of York, York, United Kingdom — [2]Laboratory for Theortical Physics, University of Tartu, Tartu, Estonia — [3]Department of Mathematics and Informatics, University of Wuppertal, Wuppertal, Germany

The behaviour of the electromagnetic field inside an uniaxial crystal can be described in the framework of premetric electrodynamics. The electromagentic excitation is related to the electromagnetic field strength by a constitutive relation which depends not only on a metric but in addition on two vector fields describing the crystal's optical axis and rest frame. In this talk we apply the quantization of premetric electrodynamics to the uniaxial crystal and show that averages of the quantized energy density of the electromagnetic field along the worldlines of suitable observers obey a Quantum Energy Inequality (QEI). Compared to the Minkowski spacetime case the QEI bound inside the crystal takes a value which depends on the parameters of the crystal, the observer wordline in consideration and its proper time normalization. The latter may be modified compared to the one employed for observer worldlines in vacuum due to the more complicated birefringent causal structure inside the crystal. I will discuss the derivation of the uniaxial crystal QEI and its dependence on worldlines classified according to the crystal's causal structure.