Microscopic origins of collective dissipation in extended systems

F. Galve[1], R. Zambrini [1], A. Mandarino [2], M. G. A. Paris [2], C. Benedetti [2], J. Alonso [3]

(1) Institute for Interdisciplinary Physics and Complex Systems, Mallorca, Spain
(2) Quantum Technology Lab, Dipartimento di Fisica, Uni. degli Studi di Milano, I-20133 Milan, Italy
(3) Eidgenssische Technische Hochschule Zrich (ETH), Zurich, Switzerland

Practical implementations of quantum technology are limited by unavoidable effects of decoherence and dissipation. With achieved experimental control for individual atoms and photons, more complex platforms composed by several units can be assembled enabling distinctive forms of dissipation and decoherence, in independent (separate) heat baths (SB) or collectively into a common bath (CB), with dramatic consequences for the preservation of quantum coherence. The cross-over between these two regimes has been widely attributed in the literature to the system units being farther apart than the baths correlation length.
Starting from a microscopic model of a structured environment (a crystal) sensed by two bosonic probes [2], here we show the failure of such conceptual relation, and identify the exact physical mechanism underlying this crossover, showing that it is not only a matter of system size. Peculiar scenarios in 1D environments or beyond isotropic dispersion relations are predicted, with collective dissipation possible for very large distances between probes, opening new avenues to deal with dissipation in phononic baths.
Further, we investigate the scenario of anomalous heating in ion traps [2], a major promising platform for quantum information processing, where this limiting factor in the rush for miniaturization is believed to be caused by a yet unknown source of dipole fluctuations in the electrodes surfaces. A geometric crossover between CB and SB, and back to anti-CB (a common bath which dissipates the relative motion instead of the center of mass) is predicted which strongly depends on spatial correlations between dipoles, and also on their orientation. We propose a protocol to measure this peculiar effect in recent state of the art segmented Paul traps, allowing for a better insight into the microscopic origin of this elusive phenomenon.

[1] F. Galve, A. Mandarino, M. G. A. Paris, C. Benedetti and R. Zambrini, Scientific Reports **7**, 42050 (2017).

[2] F. Galve, J. Alonso and R. Zambrini, manuscript in preparation.