System-reservoir entanglement during Markovian relaxation of a quantum dot

K. Ptaszyński[1,2] and M. Esposito[1]

[1] *Complex Systems and Statistical Mechanics, Department of Physics and Materials Science, University of Luxembourg, L-1511 Luxembourg, Luxembourg*

[2] *Institute of Molecular Physics, Polish Academy of Sciences, Mariana Smoluchowskiego 17, 60-179 Poznań, Poland*

Nanoelectronic systems (e.g., quantum dots) weakly coupled to the reservoirs can be effectively described by means of a Markovian (i.e., memoryless) master equation for the charge states populations. It has been sometimes asserted that the validity of such description precludes the presence of the system-reservoir entanglement, as its derivation assumes the system and the environment to be uncorrelated. Here we question this assertion by investigating the entanglement dynamics during relaxation of a charge state of a spinful quantum dot. It is shown that a transient entanglement can be observed even in the weak coupling regime, when the reduced dynamics of the system can be well described by a Markovian master equation. This entanglement vanishes at long times, but is preserved at timescales comparable to the relaxation time. Its magnitude only weakly depends on the system-reservoir coupling, but instead strongly on the purity of the initial state of the system. We relate the presence of such transient entanglement to the quantum coherent character of the microscopic system-reservoir dynamics underlying the effectively classical reduced Markovian description.

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