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Parallel decoherence in composite quantum systems

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Abstract. For the standard quantum Brownian motion (QBM) model, we point out the occurrence of simultaneous (parallel), mutually irreducible and autonomous decoherence processes. Besides the standard Brownian particle, we show that there is at least another system undergoing the dynamics described by the QBM model. We do this by selecting the two mutually irreducible, global structures (decompositions into subsystems) of the composite system of the QBM model. The generalization of this observation is a new, challenging task in the foundations of the decoherence theory. We do not place our findings in any interpretational context.

Keywords. Quantum decoherence; quantum Brownian motion; quantum structure; entanglement relativity.

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1. Introduction

"In particular, one issue which has been often taken for granted is looming big, as a foundation of the whole decoherence program. It is the question of what are the 'systems' which play such a crucial role in all the discussions of the emergent classicality. (. . .) [A] compelling explanation of what are the systems – how to define them given, say, the overall Hamiltonian in some suitably large Hilbert space – would be undoubtedly most useful." (p. 1820 in ref. [1]).

In this paper, we consider the two specific structures (decompositions, partitions into subsystems) of the standard quantum Brownian motion (QBM) set-up [2–5] and we obtain QBM effect for both the structures considered. The structures are mutually irreducible (i.e. can *not* be obtained from each other by decomposing, grouping or permutations of the constituent subsystems) and global (do *not* have even a single degree of freedom in common). The structures are mutually linked by the linear canonical transformations (LCTs) and thus are dynamically independent, autonomous structures of the one and the

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