Effects of Different Noise Environments on the Coherence Time of Open Quantum Systems

Pietro De Checchi[a], Giulio G. Giusteri[a]

[a] Department of Mathematics, University of Padova, Italy

The use of Stochastic Schrödinger Equations (SSE) to describe open quantum systems is a well-known class of methods, that can be used as an unravelling scheme of associated Quantum Master Equations and as a starting point to derive new ones. From the perspective of simulating quantum systems in Quantum Computers (QC), one can exploit stochastic averages to implement intrinsically contractive mappings into unitary-gates based QC since each trajectory is a unitary evolution of the system [1,2] and harnesses the repeated noisy measures in lieu of classical parallelization. On the other hand, understanding non-conventional noise effects can helps us design environments with desired qualities and inducing specific behaviors. Recent studies have shown the ability to engineer environmental effects, in particular concerning non-Markovian environments [3,4]. Such noises can be either detrimental to or enhance the coherence time and the transport properties of the system, both energy and information. Here, we present a theoretical description of the differences between using a stochastic process and its derived noise as sources of fluctuations in the stochastic formulation of the dynamics of an open quantum system, and their associated QME.

The starting point is the model presented in [6], leading to non-Markovian quantum evolution in small model systems. Showing different interpretations of stochastic approaches, we remark the differences with respect to the usual memoryless approximations and the effects on initial coherence time and stationary distributions. Insights on the particular robustness to decoherence displayed by the coloured noise are gained and showed using an approximate time dependent Redfield QME.

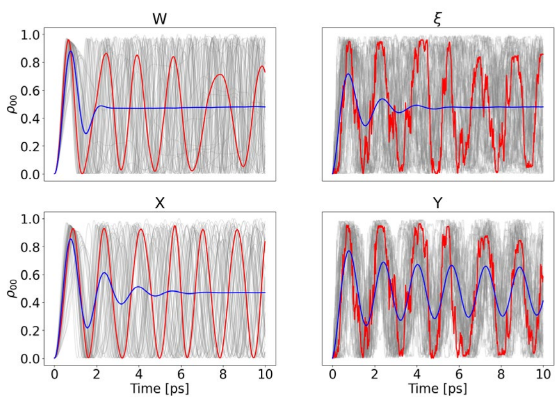

Figure 1. Comparison of the dynamics of population of a two-site system under different noises and processes type, a swarm of 50 each trajectories each (grey line in transparency, one hilighted in red) and their mean dynamics (blue line).

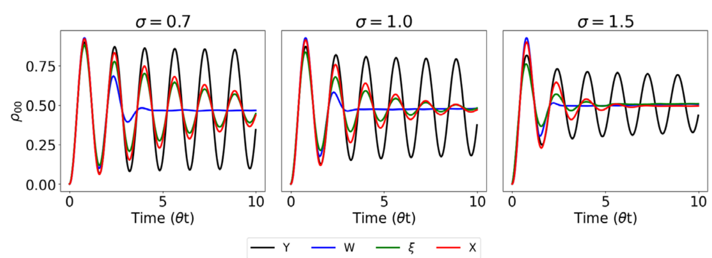

Figure 2. Comparison of the dynamics of population of a two-site system under different noises type and intensities (σ).

[1] S. Lloyd (**1996**), *Science*, 273(5278)
[2] Z. Hu, R. Xia, S. Kais (**2020**), Scientific Reports, 10(1)
[3] S. Cialdi, C. Benedetti, D. Tamascelli, S. Olivares, M.G.A. Paris, B. Vacchini (**2019**), *Physical Review A*, 100(5)
[4] A. Carmele, S. Parkins, A. Knorr (**2020**), *Physical Review A*, 102(3)
[6] A. Barchielli, C. Pellegrini, F. Petruccione (**2010**), *Europhysics Letters*, 91(2)