Review of: "Correlated noise enhances coherence and fidelity in coupled qubits"

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Potential competing interests: No potential competing interests to declare.

In this work, the authors introduce a model for spatially correlated errors acting on two qubits by incorporating these correlations into the Redfield equation governing the time evolution of the two qubits. They argue that noise correlations are able to enhance purity and fidelity of a maximally entangled state.

It is a relevant question to what extent correlated errors affect the time evolution of multipartite quantum systems. The introduction of these correlations via the Redfield equation and the result that noise correlations may improve purity and fidelity would form a relevant contribution to the field of quantum information and open quantum systems.

However, in its current form, the manuscript does not provide enough introduction and detail of the concepts and notation for us to assess the validity of the methods and the results. The manuscript needs to be revised extensively before it can be considered a contribution to the scientific community.

Our main suggestion is that all concepts and notation are introduced with more detail. Below follows an inexhaustive list of concrete points mainly concerning this point.

- There is an unnatural discontinuity within the first paragraph at "From the Anderson-Kubo (AK) model ...". The paragraph starts very general and at said point becomes technical and detailed, without introduction of the mathematical and physical concepts, and notation. We suggest breaking the paragraph and adding a paragraph where the AK model is introduced, suspending the formal treatment of this model to later in the manuscript.
- There are undefined symbols and inconsistency of symbols throughout the manuscript. For legibility, we suggest that every symbol is defined and that the notation is made consistent.
- How do the last paragraphs of the introduction relate to the rest of the manuscript?
- We suggest that the results are put in a separate section or that Sec. II A is divided into subsections.
- In Eq. (3), dW_t is used. In the same sentence, also $dW_1(t)$ appears. Should dW_t in Eq. 3 read $dW(t)$ or something similar?
- In Eq. (8), both $E(\tau)$ and E_τ appears, do they refer to different entities?
- In Eq. (12), is d_t the derivative to time?
- In Eq. (15), what is $\hat \sigma_i(3)$? Considering the notation $\hat \sigma^+_i$, $\hat \sigma_i(3)$ should perhaps read $\hat \sigma_i^3$, which we suppose would mean the Pauli-z operator at location i?
- Should "Any system operators in the state space $SU(2)\otimes SU(2)$..." perhaps be "Any system operators acting on

the state space $\mathbb{C}^2\otimes \mathbb{C}^2$ ..." or "Any system operators in $SU(2)\otimes SU(2)$..."?

- In Eq. (17), there are unmatched brackets and dt is missing.
- Should "Schrödinger" be deleted from "... where $\hat \mu(t)$ is the dipole operator in the Heisenberg/Schrödinger representation ..."? As we understand it, an operator cannot be in two pictures at the same time (unless the Hamiltonian is trivial or at time $t=0$).
- In Fig. 2, what is, e.g., "$\sigma_x\sigma_x$ correlation"?
- There are many free parameters in the noise model, of which in Fig. 3 it is only stated what numerical value of ξ is used. For completeness and reproducibility, we suggest that all (numerical values of) the other free parameters are stated. Also, is ω related to ϵ? What Redfield tensor is used? Is the secular approximation applied? How much of a difference would it make?
- Why is there a shaded area under the lines in Fig. 3.d?
- In the discussion section, you write that "We also suggest that the local noise correlation can be tuned by manipulating the local environment around the two qubits." Is there detail on this suggestion in the preceding sections?
- Angular brackets are missing in Eq. (A2).
- In the PDF version of the manuscript, there appears a strange symbol instead of the identity operator [e.g., Eq. (A3)]. On the web page, the identity operator renders without problems. This is possibly a conversion error.
- In Eq. (B1), the parentheses do not match. Also, should $beta$ be β?
- There is a recent work [https://doi.org/10.1103/PhysRevA.107.042426] where the authors come to the same conclusion as in the current manuscript, namely that correlations in environmental noise are able to mitigate the adverse effects of that noise, albeit with a completely different noise model. It would be interesting to see if in the aforementioned recent work and the current manuscript the same underlying mechanisms are responsible for this effect.