Responses to Referee

immediate

January 9, 2021

Manuscript Title : QMetrology from QCosmology: Study with Entangled Two Qubit
Open Quantum System in De Sitter Space
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Dear Editor,

We thank the referees for their reports and insightful comments on our work. Based
on the comments, we have modified the paper as needed, corrected all the errors that
they mentioned and provided clarifications where required. We request reconsidering this
paper for publication in SciPost. Below are our responses to the referee's comments :

Responses to Referee 1

1. **Referee's Comment :**
   As far as I understood, the authors are studying a quantum system. Hence it is a
   little bit confusing to me when they talk about using classical Fisher information
   and compare it with quantum Fisher information. They should clarify this point.

   Authors' Response :
   Unlike many other quantum properties, Quantum Fisher Information has a classical
   counterpart. Since we are studying a quantum system one might wonder whether
   the classical part washes out or hides the information conveyed by the quantum
   part. To be more specific, one might want to understand the interplay between
   classical and quantum versions. This arises because the total fisher information is
   the sum of classical and quantum fisher information (taking away a mixed term)
   given that total information has to be non-negative. So, it might be the case that
   the magnitude of classical fisher information is such that the quantum fisher infor-
   mation becomes insignificant. If so, then one can conclude that for the particular
   system in consideration the information is mostly classical which can greatly sim-
   plify many calculations and experiments. Hence, we felt that we should study the
   interplay between quantum and classical fisher information. We thank the referee
   for this clarification and have included a table in the modified draft where we have

explained the characteristic differences between CFI and QFI for the better understanding of our general readers.

2. **Referee's Comment :**
The definition of quantum Fisher information matrix given in equation (39) of the paper. Then for a using the spectral decomposition of the density matrix of the system it the takes the form mentioned in equation (47) and various terms in (47) are mentioned in (48), (49) and (50). The part mentioned in (48) is termed as "Classical Fisher Information." In equation (38), another definition of classical Fisher Information is given. How do these two things correlate?

Authors' Response :
As suggested by the referee in the next comment we have removed the section altogether in which equation 38 appeared, from the modified version of the draft.

3. **Referee's Comment :**
Furthermore, in the subsequent section, the authors claimed that they had computed both the classical and quantum Fisher Information. I believe they have used (48) to compute the classical Fisher Information. Then where the discussion of section A of page-6 of the paper enters into the picture? If not, I will suggest removing that from the paper.

Authors' Response :
We have indeed used equation (48) for computing the Classical Fisher Information. Since we had the explicit structure of density matrix for the system under consideration, the computation of eigenvalues was trivial. Hence, the use of equation (48) to compute the Classical Fisher Information was the most feasible one rather than using other expressions given in section A of page 6. However, to avoid any kind of confusion we removed that section in our modified draft.

4. **Referee's Comment :**
If what I mentioned in the previous point is correct then, there is no reason to only compute the first term (the classical part) of the equation (47) and then compare with the full expression. More clarifications are needed in this regard.

Authors' Response :
We believe our response to Referee's first comment has clarified this point sufficiently.

5. **Referee's Comment :**
Last but not least, the significance of the result is not clear at all. There are already various works on Quantum Fisher Information where it is used to study the dynamics of a quantum system (some of them are already cited in the paper itself) and its usefulness is also discussed. So what new things we learn from this exercise about the underlying system? Impact of the result mentioned in the paper is not very clear to me. Authors should expand upon on it.

Authors' Response :
It is indeed true that a lot of works on QFI does exists where people have tried to discuss about the dynamics of a quantum system. However, to the best of our knowledge no literature exists where people have done analysis of an open quantum system in the context of cosmology with Fisher Information. People mainly dealt with closed systems however our universe is far from a closed system and a knowledge of how the interaction between the subsystems of the universe propagates requires studies with open quantum system. Moreover, computing the fisher information, both classical and quantum using open quantum systems gives us an idea of how the quantum fluctuations in the early universe leads to classical perturbations at late time scales. Also, as per our knowledge, there is no currently known literature which shows a revival of QFI which can be significant for early universe - late universe correlations and some of the present day anomalies may very well be connected to this very revival.

Responses to Referee 2

1. **Referee's Comment :**
   I was very lost in page 2-5; for example in page 4 it took me a while to realize that the bottom left part is the unfinished footnote in page 3. I think the authors should not write so long footnotes: if the contents are important please move them to the main text; otherwise please remove them.

   Authors' Response :
   We sincerely apologise for the inconvenience caused to the referee. We have made sure to make necessary changes and include the important portions of the footnote in the main draft, which eventually shortened the length of the footnotes.

2. **Referee's Comment :**
   Also, I recommend the authors to remove the review of Fisher information and leave the necessary references should be enough.

   Authors' Response :

   We have removed the portions that were just a review of the fisher information and have kept only those equations which were actually used for the purpose of computation in our case.

3. **Referee's Comment :**
   The authors should add paragraphs about quantum metrology in the introduction part.

   Authors' Response :
   We thank the referee for this suggestion. We have included paragraphs on quantum metrology in the introduction part in the modified version of the paper.

4. **Referee's Comment :**
   And the introduction in its current form contains too many unnecessary terms and abbreviations which are irrelevant to the whole paper, making it unreadable. In fact, there are way too many introduced concepts all over the paper, which are barely used later in the paper.

   Authors' Response :

   We thank the referee for pointing this out. We have removed all the unnecessary discussions and the concepts which are irrelevant for our case from the introduction of the modified draft.

We believe that our comments in this report along with the modified version of our manuscript have addressed all the concerns raised by the referees. We, therefore, request the Editor to reconsider our paper for publication in SciPost.