Ke Li, Yongsheng Yao: Reliability Function of Quantum Information Decoupling via the Sandwiched Rényi Divergence

Referee report

The authors investigate the reliability function for the task of catalytic quantum information decoupling, describing the exponent of the asymptotic decay of the error. An upper and lower bound for the reliability functions are obtained, in terms of the sandwiched Rényi mutual information. If the decoupling cost is under a certain critical value, these bounds coincide, giving an exact formula.

This gives a significant improvement over previous works, where only achievability bounds were obtained. Besides, the catalytic setting and the description of the error in terms of the purified distance enables the authors to connect three different types of decoupling operations, as well as to relate their scenario to the task of quantum state merging, which gives a broader applicability of the findings. It is also remarkable that the results imply an operational interpretation of the sandwiched Rényi divergence in the exact domain, in contrast with the operational interpretations established before.

The proofs of the main results are based on a newly obtained bound in the convex split lemma and on the formula for the smoothing quantity for the max information and conditional min entropy, which are given in terms of the sandwiched Rényi divergence. These results are of independent interest.

The paper is quite well written and I have only a few minor remarks listed below.

1. p. 2: "There is no discuss"
2. p. 3: "the notation" -> The notation
3. p. 5: "a sate" -> state
4. p. 14: "the optimal state that makes ... achieves the minimum" -> e.g.: ...the optimal state at which ... achieves the minimum
5. p. 7, Sec. III. B: better specify also here where the proofs of Prop. 6, Thms. 7 and 8 can be found.
6. Some of the proofs especially in Sec. IV.B refer to statements that are stated and proved only later (such as Lemmas 17 and 18 in the proof of Prop. 16). This makes the reading less smooth. It might be better to slightly reorganize this part, if possible.