Quantum Wasserstein distance based on an optimization over separable states

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Abstract

Most distance measures for quantum states are maximal for two orthogonal states, thus the distance of, say, states |1> and |2> is the same as the distance of |1> and |100>. The quantum Wasserstein distance is different, since it is sensitive to the underlying metric. It might offer a new type of distance for quantum states, with advantageous properties for machine learning and many areas of quantum physics.

The quantum Wasserstein distance is typically defined as an optimization of a cost function over bipartite quantum states with given marginals. In this work, we define the quantum Wasserstein distance such that the optimization of the coupling is carried out over bipartite separable states rather than bipartite quantum states in general, and examine its properties. Surprisingly, we find that the self-distance is related to the quantum Fisher information. We present a transport map corresponding to an optimal bipartite separable state. We discuss how the quantum Wasserstein distance introduced is connected to criteria detecting quantum entanglement.

Figures

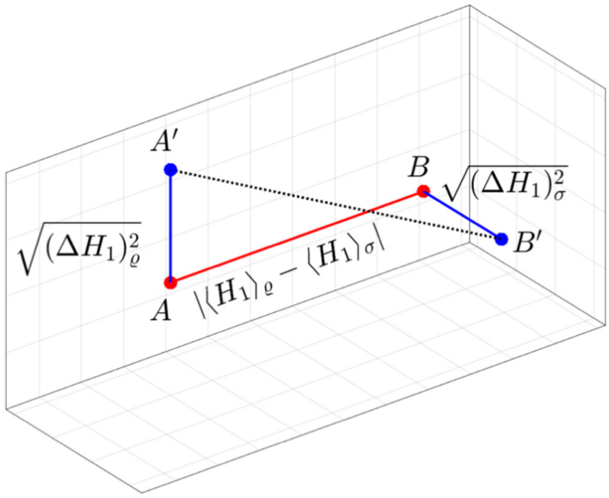

Figure 1: Geometric representation of the quantum Wasserstein distance between a pure state ρ and a mixed state σ for the case of a single H_1 operator. The quantum Wasserstein distance equals 1/ 2 times the usual Euclidean distance between A' and B'.

References

[1] Géza Tóth and József Pitrik, Quantum 7, 1143 (2023).