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Assessing Quantum and Classical Approaches to Combinatorial Optimization: Testing Quadratic Speed-ups for Heuristic Algorithms

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Many recent investigations conclude, based on asymptotic complexity analyses, that quantum computers could accelerate combinatorial optimization (CO) tasks relative to a purely classical computer. However, asymptotic analysis alone cannot support a credible claim of quantum advantage. Here, we highlight the challenges involved in benchmarking quantum and classical heuristics for combinatorial optimization (CO), with a focus on the Sherrington-Kirkpatrick problem. Whereas hope remains that a quadratic quantum advantage is possible, our numerical analysis casts doubt on the idea that current methods exhibit any quantum advantage at all. This doubt arises because even a simple classical approach can match with quantum methods we investigated. We conclude that more careful numerical investigations are needed to evaluate the potential for quantum advantage in CO, and we give some possible future directions for such investigations.

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