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Compact graphs and quantum automorphisms

Compact graphs are graphs for which the fractional automorphism polytope has no genuinely fractional vertices. This paper proposes a quantum analogue of this idea by evaluating the fundamental magic unitary of the quantum automorphism group on states, which we show to produce a closed convex set of doubly stochastic matrices sitting between the classical automorphism polytope and the full fractional automorphism polytope. Our main result is that the natural quantum analogue of compactness is classical, that is, a quantum compact graph is classically compact. We also relate this set to the quantum orbital algebra and obtain a hierarchy of classical and quantum compactness pseudo notions. The framework recovers familiar consequences of compactness through commutants and suggests quantum analogues of generous transitivity and distance-transitivity. We also isolate examples and open problems indicating where quantum symmetries may strictly refine the classical compactness theory.