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A singlet projector based NPA hierarchy for the quantum MAXCUT problem

The QMA-hard quantum MAXCUT (QMC) problem, a quantum analog of the classical MAXCUT problem, studies the maximum eigenvalue of the so-called anti-ferromagnetic Heisenberg model. The quantum Heisenberg model plays a central role in condensed matter physics for understanding quantum magnetism and is one of the simplest models that exhibit genuine quantum computational hardness. The NPA hierarchy is the quantum (noncommutative) analog of the Lasserre hierarchy, which consists of a sequence of converging semidefinite programming (SDP) relaxations and has played an important role in studying combinatorial optimization problems. In this talk, I will introduce an NPA hierarchy for QMC based on the singlet projectors (projectors of the form $h = |\psi^-\rangle\langle\psi^-|$, where $|\psi^-\rangle = \frac{1}{\sqrt{2}}(|01\rangle - |10\rangle)$). The singlet projector follows the $SU(2)$ symmetry naturally, and the obtained NPA hierararchy is conceptually simpler and practically implementable. I will show several analytic and computational results concerning this new hierarchy.

(Based on work with Jun Takahashi, Chaithanya Rayudu, Robbie King, Kevin Thompson, and Ojas Parekh.)