Networks of non-equilibrium condensates for simulation of spin Hamiltonians

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There is a growing interest in investigating the potential of various physical systems to solve hard optimisation problems. One promising class of optimisers can be based on a driven-dissipative physical platform, namely gain-dissipative simulators. The underlying operational principle of such simulators depends on the gain (pumping) mechanism. As the gain increases from below threshold until a nonzero occupation appears, the system becomes globally coherent. Such a phase transition to a coherent state of matter occurs at the minimum of an associated spin Hamiltonian that describes the maximum occupation of the state for the given gain. Examples of such spin Hamiltonians include Ising, XY, Potts, and Heisenberg models. Finding the global minimum of such spin Hamiltonian problems is known to be strongly NP-complete, meaning that an efficient way of solving them can be used to solve all problems in the complexity class NP. We have developed a general framework for the operation of the gain-dissipative analogue simulators [1] and demonstrated how the minimization of the Ising and XY models can be tackled with polariton graphs [2]. Moreover, motivated by the operation of such physical systems, we have developed a novel class of classical optimisation algorithms that can outperform standard built-in methods [3]. We have also shown recently that other models, including Kuramoto and Stuart-Landau, can be realised with polaritonic networks under different conditions [4]. Together with an individual control of pairwise interactions via spatially varying the dissipation profile [5], the networks of polariton condensates offer great potential for an efficient analogue Hamiltonian optimiser and for reservoir computing.

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