# Coherent Ising Machines – Phase-Space Simulations and Quantum Supremacy

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Coherent Ising Machines (CIM) are a relatively novel [1] type of quantum computational device. Although different types of CIMs exist, they typically involve a system of degenerate optical parametric oscillators (DOPOs). These are coupled in a way that closely resembles an Ising model where the Ising spin states are represented by the parity of the quadrature of the DOPO signal fields. Through an appropriate choice of the coupling matrix, $\mathbf{J}$, a variety of difficult (including NP-hard) problems can be expressed in terms of an Ising model, where the optimal solution corresponds to the ground state and other low-energy states represent good (heuristic) solutions, respectively.

Because that the system is realized by laser pulses, the CIM already exhibits great potential due to very short operating times. An even greater potential lies in the prospect of quantum effects that could steer the CIM into its ground state faster and more reliably than a purely classical system. The role of non-classical effects in CIMs and the conditions under which they appear has been an open question so far.

In this talk, we will give a comprehensive introduction to the topic of Coherent Ising Machines. We pay special emphasis to the role of quantum effects in CIMs. Further, we present a method we have developed for the integration of the system dynamics of a particular type of CIM system via the positive-P phase-space representation, which will bring us one step closer to the study of quantum effects in these systems.

**References**

[1] A Marandi, Z Wang, K Takata, R L Byer and Y Yamamoto, Nat. Photonics **8**, 937 (2014)