A non-quantum computer based on a coherent Ising machine

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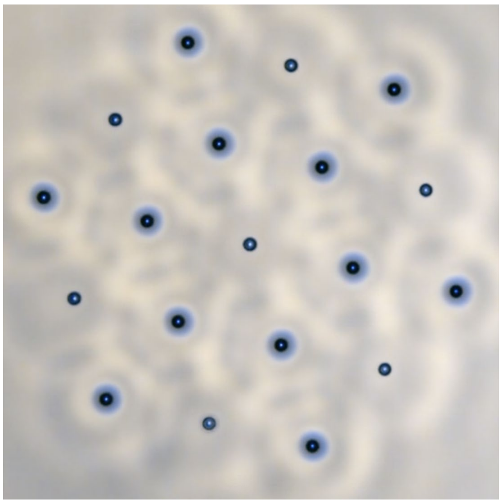

Figure: Coherent Ising machine using interacting bouncing drops as “spins”: image of the bath from above showing the solution (spin up are circled in blue) of a problem with 19 “spins”.

Quantum computing, and quantum-inspired computing, could be the new frontier in answering complex optimization problems that are historically unsolvable on classical computers. Today’s fastest computers may take millennia to conduct highly complex calculations (NP-hard problems), including combinatorial optimization problems involving many variables. The Coherent Ising Machine (CIM) is the most promising solution to date. Combinatorial optimization problems can be mapped onto ground-state-search problems of the Ising model, composed of interacting spins, with polynomial resources. Several approaches have thus been proposed to find solutions to Ising problems using networks of artificial spins based on various physical systems. Recently, interacting degenerated optical parametric oscillators have been coupled to produce a coherent Ising machine [1,2].

We have recently implemented a CIM using small bouncing droplets on a vertically excited bath. Above a certain excitation threshold, the droplets undergo period doubling creating a “spin” with 2 possible states “long jump-small jump” or the opposite. Each droplet interacts with its neighbours through the waves it emits. Depending on the distance between droplets, this interaction will favour in-phase or out-of-phase bouncing. Hence, a problem can be mapped and implemented on this CIM by placing the droplets in specific positions. Then, by increasing the bath excitation, the droplets will try to undergo period doubling and will succeed only when the excitation reaches the first stable possible spin configuration (see figure). Droplets are however limited because their bouncing imposes only in and out-of-phase projections and they have preferred initial positions restricting the mapping.

The aim of this project is to eliminate droplets and the restrictions they impose using controllable electrostriction. Using little modulated electric rod above the surface it is possible to create “spins” with arbitrary phase and positions. This project is experimental and aim to build this wave computer. It is possible to pursue with a funded thesis.

References

[1] A. Marandi et al., Nature Photonics 8, 937– 942 (2014)
[2] P. L. McMahon et al., Science 354, 614–617 (2016)