THESIS TOPICS: 2024-2025

Title: Phase Space Steering of Photonic Ising machines

Description:
Ising machines (IMs) are a newly emerging approach to efficiently perform difficult computational tasks such as solving optimization problems and machine learning. These tasks can otherwise be hard to solve on conventional digital computers. Similar to quantum annealing devices such as the D-WAVE system, IMs allow to efficiently solve hard optimization problems by performing a ground state search of Ising models. But instead of reaching the ground state, these solvers can also get stuck in local optima. Therefore, IMs are typically run several times subsequently in the hope that at least one run will end up in the ground state.

The objective of this project is to develop tools to understand why the IM sometimes get stuck in sub-optimal solutions and to develop techniques to increase the probability of finding the ground state. For this purpose, you will learn to use tools from the study of non-linear dynamical (optical) systems: there exist advanced mathematical tools with which it is possible in simulations to trace all possible solutions – both stable and unstable ones – of a complex system when the parameters of the system are varied. With this numerical approach we want to investigate if there are other, better approaches to drive an IMs towards the ground state by changing the internal parameters of the machine in a controlled way. With this approach, you will try to steer the IMs through the phase space of the system in an optimized manner.

The work will be mainly theoretical and numerical, with some possibilities to experimentally verify the theoretical research work.

Link to current research project: aphy.research.vub.be/eos-project

Location: VUB - Etterbeek

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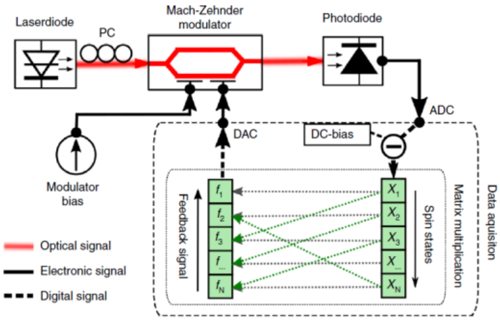

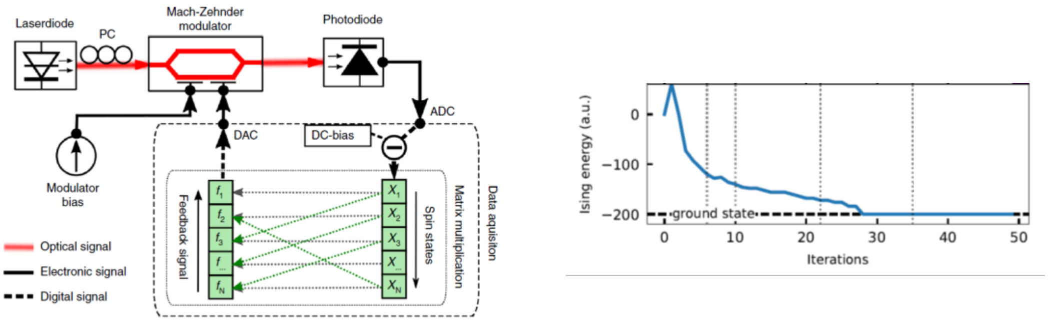

Schematic setup of an opto-electronic Ising machine. The light of a single-mode laser is sent through a Mach-Zehnder modulator. After detecting the optical power, the value of the time-multiplexed artificial spins is recorded using an FPGA. The electrical feedback signal is then calculated in the FPGA and sent to the modulation signal port of the modulator, closing the electro-optical feedback loop. (right) Typical evolution of the energy of the Ising machine, showing a gradual decrease of the energy until the lowest energy ground state is reached. The value of the spins in the ground state then corresponds to the optimum solution of the encoded optimization problem.