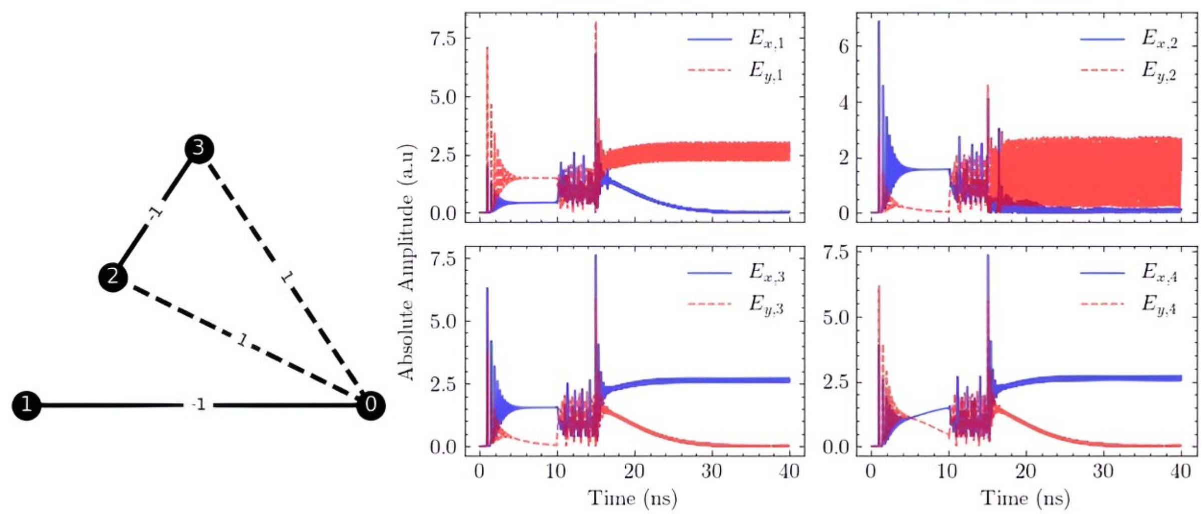
Researchers develop a computer from an array of VCSELs with optical feedback

February 23 2024



In an Ising computer (illustrated here with 4 bits), the variables all evolve towards a solution in parallel. Credit: *Journal of Optical Microsystems* (2023). DOI: 10.1117/1.JOM.4.1.014501

In our data-driven era, solving complex problems efficiently is crucial. However, traditional computers often struggle with this task when dealing with a large number of interacting variables, leading to inefficiencies such as the von Neumann bottleneck. A new type of collective state computing has emerged to address this issue by mapping these optimization problems onto something called the Ising problem in magnetism.

Here's how it works: Imagine representing a problem as a graph, where nodes are connected by edges. Each node has two states, either +1 or -1, representing the potential solutions. The goal is to find the configuration that minimizes the system's total energy based on a concept called a Hamiltonian.

Researchers are exploring physical systems that could outperform traditional computers to solve the Ising Hamiltonian efficiently. One promising approach involves using light-based techniques, where information is encoded into properties like polarization state, phase, or amplitude. These systems can quickly find the correct solution by leveraging effects like interference and optical feedback.

In a study published in the *Journal of Optical Microsystems*, researchers from the National University of Singapore and the Agency for Science, Technology, and Research looked at using a system of vertical-cavity surface-emitting lasers (VCSELs) to solve Ising problems. In this setup, information is encoded in the linear polarization states of the VCSELs, with each state corresponding to a potential solution.

The lasers are connected to each other, and the interactions between them encode the problem's structure.

The researchers tested their system on modest 2-, 3-, and 4-bit Ising problems and found promising results. However, they also identified challenges, such as the need for minimal VCSEL lasing anisotropy, which may be difficult to achieve in practice. Nonetheless, overcoming these challenges could lead to an all-optical VCSEL-based computer architecture capable of solving problems that are currently out of reach for traditional computers.

More information: Brandon Loke et al, Linear polarization state encoding for Ising computing with optically injection-locked VCSELs, *Journal of Optical Microsystems* (2023). DOI: 10.1117/1.JOM.4.1.014501

Provided by SPIE