



heisingberg

SPATIAL QUANTUM OPTICAL ANNEALER
FOR SPIN HAMILTONIANS



Heisingberg insights

Stay ahead in spatial photonic Ising machines!

Welcome to the new edition of Heisingberg Newsletter!

As we strive to clarify the nature of the quantum advantage available in photonic simulators, we're excited to share key updates in the development of efficient solving of NP-hard problems, groundbreaking research publications, and presentations in important events.

Stay with us as we explore the latest advancements shaping the future of spatial optical annealers!

Consortium



SAPIENZA
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Funded by the European Union GA No: 101114978.



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Publications

1. [Ising Hamiltonian minimization: Gain-based computing with manifold reduction of soft spins vs quantum annealing](#), *Phys. Rev. Research* **7**, 013150 (2025)
2. [Unlocking multiphoton emission from a single-photon source through mean-field engineering](#), arXiv:2411.10441
3. [Complex vector gain-based annealer for minimizing XY Hamiltonians](#), arXiv:2411.02010
4. [Observation of 2D dam break flow and a gaseous phase of solitons in a photon fluid](#), *Phys. Rev. Lett.* **133**, 183801 (2024)
5. [Correlations in Circular Quantum Cascades](#), *Phys. Rev. A* **111**, 023704 (2025)
6. [Encoding arbitrary Ising Hamiltonians on Spatial Photonic Ising Machines](#), *Phys. Rev. Lett.* **134**, 203801 (2025)
7. [Training of Physical Neural Networks](#), arXiv:2406.03372
8. [A Fully Analog Pipeline for Portfolio Optimization](#), arXiv:2411.06566
9. [Localization in Quantum Field Theory for inertial and accelerated observers](#), *J. Phys. A: Math. Theor.* **58**, 045401 (2025)
10. [Fully Programmable Spatial Photonic Ising Machine by Focal Plane Division](#), *Phys. Rev. Lett.* **134**, 063802 (2025)
11. [Roadmap on Neuromorphic Photonics](#), arXiv:2501.07917
12. [Unveiling Asymmetric Topological Photonic States in Anisotropic 2D Perovskite Microcavities](#), *Light: Science & Applications* **14**, 207 (2025)



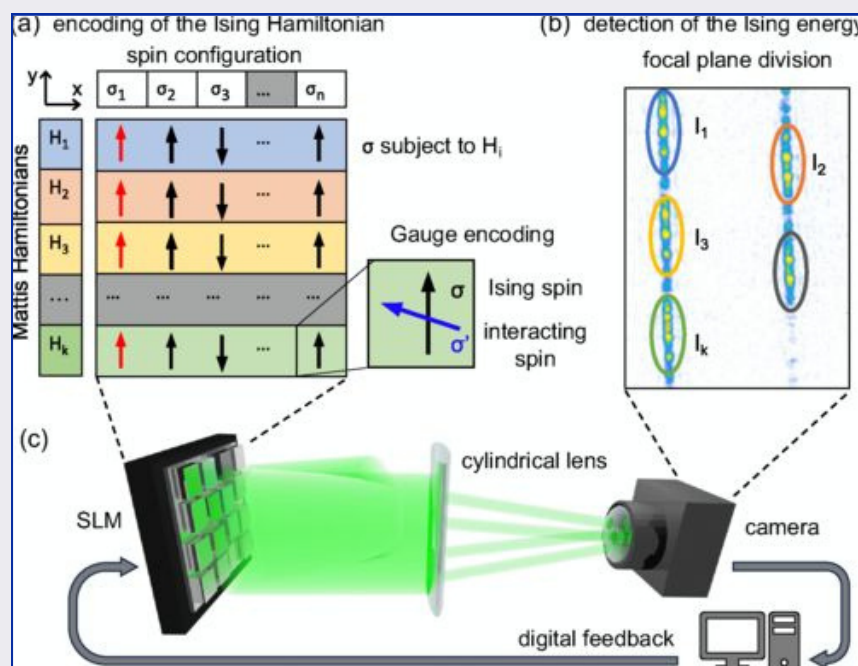
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Research Highlights

Fully Programmable Spatial Photonic Ising Machine by Focal Plane Division

Phys. Rev. Lett. **134**, 063802 – Published 14 February, 2025



A fully programmable SPIM is achieved through a novel operation method based on the division of the focal plane. In our scheme, a general Ising problem is decomposed into a set of Mattis Hamiltonians, whose energies are simultaneously computed optically by measuring the intensity on different regions of the camera sensor. Exploiting this concept, we experimentally demonstrate the computation with high success probability of ground-state solutions of up to 32-spin Ising models on unweighted maximum cut graphs with and without ferromagnetic bias.

[Read full article](#)



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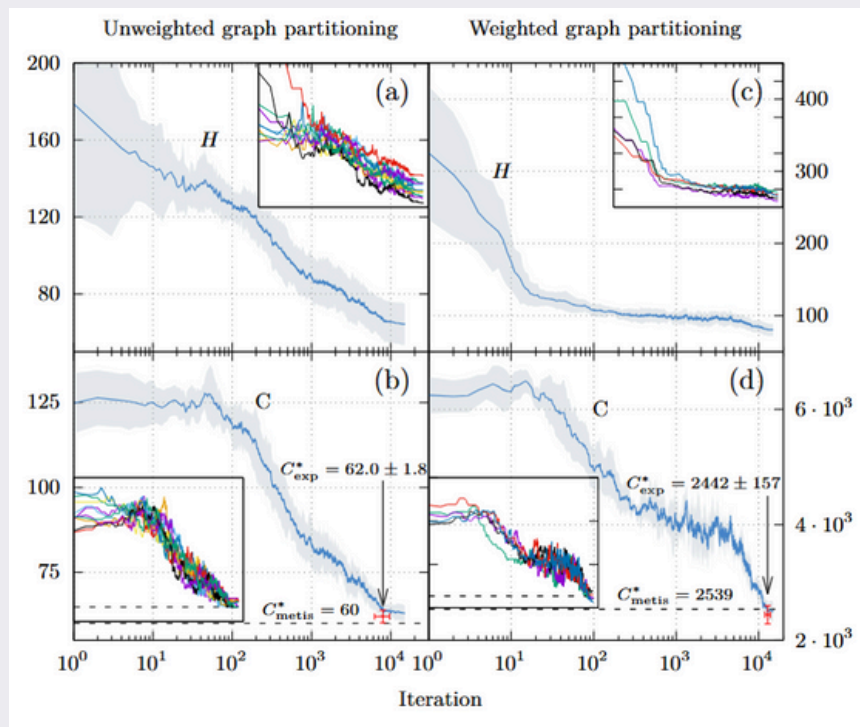


SPATIAL QUANTUM OPTICAL ANNEALER
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Research Highlights

Encoding Arbitrary Ising Hamiltonians on Spatial Photonic Ising Machines

Phys. Rev. Lett. **134**, 203801 – Published 20 May, 2025



We introduce and experimentally validate a SPIM instance that enables direct control over the full interaction matrix, allowing the encoding of Ising Hamiltonians with arbitrary couplings and connectivity. We demonstrate the conformity of the experimentally measured Ising energy with the theoretically expected value and then proceed to solve both the unweighted and weighted graph partitioning problems, showcasing a systematic convergence to an optimal solution via simulated annealing. Our approach significantly expands the applicability of SPIMs for real-world applications, as it is more efficient than matrix decomposition methods in the case of sparse problems.

[Read full article](#)



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Events

PLMCN Conference 2025 8-15 April, Xiamen, China



Profs. Pavlos Savvidis and Fabrice Laussy participated with invited talks at the 2025 PLMCN Conference in Xiamen, China

Quantum Light and Fluids 28 April - 2 May, 2025, IBS, Daejeon, South Korea



Profs. Pavlos Savvidis and Fabrice Laussy participated with invited talks at the Quantum Light and Fluids meeting, held at the Institute for Basic Science in Daejeon, South Korea

CLEO Conference 2025 4 - 9 May, Long Beach, CA, USA



Prof. Claudio Conti, from Sapienza team, and Prof. Natalia Berloff, representing the University of Cambridge team, shared insights from their joint work on Heisingberg, with invited talks at the conference.

2nd International workshop on Ising machines 13 - 15 May, Chicago, IL, USA



Prof. Natalia Berloff gave an invited talk and Davide Pierangeli presented the "Ising machine based on nonlinear polarization oscillators".



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Fact Sheet

Title: **Spatial Quantum Optical Annealer for Spin Hamiltonians**

Acronym: HEISINGBERG

GA No: 101114978

Start: 01 November 2023

End: 31 October 2027

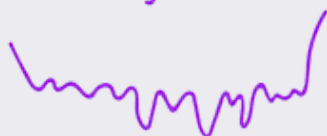
Budget: € 3.260.250 €

EU Fund: € 3.260.250 €

Topic: HORIZON-EIC-2022-PATHFINDERCHALLENGES-01-06

Scheme: HORIZON-EIC Grants

Call: EIC Pathfinder Challenge: Alternative approaches
to Quantum Information, Processing,
Communication, and Sensing

$$H = - \sum_{ij} J_{ij} \sigma_i \sigma_j$$


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