



Hands-on Workshop with D-Wave Quantum Computers

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D-WAVE

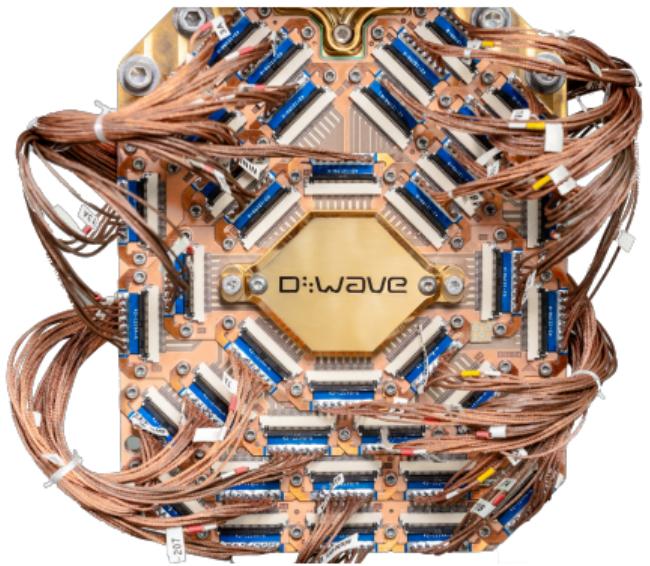
In this workshop

The aim of the workshop is to showcase and work hands-on with some OceanTM SDK tools useful for physics experiments

- Landau-Zener and Kibble-Zurek experiments
- Jupyter notebook, with code snippets and links
- Question and answer

Check your email for an invitation to the Leap project, which provides the API token necessary for D-Wave quantum computer access.

Log in to github, or download the code:
<https://github.com/dwave-training/2025-aqc-workshop>



D-Wave



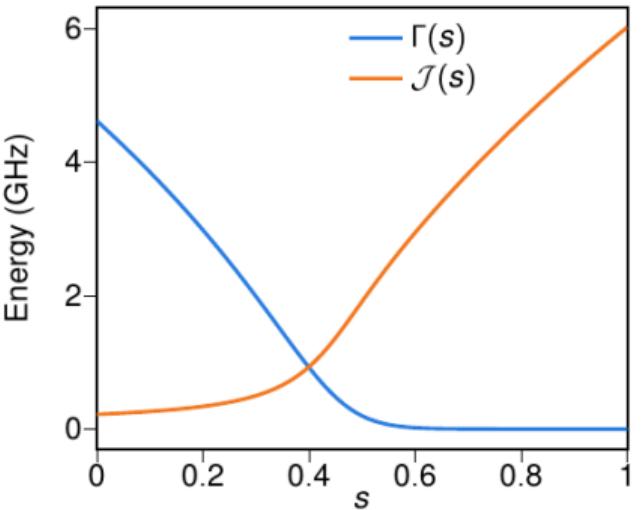
Quantum annealing

Evolve a multi-spin system for time t_a ,

$$H(s = t/t_a) = -\Gamma(s) \sum_i \sigma_i^x + \mathcal{J}(s) H_p$$

- 1 Program a problem Hamiltonian
 $H_P = \sum_{ij} J_{ij} \sigma_i^z \sigma_j^z + \sum_i h_i \sigma_i^z$
- 2 Prepare a ground state at (large $\Gamma(s=0)$ and small $\mathcal{J}(s=0)$)
- 3 Evolve to large $\mathcal{J}(s=1)$ and small $\Gamma(s=1)$
- 4 Measure in the computational basis

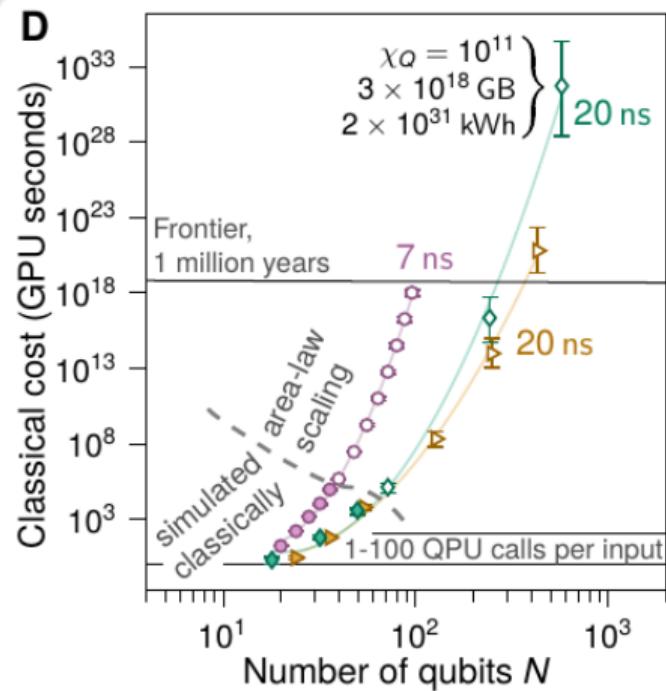
Kadowaki and Nishimori, Phys. Rev. E 58,
5355 (1998)



Six recent papers

- 1 Coherent quantum annealing in a programmable 2,000 qubit Ising chain, *Nature Physics* (2022)
- 2 Quantum critical dynamics in a 5,000-qubit programmable spin glass, *Nature* (2023)
- 3 Quantum error mitigation in quantum annealing, *npj Quantum Information* (2025)
- 4 Beyond-classical computation in quantum simulation, *Science* (2025)
- 5 Blockchain with proof of quantum work (arXiv:2503.14462)
- 6 Quantum dynamics in frustrated Ising fullerenes (arXiv:2505.08994)

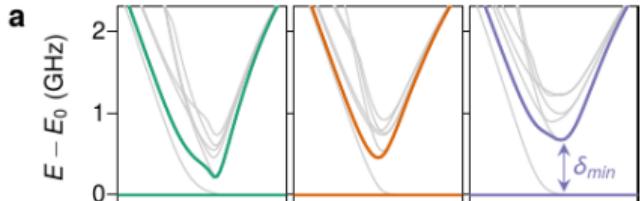
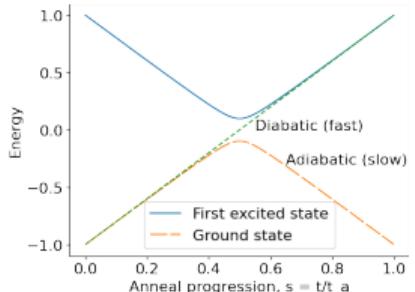
Projected classical resources to match QPU



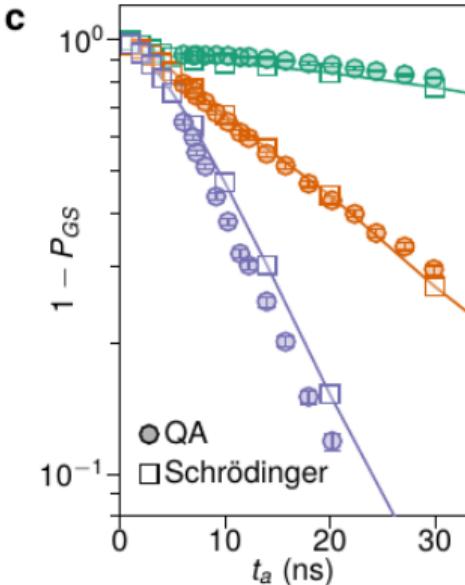
Landau-Zener dynamics with 16-qubit frustrated models



The probability to excite away from the ground state decays exponentially with the annealing time: the exponent determined by the inverse square gap.



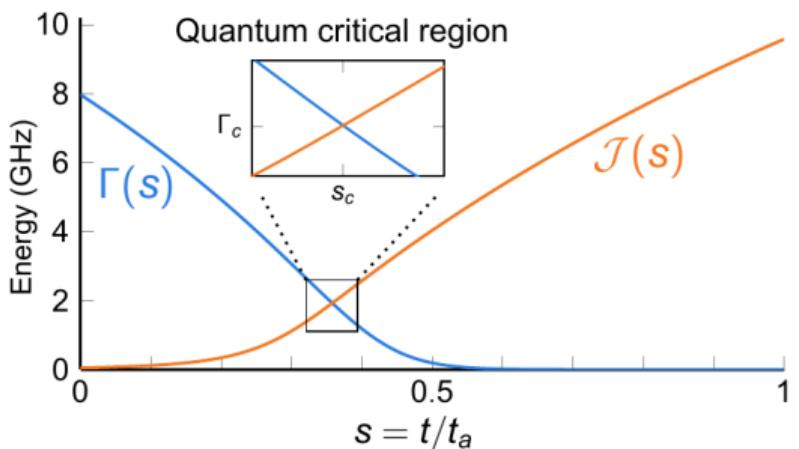
Quantum critical dynamics in a 5,000-qubit programmable spin glass, Nature (2023)



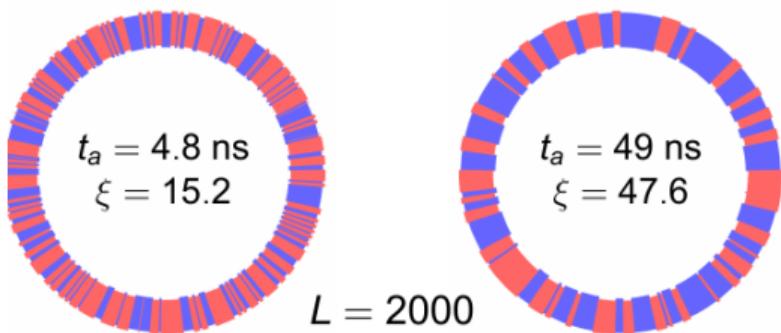
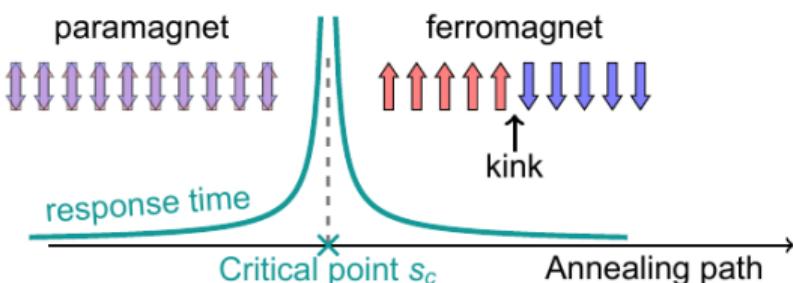


Kibble-Zurek dynamics in 1D

Defect rates (equivalently residual energy) decays as a power of the annealing time; the power determined by the universality class of the phase transition.



Coherent quantum annealing in a programmable 2,000 qubit Ising chain, Nature Physics (2022)





Run the code (locally or codespaces)

At <https://github.com/dwave-training/2025-aqc-workshop>
Code > codespace > +

dwave setup --oob # Paste the workshop token for the Leap quantum cloud service access

python main.py # Run with defaults

python main.py --help # Show experiment options:

- solver_name: e.g. Advantage2_system1.1
- model: Landau-Zener or Kibble-Zurek
- use_srt: Randomize (sign flip) the computational basis definition. A means to mitigate control errors.
- parallelize_embedding: embed many times. A means to mitigate control, and sampling, errors.

Question and answer



- Questions welcome!
- Please see the experiments_supplementary_notebook.ipynb repository notebook for further exploration of physics-orientated Ocean SDK tools and resources.
- We're hiring: <https://www.dwavequantum.com/company/careers/>
- Thanks for attending, feedback is welcome: jraymond@dwavesys.com

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