Counting defects in quantum computers

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6. All of these calls for a simple test.

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2. Going back to the D-Wave annealer (10^3 qubits):

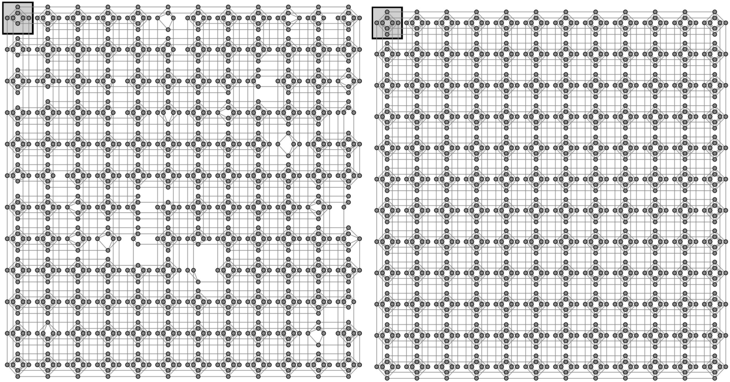


Figure: D-Wave chip. Real (virtual) chimera graph on the left (right).

Ising

$$H(t)/\hbar = -g(t)\sum_{i=1}^{L}\sigma_i^x - J(t)\sum_{i=1}^{L-1}\sigma_i^z\otimes\sigma_{i+1}^z. \tag{1}$$

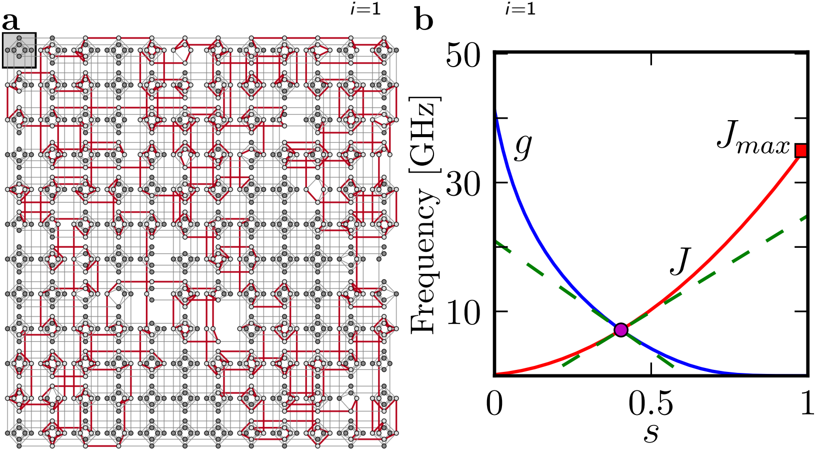
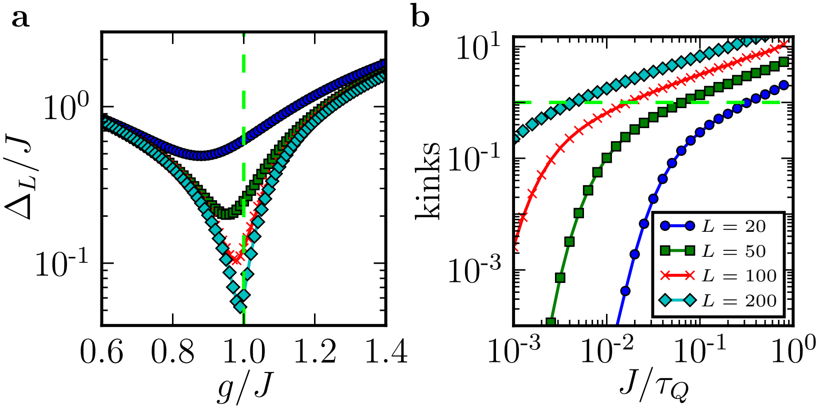


Figure: 1D transverse Ising model. $s = t/t_a$, t_a - annealing time.

Defects aka kinks

Initial state (easy to prepare): $|\psi(0)\rangle = |\rightarrow\rightarrow\cdots\rightarrow\rangle$



Kibble–Zurek mechanism predicts

$$\#\text{kinks} \sim \tau_Q^{-1/2}, \quad \text{where} \quad \tau_Q^{-1} - \text{speed @ critical point} - t_a^{-1} \qquad (2)$$

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3. One defect increases this energy by $2|J_{max}|j(t_a)$.
4. Therefore, if $j(t_a)E$ denotes the final energy then

$$\#\text{kinks} = \frac{|J_{max}|(L-1)+E}{2|J_{max}|}. \tag{3}$$

Measurement in the computational basis: $|\uparrow\rangle$, $|\downarrow\rangle$

E is provided by the D-Wave solver.

Measurements

$$\#kinks \sim \tau_Q^{-1} \text{ rather than } \sim \tau_Q^{-1/2} \;!$$

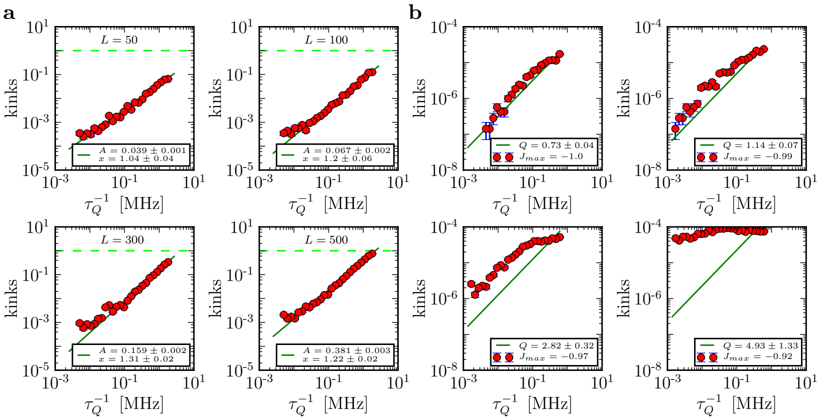

Figure: Defect generation for the quantum Ising chain on D-Wave.

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3. Is there a simple model that captures this behavior? (may not be)
4. Is dissipation relevant? (we don't believe so)

Special thanks goes to Mike Zwolak...

Thank you!