"Quantum vs. Optical Annealing: Benchmarking the Coherent Ising Machine and D-Wave"

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Physical annealing machines are promising tools for combinatorial optimization problems. This talk presents a comparison between two types of annealing machines—a quantum annealer (QA) built by D-Wave Systems and coherent Ising machines (CIMs) based on optical parametric oscillators—on two problem classes, the Sherrington-Kirkpatrick (SK) model and MAX-CUT. Performance is strongly dependent on both the edge density of the benchmark problems and the intrinsic connectivity of the physical machine. For MAX-CUT problems on cubic graphs, the QA outperforms the CIMs by a small factor. For dense-graph MAX-CUT and SK instances, we notice an exponential performance penalty for the QA [$\exp(-O(N^2))$] relative to CIMs [$\exp(-O(N))$]. This leads to a several-orders-of-magnitude time-to-solution difference for instances of even moderate size ($N > 50$). We propose that the performance penalty stems from the sparse connectivity of the QA and the resulting embedding overhead, which provides strong experimental support for efforts to increase the connectivity of quantum annealers.

Biography:
Ryan had many interests when he was young, but when he saw Tesla coil in action at high school, he knew he wanted to become a physicist. He taught himself electromagnetism to build his own Tesla coil, but during his studies at Caltech, he veered off into particle physics and general relativity. In graduate school at Stanford (Mabuchi group), he returned to electromagnetism, pursuing research on quantum feedback control, quantum optics, and nonlinear optics. After graduating, he spent a gap year working at NII in Tokyo (Yamamoto group) on quantum annealing and optical parametric oscillator networks for combinatorial optimization. He is presently an IC postdoctoral fellow at MIT (Englund group) working on integrated photonics and deep learning.