# Simulations of physical systems with near-term annealing technology

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Not only does modern technology, which is centered around quantum annealers, promises to tackle "hard" optimization problems but also to pave the way for the *efficient* simulations of physical systems. This has always been a "holy-grail" of modern physics and arguably, still is one of the most exciting endeavors in current times that may also result in solving many real-life issues faster and more accurately. For instance, drug research and development, supply chain logistics, finance, encryption, and cybersecurity.

Here, we propose to explore ideas revolving around *generic* annealing-inspired computing devices, and asses their feasibility to simulate physical systems, especially models of interacting qubits, in *not* too distant future. There are two **key ideas** that we have envisioned for this project:

**I1.** Finding new algorithms that can be assisted by near-term classical and quantum annealers to simulate dynamics encoded in spin-glass instances.

**I2.** Devising classical algorithms based on tensor networks, (spiking) neural networks and Monte Carlo inspired methods to determine the underlying structure of low-energy spectrum of spin-glass problems.

Those ideas are built upon three **specific tasks** that are to be achieved within this proposal:

**T1.** Conduct experimental parallel-in-time simulations of *few*-body physical systems on annealers.

**T2.** Experimentally simulate the *many*-body dynamics through sampling with annealers.

**T3.** Numerically emulate and assess the near-term annealing technology with tensor and neural networks.

We will identify systems that could be simulated with the technology available today or in the near future. First and foremost, we are aiming at demonstrating various proof of principles involving theory, experiments, and computer simulations. Our objectives are mainly concerned with the validation of the emerging annealing technology and determining its potential applications for physics simulations. As even small systems can exhibit abundant dynamics, e.g, sudden death and revival of entanglement, we will provide feasible candidates for "hard" instances to test the *limits* of the near-term annealing technology.

Almost as a by-product, we will create a platform to emulate and assess various annealing devices with state-of-the-art approaches. Naturally, such an open-source library may be utilized to tackle optimization problems arising across various scientific disciplines and operational research.