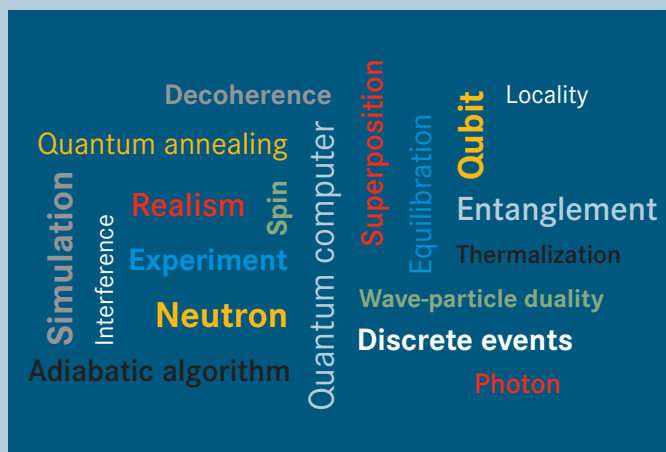


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Quantum Information Processing

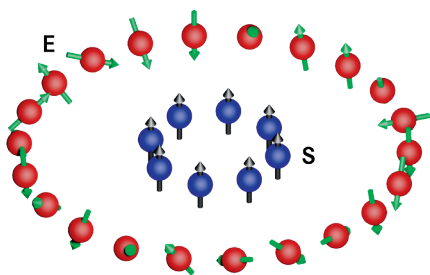


Massively parallel quantum spin dynamics simulator simulates 42-qubit quantum computer on JUGENE (262,144 CPUs)

- Nearly perfect scaling with increasing problem size and number of CPUs
- Beats exponential scaling
- Obeys Gustafson's law

Simulation of quantum spin systems

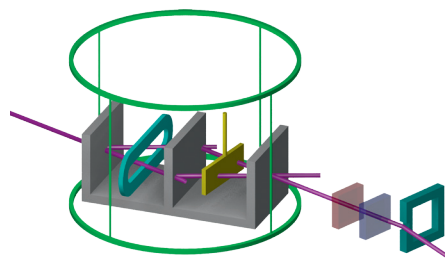
- Solve the time-dependent Schrödinger equation for systems with up to 36 qubits
- Investigate decoherence, equilibration and thermalization of a system S coupled to an environment E



- No need to postulate the canonical ensemble; it may be a natural consequence of the dynamical evolution of (small) quantum systems

Event-based simulation of quantum phenomena

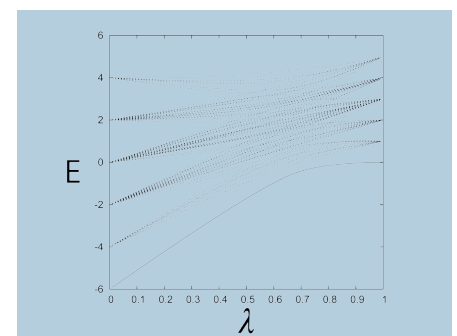
- Experiments with single photons and neutrons
- Record individual detector clicks (= events)
- Demonstrate interference and entanglement



- Discrete event (particle-like) simulations provide a realistic cause-and-effect description of experimental observations

Adiabatic quantum computing

- Algorithm: Solution to an optimization problem is encoded in the ground state of H_p . To find the solution:
 - Initialize system in "easy to reach" ground state of H_i
 - Slowly modify the Hamiltonian of the system from H_i to H_p using $H = \lambda H_p + (1-\lambda)H_i$



- Application: Solve hard instances of 2SAT (in P) and 3SAT (NP-hard) problems