Johannes-Kepler-Vorlesung

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"Components for high-fidelity quantum computing"

We have known for twenty years that quantum computers would have unique powers for solving certain classes of computational problems. Throughout these twenty years, workers have striven to identify a physical setting in which high-quality qubits can be created and employed in a quantum computing system. Very promising devices have been identified in several different areas of low-temperature electronics, namely in superconductor and in single-electron semiconductor structures (e.g., quantum dots). Rudimentary efforts at scale-up are presently reported; even for modules of 10 qubits or so, many imperfections become evident, and it is not clear how scaling to larger systems should go. In this talk I will outline two major lines of work that we have undertaken to tailor and refine couplings in qubit systems. First is a critical examination of the ubiquitous Rotating Wave Approximation; we derive a new series which defines a family of effective Hamiltonians that go systematically beyond the RWA. In the second half I will explain a new layout for qubits and resonators that we have proposed, which should significantly improve the modularity and controllability of couplings in multi-qubit layouts.