Inaugural Lectures

Faculty of Mathematics, Computer Science and Physics

Wolfgang Dür
Institute for
Theoretical Physics

Quantum networks – design and applications

Coupling quantum devices opens new possibilities, and allows one to unlock their full potential. Such quantum networks exist at different scales, and we describe methods to realize and operate them. This includes protocols such as entanglement purification and quantum repeaters for long-distance entanglement distribution, state certification and the development of novel design principles. In the latter case, pre-shared multipartite entangled states serve as a resource to fulfill network requests on demand. Such entanglement-based quantum networks offer new features such as speeding up network requests, and network optimization independent of the underlying physical structure. We show how to simulate, design and optimize such entanglement-based networks, and study their performance under noise. Finally, we discuss how to make quantum networks genuine quantum by providing them with the possibility of handling superposed tasks, which allows one to e.g. mitigate noise. We discuss applications in the context of distributed quantum computation and quantum sensing, where quantities with specific spatial dependence can be measured directly with enhanced precision, despite the influence of spatially correlated noise.

Wolfgang Lechner
Institute for
Theoretical Physics

Parity-based Quantum Computing

Quantum computers aim at solving computational problems using controlled quantum systems. The building blocks are the quantum bits (qubits) and the quantum gates between these qubits. While the prospect of speedup in these types of computers is unprecedented, there are also fundamental challenges that have not yet been overcome and new computer architectures need to be developed. The architecture of classical computers is called von Neumann architecture, which consists of memory, a processing unit and a bus system. This cannot be directly translated to quantum computers. The no-cloning theorem rules-out that quantum information can be copied and thus stored in a memory and transferred to registers.

My research is dedicated to architectures for quantum computers. My approach that does not rely on translating bits to quantum bits, but quantum information is represented as relative information, called the “parity”. With this architecture, quantum gates between qubits translate to single qubit operations. I will show how this paradigm applies to adiabatic quantum computers, measurement-based quantum computers, near term universal quantum computers, error mitigated quantum computers and fully fault tolerant quantum computers. I will also present applications of the parity architecture, and how it results in the most efficient implementation of the Quantum Fourier transform.

Tuesday, 26.11.2024 at 16:30 - HS A
(VFH-Haus)