TUT 1: Tutorial Basics of Quantum Information and Computation

Time: Sunday 15:00–16:30 Location: ZHG104

Tutorial TUT 1.1 Sun 15:00 ZHG104

Basics of quantum information and computation — •Ralf Schuetzhold — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — TU Dresden, Germany

The goal of this tutorial is to provide a brief introduction into the basics ideas and concepts of quantum information and computation at the beginners level (assuming no knowledge besides the basic laws of quantum theory). The basic question is: how can we exploit the laws of quantum physics in order to perform task better than with classical physics? Apart from computation, this may also include communication, sensing, simulation and other applications.

TUT 2: Tutorial What can Quantum Computers do – and what can't they?

Time: Sunday 15:00–16:30 Location: ZHG105

Tutorial TUT 2.1 Sun 15:00 ZHG105

What can quantum computers do - and what can't they? — •Jens Eisert — Dahlem Center for Complex Quantum Systems, Freie Universität Berlin

Quantum computers - so computers whose fundamental units of information are quantum systems - promise solutions to computational problems that are beyond the reach of classical supercomputers. However, this does not mean they can solve all problems faster. In fact, this advantage seems to apply only to a small number of highly structured problems - those for which a provable separation exists between quantum and classical capabilities.

This tutorial introduces some elementary quantum algorithms, explores more sophisticated ones, and examines both the potential and the limitations of fully fault-tolerant quantum computers. It also serves as an invitation to contribute to this field, as each new class of quantum algorithms has historically begun with a genuinely novel idea.

TUT 3: Tutorial Quantum Foundations from a QI Perspective

Time: Sunday 17:00–18:30 Location: ZHG104

Tutorial TUT 3.1 Sun 17:00 ZHG104

Quantum foundations from a QI perspective — •Markus Frembs — Leibniz University, Hannover, Germany

Even 100 years after its inception, the foundations of quantum theory remain an active area of research. A plethora of competing interpretations offer different views on long-standing issues such as the infamous measurement problem, Einstein's 'spooky action at a distance' and Bohr's complementarity. At the core of these lies the discrepancy between the unparalleled predictive success of the mathematical apparatus of quantum mechanics and our every-day experience, which by and large obeys the laws of classical physics.

The first part of the tutorial will discuss two famous no-go-theorems in quantum foundations - by Bell, Kochen and Specker - which throw into sharp relief how this discrepancy between classical and quantum physics has drastic consequences for our physical understanding of the world: first, certain quantum correlations defy a causal classical explanation and, second, contextuality expresses the incompatibility with classical realism altogether. The experimental verification of entanglement which has recently been awarded the Nobel Prize in Physics leaves little room for adhering to a classical interpretation.

Rather than challenging such counterintuitive predictions, the field of quantum information theory embraces them as features, asking if and how they can be put to use in computational or information-processing tasks. The second part of the tutorial will list a number of examples to the resourcefulness of quantum theory e.g. in cryptography and computation.

TUT 4: Tutorial Quantum Optimal Control

Time: Sunday 17:00–18:30 Location: ZHG105

Tutorial TUT 4.1 Sun 17:00 ZHG105

Quantum Optimal Control in a Nutshell — •Daniel Reich — Freie Universität Berlin, Dahlem Center for Complex Quantum Systems and Fachbereich Physik, Berlin, Germany

Since the start of the 21st century, research and development of technologies actively exploiting quantum properties of light and matter has experienced a surge in popularity. To this end, quantum optimal control is one of the main tools for devising concrete protocols to manipulate quantum systems in order to achieve specific tasks in the best way possible. In the first part of this tutorial I tell you about the main principles of quantum optimal control and provide a brief summary of the key techniques used in the field. In the second part I demonstrate the power of the quantum optimal control toolbox via practical use cases. Finally, I introduce some of the available software packages such that you can start controlling quantum systems, too.