2.3.7 Quantum Information Processing: From Atoms to Circuits

Lecturer	Prof. Dr. Alexey Ustinov
Course Objectives	The module will introduce the theoretical and technological foundations of quantum information processing. We will talk about quantum bits (qubits), quantum computing, and various qubit realizations ranging from spins to circuits. The course goal is to learn, form a practical point of view, about various modern quantum technologies ranging from quantum computing and physics of decoherence to quantum communication and quantum simulators
Contents	The following selection of topics will be presented • Physics of quantum two-level systems • Qubits and quantum gates • Quantum algorithms, quantum computers and quantum simulators • Free-space qubits (atoms, ions, and photons) • Solid qubits (NV-centers in diamond, spins in silicon) • Circuit qubits (quantum dots, superconducting qubits) • Physics of Josephson devices, phase-charge duality • Superconducting qubits (charge, flux, phase) • Phase qubit: preparation, manipulation and readout • Transmon and flux qubits • Coupled qubits and gates • Decoherence and error correction • Circuit/cavity quantum electrodynamics
Learning Targets/ Skills	After course completion, participants should ▪ understand the basic idea of quantum computing ▪ get an idea of quantum manipulation ▪ understand basics of decoherence ▪ have an overview of various types of qubits ▪ learn about basics of superconducting quantum circuits ▪ know about various implementations of quantum computers and simulators
Pre-Requisites	Basic quantum physics and electrodynamics
Duration	7 x 2 h
Teaching Method	Lectures, tutorial style discussions, lab tour, scientific literature
Course Material	Lecture slides
Literature	▪ Research papers cited in the lecture slides ▪ M. Nielsen and I. Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 10th Ed., 2010 ▪ M. Homeister, Quantum Computing verstehen, Vieweg+Teubner, 2. Aufl, 2008
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