03-IMAP-QCFT	Quantum Computing toward Fault Tolerance

Lehrform *(teaching format)* / **SWS** *(hours per week)*: 2VL + 2UE

Kreditpunkte *(credit points)*: 6

Turnus *(frequency)*: usually each winter term

Inhaltliche Voraussetzungen *(content-related prior knowledge/skills)*: A solid foundation on linear algebra is highly recommended, as well as on Python for practical exercises. Knowledge of group theory, quantum mechanics/quantum information is a plus.
Due to the depth and breadth of the lectures scope, students are expected to refresh on fundamentals and reinforce acquired knowledge, while keeping up with the pace of the course.

Sprache *(language)*: English

Lehrende *(teaching staff)*: AG-Robotik (Prof. Dr. Frank Kirchner u.a.)

Studiengang *(degree program)*	Module	Semester
Informatik (Master, MPO'20)	IMAP, IMVP-SQ	ab 1.Sem.
Informatik (Master, MPO'26)	IMAP	ab 1.Sem.

Lernergebnisse / *Learning Outcome*:

The goal of the lecture is to establish a solid theoretical foundation on the theory of fault-tolerant quantum computing. Additionally, the students will implement the learned concepts in hands-on programming exercises using established toolkits like Stim.

Inhalte / *Contents*:
The course will cover the following topics: Basics of quantum computing, noise and quantum operations, quantum circuits, quantum error correction, quantum error correcting codes (Shor-Code, Surface-Codes, CSS-Codes), logical encoding, Clifford group and magic states, concatenated codes, fault-tolerance, transversality, Shor-/Steane-/Knill-Error Correction, magic state distillation.

The practical exercises and homeworks will cover: Detectors and detecting regions, detector error models (DEMs), decoding algorithms, fault-tolerant quantum circuit design and validation,

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Hinweise *(remarks)*: The table lists only the primary / most specific modules to which this course is assigned.