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Introductory Topics in Quantum and Photonic Computing

The list below includes possible topics and the necessary literature. Modifications and extensions are generally possible. Access to the literature is provided if required.

1 Basics of quantum computing

This talk is based on [Sch19, Chapter 2 and 3]. It is meant to present the basic mathematical framework for quantum computing. The talk should not cover all the details in these chapters, but rather give a high-level introduction with selected aspects (based on preference).

2 Entanglement

This talks follows [Sch19, Chapter 4, Sections 4.1–4.5.1] and should introduce the concept of entanglement, which is a central aspect of the power of quantum computers.

3 Impossible devices

This talk is based on [Sch19, Chapter 4, particularly Sections 4.5.2–4.7]. It is partially a continuation of the previous talk (Section 4.5.2), but will also focus on certain algorithms that cannot be realized with a quantum computer. This shows important limitations of quantum computers.

4 Quantum gates

This talk follows [Sch19, Chapter 5, Sections 5.1–5.2], introducing basic operations (so-called gates), that are the basis of quantum algorithms.

5 Quantum circuits and implementation of functions

This talk follows [Sch19, Chapter 5, Sections 5.3–5.6] and uses the gates from the previous talk to construct more involved algorithms, so-called circuits. Not all aspects need to be covered but rather certain selected ones (based on preference).

6 Exploiting entanglement

This talk is based on [Sch19, Chapter 6]. The goal is to construct certain algorithms that exploit entanglement to become very efficient. Multiple specific algorithms are possible and can be selected based on personal preference.

7 Basics of Photonic Computing

This talk is based on [BPC+20] and introduces the basic ideas and principles of photonic computing.

8 Photonic devices and neural networks

This talk is based on [STH24, pages 3–48] and should present how to utilize photonic devices in the context of neural networks.

Literatur

[BPC+20] W. Bogaerts, D. Pérez, J. Capmany, D. A. B. Miller, J. Poon, D. Englund, F. Morichetti, and A. Melloni. Programmable photonic circuits. *Nature*, 586(7828):207–216, 2020.

[Sch19] W. Scherer. *Mathematics of Quantum Computing*. Springer, 2019.

[STH24] H. Suzuki, J. Tanida, and M. Hashimoto, editors. *Photonic Neural Networks with Spatiotemporal Dynamics: Paradigms of Computing and Implementation*. Springer, 2024.