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An introduction to quantum entanglement

In October 2019, a team at Google announced they achieved *quantum supremacy* [A+19b]: for the first time, a quantum computer performed a computation that a classical computer could not do in a reasonable amount of time. This remarkable technological achievement builds upon theoretical insights on the features of quantum computers that allow them to achieve speed-ups in computational tasks. One of the most important such features is **quantum entanglement**, which is provably a necassary resource in most quantum information processing tasks. The goal of this course is to give a self-contained introduction to the theory of quantum entanglement, focusing on topics such as entanglement detection, entanglement criteria, symmetric states, and multi-partite entanglement. Importantly, I will also give an introduction to quantum programming using `Qiskit` [A+19a], a `python`-based programming framework allowing access to IBM's quantum computer.

Prerequisites: basic quantum mechanics, solid knowledge of linear algebra, basic programming skills

Language: English or French, depending on the students attending

Duration: 10×2 hours

Lecture plan:

1. Review of linear algebra
2. Quantum states
3. Quantum entanglement
4. Introduction to `Qiskit`
5. Basic quantum algorithms in `Qiskit`
6. Quantum channels
7. Entanglement detection
8. Symmetric extensions
9. Multipartite entanglement
10. Entanglement in tensor network states

References

[A+19a] Héctor Abraham et al. Qiskit: An open-source framework for quantum computing, 2019.

[A+19b] Frank Arute et al. Quantum supremacy using a programmable superconducting processor. *Nature*, 574:505–510, 2019.