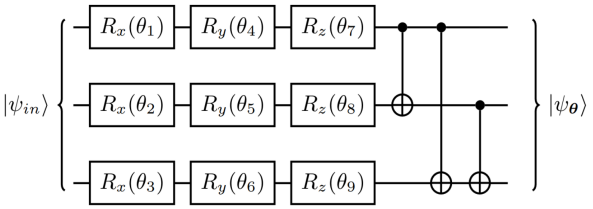
Genetic Algorithms for Quantum Circuits

One of the most promising algorithms for the current state of quantum computers is the so-called variational quantum eigensolver (VQE). This algorithm leverages both quantum and classical computing to compute the ground state energy of various many-body quantum systems.



In this project you will use genetic algorithms: an evolution-inspired reinforcement learning (RL) approach with excellent performance at various human-like tasks, such as video games. The aim is to create huge numbers of quantum circuits and 'evolve through survival of the fittest' the best performing circuits in search for the ground state wavefunction of various Hamiltonians that you may be familiar with from your courses.

You will learn to:

- Simulate quantum circuits using Python
- Use various RL algorithms to optimise the structure of a quantum circuit
- Explore the benefits/shortcomings of many RL algorithms and even design your own algorithms to best evolve a population of quantum circuits
- Contextualise your results within the larger picture of condensed matter physics

Core concepts: quantum circuits, reinforcement learning, model comparison, ground state search.

References:

- Sünkel, L., Martyniuk, D., Mattern, D., Jung, J., & Paschke, A. (2023). GA4QCO: genetic algorithm for quantum circuit optimization. *arXiv preprint arXiv:2302.01303*.
- Holland, J. H. (1992). Genetic algorithms. *Scientific american,* 267(1), 66-73.
- Sipper, M., (2023). How to Build a Genetic Algorithm from Scratch in Python with Just 33 Lines of Code, *Medium*.